Redmore environmental

Bioaerosol Risk Assessment

Attleborough Anaerobic Digestion Plant

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Prepared by	Ger Parry	Ger Parry	Ger Parry	
Position	Associate Director	Associate Director	Associate Director	
Reviewed by	Pearl Hutchinson	Pearl Hutchinson	Pearl Hutchinson	
Position	Principal Air Quality Consultant	Principal Air Quality Consultant	Principal Air Quality Consultant	
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Taylor Road, Urmston, Manchester, M41 7JQ

info@red-env.co.uk | 0161 706 0075 | www.red-env.co.uk

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1.0 INTRODUCTION

1.1 Background

1.1.1 Redmore Environmental Ltd was commissioned by Earthcare Technical Ltd to undertake a Bioaerosol Risk Assessment in support of a Substantial Variation Environmental Permit Application for Attleborough Anaerobic Digestion (AD) plant, Ellingham Road, Attleborough, Norfolk, NR17 1AE.

1.1.2 During the operation of the facility there is the potential for bioaerosol emissions and associated impacts at sensitive receptor locations in the vicinity of the site. A Risk Assessment has therefore been undertaken to identify potential emission sources and evaluate effects in the local area.

1.1.3 The purpose of this Bioaerosol Risk Assessment is to:

- Establish the likely sources of bioaerosols arising from proposed operations at the site;
- Assess the potential for significant risk of impact at sensitive locations due to emissions from the identified sources; and,
- Identify any additional mitigation required to control potential effects.

1.2 Site Location and Context

1.2.1 Attleborough AD plant is located on land off Ellingham Road, Attleborough, Norfolk, at approximate National Grid Reference (NGR): 603330, 295630. Reference should be made to Figure 1 for a map of the site and surrounding area.

1.2.2 The site currently operates as an AD facility under an Environmental Permit (No. EPR/BB3931RA) issued by the Environment Agency (EA). Existing operations include the reception and storage of crop feedstocks followed by treatment within an AD plant. Biogas generated by the process is combusted within a Combined Heat and Power (CHP) unit in order to generate electricity and heat. The site also features a flare for emergency venting of biogas during abnormal operation.

1.2.3 A Substantial Variation Environmental Permit Application is currently being made to the EA in order to authorise a number of changes to operations. These include construction of a new AD plant which will be used to process food wastes and industrial waste waters. This will comprise the following infrastructure:

- A fully enclosed reception building;
- An odour control system which will be used to treat extract air from the reception building and other process areas within;
- Three primary digesters each with 3,823m^3 working capacities;
- One secondary digester with a 3,823m^3 capacity;
- One pre-storage tank with a 424m^3 working capacity;
- Three pre-storage tanks each with 67m^3 working capacities;
- Three pasteurisation tanks each with a 30m^3 working capacity;
- A biogas gas upgrading and grid entry unit; and,
- A covered liquid digestate lagoon.

1.2.4 It should be noted that this is not an exhaustive list and reference should be made to Figure 2 for a full inventory of the relevant infrastructure.

1.2.5 The proposed changes also include removal, relocation or upgrade of a number of existing items at the site. These are summarised as follows:

- The existing crop feed hoppers will be relocated to the north of the current AD tanks;
- The existing CHP unit will be relocated northwards;
- The existing dirty water lagoon will be taken out of service and replaced by a new covered store;
- The existing flare will be repositioned;
- A cover will be fitted to the chute of the existing digestate separator;
- Four new leachate storage tanks will be installed;
- The existing Mississippi digestate dryer will be taken out of service; and,
- The existing solid digestate storage area will be changed from a bay to a covered trailer.

1.2.6 The operation of the AD plant following implementation of the proposed changes may result in bioaerosol 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.

2.0 PROCESS DESCRIPTION

2.1 Introduction

2.1.1 A brief summary of proposed operations incorporating the changes which are subject to the Substantial Variation Environmental Permit Application is provided in the following Sections. Reference should be made to Figure 2 for a site layout plan.

2.2 Management

2.2.1 The overall management responsibility for the plant will lie with Eco Verde Energy Limited. The day to day facility management will be undertaken by an appointed Manager who will deal specifically with the operation of the plant.

2.2.2 Daily checks and maintenance will be undertaken by the Manager. A range of spare parts will be kept on site. If additional items are required these will be available within a 24-hour period. In addition, there is certain amount of redundancy factored into the plant operation which allows for some items to be out of action temporarily but for the remainder of the facility to continue operating normally.

2.3 Feedstock Delivery and Storage

2.3.1 The facility will operate using a range of biodegradable feedstocks. A summary of the types and tonnages of materials that will be processed is provided in Table 1.

