Odour Assessment

Bio Dynamic UK, Nottingham

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Executive Summary

Redmore Environmental Ltd was commissioned by Bio Dynamic UK Ltd to undertake an Odour Assessment in support of an Environmental Permit Variation Application for the anaerobic digestion facility operated by the company at Colwick Industrial Estate, Nottingham.

Odours from a number of sources on site have the potential to cause impacts at sensitive locations. An Odour Assessment was therefore undertaken to quantify effects in the vicinity of the facility.

Emissions from the relevant sources were defined based on the size and nature of the plant. Impacts at sensitive receptors were quantified using dispersion modelling and the results compared with the relevant odour benchmark level.

The results indicated that predicted odour concentrations were below the relevant benchmark level at all sensitive locations in the vicinity of the site for all modelling years. As such, potential odour emissions from the facility are not considered to be significant.

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1.0 INTRODUCTION

1.1 Background

1.1.1 Redmore Environmental Ltd was commissioned by Bio Dynamic UK Ltd to undertake an Odour Assessment in support of an Environmental Permit Variation Application for the anaerobic digestion (AD) facility operated by the company at Colwick Industrial Estate, Nottingham.

1.1.2 Odours from a number of sources on site have the potential to cause impacts at sensitive locations. An Odour Assessment was therefore undertaken to consider effects in the vicinity of the facility.

1.2 Site Location and Context

1.2.1 The Bio Dynamic UK Ltd facility is located on land at Colwick Industrial Estate, Nottingham, at National Grid Reference (NGR): 463440, 339830. Reference should be made to Figure 1 for a map of the site and surrounding area.

1.2.2 The site operates as an AD facility under an Environmental Permit (No. EPR/DP3935ER) issued by the Environment Agency (EA). The facility is currently undergoing a major refurbishment. This includes changes to existing processes and infrastructure which are being formalised as part of an Environmental Permit Variation Application.

1.2.3 A brief summary of operations at the site incorporating the changes proposed under the application is provided as follows:

- The plant has an annual throughput of up to 150,000-tonnes (t).
- The site can receive quantities of animal by-products which exceed 10t per day. As such, it is permitted as an installation under Section 6.8 A(1)(c) of the Environmental Permitting (England and Wales) Regulations (2016) and subsequent amendments;
- Most of the waste received at the site is processed through the main AD plant. However, a proportion is stored and treated to produce a 'soup' which is dispatched for processing at other AD facilities;

- The treatment and dispatch activity only applies to approximately 20,000-tonnes per annum (tpa) of wastes and the remaining 130,000tpa is processed through the main AD plant;
- Wastes are received via a weighbridge and transferred into a steel framed reception building or liquid storage tanks situated externally;
- Within the reception building, packaging is removed from solid wastes where required prior to mixing and blending with other liquid materials and/or water to create a pumpable slurry. The waste is then macerated to 12mm and transferred to one of two pasteurisers where it is held at a minimum temperature of 70°C for at least one hour;
- Pasteurised wastes are transferred to a buffer tank which provides a consistent flow into two primary digesters. After being held for the minimum retention time, the material is pumped into the secondary digester. A further secondary digester is intended to be included at the site under future development plans for the facility;
- The biogas produced as part of the AD process is stored in roofs above the primary digesters and used to operate four on site combined heat and power (CHP) units. Two of these were installed when the facility was first developed and two new units have been included as part of the ongoing refurbishment;
- Biogas is also exported via pipeline to the adjacent BD Gas Permits Limited facility where it is upgraded to biomethane for injection into the national gas grid;
- Out of specification or excess unburnt biogas arising from atypical site operations is returned to the AD plant for storage or burnt in one of the two emergency flares;
- Condensate arising from treatment of gas in the adjacent upgrading facility is collected and returned to the AD plant for re-circulation within the process;
- The site features a backup dual fuel (biogas/diesel) fired boiler that can produce heat for the onsite tanks in the event of CHP unit downtime;
- Air is extracted from the waste reception building and transferred to an odour abatement system for treatment prior to release to atmosphere. Other localised abatement units are also in use at the site to treat displaced air from the waste reception tanks, buffer tanks, pasteurisers and the digestate offtake tankers;
- Digestate generated by the AD process is currently certified to the British Standards Institution (BSI) PAS110 standard and dispatched from site as an end of waste product for use as a biofertiliser in agriculture;
- Water for onsite usage is obtained from a borehole or rainwater harvested from roofs/ concrete surfaces at the facility;

- Domestic sewage is collected in a sealed cesspool and dispatched from site via tanker; and,
- The site operates in accordance with an Environmental Management System which is reviewed and updated on a regular basis.

1.2.4 Reference should be made to Figure 2 for a site layout plan.

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

1.3 Report Amendments

1.3.1 An Odour Assessment[1] was originally undertaken by Redmore Environmental in September 2022 in order to evaulate potential effects as a result of emissions from the facility. Following submission to the EA in support of the Environmental Permit Variation Application, a decision was made by the operator to remove the proposed aerobic membrane bioreactor (MBR) from the site design and replace it with a digestate storage tank of the same dimensions. This will feature a gas tight cover and any air displaced from the vessel during operation will vent to the gas line for combustion in the CHP units.

1.3.2 An updated Odour Assessment has been prepared in order to reflect the stated changes. This is provided in the following report.

[1] Odour Assessment - Bio Dynamic UK Ltd, Nottingham, 4446r1, Redmore Environmental, 2022.

2.0 ODOUR BACKGROUND

2.1 Odour Definition

2.1.1 The Department for Environment, Food and Rural Affairs (DEFRA) guidance[2] 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[3] 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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2 Odour Guidance for Local Authorities, DEFRA, 2010.

3 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.

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[4] 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

[4] 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 In order to provide a worst-case assessment, an odour benchmark level of $1.5ou_E/m^3$ 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 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

5 Odour Guidance for Local Authorities, DEFRA, 2010.

6 Odour Guidance for Local Authorities, DEFRA, 2010.

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. These 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 were identified through a visit to the facility and discussions with Bio Dynamic UK Ltd. These are summarised in Table 2. Reference should be made to Figure 3 for a graphical representation of the source locations.

Table 2 Odour Sources

Source		Source Description	Emission Point	Emission Characteristics
1	Reception building carbon filter	Emissions from a proposed carbon filter which will be used to treat air extracted from the reception building	A15	Treated air from the carbon filter will be released to atmosphere via a dedicated stack at a height of 13m
2	Tank farm carbon filter	Emissions from a carbon filter which is used to treat air extracted from the waste reception tanks, de-pack tank buffer tank and pasteurisers	A19	Treated air from the carbon filter is released to atmosphere via a dedicated stack at a height of 4.5m
3	Digestate tanker carbon filter	Emissions from a proposed carbon filter which will be used to treat air displaced from digestate tankers during filling	A6	Treated air from the carbon filter will be released to atmosphere via a vent on the top of the unit

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. Similarly, the CHP units, boiler and flares will only emit products of combustion when in use which do not typically have any associated odour. As such, they have not been considered as potential sources in the context of this assessment.

3.2.3 The proposed digestate storage tank will feature a gas tight cover and any air displaced from the vessel during normal operation will vent to the gas line for combustion in the CHP units. The tank will feature an emergency release valve to avoid over pressure. This is a necessary safety feature and any releases from the source are expected to be extremely infrequent and short-term as they would only occur in an emergency situation. As such, the risk of impact from emissions is not considered to be significant and they have not been evaluated further in the context of this assessment.

3.3 Odour Abatement Plant

3.3.1 As detailed in the previous Section, a number of existing and proposed abatement systems will be utilised at the site in order to provide control of odour emissions. These are summarised in the following Sections.

Reception Building Carbon Filter

3.3.2 Air will be extracted from the reception building and transferred to either an Aircon H or Aircon V activated carbon filter for treatment prior to discharge to atmosphere via a dedicated stack at a height of 13m. Reference should be made to Appendix 1 for the technical specification of the Aircon systems.

3.3.3 Both Aircon units have the capacity to treat 40,000m^3/hr of extract air, which is sufficient for effective treatment from the building at a rate equivalent to 3 air changes per hour, as required by EA guidance[9].

[9] How to Comply with your Environmental Permit. Additional Guidance for: Anaerobic Digestion, EA, 2013.

3.3.4 Adsorption using activated carbon is recognised within EA guidance[10] as an appropriate technique for the treatment of emissions generated by biowaste processes. In addition, carbon filtration is identified as a suitable abatement option under Best Available Techniques Conclusion (BATc) 34 which is detailed within the European Commission (EC) 'Best Available Techniques (BAT) Reference Document for Waste Treatment'[11] and is directly applicable to operations at the facility.

3.3.5 Based on the stated factors, either of the proposed carbon filter options are considered to be suitable for installation at the facility.

Tank Farm Carbon Filter

3.3.6 Air is continuously extracted from the headspaces of the liquid reception tank, the de-pack tank, the pasteurisers and the buffer tank and transferred to an Aircon 3000 activated carbon filter for treatment prior to discharge to atmosphere. This is located in the immediate vicinity of the tanks. Reference should be made to Appendix 1 for the technical specification of the Aircon system.

3.3.7 The Aircon 3000 unit has the capacity to treat a maximum volumetric air flow rate of 3,500m^3/hr. This significantly exceeds the total extract rate for the tanks and therefore provides sufficient air residence time within the carbon media to facilitate effective abatement of odours.

