Odour Assessment

Somerset Farm, Murrow

Client: Murrow AD Plant Ltd

Reference: 5500-2r4

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Executive Summary

Redmore Environmental Ltd was commissioned by Murrow AD Plant Ltd to undertake an Odour Assessment in support of an Environmental Permit Variation Application for Murrow Anaerobic Digestion facility at Somerset Farm, Murrow.

Odour emissions from the facility have the potential to cause impacts at sensitive locations. An Odour Assessment was therefore undertaken to quantify effects in the vicinity of the plant.

Emissions from the relevant sources were defined based on the nature and size of the plant, as well as information on operations provided by Murrow AD Plant Ltd. Impacts at sensitive receptors were quantified using dispersion modelling and the results compared with the relevant odour benchmark level.

Predicted odour concentrations were below the relevant benchmark at all sensitive receptor locations in the vicinity of the site for all modelling years. As such, potential impacts associated with odour emissions from the facility are not considered to be significant.

Table of Contents

1.0 INTRODUCTION

1.1 Background

1.1.1 Redmore Environmental Ltd was commissioned by Murrow AD Plant Ltd to undertake an Odour Assessment in support of an Environmental Permit Variation Application for Murrow Anaerobic Digestion (AD) facility at Somerset Farm, Murrow.

1.1.2 Odour emissions from the facility have the potential to cause impacts at sensitive locations. An Odour Assessment was therefore undertaken to quantify effects in the vicinity of the plant.

1.2 Site Location and Context

1.2.1 Murrow AD plant is located at Somerset Farm, Murrow, at National Grid Reference (NGR): 537342, 304756. Reference should be made to Figure 1 for a map of the site and surrounding area.

1.2.2 The plant is currently authorised to operate as an AD facility using farm wastes only, including the use of the resultant biogas, under a Standard Rules Environmental Permit (SR2021 No.8) issued by the Environment Agency (EA) (Permit No: EPR/FB3133AW/V005).

1.2.3 An Environmental Permit Variation Application is currently being made to the EA in order to authorise a number of changes to operations. These include an increase in processing capacity to 125,000 tonnes per annum (tpa). This exceeds the threshold for regulation of the site under the existing SR2021 No.8 Environmental Permit. As such, there is a requirement for the Operator to obtain a Bespoke Part A Environmental Permit.

1.2.4 The site operations incorporating the changes proposed under the Environmental Permit Variation can be summarised as follows:

- The facility processes purpose grown crops (principally maize), crop residues and animal manures/slurries within five primary and one secondary AD tank to produce biogas and digestate;
- Solid farm-based feedstocks are stored on a concrete pad area or within a clamp on the northern section of the facility prior to processing;

- Crops within the clamp are compacted and covered using protective plastic sheeting in order to preserve the feedstock and minimise emissions. The cover remains slightly open at one end to allow access to the feedstock for removal and transportation to the AD plant feed hoppers;
- Farm-based feedstocks with higher odour potential such as poultry manures are accepted on a 'just in time' basis according to the procedures outlined in the site Odour Management Plan (OMP) and remain covered within the concrete pad area or clamp prior to transfer to the feed hoppers;
- Vegetables are delivered to site and deposited within the concrete pad area or clamp. The vegetables within the clamp remain covered during storage in order to minimise emissions;
- Cattle manure is stored within the concrete pad area and then shredded using a mobile unit prior to introduction to the AD process;
- Liquid animal slurries are received into a covered reception tank which includes an atmospheric vent;
- All solid feedstocks are introduced into the process via feeding units which are top loaded using a telehandler;
- Biogas produced in the AD process is stored in the roof head spaces of the digesters. The biogas is combusted within two 250kW combined heat and power (CHP) units. These provide both heat and power for site operations, as do a further two 500kW CHP units which are run on imported liquified natural gas (LNG). All four engines were commissioned after December 2018;
- The remaining biogas produced at the site is upgraded to produce biomethane and injected directly to the high-pressure National Gas Transmission (NTS) system via 1km of pipework and a block valve connection. The biomethane does not need to be blended to a distribution specification because it is injected to a high-pressure network and blended therein. As no odorant is needed, no associated chemicals are handled at the site;
- During the biogas upgrading process, carbon dioxide (CO_2) is removed from the biogas and vented to atmosphere. The site undertakes an additional step to recover the CO_2 which might otherwise be vented to atmosphere. This is processed in a dedicated recovery facility that removes any final trace impurities and transforms the CO_2 into a liquid state. The recovered liquid CO_2 is then stored in a tank as a final product that reaches end of waste status and is fit for use in the food and drink manufacturing and supply industry;

- Final digestate arising from the process is passed through a separator to produce a liquid and solid fraction. The separated solid fraction drops into a bunker and is routinely taken off site for interim storage in satellite field heaps prior to use as an agricultural fertiliser or soil conditioner;
- The separated liquid digestate is piped to one of two earth bank stores/lagoons which are not located within the permit boundary proposed under the variation;
- Condensate arising from the gas line, CHP engines and upgrading unit is collected in a dedicated system and pumped back through the process;
- The site also includes an emergency flare for management of excess gas during engine or upgrading unit downtime. This is capable of burning all biogas produced at the site in an emergency situation should the need arise. The site is also equipped with an emergency backup diesel generator which provides sufficient power to operate key functions during power outage in order to maintain safe operations until normal processes resume; and,
- The whole facility is operated in accordance with an Environmental Management System (EMS) and technical competence requirements are met by inhouse staff who hold the relevant AD WAMITAB qualification.

1.2.5 The AD plant may result in odour emissions from a number of activities during operation. These have the potential to cause impacts at sensitive locations within the vicinity of the site and have therefore been assessed within this report.

2.0 ODOUR BACKGROUND

2.1 Odour Definition

2.1.1 The Department for Environment, Food and Rural Affairs (DEFRA) guidance[1] defines odour as follows:

> "An odour is the organoleptic attribute perceptible by the olfactory organ on sniffing certain volatile substances. It is a property of odorous substances that make them perceptible to our sense of smell. The term odour refers to the stimuli from a chemical compound that is volatilised in air. Odour is our perception of that sensation and we interpret what the odour means. Odours may be perceived as pleasant or unpleasant. The main concern with odour is its ability to cause a response in individuals that is considered to be objectionable or offensive.
>
> Odours have the potential to trigger strong reactions for good reason. Pleasant odours can provide enjoyment and prompt responses such as those associated with appetite. Equally, unpleasant odours can be useful indicators to protect us from harm such as the ingestion of rotten food. These protective mechanisms are learnt throughout our lives. Whilst there is often agreement about what constitutes pleasant and unpleasant odours, there is a wide variation between individuals as to what is deemed unacceptable and what affects our quality of life."

2.1.2 Although it is recognised that the DEFRA guidance[2] has been formally withdrawn, the definition of odour provided within the document is still considered to be relevant in the context of the assessment.

2.2 Odour Impacts

2.2.1 The magnitude of odour impact depends on a number of factors and the potential for complaints varies due to the subjective nature of odour perception. The **FIDOR** acronym is a useful reminder of the factors that will determine the degree of odour pollution:

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1 Odour Guidance for Local Authorities, DEFRA, 2010.