Table 1 Feedstock Types and Quantities

Feedstock Type	Quantity (t/yr)
Maize silage	27,375
Rye	2,920
Packaged food waste	8,000[a]
Kerbside collected food waste	33,000[a]
Liquid food waste	22,000
Bakery waste	17,000[a]

Feedstock Type	Quantity (t/yr)
Industrial waste waters	10,950

Note: (a) The sizing of the bays and mixing pit within the Reception Building dictate that there will be no more than a total of 204t of solid waste stored within the building at any one time. This is based on 681m^3 storage in bays (total), 100m^3 in mixing pit and a typical solid food waste density of 0.26t/m^3 (Source: Environment Agency Waste Conversion Spreadsheet).

2.3.2 A summary of the delivery and storage procedures for the feedstocks is provided in the following Sections.

Maize Silage and Rye

2.3.3 Maize silage and rye will be transferred to the facility using a tractor and trailer or Heavy Goods Vehicles (HGVs) during typical harvest periods and deposited within two existing clamps located on the northern section of the site.

2.3.4 The clamps will be compacted and covered using protective plastic sheeting. This will form an airtight layer to minimise emissions and preserve the feedstock throughout the year. It should be noted that any decomposition of the material would affect its effectiveness as a feedstock. As such, the protective sheeting will be specified to prevent water and air reaching the material and hence avoid any unwanted breakdown with associated emissions.

2.3.5 The cover on the clamps will be slightly open at one end during cutting phases in order to allow access to the feedstock for removal and transportation to the AD plant feed hoppers. It is anticipated that there will typically be two cutting phases per working day. The sheeting will be replaced at the end of each phase in order to protect the feedstock and minimise the potential for emissions.

2.3.6 Any leachate generated by maize silage and rye during storage will be transferred to the storage tanks prior to incorporation into the AD process. Air displaced from the tanks during filling will be discharged directly to atmosphere from vent near to the top of the vessels.

Solid Food Wastes

2.3.7 Solid food wastes will be transferred to the facility in enclosed HGVs. These will drive directly into the new reception building on the southern section of the site and deposit loads within dedicated storage bays.

2.3.8 The delivery areas of the reception building will feature fast-acting roller shutter doors which will be utilised to maintain a sealed environment as far as practicable. In addition, air will be extracted from the delivery area of reception building at a rate equivalent to at least 3 air changes per hour in accordance with Environment Agency (EA) guidance[1]. The extract air will be transferred to a Centriair ColdOx combined UV and activated carbon abatement system for treatment prior to discharge to atmosphere via a common stack.

Liquid Wastes and Industrial Waste Waters

2.3.9 Liquid food wastes and industrial waste waters will be delivered to the site using vacuum tankers. Following arrival, the materials will be transferred directly into one of four new pre-storage tanks using a mechanical pumping system. The pumping arrangement is a closed system and therefore the materials will not be exposed to atmosphere.

2.3.10 Air displaced from the tanks during filling will vent to the digesters. As such, there will be no emissions to atmosphere as part of the liquid food waste and industrial wastewater reception process.

2.4 Preliminary Processing of Feedstocks

2.4.1 A summary of the preliminary feedstock processing operations is provided in the following Sections.

Maize Silage and Rye

2.4.2 Maize silage and rye will be transferred from the storage clamps to the relocated feed hoppers using a bucket loader or similar. These will macerate and blend the material prior

[1] How to comply with your environmental permit. Additional guidance for Anaerobic Digestions, EA, 2013.

to processing within the Crop AD plant. It is anticipated that the hoppers will be loaded twice daily.

Solid Food Wastes

2.4.3 Packaged food wastes will be transferred to a de-packaging unit located within the reception building. This will remove plastics and any other contaminants. Air will be extracted from the de-packaging area using a ventilation hood at a rate equivalent to at least 3 air changes per hour. The extract air will be transferred to the Centirair ColdOx UV and activated carbon abatement system for treatment prior to discharge to atmosphere via the common stack.

2.4.4 The de-packaged material will be transferred to the mixing pit where it will be macerated and blended to facilitate pumping to the Waste AD plant.

2.4.5 Unpackaged food wastes will be removed from the relevant storage areas within the reception building and transferred to the mixing pit for maceration and blending prior to transfer to the Waste AD plant.

2.4.6 Air will be extracted from the mixing pit and transferred to a Centriair DEO-500 regenerative catalytic conversion and sulphared pellet abatement system for treatment prior to discharge to atmosphere via the common stack.

Liquid Wastes

2.4.7 Liquid wastes will be transferred from the external storage tanks to the mixing pit using a mechanical pumping system. The pumping arrangement is a closed system and therefore the feedstocks will not be exposed to atmosphere.

2.5 AD Plant Operation

2.5.1 The crop feedstocks will be digested within three existing sealed AD tanks. Food wastes and industrial waste waters will be processed in four new fermenters. All AD tanks include all necessary non-return valves and pumps to ensure there are no losses from any part of the process. The facility will be fully automated to maintain maximum efficiency at all times.

2.5.2 The biogas produced by the Waste AD plant, a mixture of methane (CH_4) and carbon dioxide (CO_2), will be collected in domes above the digesters prior to upgrade for injection into the gas grid. This involves stripping out impurities, mainly CO_2, specific volatile organic compounds (VOCs) and hydrogen sulphide (H_2S), before treatment with an odorant and transfer off-site. Exhaust gases generated by the upgrading process will be discharged to atmosphere via dedicated vent. The upgrade plant also features and emergency release valve to avoid over pressure.