3.3.8 As stated previously, adsorption using activated carbon is recognised within EA guidance[12] and the EC document[13] as an appropriate technique for the treatment of emissions generated by biowaste processes. As such, the Aircon 3000 unit is considered to represent a suitable emission control system for the facility.

10 How to comply with your environmental permit. Additional guidance for Anaerobic Digestion, EA, 2013.

11 Best Available Techniques (BAT) Reference Document for Waste Treatment, EC, 2018.

12 How to comply with your environmental permit. Additional guidance for Anaerobic Digestion, EA, 2013.

13 Best Available Techniques (BAT) Reference Document for Waste Treatment, EC, 2018.

Digestate Tanker Carbon Filter

3.3.9 Air displaced from digestate tankers during offtake will be treated by a separate carbon filter prior to discharge to atmosphere. The system specification is currently being developed. However, the operator has confirmed that the final design principles will comply with the requirements of EA guidance[14] and the EC document[15].

3.4 Odour Emissions Data

3.4.1 The EC[16] suggests that a BAT odour Associated Emission Level (AEL) range of 200ou_E/m^3 to 1,000ou_E/m^3 is applicable to channelled emissions to air from the biological treatment of waste. The upper range AEL of 1,000ou_E/m^3 is routinely specified by the EA as an odour Emission Limit Value (ELV) in compliance monitoring schedules for abatement at other regulated facilities. As such, this value was utilised to calculate emissions from the existing and proposed carbon filters at the site.

3.5 Dispersion Modelling

3.5.1 Dispersion modelling was undertaken using ADMS-6 (v6.0.0.1), which is developed by Cambridge Environmental Research Consultants (CERC) Ltd. ADMS-5 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.

3.5.2 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.

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

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14 How to comply with your environmental permit. Additional guidance for Anaerobic Digestion, EA, 2013.

15 Best Available Techniques (BAT) Reference Document for Waste Treatment, EC, 2018.

16 Best Available Techniques Reference Document for Waste Treatment, EC, 2018.

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

3.5.4 These are detailed in the following Sections.

3.6 Modelling Scenarios

3.6.1 The scenarios considered in the modelling assessment are summarised in Table 3.

Table 3 Assessment Scenarios

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

3.7 Process Conditions

3.7.1 The inputs used to describe the relevant emission sources within the model were derived from the odour emissions data shown in Section 3.4 and information provided by Bio Dynamic UK Ltd. A summary is provided in the following Sections.

Reception Building Carbon Filter

3.7.2 The following assumptions were utilised to describe odour releases from the reception building carbon filter within the model:

- The volumetric flow rate of air treated by the carbon filter is 34,560m^3/hr. This is equivalent to 3 building air changes per hour in accordance with EA guidance[17];

[17] How to Comply with your Environmental Permit. Additional Guidance for: Anaerobic Digestion, EA, 2013.

- Treated air from the carbon filter will be discharged to atmosphere via a dedicated stack which terminates at a height of 13m; and,
- The odour concentration of treated is 1,000ou_E/m^3, which is equivalent to the upper BAT AEL.

3.7.3 The model input data is summarised in Table 4.

Table 4 Building Carbon Filter Model Input

Parameter	Unit	Value
Source type	-	Point
Position (centre point)	NGR	463395.0, 339833.6
Source height	m	13.0
Source diameter	m	0.8
Emission temperature	°C	15.0
Volumetric flow rate	m^3/hr	34,560
Efflux velocity	m/s	19.1
Odour emission concentration	ou_E/m^3	1,000
Odour emission rate	ou_E/s	9,600

3.7.4 Emissions were assumed to be constant, 24-hours per day, 365-days per year.

Tank Farm Carbon Filter

3.7.5 The following assumptions were utilised to describe odour releases from the tank farm carbon filter within the model:

- The volumetric flow rate of air treated by the carbon filter is 3,600m^3/hr. This is equivalent to the maximum design capacity for the system;
- Treated air from the carbon filter is discharged to atmosphere via a dedicated stack which terminates at a height of 4.5m; and,
- The odour concentration of treated is 1,000ou_E/m^3, which is equivalent to the upper BAT AEL.

3.7.6 The model input data is summarised in Table 5.

Table 5 Tank Farm Carbon Filter Model Input

Parameter	Unit	Value
Source type	-	Point
Position (centre point)	NGR	463420.2, 339838.8
Source height	m	4.5
Source diameter	m	0.2
Emission temperature	°C	15.0
Volumetric flow rate	m^3/hr	3,600
Efflux velocity	m/s	31.8
Odour emission concentration	ou_E/m^3	1,000
Odour emission rate	ou_E/s	1,000

3.7.7 Emissions were assumed to be constant, 24-hours per day, 365-days per year.

Digestate Tanker Carbon Filter

3.7.8 The following assumptions were utilised to describe odour releases from the digestate tanker carbon filter within the model:

- The volumetric flow rate of air treated by the carbon filter is $0.024m^3/s$. This was calculated based on information provided by the Operator which indicated that digestate offtake involves the use of standard $29m^3$ tankers, with each loading event taking approximately 20-minutes to complete;
- Treated air from the carbon filter is discharged to atmosphere via a vent on the top of the unit which terminates at a height of 2.5m; and,
- The odour concentration of treated is $1,000ou_E/m^3$, which is equivalent to the upper BAT AEL.

3.7.9 The model input data is summarised in Table 6.

Table 6 Digestate Tanker Carbon Filter Model Input

Parameter	Unit	Value
Source type	-	Point
Position (centre point)	NGR	463444.4, 339879.6
Source height	m	2.5
Source diameter	m	0.2
Emission temperature	°C	15.0
Volumetric flow rate	m^3/s	0.024
Efflux velocity	m/s	0.77
Odour emission concentration	ou_E/m^3	1,000
Odour emission rate	ou_E/s	24.2

3.7.10 Emissions were assumed to be constant, 24-hours per day, 365-days per year. This is considered to represent a worst-case assessment approach as digestate offload will not be undertaken continuously at the site.

3.8 Assessment Area

3.8.1 The assessment area was defined based on the facility location, anticipated pollutant dispersion patterns and the positioning of sensitive receptors. Ambient concentrations were predicted over NGR: 462670, 339090 to 464170, 340590. 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.

3.8.2 Reference should be made to Figure 3 for a graphical representation of the assessment grid extents.

3.8.3 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 7.

Table 7 Sensitive Receptor Locations

Receptor		NGR (m)	
		X	Y
R1	Industrial - Colwick Industrial Estate	463339.0	339894.3
R2	Industrial - Colwick Industrial Estate	463365.9	339924.8
R3	Industrial - Colwick Industrial Estate	463276.9	339889.4
R4	Industrial - Colwick Industrial Estate	463279.6	339920.2
R5	Industrial - Colwick Industrial Estate	463243.5	339820.6
R6	Commercial / Residential - Holme Lane	463049.4	339297.0
R7	Residential - Island Lane	463993.1	339410.0

3.8.4 Reference should be made to Figure 4 for a map of the receptor locations.

3.9 Terrain Data

3.9.1 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.

3.10 Building Effects

3.10.1 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.

3.10.2 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 8.

Table 8 Building Geometries

Building	NGR (m)		Height (m)	Length / Diameter (m)	Width (m)	Angle (°)
	X	Y				
B1	463405.8	339857.7	10.3	23.0	48.0	129.1
B2	463404.1	339830.6	14.0	4.3	-	-
B3	463406.8	339834.4	6.0	3.4	-	-
B4	463409.4	339837.6	8.0	3.4	-	-
B5	463418.3	339844.9	8.4	7.7	-	-
B6	463431.0	339842.0	12.0	10.8	-	-
B7	463424.3	339852.1	8.4	7.7	-	-
B8	463433.5	339851.5	8.0	4.3	-	-
B9	463431.1	339860.6	8.4	7.7	-	-
B10	463424.4	339820.4	6.0	28.0	-	-
B11	463435.1	339790.5	6.0	28.0	-	-
B12	463455.8	339771.6	10.0	22.0	-	-
B13	463476.8	339786.2	10.0	24.0	-	-
B14	463465.4	339815.8	8.0	33.0	-	-

3.11 Meteorological Data

3.11.1 Meteorological data used in the assessment was taken from Nottingham Watnall meteorological station over the period 1st January 2017 to 31st December 2021 (inclusive). Nottingham Watnall observation station is located at NGR: 450431, 345004, which is approximately 14.3km north-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.

3.11.2 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 5 for wind roses of utilised meteorological records.

3.12 Roughness Length

3.12.1 A z_0 of 0.5m was used to describe the modelling extents and the meteorological site. This value is considered appropriate for the morphology of both areas and is suggested within ADMS-5 as being suitable for 'parkland, open suburbia'.

3.13 Monin-Obukhov Length

3.13.1 The Monin-Obukhov length provides a measure of the stability of the atmosphere. A minimum Monin-Obukhov length of 10m was used to describe the modelling extents and meteorological site. This value is considered appropriate for the nature of both areas and is suggested within ADMS-5 as being suitable for 'small towns < 50,000'.

3.14 Assessment Criteria

3.14.1 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.

3.15 Modelling Uncertainty

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

- 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.