2 Odour Guidance for Local Authorities, DEFRA, 2010.

- **F**requency of detection - frequent odour incidents are more likely to result in complaints;
- **I**ntensity as perceived - intense odour incidents are more likely to result in complaints;
- **D**uration of exposure - prolonged exposure is more likely to result in complaints;
- **O**ffensiveness - more offensive odours have a higher risk of resulting in complaints; and,
- **R**eceptor sensitivity - sensitive areas are more likely to have a lower odour tolerance.

2.2.2 It is important to note that even infrequent emissions may cause loss of amenity if odours are perceived to be particularly intense or offensive.

2.2.3 The FIDOR factors can be further considered to provide the following in regards the potential for an odour emission to cause an impact:

- The rate of emission of the compound(s);
- The duration and frequency of emissions;
- The time of the day that this emission occurs;
- The prevailing meteorology;
- The sensitivity of receptors to the emission i.e. whether the odorous compound is more likely to cause nuisance, such as the sick or elderly, who may be more sensitive;
- The odour detection capacity of individuals to the various compound(s); and,
- The individual perception of the odour (i.e. whether the odour is regarded as unpleasant). This is greatly subjective and may vary significantly from individual to individual. For example, some individuals may consider some odours as pleasant, such as petrol, paint and creosote.

2.3 Odour Legislative Control

2.3.1 The main requirement with respect to odour control from industrial activities is the Environmental Permitting (England and Wales) Regulations (2016) and subsequent amendments. If a process is deemed potentially odorous then the relevant regulator will usually include an appropriate condition in the site's Environmental Permit to restrict impacts beyond the facility boundary through the implementation of an OMP.

2.3.2 Enforcement of the condition is by the relevant regulator, either the EA for Part A(1) processes, or the Local Authority for Part A(2) and B processes. If the regulator is satisfied that odour from a facility is causing pollution beyond the site boundary, then they can serve an improvement notice that requires remedial works to be undertaken to reduce impacts to an acceptable level. The measures that are deemed appropriate will depend on the industry sector and site-specific circumstances and will take costs and benefits into account. Should appropriate actions not be taken by the operator then the regulator has a number of available options, cumulating in the revocation of the Environmental Permit and cessation of all activities on site.

2.4 Odour Benchmark Levels

2.4.1 There is no statutory limit in the UK for ambient odour concentrations, whether set for individual chemical species or for mixtures. However, the EA has issued guidance on odour[3] which contains indicative benchmark levels for use in the assessment of potential impacts from industrial facilities.

2.4.2 Benchmark levels are stated as the 98th percentile (%ile) of hourly mean concentrations in European odour units (ou_E) over a year for odours of different offensiveness. In practice this means that for 2% of the year, or 175-hours, concentrations will be higher than this value, whilst for 98% of the year, or 8,585-hours, they will be lower. This parameter reflects the previously described **FIDOR** factors, where an odour is likely to be noted on several occasions above a particular threshold concentration before an annoyance occurs. EA odour benchmark levels are summarised in Table 1.

Table 1 Odour Benchmark Levels

Relative Offensiveness of Odour	Benchmark Level as 98th %ile of 1-hour Means (ou_E/m^3)
Most offensive odours: • Processes involving decaying animal or fish • Processes involving septic effluent or sludge • Biological landfill odours	1.5

3 H4: Odour Management, EA, 2011.

Relative Offensiveness of Odour	Benchmark Level as 98th %ile of 1-hour Means (ou_E/m^3)
Moderately offensive odours: • Intensive livestock rearing • Fat frying (food processing) • Sugar beet processing • Well aerated green waste composting	3.0
Less offensive odours: • Brewery • Confectionery • Coffee roasting • Bakery	6.0

2.4.3 The facility processes agricultural feedstocks including purpose grown crops, waste and non-waste crop residues and animal manures/slurries. Odours from these materials would be classified as 'moderately offensive' in accordance with the EA guidance[4] as they are likely to be similar to green waste composting or intensive livestock rearing. As such, an odour benchmark level of 3.0ou_E/m^3 as the 98th %ile of 1-hour mean concentrations has been utilised throughout the report.

2.4.4 In order to provide some context to the odour benchmark values, DEFRA have provided the following descriptors[5]:

- 1ou_E/m^3 is the point of detection;
- 5ou_E/m^3 is a faint odour; and,
- 10ou_E/m^3 is a distinct odour.

2.4.5 An odour at a strength of 1ou_E/m^3 is in reality so weak that it would not normally be detected outside the controlled environment of an odour laboratory by the majority of people (that is individuals with odour sensitivity in the "normal" range - approximately 96% of the population[6]). It is important to note that these values are based on laboratory

4 H4: Odour Management, EA, 2011.

5 Odour Guidance for Local Authorities, DEFRA, 2010.

6 Odour Guidance for Local Authorities, DEFRA, 2010.

measurements and in the general environment other factors affect our sense of odour perception. These include:

- The population is continuously exposed to a wide range of background odours at a range of different concentrations, and usually people are unaware of there being any background odours at all due to normal habituation. Individuals can also develop a tolerance to background and other specific odours. In an odour laboratory the determination of detection threshold is undertaken by comparison with non-odorous air, and in carefully controlled, odour-free, conditions. Normal background odours such as those from traffic, vegetation, grass mowing etc, can provide background odour concentrations from 5 to 60ou_E/m^3 or more[7];
- The recognition threshold may be about 3ou_E/m^3 [8], although it might be less for offensive substances or higher if the receptor is less familiar with the odour or distracted by other stimuli; and,
- An odour which fluctuates rapidly in concentration is often more noticeable than a steady odour at a low concentration.

7 Odour Guidance for Local Authorities, DEFRA, 2010.

8 Odour Guidance for Local Authorities, DEFRA, 2010.

3.0 METHODOLOGY

3.1 Introduction

3.1.1 The facility may result in odour emissions during normal operation. Associated impacts were assessed in accordance with the following stages:

- Identification of odour sources;
- Identification of odour emission rates;
- Dispersion modelling of odour emissions; and,
- Comparison of modelling results with relevant criteria.

3.1.2 The following Sections outline the methodology and inputs used for the assessment.

3.2 Odour Sources

3.2.1 Potential odour sources associated with the facility were identified from information provided by Murrow AD Plant Ltd. These are summarised in Table 2.

Table 2 Odour Sources

Source		Source Description	Emission Point	Emission Characteristics
1	Exposed materials within the concrete pad storage area	Odours generated by exposed feedstocks within the concrete pad storage area	-[a]	Diffuse emissions from exposed materials
2	Exposed and covered materials within the clamp storage area	Odours generated by exposed and covered feedstocks within the clamp storage area	-[a]	Diffuse emissions from exposed and covered materials
3	Exposed cattle manure within the shredder	Odours generated by exposed cattle manure during shredding	-[a]	Diffuse emissions from exposed materials
4	Exposed materials within the feed hoppers	Odours generated by exposed feedstocks within the hoppers	-[a]	Diffuse emissions from exposed materials

Source		Source Description	Emission Point	Emission Characteristics
5	Covered slurry tank	Odours generated by animal slurries within the tank	A8	The tank will be covered in order to provide containment of emissions. Air displaced from the tank during filling will discharge to atmosphere via a vent
6	Exposed solid digestate within the separator bunker	Odours generated by exposed solid digestate within the bunker	-[(a)]	Diffuse emissions from exposed materials
7	Poultry manure within the trailer on the concrete pad area prior to input to the plant	Odours generated by poultry manure within the trailer	-[(a)]	Fugitive emissions from the covered trailer

NOTE: (a) Emission point reference not provided.