2.5.3 Biogas produced by the Crop AD plant process will be transferred to the existing relocated CHP unit where it will be combusted for the generation of electricity and heat. Exhaust gases from the plant will be dispersed to atmosphere via a dedicated stack.

2.5.4 The site will feature two automatic back-up flares that burn gas in a controlled manner if the upgrade system or CHP unit stop temporarily, or if plant maintenance is required. Should the flares fail for any reason the digester tanks are fitted with emergency release valves to avoid over pressure. These are a necessary safety feature. A record of their use will be kept and the reason for utilisation fully documented.

2.5.5 Frequent or extended use of the pressure release valves would indicate the plant is not being managed correctly and would have financial consequences for the operator due to loss of biogas and potential impacts to the digester conditions. It is therefore in their best interest to ensure they are utilised as infrequently as possible.

2.6 Digestate

2.6.1 The AD process will create digestate in liquid and solid form which can be used as a biofertiliser.

2.6.2 Digestate generated by the Crop AD plant will be divided into solid and liquid fractions using a screw separator. Solid digestate will be discharged from the separator via an enclosed chute into a covered trailer where it will be stored prior to removal from the site. The liquid fraction will be transferred to the existing lagoon for holding prior to removal from the facility using vacuum tankers. This features a floating cover in order to provide containment of digestate and reduce the potential for any associated emissions to atmosphere.

2.6.3 Digestate generated by the Waste AD plant will be heat treated in one of three pasteurisation units before being pumped to a screw separator located within the reception building. Air displaced from the pasteurisers during filling will vent directly to the gas line. As such, there will be no bioaerosol release to atmosphere from these sources during normal operation.

2.6.4 Solid digestate will be discharged from the separator via a chute into a trailer where it will be stored prior to removal from the site. Air will be extracted from the trailer room and transferred to a Centriair DEO-500 regenerative catalytic conversion and sulphared pellet abatement system for treatment prior to discharge to atmosphere via the common stack.

2.6.5 The liquid fraction will be transferred to the proposed lagoon for holding prior to removal from the facility. This will feature a floating cover in order to provide containment of digestate and reduce the potential for any associated emissions to atmosphere.

2.6.6 Liquid digestate will be transported off site in vacuum tankers. These will couple to an outlet point on the lagoons using a hose before material is transferred using a mechanical pumping system. The pumping arrangement is a closed system and as such the digestate will not be exposed to atmosphere. Air displaced from the tankers during filling will vent directly to atmosphere.

3.0 BIOAEROSOL BACKGROUND

3.1 Bioaerosol Definition

3.1.1 Bioaerosol is a general term for microorganisms suspended in the air. These microorganisms include fungi and bacteria, as well as their components such as mycotoxins, endotoxins and glucans. Bioaerosols are generally less than 100μm in size and are not filtered out by hairs and specialised cells that line the nose. Due to their airborne nature and small size, many bioaerosols can penetrate the human respiratory system, resulting in inflammatory and allergic responses.

3.1.2 Although bioaerosols are ubiquitous, operations involving biodegradable materials provide environments that are conducive to their growth. Bioaerosols are therefore likely to be associated with AD feedstocks and products, and in particular, handling activities, which release the microorganisms into the air.

3.2 Health Risks from Bioaerosols

3.2.1 Exposure to bioaerosols has been associated with human health effects, symptoms can include inflammation of the respiratory system, coughs and fever. Inhalation of bioaerosols may also cause or exacerbate respiratory diseases[2]. They have been known to cause gastrointestinal illness, eye irritation and dermatitis.

3.2.2 Possible links have also been made between exposure to bioaerosols and organic dust toxic syndrome. This is an acute disease that causes symptoms resembling those of influenza, such as shivering, an increase in body temperature, dry cough and muscle and joint pains. Of particular relevance to waste management facilities are infections caused by Aspergillus fumigatus. Invasive aspergillosis is a particularly severe infection, which may be fatal and is primarily a concern with at risk and immuno-suppressed patients.

3.2.3 Although some data is available, one of the major knowledge gaps for bioaerosols is their associated dose-response relationships. It is not currently possible to state with any certainty that a given concentration will result in a particular health impact. This is due to

[2] Guidance on the evaluation of bioaerosol risk assessments for composting facilities, EA, undated.

the number of bioaerosols that are naturally present within the environment as well as the complexities associated with human responses to different microorganisms.

3.3 Bioaerosol Emissions from Waste Management Operations

3.3.1 Most scientific research on bioaerosol emissions from waste management operations focusses on open windrow and In-Vessel Composting (IVC) systems. Although it is recognised that there are fundamental differences between composting and AD processes, there are similarities between the types of feedstocks, handling activities and infrastructure utilised. As such, a review of relevant research has been undertaken in order to inform the assessment. The findings are detailed in the following Section.