3.15.2 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-5 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 site to account for inter-year variability. 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;
- Operating conditions - Information was provided by Bio Dynamic UK Ltd to describe existing and proposed activities at the facility. As such, these are considered to be representative of likely operating conditions;
- Emission rates - Emission rates were derived the relevant BAT AEL. 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.

3.15.3 Results were considered in the context of the relevant 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 9. 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 9 Predicted Odour Concentrations

Receptor		Predicted 98th %ile 1-hour Mean Odour Concentration (ou_E/m^3)				
		2017	2018	2019	2020	2021
R1	Industrial - Colwick Industrial Estate	0.49	0.58	**0.59**	0.45	0.43
R2	Industrial - Colwick Industrial Estate	0.78	0.77	**0.84**	0.75	0.67
R3	Industrial - Colwick Industrial Estate	0.53	**0.55**	**0.55**	0.50	**0.55**
R4	Industrial - Colwick Industrial Estate	0.47	**0.49**	**0.49**	0.42	0.42
R5	Industrial - Colwick Industrial Estate	0.42	0.51	0.51	0.44	**0.53**
R6	Commercial / Residential - Holme Lane	0.06	0.10	0.09	0.11	**0.12**
R7	Residential - Island Lane	0.09	0.09	**0.10**	0.07	**0.10**

4.1.2 As indicated in Table 9, predicted odour concentrations were below the EA odour benchmark of $1.5ou_E/m^3$ at all receptor locations for all modelling years.

4.1.3 Reference should be made to Figure 6 to Figure 10 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 Bio Dynamic UK Ltd to undertake an Odour Assessment in support of an Environmental Permit Variation Application for the AD facility operated by the company at Colwick Industrial Estate, Nottingham.

5.1.2 Odours from a number of sources on site have the potential to cause impacts at sensitive receptors. An Odour Assessment was therefore undertaken to consider effects in the vicinity of the facility.

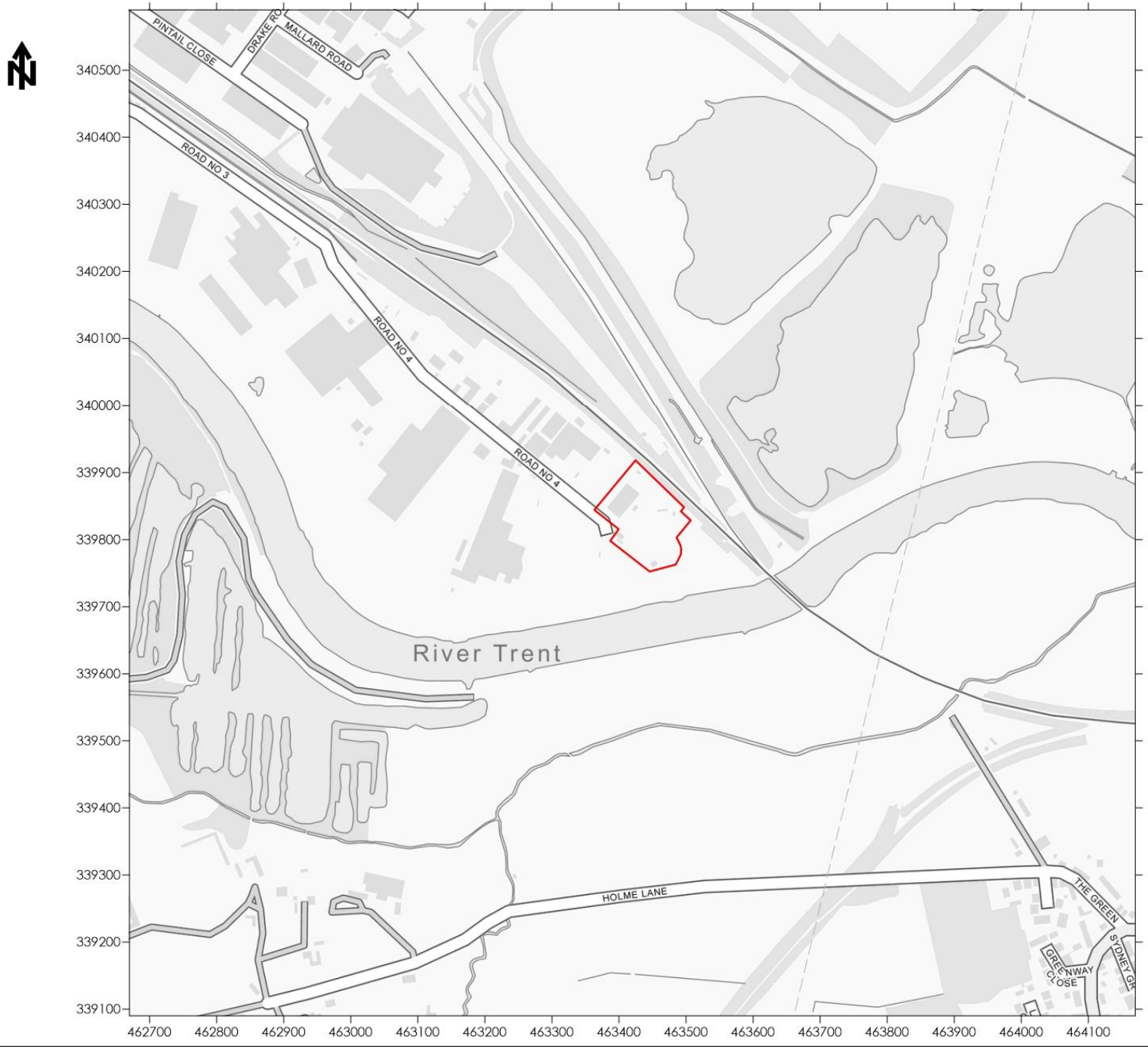
5.1.3 Potential odour sources were identified and emissions defined based on the size and nature of the plant. Impacts at sensitive receptors were quantified using dispersion modelling and the results compared with the relevant odour benchmark level.

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

6.0 ABBREVIATIONS

AD	Anaerobic Digestion
AEL	Associated Emission Limit
BAT	Best Available Techniques
BATc	Best Available Techniques Conclusion
BSI	British Standards Institution
CERC	Cambridge Environmental Research Consultants
CHP	Combined Heat and Power
DEFRA	Department for Environment, Food and Rural Affairs
EA	Environment Agency
EC	European Commission
MBR	Membrane Bioreactor
NGR	National Grid Reference
z_0	Roughness length
%ile	Percentile