3.2.2 It should be noted that the actual AD process itself is sealed and therefore does not form a source of odour, or other emissions such as methane (CH_4) or hydrogen sulphide (H_2S) under normal operation. Should releases of these species occur then this would indicate a fault with the plant and immediate remedial measures would be taken to eliminate the problem to avoid affecting the AD process, with associated financial consequences for the operator. Similarly, the CHP units and flare only emit products of combustion which do not typically have any associated odour. As such, they have not been considered as potential sources in the context of this assessment.

3.3 Odour Emission Rates

3.3.1 Estimations of odour emission rates were identified for use in the assessment based on monitoring data reported at similar facilities. These are summarised in Table 3.

Table 3 Odour Emission Rates

Source	Odour Emission Rate	Unit	Reference
Liquid digestate	1.0	$ou_E/m^2/s$	University of Liège and Universidad Politécnica de Valencia[(1)]
Cattle manure	0.8	$ou_E/m^2/s$	Odournet UK Ltd[(2)]
Maize, rye, barley, sugar beet,	20.0	$ou_E/m^2/s$	ADAS[(3)]

Source	Odour Emission Rate	Unit	Reference
fodder beet, grass and other whole crops			
Vegetables	10.0	$ou_E/m^2/s$	Odournet UK Ltd[4]
Poultry manure	75.0	$ou_E/m^2/s$	Odournet UK Ltd[5]
Dewatered digestate	2.8	$ou_E/m^2/s$	Odournet UK Ltd[4]
Cattle Slurry	2.7	$ou_E/m^2/s$	L. Valli et al.[6]

NOTES: (1) Multi-method Monitoring of Odor Emissions in Agricultural Biogas Facilities, Jacques Nicolas, Gilles Adam, Yolanda Ubeda, Anne-Claude Romain, University of Liège and Universidad Politécnica de Valencia.
(2) Odour Impact Assessment for a proposed Biomass AD Facility near Kenninghall, Norfolk, produced by Odournet UK Ltd.
(3) An Odour Impact Study for a Proposed Agricultural Anaerobic Digester at Cleat Hill Farm, Haunton, ADAS.
(4) Odour Impact Assessment for a proposed Anaerobic Digestion facility in Chatteris, Cambridgeshire, Odournet UK Ltd.
(5) Odour Impact Assessment for a proposed Anaerobic Digestion facility near Kenninghall, Norfolk, Odournet UK Ltd.
(6) Odour emissions from livestock production facilities, L. Valli, G. Moscatelli, N.Labartino, Centro Ricerche Produzioni Animali, Chemical Engineering Transactions, Vol.15, 2008.

3.4 Dispersion Modelling

3.4.1 Dispersion modelling was undertaken using ADMS-6 (v6.0.0.1), which is developed by Cambridge Environmental Research Consultants (CERC) Ltd. ADMS-6 is a short-range dispersion modelling software package that simulates a wide range of buoyant and passive releases to atmosphere. It is a new generation model utilising boundary layer height and Monin-Obukhov length to describe the atmospheric boundary layer and a skewed Gaussian concentration distribution to calculate dispersion under convective conditions.

3.4.2 The model utilises hourly meteorological data to define conditions for plume rise, transport and diffusion. It estimates the concentration for each source and receptor combination for each hour of input meteorology and calculates user-selected long-term and short-term averages.

3.4.3 The model requires input data that details the following parameters:

- Assessment area;
- Process conditions;
- Pollutant emission rates;
- Terrain information;
- Building dimensions;
- Meteorological data;
- Roughness length (z_0); and,
- Monin-Obukhov length.

3.4.4 These are detailed in the following Sections.

3.5 Modelling Scenarios

3.5.1 The scenarios considered in the modelling assessment are summarised in Table 4.

Table 4 Assessment Scenarios

Parameter	Modelled As	
	Short Term	Long Term
Odour	98th %ile 1-hour mean	-

3.6 Process Conditions

3.6.1 The inputs used to describe the relevant emission sources within the model were derived from the data shown in Table 3 and information provided by Murrow AD Plant Ltd. A summary of the input data is provided in Table 5.

Table 5 Process Conditions

Source		Characteristics and Assumptions
1	Exposed cattle manure within the concrete pad storage area	• A single area source was used to represent emissions from the source within the model • The emission rate for cattle manure is $0.8ou_E/m^2/s$, as shown in Table 3 • Approximately $166m^2$ of cattle manure is exposed within the area • Emissions were assumed to be constant, 24-hours per day, 365-days per year. This is considered to be a worst-case assessment scenario as periods of reduced

	Source	Characteristics and Assumptions
		operating capacity are not reflected in the modelled emissions
	Exposed crops within the concrete pad storage area	• A single area source was used to represent emissions from the source within the model • The emission rate for crops is 20ou_E/m^2/s, as shown in Table 3 • Approximately 166m^2 of crops are exposed within the area • Emissions were assumed to be constant, 24-hours per day, 365-days per year. This is considered to be a worst-case assessment scenario as periods of reduced operating capacity are not reflected in the modelled emissions
	Exposed vegetables within the concrete pad storage area	• A single area source was used to represent emissions from the source within the model • The emission rate for vegetables is 10ou_E/m^2/s, as shown in Table 3 • Approximately 166m^2 of vegetables are exposed within the area • Emissions were assumed to be constant, 24-hours per day, 365-days per year. This is considered to be a worst-case assessment scenario as periods of reduced operating capacity are not reflected in the modelled emissions
2	Exposed crops within the clamp storage area	• A single area source was used to represent emissions from the source within the model • The emission rate for crops is 20ou_E/m^2/s, as shown in Table 3 • Approximately 45m^2 of crops are exposed within the area. The remaining materials are contained under the protective sheeting • Emissions were assumed to be constant, 24-hours per day, 365-days per year. This is considered to be a worst-case assessment scenario as periods of reduced operating capacity are not reflected in the modelled emissions
	Covered poultry manure within the clamp storage area	• A single area source was used to represent emissions from the source within the model • The emission rate for poultry manure is 75ou_E/m^2/s, as shown in Table 3 • Approximately 400m^2 of poultry manure is stored within the clamp • The manure will remain covered at all times other than when transfer is made to the feed hoppers. The SCAIL-