3.3.2 The EA document 'Health Effects of Composting - A Study of Three Compost Sites and Review of Past Data'[3] summarises the findings of emissions measurement work undertaken at three composting facilities, including two open air turned windrow sites and one IVC plant. The results from the work indicated a well-defined decline in concentrations of bioaerosols with increased distance from source. In most cases, measured concentrations were at or below background levels within 250m of the sources assessed.

3.3.3 The ADAS report 'Bioaerosol Monitoring and Dispersal from Composting Sites'[4] provides a summary of the findings from measurement work undertaken at three composting sites. Sampling for bioaerosols was undertaken downwind of a wide range of composting activities including shredding, turning, loading, unloading and screening. The results indicated that 91% of all micro-organisms sampled across all three sites were below 1,000cfu/m^3 at a downwind distance of 125m.

3.3.4 The Scotland and Northern Ireland Forum for Environmental Research (SNIFFER) report 'Measurement and Modelling of Emissions from Three Composting Sites'[5] provides a summary of the findings from monitoring work undertaken at three composting sites, which included two IVC facilities and one open windrow system. The findings indicated that there is the potential for seasonal variation in ambient concentrations of the mould of Aspergillus fumigatus, with concentrations being the highest in the autumn. In most

3 Health Effects of Composting - A Study of Three Compost Sites and Review of Past Data, EA, 2001.

4 Bioaerosol Monitoring and Dispersal from Composting Sites, ADAS, 2005.

5 Measurement and Modelling of Emissions from Three Composting Sites, SNIFFER, 2007.

cases, levels of all bioaerosols assessed were at or below background equivalent concentrations within 250m of the sources assessed.

3.3.5 The Department for Environment Food and Rural Affairs (DEFRA) research report 'Bioaerosols and odour emissions from composting facilities'[6] focusses on the comparability of different sampling methodologies and the influence of spatial and temporal variation on ambient bioaerosol concentrations. Measurements were undertaken at four different composting facilities in England, which represent a range of system types. The results of the study corroborate existing research and suggest that concentrations of bioaerosols generally return to background levels within 250m of the source.

3.3.6 The findings of the review have been considered as appropriate throughout the assessment.

3.4 Legislative Control

3.4.1 Atmospheric emissions from industry are controlled in the UK through the Environmental Permitting (England and Wales) Regulations (2016) and subsequent amendments. The operation of an AD plant is included within the Regulations and as such the facility is required to operate in accordance with an Environmental Permit issued by the EA.

3.5 Environment Agency Policy

3.5.1 The EA Regulatory Position Statement (RPS) 'Bioaerosol monitoring at regulated facilities - use of M9: RPS 209'[7] outlines the conditions that apply to facilities in relation to bioaerosol emissions.

3.5.2 The RPS states that if a regulated facility is located within 250m of a sensitive receptor (a place where people live or work for more than 6-hours at a time), the operator must:

6 Bioaerosols and odour emissions from composting facilities, DEFRA, 2013.

7 Bioaerosol monitoring at regulated facilities - use of M9: RPS 209, EA, 2018.

- Monitor bioaerosols in accordance with EA guidance 'M9: environmental monitoring of bioaerosols at regulated facilities'[8]; and,
- Undertake a site specific Bioaerosol Risk Assessment.

3.5.3 The conditions outlined within the RPS have been considered as appropriate throughout the assessment.

3.6 Benchmark Levels

3.6.1 In the absence of dose-response data, the EA have adopted a precautionary risk-based approach in determining guidance levels for bioaerosols. The EA position statement 'Composting and potential health effects from bioaerosols: our interim guidance for permit applicants'[9] specifies the following criteria for acceptable concentrations of Aspergillus fumigatus and total bacteria at sensitive receptor locations:

- Aspergillus fumigatus - 500cfu/m^3; and,
- Total bacteria - 1,000cfu/m^3.

3.6.2 The relevant benchmark levels have been considered as appropriate throughout the assessment.

3.7 Technical Guidance

3.7.1 The EA guidance 'How to comply with your environmental permit. Additional technical guidance for: Anaerobic Digestion'[10] sets out indicative Best Available Technique (BAT) or appropriate measures for the AD of organic materials. The document provides practical guidance on how and why bioaerosol emissions occur, as well as measures that can be employed to prevent or minimise release.

3.7.2 The requirements of the guidance have been considered throughout the assessment.

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8 M9: environmental monitoring of bioaerosols at regulated facilities, EA, 2018.

9 Composting and potential health effects from bioaerosols: our interim guidance for permit applicants, EA, 2010.

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

4.0 PROBLEM DEFINITION

4.1 Introduction

4.1.1 The first stage of any risk assessment is to clearly set out the problem, including what will be addressed and what will not. This determines the scope, level of detail and focus. In particular, the temporal and spatial scales, contaminants to be assessed, persons at risk and the endpoint are identified. These factors are considered in the following Sections.