Figures



Legend

Site Boundary

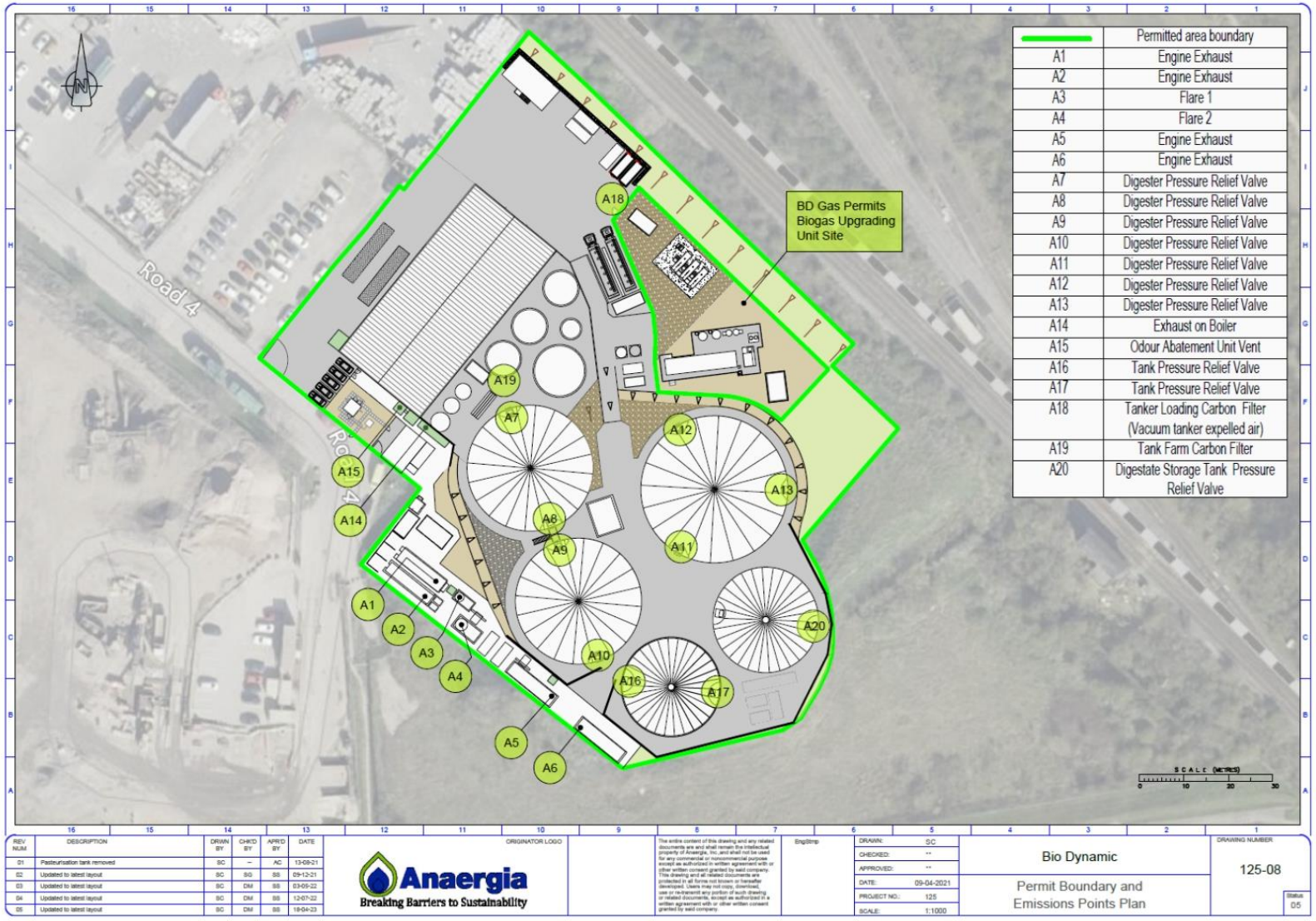
Title
Figure 1 - Site Location Plan

Project
Odour Assessment -
Bio Dynamic UK, Nottingham

Project Reference
4446

Client
Bio Dynamic UK Ltd

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



	Permitted area boundary
A1	Engine Exhaust
A2	Engine Exhaust
A3	Flare 1
A4	Flare 2
A5	Engine Exhaust
A6	Engine Exhaust
A7	Digester Pressure Relief Valve
A8	Digester Pressure Relief Valve
A9	Digester Pressure Relief Valve
A10	Digester Pressure Relief Valve
A11	Digester Pressure Relief Valve
A12	Digester Pressure Relief Valve
A13	Digester Pressure Relief Valve
A14	Exhaust on Boiler
A15	Odour Abatement Unit Vent
A16	Tank Pressure Relief Valve
A17	Tank Pressure Relief Valve
A18	Tanker Loading Carbon Filter (Vacuum tanker expelled air)
A19	Tank Farm Carbon Filter
A20	Digestate Storage Tank Pressure Relief Valve

REV NUM	DESCRIPTION	DRAWN BY	CHK'D BY	APP'D BY	DATE
01	Pasteurisation tank removed	SC	--	AC	13-09-21
02	Updated to latest layout	SC	SG	SS	09-12-21
03	Updated to latest layout	SC	DM	SS	03-05-22
04	Updated to latest layout	SC	DM	SS	12-07-22
05	Updated to latest layout	SC	DM	SS	18-04-23

ORIGINATOR LOGO

Anaergia
Breaking Barriers to Sustainability

Eng/Stmp

DRAWN: SC
CHECKED: **
APPROVED: **
DATE: 09-04-2021
PROJECT NO.: 125
SCALE: 1:1000

Bio Dynamic

Permit Boundary and Emissions Points Plan

DRAWING NUMBER
125-08
Status 05

Legend

Title
Figure 2 - Site Layout Plan

Project
Odour Assessment -
Bio Dynamic UK, Nottingham

Project Reference
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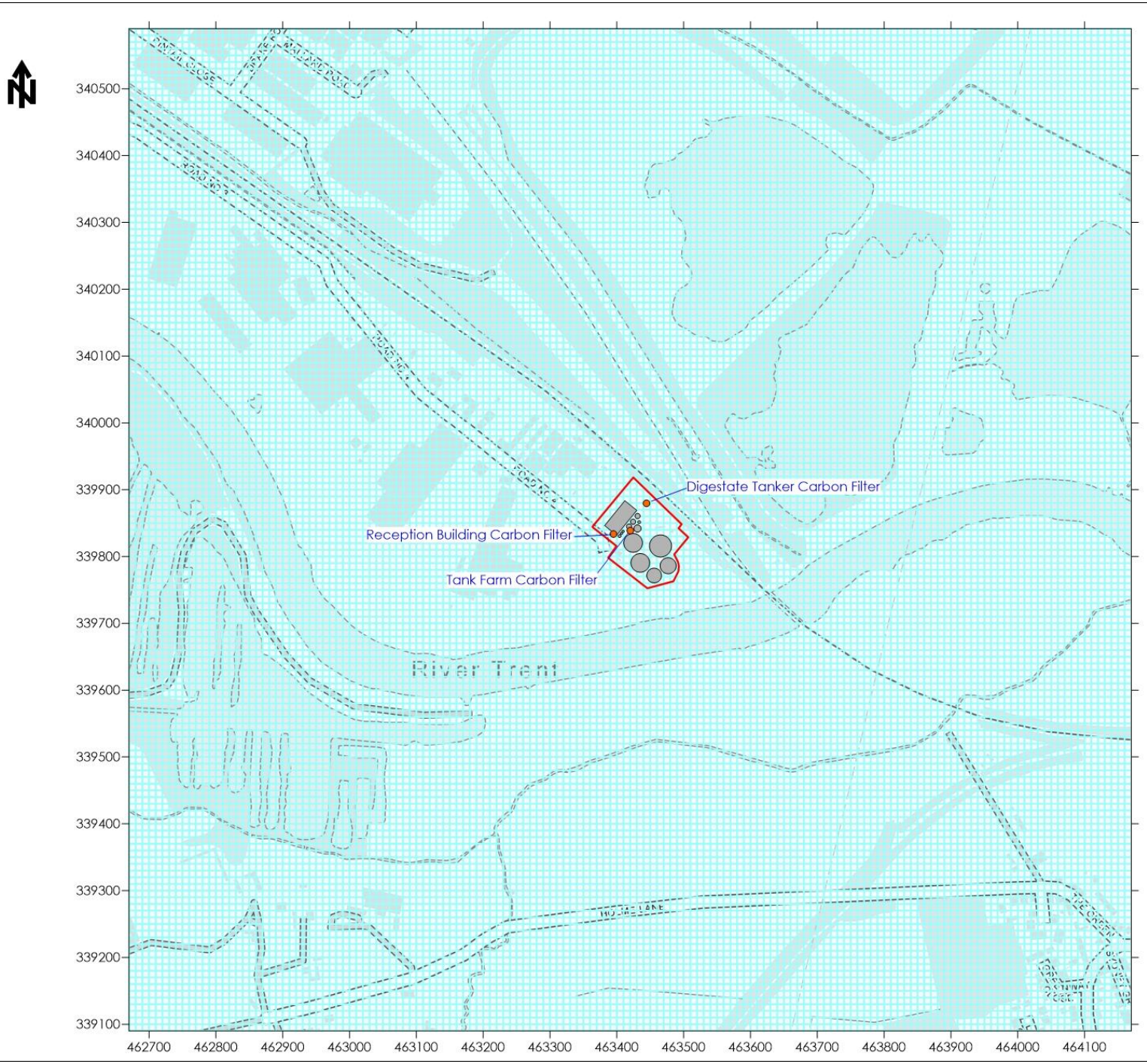

Legend

- Site Boundary
- ADMS Output Grid
- Building
- Point Source

Title
Figure 3 - ADMS-6 Inputs

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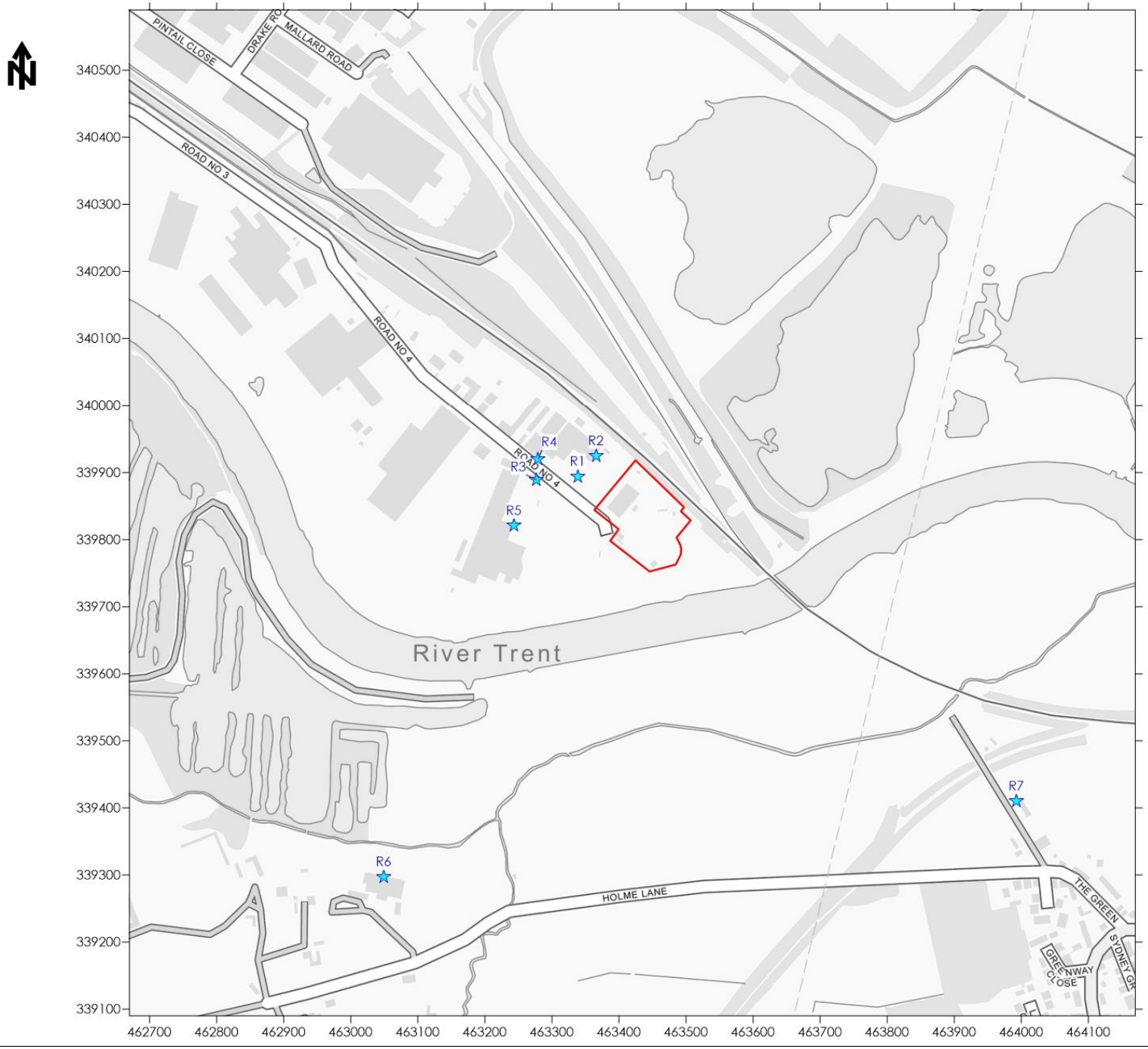