Source		Characteristics and Assumptions
		Agriculture Update report[9] produced by SNIFFER indicates that a reduction of 90% would be expected from engineered covers. As such, the stated emission rate was reduced by this factor in order to represent containment of the material prior to loading • Emissions were assumed to be constant, 24-hours per day, 365-days per year. This is considered to be a worst-case assessment scenario as poultry manures will be accepted on a 'just in time' basis according to the procedures outlined in the site OMP and will not be stored for prolonged periods at the facility
	Covered vegetables within the clamp storage area	• A single area source was used to represent emissions from the source within the model • The emission rate for vegetables is 10ou$_E$/m^2/s, as shown in Table 3 • Approximately 525m^2 of vegetables are stored within the clamp • The vegetables will remain covered at all times other than when transfer is made to the feed hopper. The SCAIL-Agriculture Update report[10] produced by SNIFFER indicates that a reduction of 90% would be expected from engineered covers. As such, the stated emission rate was reduced by this factor in order to represent containment prior to loading • Emissions were assumed to be constant, 24-hours per day, 365-days per year. This is considered to be a worst-case assessment scenario as periods of reduced operating capacity are not reflected in the modelled emissions
3	Exposed cattle manure within the shredder	• A single area source was used to represent emissions from the source within the model • The emission rate for cattle manure is 0.8ou$_E$/m^2/s, as shown in Table 3. This was multiplied by a factor of 5 to represent the potential for increased emissions as a result of agitation of the material within the shredder • Approximately 29m^2 of cattle manure is exposed during operation of the shredder • Emissions were assumed to occur from the shredder for 2-hours each day in accordance with information provided by Murrow AD Plant Ltd
4	Exposed cattle manure within feed hopper 1	• A single area source was used to represent emissions from the source within the model • Approximately 27m^2 of cattle manure is exposed within the hopper during operation

9 SCAIL-Agriculture Update Sniffer ER26: Final Report, Sniffer, 2014.

10 SCAIL-Agriculture Update Sniffer ER26: Final Report, Sniffer, 2014.

Source		Characteristics and Assumptions
		• The emission rate for cattle manure is 0.8ou$_E$/m^2/s, as shown in Table 3. This was multiplied by a factor of 5 to represent the potential for increased emissions as a result of agitation of the material within the hopper • Emissions were assumed to be constant, 24-hours per day, 365-days per year. This is considered to be a worst-case assessment scenario as periods of shut down or reduced operating capacity are not reflected in the modelled emissions
	Exposed crops within feed hopper 2	• A single area source was used to represent emissions from the source within the model • Approximately 27m^2 of crops are exposed within the hopper during operation • The emission rate for crops is 20ou$_E$/m^2/s, as shown in Table 3. This was multiplied by a factor of 5 to represent the potential for increased emissions as a result of agitation of the material within the hopper • Emissions were assumed to be constant, 24-hours per day, 365-days per year. This is considered to be a worst-case assessment scenario as periods of shut down or reduced operating capacity are not reflected in the modelled emissions
	Exposed vegetables within feed hopper 3	• A single area source was used to represent emissions from the source within the model • Approximately 27m^2 of vegetables are exposed within the hopper during operation • The emission rate for vegetables is 10ou$_E$/m^2/s, as shown in Table 3. This was multiplied by a factor of 5 to represent the potential for increased emissions as a result of agitation of the material within the hopper • Emissions were assumed to be constant, 24-hours per day, 365-days per year. This is considered to be a worst-case assessment scenario as periods of shut down or reduced operating capacity are not reflected in the modelled emissions
	Exposed poultry manure within feed hopper 4	• A single area source was used to represent emissions from the source within the model • Approximately 27m^2 of poultry manure is potentially exposed within the hopper during operation • The emission rate for poultry litter is 75ou$_E$/m^2/s, as shown in Table 3. However, information provided by Murrow AD Plant Ltd indicated that the manure will be covered by a layer of crops immediately following loading in order to reduce the odour emission potential. As such, the corresponding emission rate of 20ou$_E$/m^2/s for crops was applied to the source. This was then multiplied by a factor of 5 to represent the potential for increased emissions as a result of agitation of the material within the hopper

Source		Characteristics and Assumptions
		• Emissions were assumed to be constant, 24-hours per day, 365-days per year. This is considered to be a worst-case assessment scenario as periods of shut down or reduced operating capacity are not reflected in the modelled emissions
5	Covered slurry tank	• The tank will be covered in order to provide containment of emissions. Air displaced from the tank during filling will discharge to atmosphere via a vent • A single area source of 76.5m^2 was used to represent emissions from the source within the model • The emission rate for slurry is 2.7ou$_E$/m^2/s, as shown in Table 3 • The SCAIL-Agriculture Update report[11] produced by SNIFFER indicates that a reduction of 90% would be expected from engineered covers. As such, the stated emission rate was reduced by this factor in order to represent containment prior to loading • Emissions were assumed to be constant, 24-hours per day, 365-days per year. This is considered to be a worst-case assessment scenario as periods of reduced operating capacity are not reflected in the modelled emissions
6	Exposed solid digestate within the separator bunker	• A single area source was used to represent emissions from the source within the model • The emission rate for solid digestate is 2.8ou$_E$/m^2/s, as shown in Table 3 • Approximately 10m^2 of solid digestate is exposed within the area • Emissions were assumed to be constant, 24-hours per day, 365-days per year. This is considered to be a worst-case assessment scenario as periods of reduced operating capacity are not reflected in the modelled emissions
7	Poultry manure within the trailer on the concrete pad prior to input to the plant	• A single area source was used to represent emissions from the source within the model • The emission rate for poultry litter is 75ou$_E$/m^2/s, as shown in Table 3 • Approximately 39m^2 of poultry litter is exposed within the trailer • The poultry litter trailer will remain sheeted at all times other than when transfer is made to the feed hopper. The SCAIL-Agriculture Update report[12] produced by Sniffer indicates that a reduction of 90% would be expected from engineered covers. As such, the stated

11 SCAIL-Agriculture Update Sniffer ER26: Final Report, Sniffer, 2014.

12 SCAIL-Agriculture Update Sniffer ER26: Final Report, Sniffer, 2014.

Source		Characteristics and Assumptions
		emission rate was reduced by this factor in order to represent containment of the material prior to loading • Emissions were assumed to be constant, 24-hours per day, 365-days per year. This is considered to be a worst-case assessment scenario as poultry manures will be accepted on a 'just in time' basis according to the procedures outlined in the site OMP and will not be stored for prolonged periods at the facility

3.6.2 Reference should be made to Figure 2 for a graphical representation of the source locations.

3.7 Assessment Area

3.7.1 The assessment area was defined based on the site location, anticipated pollutant dispersion patterns and the positioning of sensitive receptors. Ambient concentrations were predicted over NGR: 536289, 303628 to 538289, 305628. One Cartesian grid with a resolution of 10m was used within the model to produce data suitable for contour plotting using the Surfer software package.

3.7.2 Reference should be made to Figure 2 for a graphical representation of the assessment grid extents.

3.7.3 A desk-top study was undertaken in order to identify any sensitive receptor locations in the vicinity of the site that required specific consideration during the assessment. These are summarised in Table 6.