4.2 Conceptual Model

4.2.1 A summary of the conceptual model utilised as part of the assessment is provided in Table 2.

Table 2 Conceptual Model

Criteria	Comment
Source	Feedstocks and products on the site as outlined in Section 4.3
Hazard	Potential adverse health impacts as outlined in Section 3.2
Transport Mechanism	Airborne
Medium of Exposure	Inhalation, ingestion, absorption, injection
Receptor	Human receptors at the proposed site as outlined in Section 4.5

4.3 Sources

4.3.1 The operation of the facility may result in bioaerosol emissions from a number of activities. The following potential sources were identified based on a review of existing and proposed operations:

- Exposed maize silage and rye during delivery and storage within the clamps;
- Exposed maize silage and rye during transfer to the feed hoppers;
- Exposed material within the feed hoppers;
- Fugitive emissions from the reception building;
- Air displaced from the leachate storage tanks;
- Air released from the common stack serving the Centriair abatement systems;

- Air released from the upgrade system CO_2 vent;
- Fugitive emissions from the covered solid digestate storage trailer serving the Crop AD plant;
- Fugitive emissions from the covered liquid digestate storage lagoons;
- Fugitive emissions from the covered dirty water lagoon; and,
- Air expelled from the liquid digestate tankers.

4.3.2 As stated previously, the actual AD process itself is sealed and therefore does not form a source of bioaerosols under normal operation. The digesters will feature release valves to avoid over pressure. Any gases released from the valves are likely to contain bioaerosols as a result of the digestion processes. However, releases from these sources 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 these emissions is not considered to be significant and they have not been evaluated further in the context of this assessment.

4.3.3 The CHP unit and flare stacks will only emit products of combustion which do not contain any bioaerosols. As such, they have not been considered further in this report.

4.3.4 The potential for bioaerosol emissions from each remaining source is considered further in the following Sections.

Exposed Maize Silage and Rye During Delivery and Storage

4.3.5 Maize silage and rye will be transferred to the facility using a tractor and trailer or HGVs during typical harvest periods. The feedstocks will be deposited within the existing storage clamps located on the northern section of the site. Disturbance of the material during delivery may cause bioaerosol release. However, the seasonal nature of deliveries and short amount of time required to deposit loads is likely to minimise potential exposure durations.

4.3.6 Following delivery, the crop feedstocks will be compacted and covered with protective sheeting. This will help to minimise bioaerosol release during storage.

4.3.7 The cover on the clamps will be slightly open at one end during cutting phases in order to allow access to the feedstock for removal and transportation to the Crop AD plant feed hoppers. It is anticipated that there will typically be two cutting phases per working day.

The sheeting will be replaced at the end of each phase in order to protect the feedstock and minimise the potential for emissions. The area of uncovered material during transfer to the hopper will be kept to a minimum at all times in order to limit the potential for surface wind stripping of microorganisms.

4.3.8 The clamps will be inspected on a daily basis to ensure the sheeting is intact and providing effective coverage of the feedstock material.

Exposed Maize Silage and Rye During Transfer

4.3.9 Maize silage will be transferred from the storage clamps using a bucket loader or similar and then deposited into the relocated feed hoppers.

4.3.10 There is the potential for bioaerosol release during removal of maize silage from the clamps and loading into the hoppers. As such, all reasonable measures will be undertaken to minimise disturbance of the material during this operation. In addition, the shortest transfer routes will be utilised in order to limit potential exposure durations.

4.3.11 Full training will be provided to the bucket loader operative to avoid material spillage during transfer. Any spilled material will be cleared within the working day.

Feed Hoppers

4.3.12 The feed hoppers will macerate and blend the maize silage prior to processing within the Crop AD plant. Bioaerosol emissions may occur during operation of the hoppers. As such, potential releases have been considered further as part of the assessment.

Fugitive Emissions from the Reception Building

4.3.13 The reception building will utilise fast acting roller shutter doors in order to promote effective containment of bioaerosols. In accordance with EA guidance[11], the delivery area of the reception building will feature a ventilation system which is capable of achieving an extraction rate equivalent to 3 air changes per hour. This will help to ensure

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11 How to comply with your environmental permit. Additional technical guidance for: composting and aerobic treatment sector, EA, 2013.

that negative pressure is maintained within the building and reduce the potential for fugitive emissions when the roller shutter doors are opened to allow vehicle access.

Leachate Tank Vent

4.3.14 Air displaced from the leachate storage tanks during filling will exhaust directly to atmosphere via vents near to the tops of the vessels. This may contain bioaerosols. As such, potential impacts associated with emissions from the source have been considered further as part of the assessment.

Centriair Abatement System Stack

4.3.15 Air extracted from the reception building will transferred to a Centriair ColdOx combined UV and activated carbon abatement system for treatment. Air extracted from the mixing pit and digestate separation room will be transferred to Centriair DEO-500 regenerative catalytic conversion and sulphared pellet abatement units. Treated air from all systems will be released to atmosphere via a common stack at a height of 14m.