Legend

Site Boundary

Sensitive Receptor

Title
Figure 4 - Sensitive Receptor Locations

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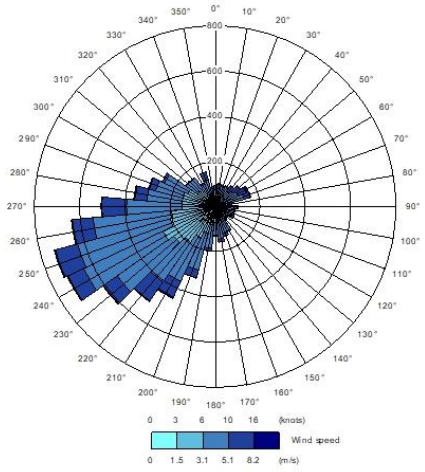
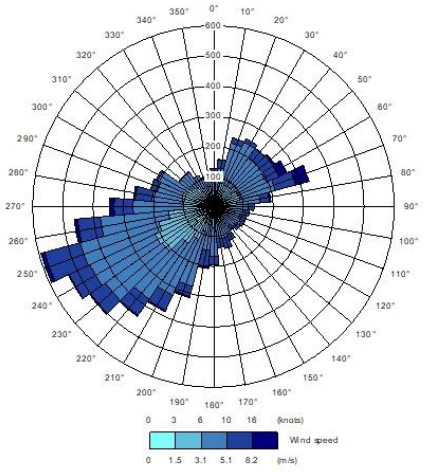
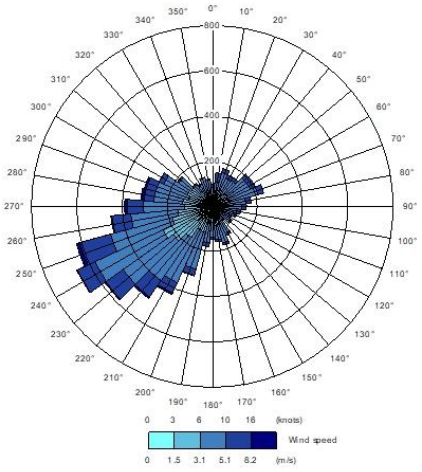


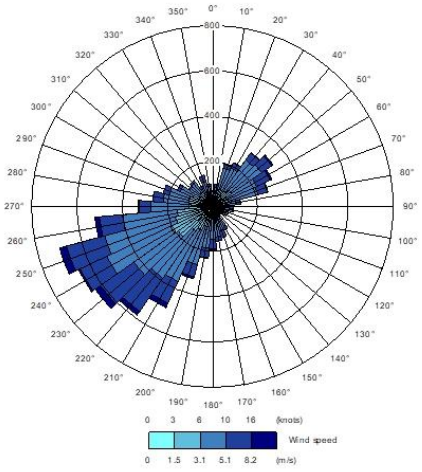
2017 Meteorological Data



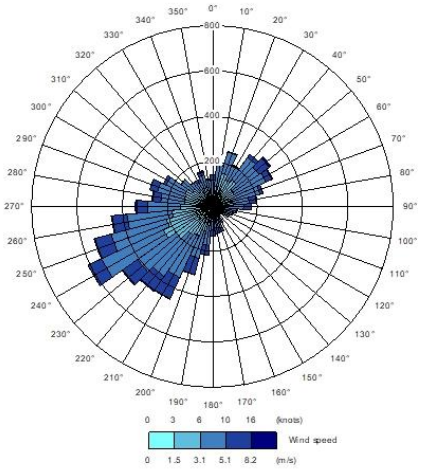
2018 Meteorological Data



2019 Meteorological Data



2020 Meteorological Data



2021 Meteorological Data

Legend

Title
Figure 5 - Wind Roses of 2017 to 2021 Nottingham Watnall Meteorological Data

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Odour Assessment -
Bio Dynamic UK, Nottingham

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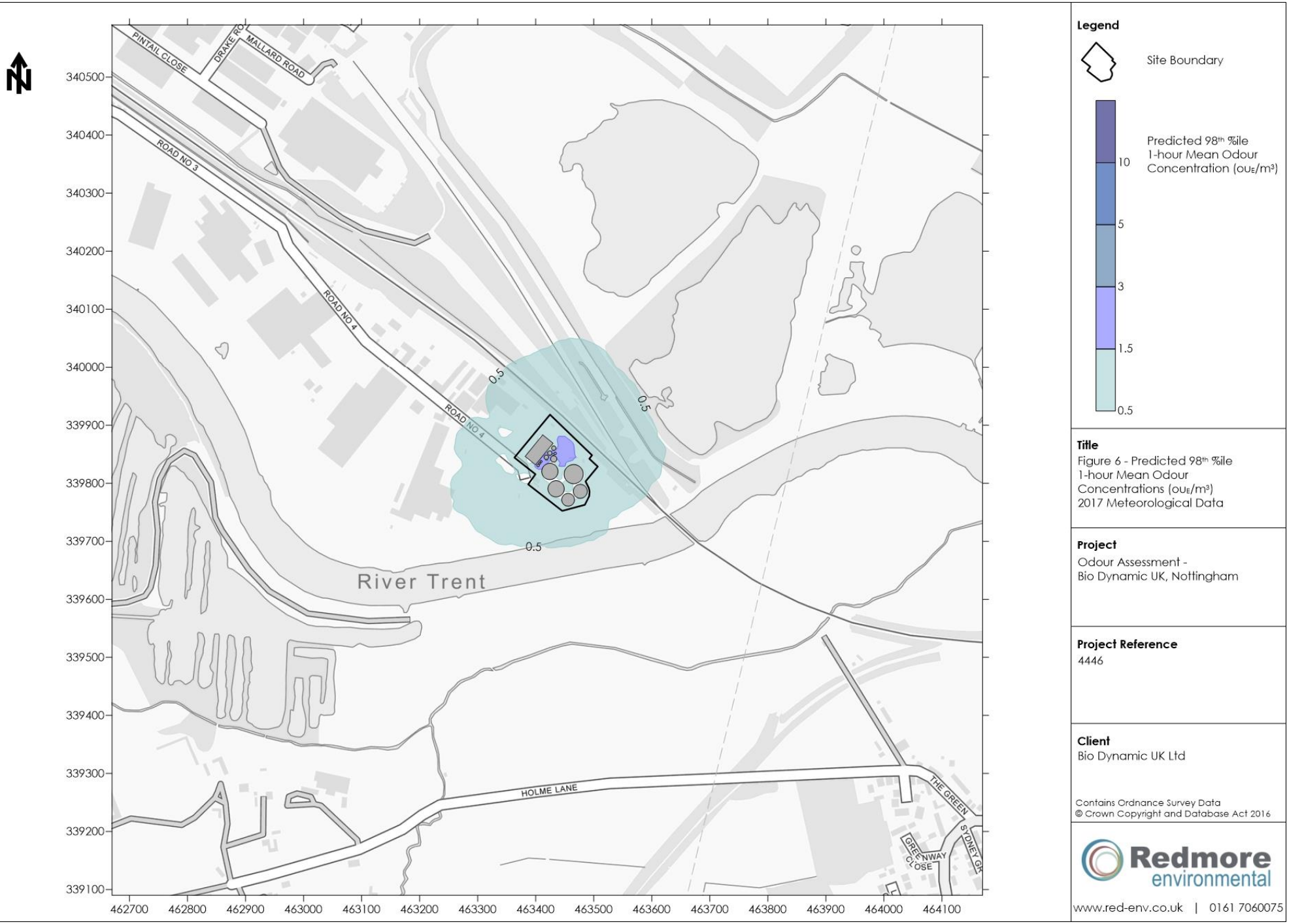

Legend

Site Boundary

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

10
5
3
1.5
0.5

Title

Figure 6 - Predicted 98th %ile 1-hour Mean Odour Concentrations (ou_E/m^3) 2017 Meteorological Data