Table 6 Sensitive Receptor Locations

Receptor		NGR (m)	
		X	Y
R1	Residential - Willow Lodge	537272.8	304994.9
R2	Residential - Poplar House	537342.8	304942.5
R3	Residential - Coronation Cottage	537456.6	304927.1
R4	Residential - Bank Farm Cottage	537964.2	305587.8
R5	Residential - Two Bridges	538072.5	305461.4

Receptor		NGR (m)	
		X	Y
R6	Residential - Sidmouth House	538256.7	304908.8
R7	Residential - Flagg House	538243.4	304832.8
R8	Residential - Tower Farm	537474.2	303673.4
R9	Residential - Fort Farm	537164.4	304330.0
R10	Residential - Hope Cottage	536762.4	304276.4
R11	Residential - Gull Drove Cottage	536540.9	304315.1
R12	Residential - Ivy Farm	536457.3	304328.0
R13	Residential - Hope Farm	536361.7	304383.6
R14	Residential - The Cottage	536846.0	305060.8
R15	Residential - Redfern House	536862.6	305017.7
R16	Residential - White Lion Farm	537028.7	305035.7
R17	Residential - Cant's Drove Cottage	537131.2	305004.1
R18	Residential - Ivy Home	537158.6	305003.5
R19	Residential - Homefield	537202.7	305005.9

3.7.4 Reference should be made to Figure 3 for a map of the receptor locations.

3.8 Building Effects

3.8.1 The dispersion of substances released from elevated sources can be influenced by the presence of buildings close to the emission point. Structures can interrupt the wind flows and cause significantly higher ground-level concentrations close to the source than would arise in the absence of the buildings.

3.8.2 Analysis of the site layout indicated that a number of structures should be included within the model in order to take account of effects on pollutant dispersion. Building input geometries are shown in Table 7.

Table 7 Building Geometries

Building	NGR (m)		Height (m)	Length / Diameter (m)	Width (m)	Angle (°)
	X	Y				
Biogas Engine Building	537229.1	304661.9	4.80	8.3	17.9	153.8
CHP Unit 3 Container	537412.1	304612.3	2.60	2.5	6.8	98.1
CHP Unit 4 Container	537410.9	304602.7	2.60	2.5	6.8	97.3
Digester 1	537238.9	304644.2	12.75	20.7	-	-
Digester 2	537251.1	304622.1	12.75	22.7	-	-
Digester 3	537298.8	304642.3	12.75	24.6	-	-
Digester 4	537326.1	304635.4	12.75	24.6	-	-
Digester 5	537306.5	304615.3	12.75	24.6	-	-
Digester 6	537277.5	304621.9	12.75	25.5	-	-
Slurry Tank	537277.1	304647.6	5	10.4	-	-

3.8.3 It should be noted that the digesters and liquid feedstock tank specified in Table 7 are circular structures. Widths and angles for these structures have therefore not been defined.

3.9 Meteorological Data

3.9.1 Meteorological data used in the assessment was taken from Wittering meteorological station over the period 1st January 2017 to 31st December 2021 (inclusive). This observation station is located at NGR: 503490, 302412, which is approximately 32.9km west of the facility. It is anticipated that conditions would be reasonably similar over a distance of this magnitude. The data was therefore considered suitable for an assessment of this nature.

3.9.2 All meteorological files used in the assessment were provided by Atmospheric Dispersion Modelling Ltd, which is an established distributor of data within the UK. Reference should be made to Figure 4 for wind roses of utilised meteorological records.

3.10 Roughness Length

3.10.1 A z_0 of 0.3m was used within the model to describe the modelling extents and meteorological site. This value is considered appropriate for the morphology of both areas and is suggested within ADMS-6 as being suitable for 'agricultural areas (max)'.

3.11 Monin-Obukhov Length

3.11.1 The Monin-Obukhov length provides a measure of the stability of the atmosphere. A minimum Monin-Obukhov length of 1m was used to describe the modelling extents. This value is considered appropriate for the nature of the area and is suggested within ADMS-6 as being suitable for 'rural areas'.

3.11.2 A minimum Monin-Obukhov length of 10m was used to describe the meteorlogical site. This value is considered appropriate for the nature of the area and is suggested within ADMS-6 as being suitable for 'small towns < 50,000'.

3.12 Terrain Data

3.12.1 Ordnance Survey OS Terrain 50 data was included in the model for the site and surrounding area in order to take account of the specific flow field produced by variations in ground height throughout the assessment extents. This was pre-processed using the method suggested by CERC[13].

3.13 Assessment Criteria

3.13.1 Predicted ground level odour concentrations were compared with the odour benchmark level of 1.5ou_E/m^3 as a 98th percentile of 1-hour means, as a worst case.

3.14 Modelling Uncertainty

3.14.1 Uncertainty in dispersion modelling predictions can be associated with a variety of factors, including:

13 Note 105: Setting up Terrain Data for Input to CERC Models, CERC, 2016.

- Model uncertainty - due to model limitations;
- Data uncertainty - due to errors in input data, including emission estimates, operational procedures, land use characteristics and meteorology; and,
- Variability - randomness of measurements used.

3.14.2 Potential uncertainties in the model results were minimised as far as practicable and worst-case inputs used in order to provide a robust assessment. This included the following:

- Choice of model - ADMS-6 is a commonly used atmospheric dispersion model and results have been verified through a number of studies to ensure predictions are as accurate as possible;
- Meteorological data - Modelling was undertaken using five annual meteorological data sets from the closest observation station to the development to take account of a range of conditions. The assessment was based on the worst-case year to ensure maximum concentrations were considered;
- Surface characteristics - The z_0 and Monin-Obukhov length were determined for both the dispersion and meteorological sites based on the surrounding land uses and guidance provided by CERC;
- Plant operating conditions - Parameters were supplied by Murrow AD Plant Ltd to describe the activities that will be undertaken at the facility and associated durations. As such, these are considered to be representative of likely operating procedures;
- Emission rates - Emission rates were derived from monitoring undertaken at similar facilities. As such, they are considered to be representative of potential releases during normal operation;
- Receptor locations - A Cartesian Grid was included in the model in order to provide suitable data for contour plotting. Receptor points were also included at sensitive locations to provide additional consideration of these areas; and,
- Variability - All model inputs are as accurate as possible and worst-case conditions were considered as necessary in order to ensure a robust assessment of potential pollutant concentrations.

3.14.3 Results were considered in the context of the relevant EA odour benchmark level. It is considered that the use of the stated measures to reduce uncertainty and the use of worst-case assumptions when necessary has resulted in model accuracy of an acceptable level.

4.0 ASSESSMENT

4.1.1 Dispersion modelling of potential odour emissions was undertaken using the input data specified previously. Predicted odour concentrations at the discrete receptor locations are summarised in Table 8. It should be noted that the odour concentrations are presented as a 98th %ile of 1-hour mean values over the relevant assessment year. The maximum concentration across the five years of results is highlighted in **bold**.