4.3.16 The proposed abatement systems are likely to provide beneficial reductions in bioaerosol concentrations between inlet and outlet air due to the following:

- UV radiation is mutagenic to bacteria and is therefore likely to lead to death or inactivation of components within the reception building extract air;
- Secondary treatment using activated carbon housed within the ColdOx unit is likely to result in the impaction of fungi and residual viable bacterial components not removed by the UV stage; and,
- The catalytic oxidation process is heat assisted and is therefore likely to result in the thermal deconstruction of microorganisms present within air.

4.3.17 Although it is considered that the stated control mechanisms will provide effective reductions in bioaerosol concentrations, it is recognised that there is the potential for the release of residual microorganisms. As such, emissions have been evaluated further as part of the assessment.

Upgrade System Vent

4.3.18 Biogas which is upgraded to biomethane for injection into the gas grid will be passed through an activated carbon filter to remove specific compounds before CO_2 is stripped through selective membranes and vented to atmosphere. The system is likely to provide beneficial reductions in bioaerosol concentrations between inlet and vented air due to the impaction of microorganisms onto the carbon media during operation. However, there may be the potential for the release of residual components which pass straight through the filter. As such, emissions have been evaluated further as part of the assessment.

Solid Digestate

4.3.19 Digestate generated by the Crop AD plant will be divided into solid and liquid fractions using an existing screw separator on the central section of the site. Solid digestate will be discharged from the separator via an enclosed chute into a covered trailer. Although the AD process will reduce the quantities of some bioaerosols, particularly pathogens[12], there is the potential for emissions from this part of the process.

4.3.20 Solid digestate will remain covered within the trailer during storage in order to reduce the exposed surface area of material and limit the potential for surface wind stripping of microorganisms. In addition, the material will be removed from site daily to avoid storage of significant amounts and the associated potential for bioaerosol release. However, residual emissions may occur and have therefore been considered further as part of the assessment.

4.3.21 As stated previously, digestate generated by the Waste AD plant will be divided into solid and liquid fractions using a screw separator located within the reception building. Solid digestate will be discharged from the separator via a chute into a trailer where it will be stored prior to removal from the site. Air will be extracted from the trailer room and transferred to a Centriair DEO-500 regenerative catalytic conversion and sulphared pellet abatement system for treatment prior to discharge to atmosphere via the common stack.

12 Anaerobic digestion, storage, oligolysis, lime, heat and aerobic treatment of livestock manures, FEC Services Ltd, 2003.

Liquid Digestate Lagoons

4.3.22 The liquid digestate generated by the Crop and Waste AD processes will be stored within two lagoons (one existing and one proposed). Both lagoons will feature floating covers in order to provide containment of materials and minimise the potential for associated emissions to atmosphere.

4.3.23 Although the floating covers are anticipated to provide effective control of bioaerosol emissions, there is the potential for residual fugitive releases. As such, emissions have been evaluated further as part of the assessment.

Digestate Tanker

4.3.24 Liquid digestate will be transported off site in vacuum tankers. These will couple to an outlet point on the lagoons using a hose before material is transferred using a mechanical pumping system. The pumping arrangement is closed and therefore digestate will not be exposed to atmosphere during transfer.

4.3.25 Emissions from the digestate tanker are associated with the air being expelled during filling. The bioaerosol release potential depends largely on the material previously being transported rather than the digestate itself.

4.3.26 Tankers are most commonly used to transport liquids and semi-solid materials which generally have a low emission potential. As such, releases from this source are not considered to be significant. However, emissions have been considered further as part of the assessment in order to provide a comprehensive appraisal of potential impacts.

4.4 Other Sources of Bioaerosols

4.4.1 There is agricultural land use in the immediate vicinity of the site. Arable fields may form further sources of bioaerosols if fertilised with animal manures or slurries, as well as during crop harvest periods. However, likely impacts associated with these releases are not considered to be significant and would be expected for any rural location within the UK.

4.5 Receptors

4.5.1 EA guidance 'M9: environmental monitoring of bioaerosols at regulated facilities'[13] defines a sensitive receptor as follows:

> "Nearest sensitive receptor means the nearest place to the permitted activities where people are likely to be for prolonged periods. This term would therefore apply to dwellings (including any associated gardens) and to many types of workplaces. We would not normally regard a place where people are likely to be present for less than 6 hours at one time as being a sensitive receptor. The term does not apply to those controlling the permitted facility, their staff when they are at work or to visitors to the facility, as their health is covered by Health and Safety at Work legislation, but would apply to dwellings occupied by the family of those controlling the facility."

4.5.2 A desk-top study was undertaken in order to identify any sensitive receptors in the vicinity of the site that required specific consideration during the assessment. These are summarised in Table 3.