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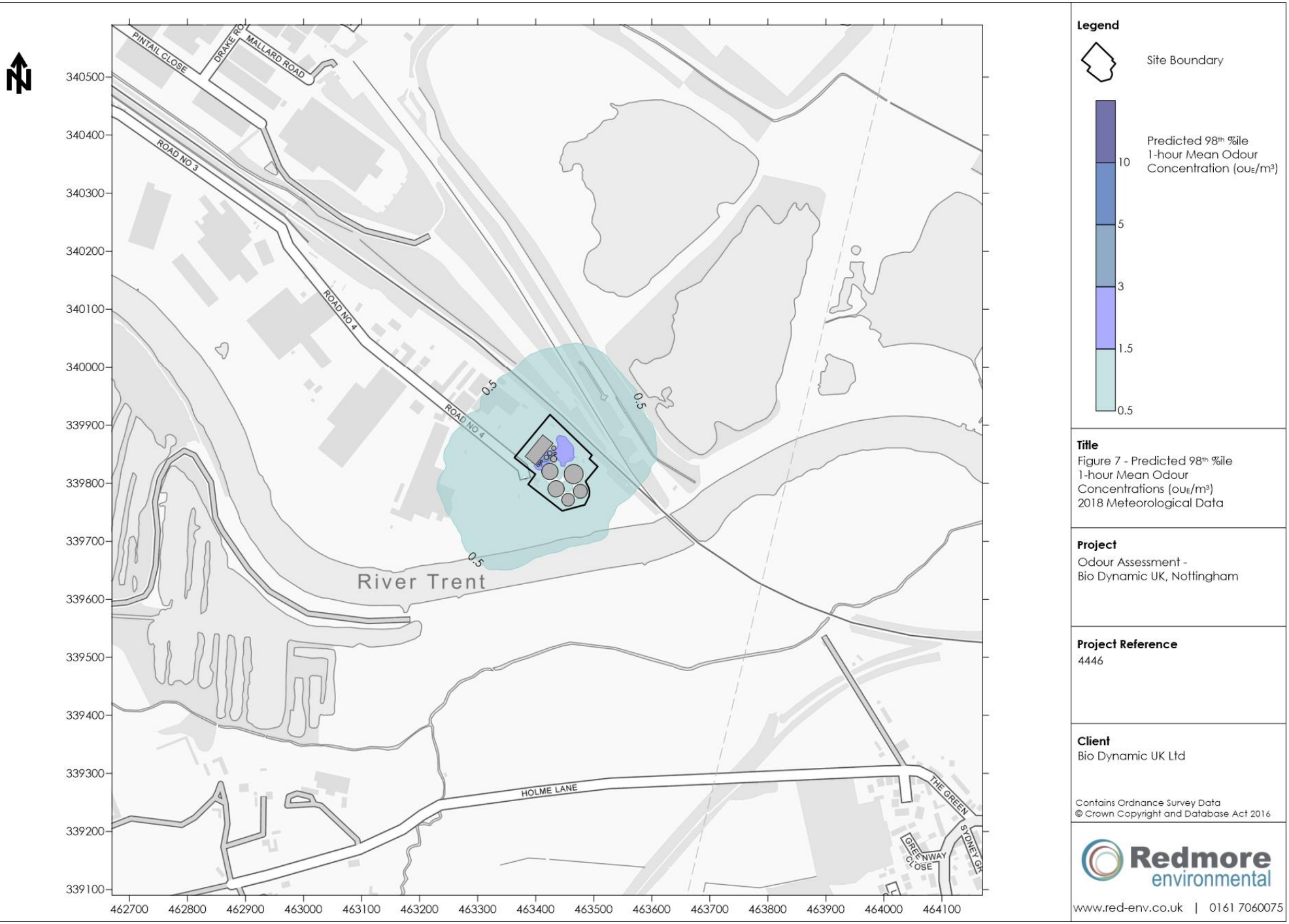

Legend

Site Boundary

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

10
5
3
1.5
0.5

Title

Figure 7 - Predicted 98th %ile 1-hour Mean Odour Concentrations (ou_E/m^3) 2018 Meteorological Data

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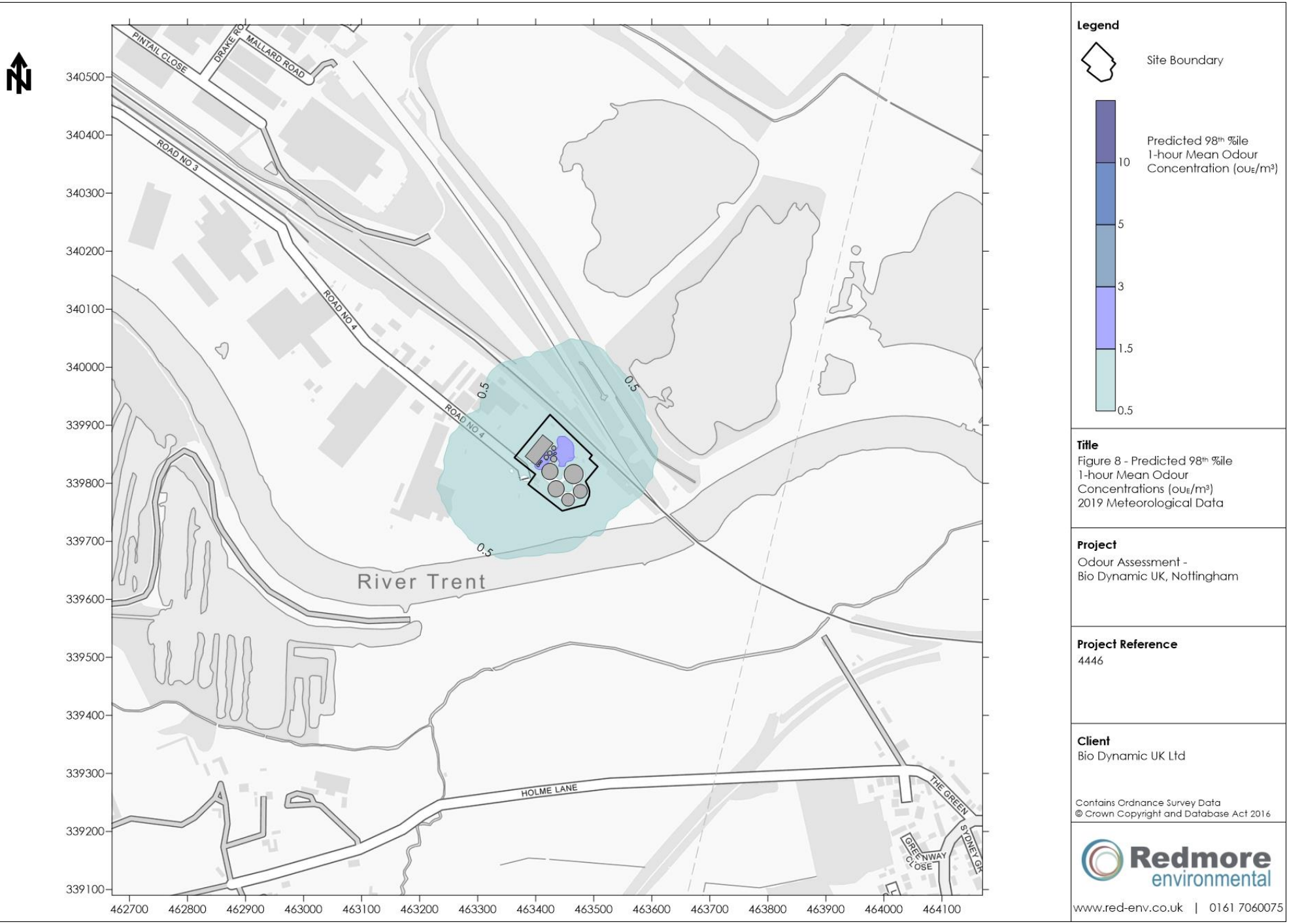

Legend

Site Boundary

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

10
5
3
1.5
0.5

Title

Figure 8 - Predicted 98th %ile 1-hour Mean Odour Concentrations (ou_E/m^3) 2019 Meteorological Data