Table 8 Predicted Odour Concentrations

Receptor		Predicted 98th %ile 1-hour Mean Odour Concentration (ou_E/m^3)				
		2017	2018	2019	2020	2021
R1	Residential - Willow Lodge	1.51	1.43	1.66	1.29	**1.84**
R2	Residential - Poplar House	2.28	2.14	**2.81**	2.21	2.73
R3	Residential - Coronation Cottage	2.00	1.79	**2.11**	1.69	1.93
R4	Residential - Bank Farm Cottage	0.15	0.14	**0.16**	0.11	0.15
R5	Residential - Two Bridges	0.16	0.14	**0.16**	0.12	0.14
R6	Residential - Sidmouth House	**0.18**	0.17	0.15	0.16	0.17
R7	Residential - Flagg House	**0.18**	0.17	0.16	0.17	0.17
R8	Residential - Tower Farm	0.06	0.11	0.08	0.09	**0.13**
R9	Residential - Fort Farm	0.35	0.66	0.64	0.66	**0.90**
R10	Residential - Hope Cottage	0.15	0.20	0.18	0.18	**0.25**
R11	Residential - Gull Drove Cottage	0.08	0.13	0.12	0.11	**0.15**
R12	Residential - Ivy Farm	0.07	**0.12**	0.10	0.08	0.12
R13	Residential - Hope Farm	0.05	**0.10**	0.09	0.06	0.10
R14	Residential - The Cottage	0.50	0.50	0.46	0.30	**0.56**
R15	Residential - Redfern House	0.55	0.54	0.52	0.35	**0.66**
R16	Residential - White Lion Farm	**1.10**	1.02	0.91	0.57	0.98
R17	Residential - Cant's Drove Cottage	1.54	1.46	1.23	0.94	**1.66**
R18	Residential - Ivy Home	1.62	1.59	1.31	0.94	**1.77**

Receptor		Predicted 98th %ile 1-hour Mean Odour Concentration (ou_E/m^3)				
		2017	2018	2019	2020	2021
R19	Residential - Homefield	1.43	1.57	1.41	1.03	**1.86**

4.1.2 As indicated in Table 8, predicted odour concentrations were below the EA odour benchmark of 3.0ou_E/m^3 at all receptor locations for all modelling years.

4.1.3 Reference should be made to Figure 5 to Figure 9 for graphical representations of predicted odour concentrations throughout the assessment extents. These indicate maximum levels in close proximity to the odour sources with levels reducing sharply over a short distance.

5.0 CONCLUSION

5.1.1 Redmore Environmental Ltd was commissioned by Murrow AD Plant Ltd to undertake an Odour Assessment in support of an Environmental Permit Variation Application for Murrow AD facility at Somerset Farm, Murrow.

5.1.2 Odour emissions from the facility have the potential to cause impacts at sensitive locations. An Odour Assessment was therefore undertaken to quantify effects in the vicinity of the plant.

5.1.3 Potential odour releases were defined based on the size and nature of the facility. These were represented within a dispersion model produced using ADMS-6. Impacts at sensitive receptor locations in the vicinity of the site were quantified, the results compared with the relevant odour EA benchmark level.

5.1.4 Predicted odour concentrations were below the relevant EA odour benchmark level at all residential receptor locations for all modelling years. As such, potential odour emissions from the facility are not considered to be significant.

6.0 ABBREVIATIONS

AD	Anaerobic digestion
CERC	Cambridge Environmental Research Consultants
CH_4	Methane
CHP	Combined Heat and Power
CO_2	Carbon dioxide
DEFRA	Department for Environment, Food and Rural Affairs
EA	Environment Agency
EC	European Commission
H_2S	Hydrogen sulphide
IAQM	Institute of Air Quality Management
NGR	National Grid Reference
OMP	Odour Management Plan
z_0	Roughness length
%ile	Percentile

Figures

Legend

Site Boundary

Title

Figure 1 - Site Location Plan

Project

Odour Assessment
Somerset Farm, Murrow

Project Reference

5500-2

Client

Murrow AD Plant Ltd

Redmore environmental

www.red-env.co.uk | 0161 7060075

Legend

Site Boundary

Output Grid

Emission Source

Building

Title

Figure 2 - ADMS-6 Inputs

Project

Odour Assessment
Somerset Farm, Murrow

Project Reference

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Site Boundary

Receptor

Title

Figure 3 - Sensitive Receptors

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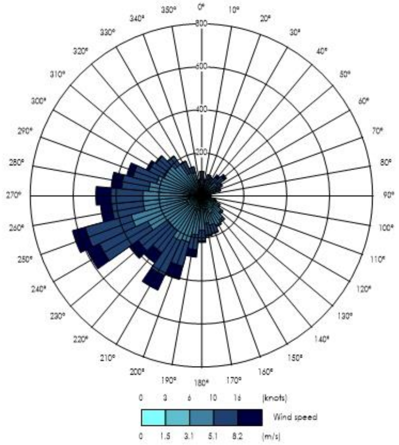
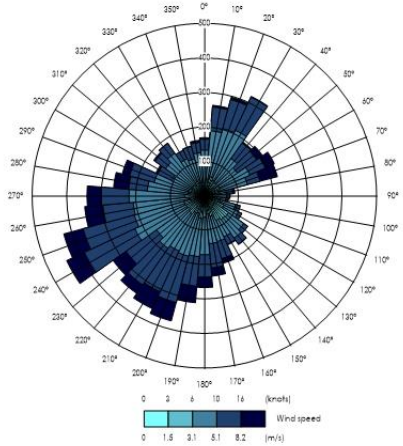
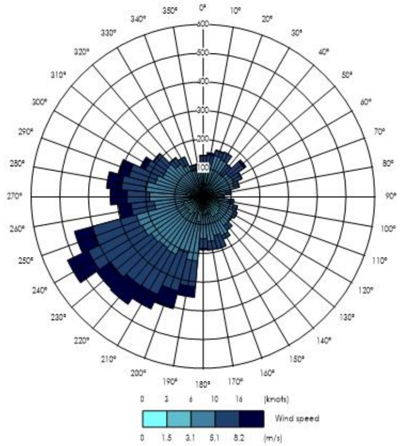