Table 3 Sensitive Receptors

Receptor		NGR (m)		Distance from AD Plant Boundary (m)	Direction from AD Plant
		X	Y		
R1	Commercial - Crowshall Veterinary Services	603479	295790	70	North-east
R2	Residential - Stuart House	603530	295863	140	North-east
R3	Residential - Cakes Hill	603486	295927	200	North-east
R4	Residential - Crowshall Lane	603463	296047	300	North
R5	Residential - Ellingham Road	603296	296176	400	North
R6	Residential - Ellingham Road	603174	296152	410	North
R7	St Luke's Hospital	603013	296096	410	North-west
R8	Residential - Cades Hill Farm	602860	296089	500	North-west

13 M9: environmental monitoring of bioaerosols at regulated facilities, EA, 2018.

Receptor		NGR (m)		Distance from AD Plant Boundary (m)	Direction from AD Plant
		X	Y		
R9	Residential - Shrugg's Lane	602783	295883	440	North-west
R10	Residential - Lyng Farm	602487	295286	830	South-west
R11	Industrial - Wastewater Treatment Works	602861	295200	530	South-west
R12	Commercial - West Carr Road	603119	294819	720	South
R13	Residential - Carver's Lane	603528	294910	620	South
R14	Residential - Carver's Lane	603583	295146	420	South-east
R15	Residential - Carver's Lane	603683	295248	370	South-east
R16	Residential - Chapel Road	603966	295468	450	East
R17	Residential - Baconsthorpe	604061	295923	540	North-east
R18	Residential - Ash Farm	603151	296756	1,000	North

4.5.3 Reference should be made to Figure 3 for a visual representation of the identified receptors.

4.6 Prevailing Meteorological Conditions

4.6.1 The potential for bioaerosol emissions to impact at sensitive locations depends significantly on the meteorology, particularly wind direction, during release. In order to consider prevailing conditions at the site review of historical weather data was undertaken. Norwich Airport meteorological station is located at NGR: 622041, 313948, which is approximately 26.1km north-east 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.

4.6.2 Meteorological data was obtained from Norwich Airport meteorological station over the period 1st January 2015 to 31st December 2019 (inclusive). The frequency of wind from the eight sectors which best describe the directions which may cause impacts in the vicinity of the site is shown in Table 4. Reference should be made to Figure 4 for a wind rose of the meteorological data.

Table 4 Wind Frequency Data

Wind Direction (°)	Frequency of Wind (%)
337.5 - 22.5	9.28
22.5 - 67.5	7.62
67.5 - 112.5	7.79
112.5 - 157.5	5.87
157.5 - 202.5	16.00
202.5 - 247.5	24.17
247.5 - 292.5	20.52
292.5 - 337.5	6.32
Sub-Total	97.57
Calms	1.46
Missing/Incomplete	0.98

4.6.3 All meteorological data used in the assessment was provided by Atmospheric Dispersion Modelling Ltd, which is an established distributor of meteorological data within the UK.

4.6.4 As shown in Table 4, the prevailing wind direction at the AD facility is from the south-west with significant frequencies from the west. Winds from the north and east are relatively infrequent, which is indicative of conditions throughout the majority of the UK.

5.0 RISK ASSESSMENT METHODOLOGY

5.1 Overview

5.1.1 The Bioaerosol Risk Assessment has been undertaken in accordance with the general principles of EA document 'Guidance on the evaluation of bioaerosol risk assessments for composting facilities'[14]. This included consideration of the following:

- Receptor - what is at risk? What do I wish to protect?
- Source - what is the agent or process with potential to cause harm?
- Harm - what are the harmful consequences if things go wrong?
- Pathway - how might the receptor come into contact with the source?
- Probability of exposure - how likely is this contact?
- Consequence - how severe will the consequences be if this occurs?
- Magnitude of risk - what is the overall magnitude of the risk? and,
- Justification for magnitude - on what did I base my judgement?

5.1.2 Based on the Bioaerosol Risk Assessment outcomes potential mitigation and control options were identified.

5.1.3 Further explanation for the key assessment areas is provided below.

5.2 Receptor

5.2.1 The first step was to consider how the activity could harm the environment. This involved identifying 'receptors' that may be affected by bioaerosol emissions from the facility and for the purpose of the assessment focussed on relevant sensitive human receptor locations in the vicinity of the site, as set out in Section 4.5.

5.3 Probability of Exposure

5.3.1 The probability of exposure was defined based on the likelihood of exposure of the specific receptor to the identified sources. This depended on several factors, such as:

14 Guidance on the evaluation of bioaerosol risk assessments for composting facilities, EA, undated.

- Distance between source and receptor;
- Dispersion potential of emission;
- Duration of emission; and,
- Frequency of emission.

5.3.2 Probability was categorised in accordance with the following criteria:

- High - exposure is probable, direct exposure likely with no/few barriers between source and receptor;
- Medium - exposure is fairly probable, barriers less controllable;
- Low - exposure unlikely, barriers exist to mitigate; or,
- Very low - exposure very unlikely, effective and multiple barriers.

5.4 Harm

5.4.1 The severity of harm from a risk depends on:

- How much a person or part of the environment is exposed; and,
- How sensitive a person or part of the environment is.

5.4.2 Some parts of the environment can be very sensitive. For example, serious health effects can occur if humans are exposed to certain chemicals for only short periods of time.