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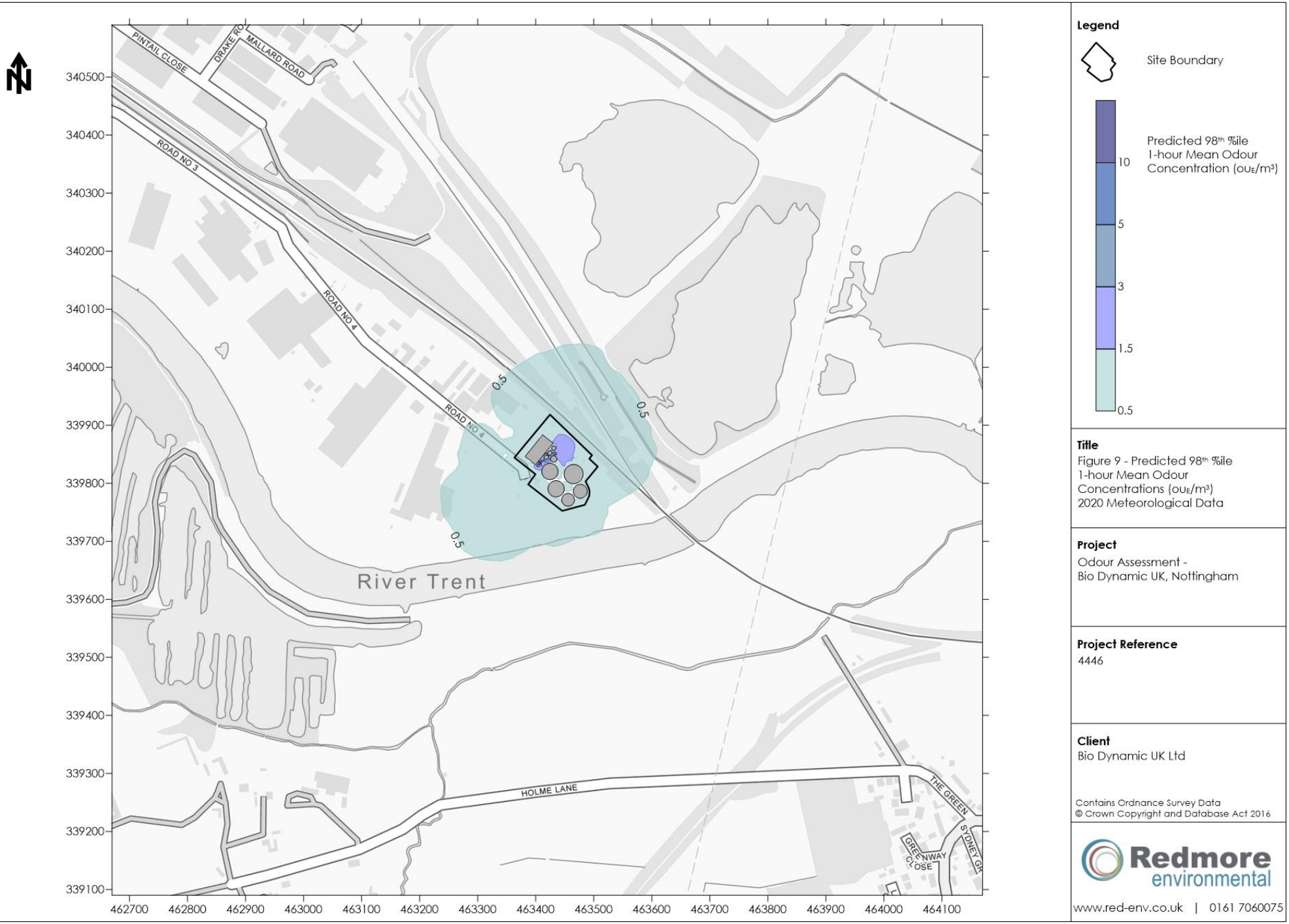

Legend

Site Boundary

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

10
5
3
1.5
0.5

Title

Figure 9 - Predicted 98th %ile 1-hour Mean Odour Concentrations (ou_E/m^3) 2020 Meteorological Data

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Odour Assessment - Bio Dynamic UK, Nottingham

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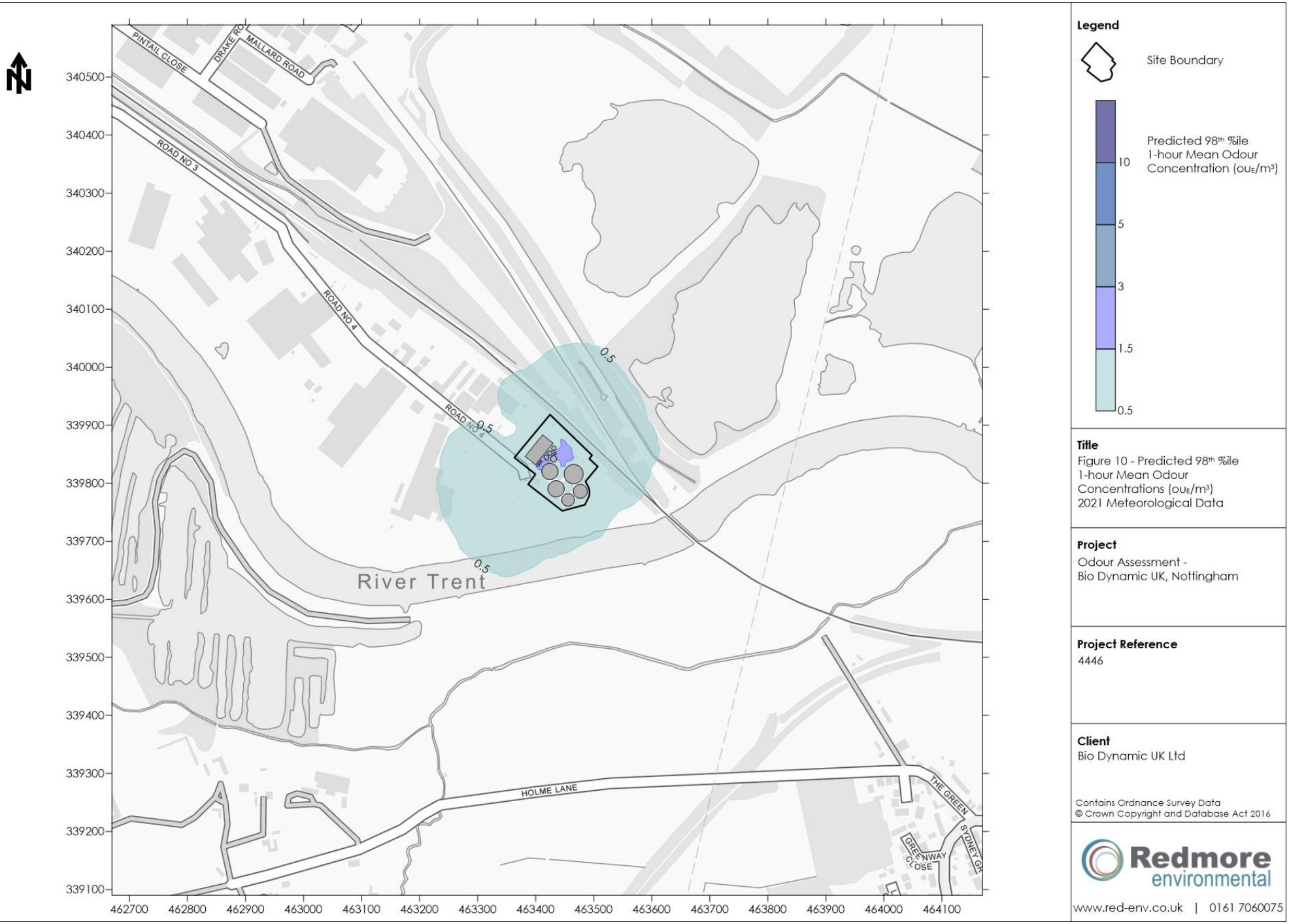

Legend

Site Boundary

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

10
5
3
1.5
0.5

Title

Figure 10 - Predicted 98th %ile 1-hour Mean Odour Concentrations (ou_E/m^3) 2021 Meteorological Data

Project

Odour Assessment - Bio Dynamic UK, Nottingham

Project Reference

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Appendix 1 - Carbon Filter Specification

DESOTEC ACTIVATED CARBON

AIRCON® V

The AIRCON® is a mobile replaceable adsorption filter which has been specially developed for air and gas treatment and purification.

KEY FEATURES

- quick and easy to install and connect (plug & play)
- can be hired without investment and maintenance costs (via daily contracts)
- no handling of activated carbon on site
- combined transport vessel and filter
- option to test and evaluate new applications without capital investment
- efficient design (low pressure drop / high kinetics), can be installed in series or in parallel

SPECIAL FEATURES

- vertical filter that requires little floor space
- high flow rate per filter module
- sampling point for saturated activated carbon

DIMENSIONS h: 7.1m x 2.6m x 2.4m

TECHNICAL INFORMATION ON THE BACK

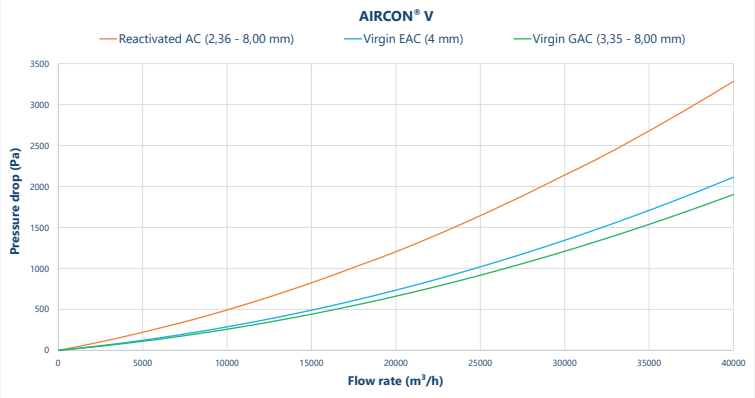
AIRCON® V

MAXIMUM FLOW RATE	40,000 m^3/h
MINIMUM FLOW RATE	4,000 m^3/h
MATERIAL	steel
COATING	Finliner
DIMENSIONS	h: 7.1m x 2.6m x 2.4m
TOTAL VOLUME	40 m^3
MAXIMUM FILL VOLUME	13.5 m^3
MAXIMUM WEIGHT, DRAINED	17.5 tonnes
MAXIMUM FULL LOAD	17,5 ton
TARE	5000 kg
MAXIMUM PRESSURE	100 mbar
EXCESS PRESSURE PROTECTION	to be provided by customer
MAXIMUM NEGATIVE PRESSURE	100 mbar
NEGATIVE PRESSURE PROTECTION	to be provided by customer
OPERATING TEMPERATURE	40°C
MAXIMUM DESIGN TEMPERATURE *	60°C
INLET **	800 diameter
OUTLET **	800 diameter
DRAIN **	1" brass/PTFE ball valve
SEALS	EPDM
PIPEWORK	-
SHUT-OFF VALVE	-
WATER / AIR SAMPLING - CUSTOMER	-
EARTHING	yes
VENTING	-
VENTING DATA TYPE	-
SIPHON BREAKER	-
PED 2014/68/EU	-