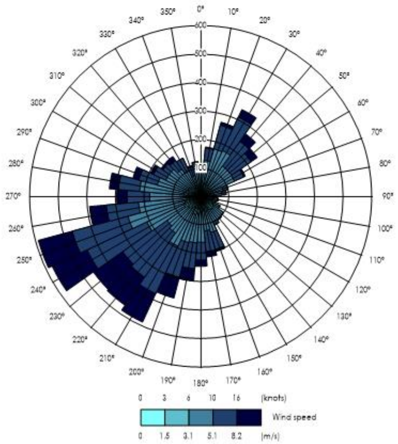
2017 Meteorological Data



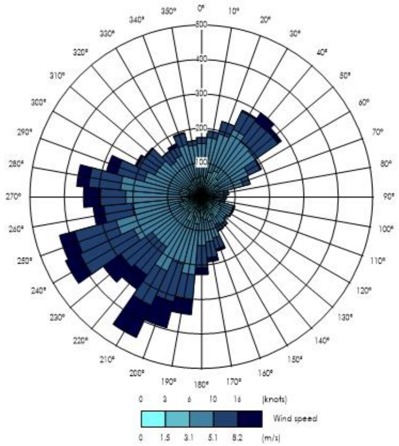
2018 Meteorological Data



2019 Meteorological Data



2020 Meteorological Data



2021 Meteorological Data

Legend

Title

Figure 4 - Wind Roses of 2017 to 2021 Wittering Meteorological Station Data

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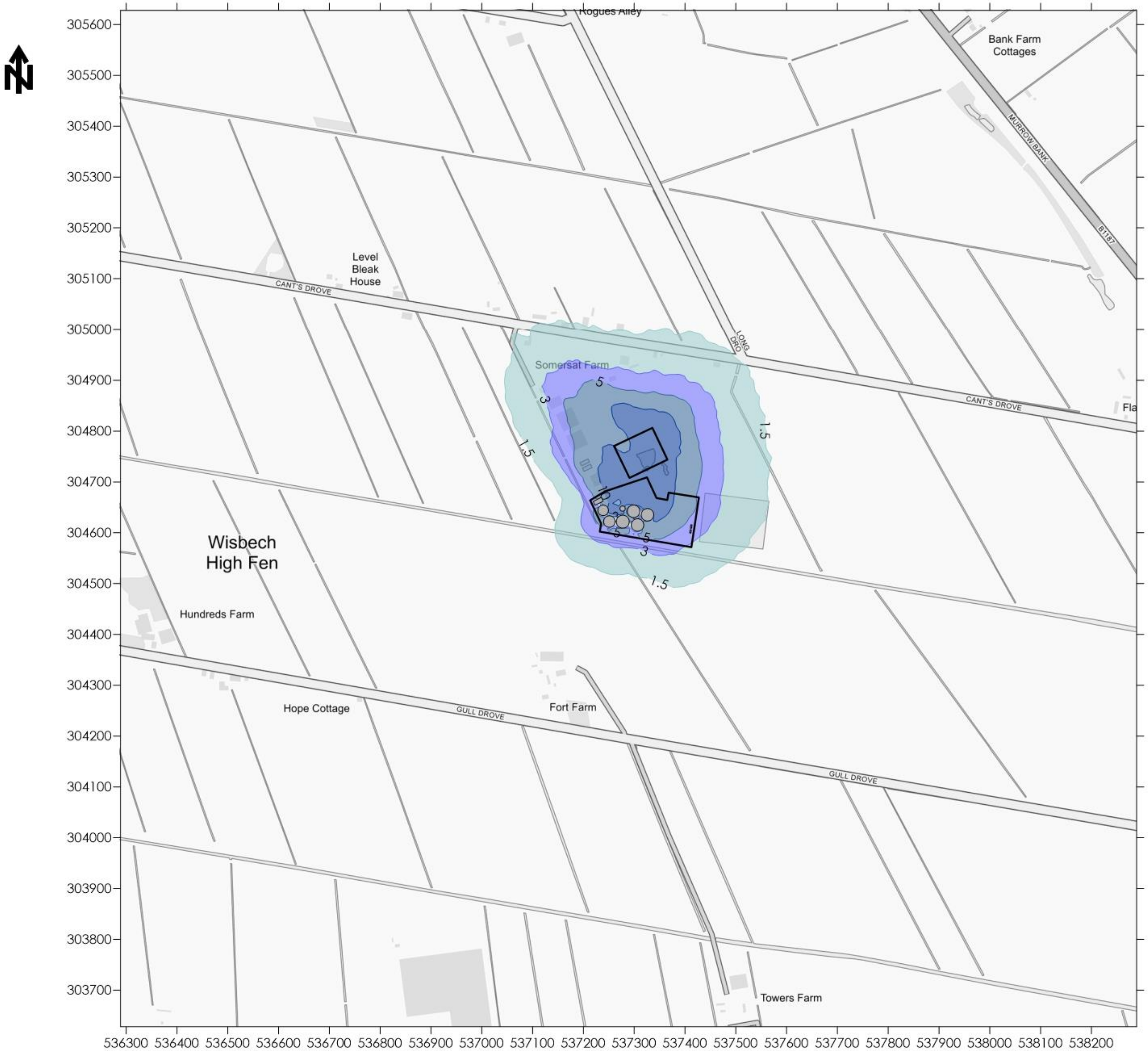

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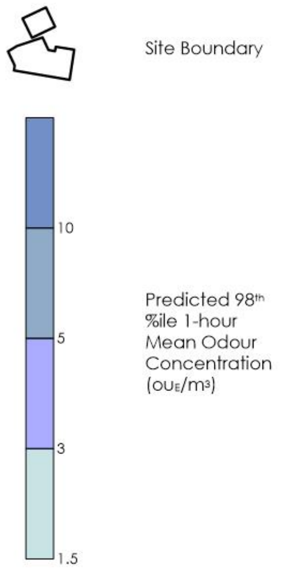

Title

Figure 5 - Predicted 98th %ile 1-hour Mean Odour Concentration (ouE/m³) 2017 Meteorological Data

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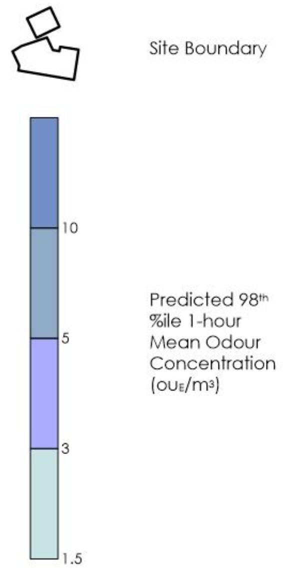

Title

Figure 6 - Predicted 98th %ile 1-hour Mean Odour Concentration (ou_E/m^3) 2018 Meteorological Data