** A higher temperature should always be discussed upfront with the sales department and requires extra safety measures by the customer.*

*** Connections available according to customer requirements*

It is the customer's responsibility to determine the suitability of the filter materials for the process flow.
This filter is protect by a EU registered community design right, reference 001723511-0003
This filter is protect by a UK registered community design right, reference 90008982670002



For dimensioning please take a 30% security into account

PRESSURE DROP CURVE

You can use the pressure-drop graph to calculate and predict the pressure drop (extra info on demand). The pressure drop is dependent on the particle size and the design of the filter itself, and should only be used as a guideline.

SAFETY

Wet activated carbon preferentially removes oxygen from air. In closed or partially closed containers and vessels, oxygen depletion may reach hazardous levels. If workers are to enter a vessel containing activated carbon, appropriate sampling and work procedures including local requirements for potentially low-oxygen spaces should be followed. For certain groups of chemical products, the reaction with or adsorption by the activated carbon surface can be accompanied by the release of a large quantity of exothermic heat, which could give rise to hotspots in the activated carbon bed. In the event of the generally rare occurrence of such hotspots, it is recommended that the activated carbon bed be inertised with a gas such as nitrogen.

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www.desotec.com

MK0097.4

ISO 9001 I 12/01/22

DESOTEC ACTIVATED CARBON

AIRCON® H

The AIRCON® is a mobile replaceable adsorption filter which has been specially developed for air and gas treatment and purification.

KEY FEATURES

- quick and easy to install and connect (plug & play)
- can be hired without investment and maintenance costs (via daily contracts)
- no handling of activated carbon on site
- combined transport vessel and filter
- option to test and evaluate new applications without capital investment
- efficient design (low pressure drop / high kinetics), can be installed in series or in parallel

SPECIAL FEATURES

- easy to place horizontally, even on uneven surfaces
- sampling point for saturated activated carbon
- high flow rate per filter module

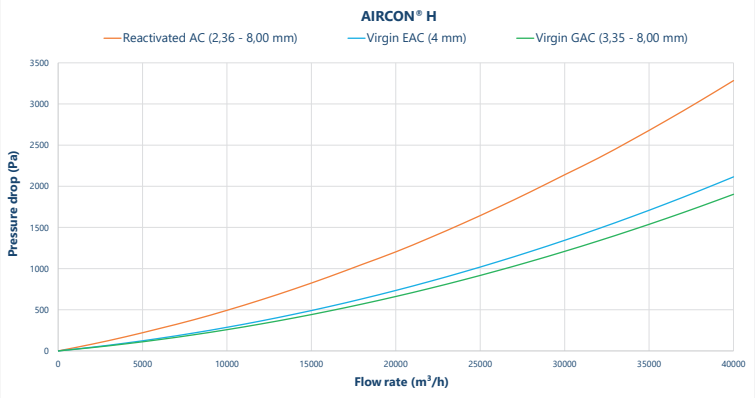
DIMENSIONS h: 2.6m x 7.4m x 2.6m

TECHNICAL INFORMATION ON THE BACK

AIRCON® H	
MAXIMUM FLOW RATE	40,000 m^3/h
MINIMUM FLOW RATE	4,000 m^3/h
MATERIAL	steel
COATING	Finliner
DIMENSIONS	h: 2.6m x 7.4m x 2.6m
TOTAL VOLUME	40 m^3
MAXIMUM FILL VOLUME	13.5 m^3
MAXIMUM WEIGHT, DRAINED	17.5 tonnes
MAXIMUM FULL LOAD	17,5 ton
TARE	4700 kg
MAXIMUM PRESSURE	100 mbar
EXCESS PRESSURE PROTECTION	to be provided by customer
MAXIMUM NEGATIVE PRESSURE	100 mbar
NEGATIVE PRESSURE PROTECTION	to be provided by customer
OPERATING TEMPERATURE	40°C
MAXIMUM DESIGN TEMPERATURE *	60°C
INLET **	800 diameter
OUTLET **	800 diameter
DRAIN **	1" brass/PTFE ball valve
SEALS	EPDM
PIPEWORK	-
SHUT-OFF VALVE	-
WATER / AIR SAMPLING - CUSTOMER	-
EARTHING	yes
VENTING	-
VENTING DATA TYPE	-
SIPHON BREAKER	-
PED 2014/68/EU	-

** A higher temperature should always be discussed upfront with the sales department and requires extra safety measures by the customer.*

*** Connections available according to customer requirements*



For dimensioning please take a 30% security into account

PRESSURE DROP CURVE

You can use the pressure-drop graph to calculate and predict the pressure drop (extra info on demand). The pressure drop is dependent on the particle size and the design of the filter itself, and should only be used as a guideline.

SAFETY

Wet activated carbon preferentially removes oxygen from air. In closed or partially closed containers and vessels, oxygen depletion may reach hazardous levels. If workers are to enter a vessel containing activated carbon, appropriate sampling and work procedures including local requirements for potentially low-oxygen spaces should be followed. For certain groups of chemical products, the reaction with or adsorption by the activated carbon surface can be accompanied by the release of a large quantity of exothermic heat, which could give rise to hotspots in the activated carbon bed. In the event of the generally rare occurrence of such hotspots, it is recommended that the activated carbon bed be inertised with a gas such as nitrogen.

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www.desotec.com

MK0096.4

ISO 9001 I 12/01/22

DESOTEC ACTIVATED CARBON

AIRCON® 3000

The AIRCON® is a mobile replaceable adsorption filter which has been specially developed for air and gas treatment and purification.

KEY FEATURES

- quick and easy to install and connect (plug & play)
- can be hired without investment and maintenance costs (via daily contracts)
- no handling of activated carbon on site
- combined transport vessel and filter
- option to test and evaluate new applications without capital investment
- efficient design (low pressure drop / high kinetics), can be installed in series or in parallel

DIMENSIONS h: 2.3m x 1.8m x 1.7m

TECHNICAL INFORMATION ON THE BACK

AIRCON® 3000

MAXIMUM FLOW RATE	3,500 m^3/h
MINIMUM FLOW RATE	350 m^3/h
MATERIAL	stainless steel 304
COATING	-
DIMENSIONS	h: 2.3m x 1.8m x 1.7m
TOTAL VOLUME	3.5 m^3
MAXIMUM FILL VOLUME	3 m^3
MAXIMUM WEIGHT, DRAINED	3.8 tonnes
MAXIMUM FULL LOAD	6 tonnes
TARE	710 kg
MAXIMUM PRESSURE	100 mbar
EXCESS PRESSURE PROTECTION	to be provided by customer
MAXIMUM NEGATIVE PRESSURE	50 mbar
NEGATIVE PRESSURE PROTECTION	to be provided by customer
OPERATING TEMPERATURE	40°C
MAXIMUM DESIGN TEMPERATURE *	80°C
INLET **	DN350 PN10 flange + blind flange
OUTLET **	DN400 PN10 flange + blind flange
DRAIN **	1" brass/PTFE ball valve
SEALS	-
PIPEWORK	-
SHUT-OFF VALVE	-
WATER / AIR SAMPLING - CUSTOMER	-
EARTHING	via earthing clamp at the filter body or filter frame
VENTING	-
VENTING DATA TYPE	-
SIPHON BREAKER	-
PED 2014/68/EU	-

** A temperature above 60°C requires extra safety measures by the customer*

*** Connections available according to customer requirements*

It is the customer's responsibility to determine the suitability of the filter materials for the process flow.
This filter is protect by a EU registered community design right, reference 007732722-0004
This filter is protect by a UK registered community design right, reference 90077327220004

For dimensioning please take a 30% security into account

PRESSURE DROP CURVE

You can use the pressure-drop graph to calculate and predict the pressure drop (extra info on demand). The pressure drop is dependent on the particle size and the design of the filter itself, and should only be used as a guideline.

SAFETY

Wet activated carbon preferentially removes oxygen from air. In closed or partially closed containers and vessels, oxygen depletion may reach hazardous levels. If workers are to enter a vessel containing activated carbon, appropriate sampling and work procedures including local requirements for potentially low-oxygen spaces should be followed. For certain groups of chemical products, the reaction with or adsorption by the activated carbon surface can be accompanied by the release of a large quantity of exothermic heat, which could give rise to hotspots in the activated carbon bed. In the event of the generally rare occurrence of such hotspots, it is recommended that the activated carbon bed be inertised with a gas such as nitrogen.

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