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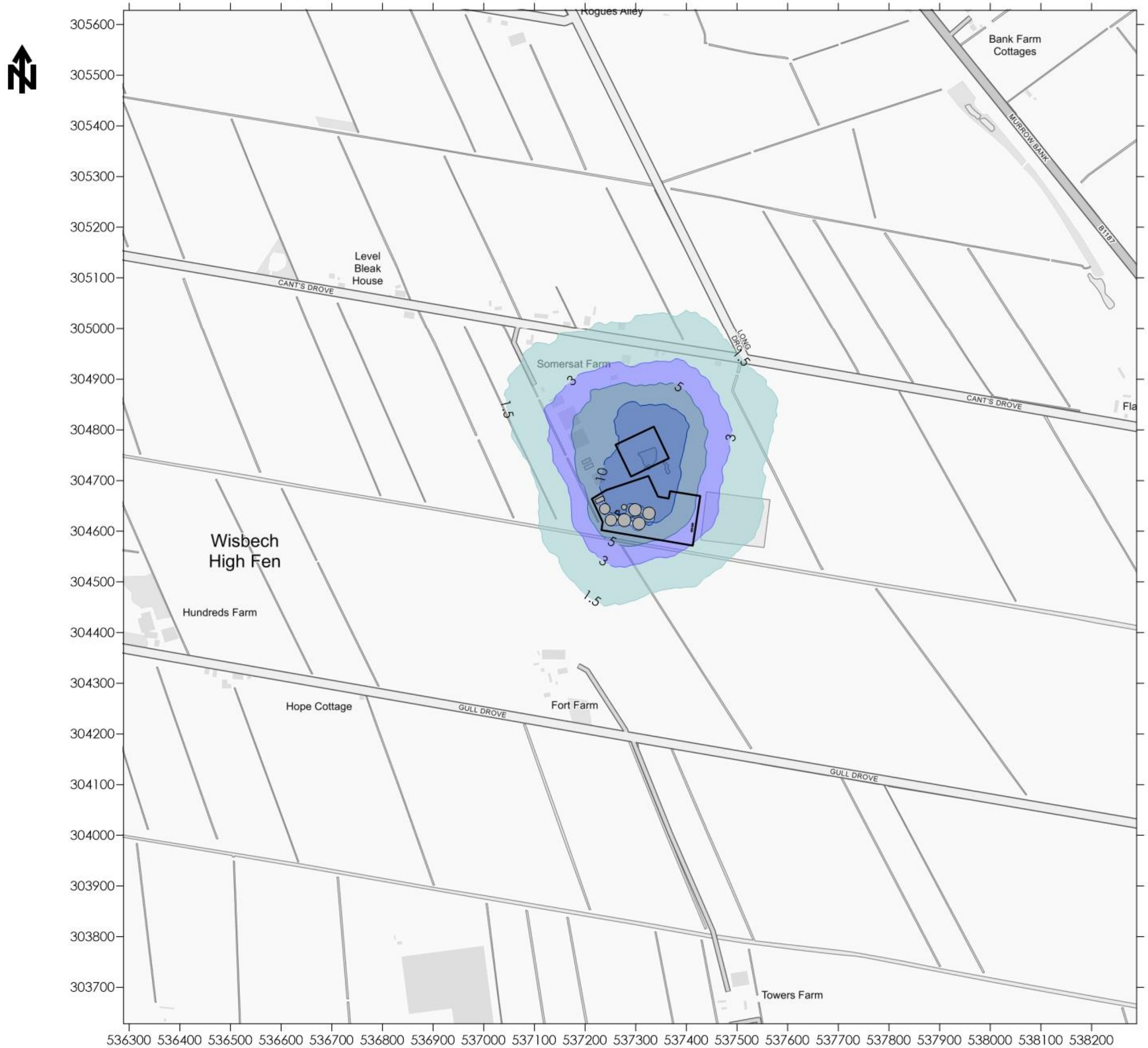

Legend

Site Boundary

Predicted 98th %ile 1-hour Mean Odour Concentration (ou_E/m^3)

10
5
3
1.5

Title

Figure 7 - Predicted 98th %ile 1-hour Mean Odour Concentration (ou_E/m^3) 2019 Meteorological Data

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Site Boundary

Predicted 98th %ile 1-hour Mean Odour Concentration (ou_E/m^3)

10
5
3
1.5

Title

Figure 8 - Predicted 98th %ile 1-hour Mean Odour Concentration (ou_E/m^3) 2020 Meteorological Data

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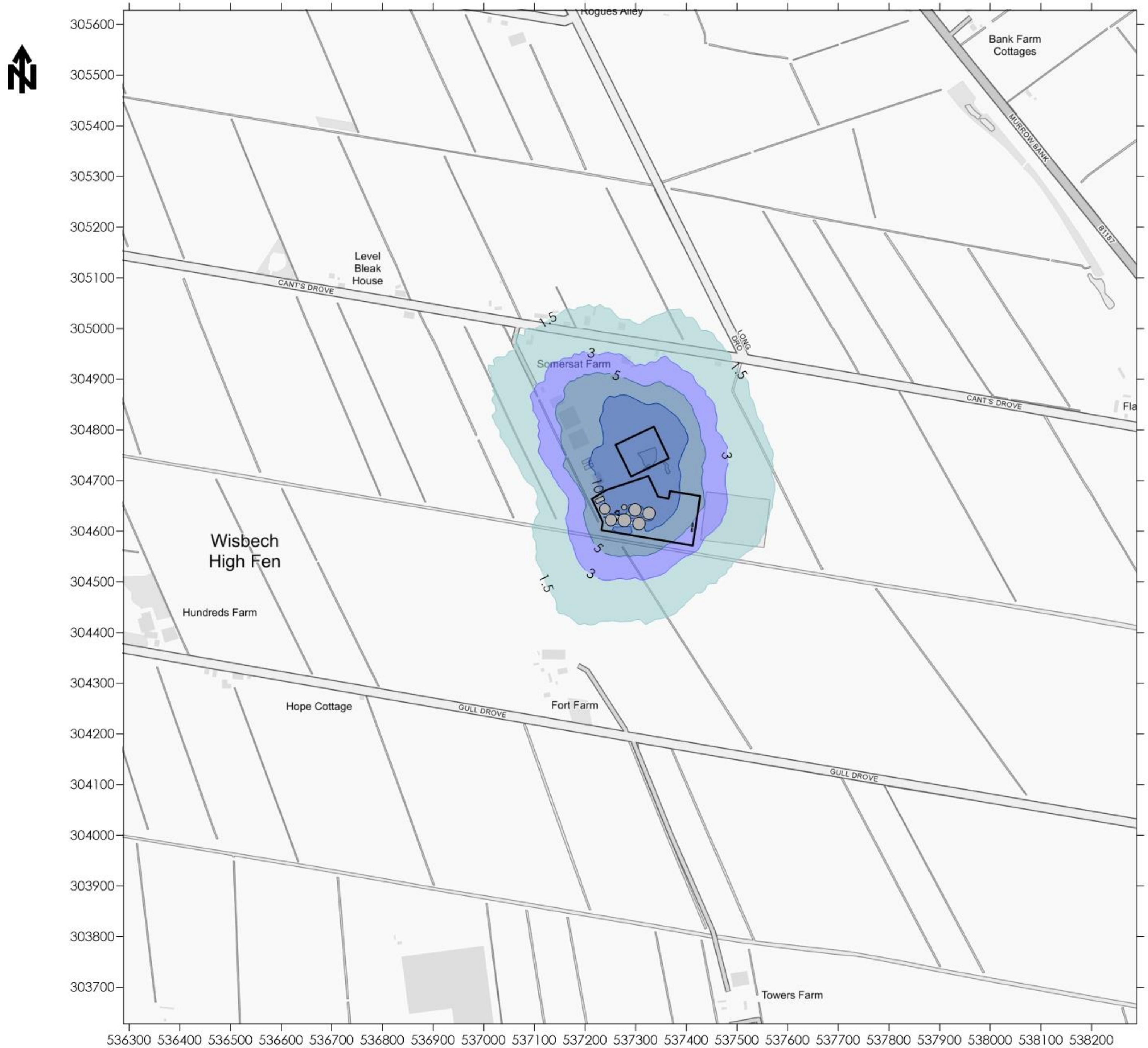

Legend

Site Boundary

10
5
3
1.5

Predicted 98th %ile 1-hour Mean Odour Concentration (ouE/m³)

Title

Figure 9 - Predicted 98th %ile 1-hour Mean Odour Concentration (ouE/m³) 2021 Meteorological Data

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