5.4.3 Harm can be described as follows:

- High - severe consequences, evidence that exposure may result in serious damage;
- Medium - significant consequences, evidence that exposure may result in damage that is not severe and is reversible;
- Low - minor consequences, damage not apparent, reversible adverse changes possible; and,
- Very low - negligible consequences, no evidence for adverse changes.

5.5 Magnitude of Risk

5.5.1 The level of risk is a combination of:

- How likely a problem is to occur; and,
- How serious the harm might be.

5.5.2 Risk is highest where both the likelihood of a problem is high and the potential harm is severe. Risk is lowest where a problem is unlikely to occur and the harm that might result is not serious.

5.5.3 Risk was defined based on the interaction between the probability of exposure and potential harm, as outlined in Table 5.

Table 5 Magnitude of Risk

Probability of Exposure	Potential Harm			
	Very Low	Low	Medium	High
High	Low	Medium	High	High
Medium	Low	Medium	Medium	High
Low	Low	Low	Medium	Medium
Very Low	Very Low	Low	Low	Medium

5.6 Further Requirements

5.6.1 Based on the outcomes of the risk assessment the EA document provides guidance on further requirements for different risks. These can be summarised as follows:

- High risks - additional assessment and active management;
- Medium risks - likely to require further assessment and may require either active management or monitoring; and,
- Low and very low risk - will only require periodic review.

5.6.2 Mitigation to reduce risk can also be applied to avoid the requirement for further assessment and/or monitoring.

6.0 RISK ASSESSMENT

6.1.1 The Bioaerosol Risk Assessment is shown in Table 6.

Table 6 Risk Assessment

Source	Probability of Exposure	Harm	Magnitude of Risk	Control Measures	Residual Risk	Justification for Residual Risk
Exposed maize silage during delivery and storage	**Medium** at R1 to R3 due to the separation distance between the receptors and source, the frequency of winds blowing towards the receptors and containment of feedstocks during storage **Low** at R4 to R18 due to the separation distance between the receptors and source, the frequency of winds blowing towards the receptors and containment of feedstocks during storage	**Medium**	**Medium**	All reasonable measures will be undertaken to reduce the drop height of materials during unloading of the delivery vehicles Feedstocks will be stored under sheeting following delivery The area of uncovered material will be kept to a minimum during storage and will only be exposed when cutting and transfer to the AD plant is required. This will help to limit the potential for surface wind stripping of microorganisms The clamps will be inspected on a daily basis to ensure the sheeting is intact and providing effective containment of emissions Training in the use of relevant equipment will be provided to all staff Any spilled material will be cleared by a site operative on the same working day	**Low**	The seasonal nature and short duration of delivery activities, as well as full implementation of the stated control measures is considered to result in a **low** residual risk of impact occurring

Source	Probability of Exposure	Harm	Magnitude of Risk	Control Measures	Residual Risk	Justification for Residual Risk
Exposed maize silage during transfer to the feed hoppers	**Low** at R1 to R3 due to the separation distance between the receptors and source, the frequency of winds blowing towards the receptors and the limited duration of transfer operations **Very Low** at R4 to R18 due to the separation distance between the receptors and source, the frequency of winds blowing towards the receptors and the limited duration of transfer operations	**Medium**	**Medium** or **Low**	All reasonable measures will be undertaken to minimise disturbance of the feedstocks during removal from the clamp area and transfer to the hoppers The shortest transfer routes will be utilised in order to limit potential exposure durations Full training will be provided to the bucket loader operative to avoid material spillage during transfer Any spilled material will be cleared by a site operative within the working day	**Low**	The distance between source and receptors, as well as and full implementation of the stated control measures, is considered to result in a **low** residual risk of impact occurring

Source	Probability of Exposure	Harm	Magnitude of Risk	Control Measures	Residual Risk	Justification for Residual Risk
Exposed material within the feed hoppers	**Low** at R1 to R3 due to the separation distance between the receptors and source, the frequency of winds blowing towards the receptors and frequency of operation **Very Low** at R4 to R18 due to the separation distance between the receptors and source and frequency of operation	**Medium**	**Medium** or **Low**	The feed hoppers will only operate twice daily Where practicable the drop height of material will be minimised in order to reduce release potential Full training will be provided to the bucket loader operative to avoid material spillage during transfer Any spilled material will be cleared by a site operative within the working day	**Low**	The distance between source and receptors, as well as and full implementation of the stated control measures, is considered to result in a **low** residual risk of impact occurring
Fugitive emissions from reception building	**Very Low** due to effective containment of emissions within the building and the distance between source and receptors	**Medium**	**Low**	The reception building will feature fast-acting roller shutter doors. These will remain shut at all times except for when vehicles require access to the building The delivery area of the building will feature a ventilation system capable of achieving an extraction rate equivalent to 3 air changes per hour. This will help to ensure that negative pressure is maintained within the building and reduce the potential for fugitive bioaerosol emissions when the roller shutter doors are opened to allow vehicle access	**Very Low**	Full application of the proposed control measures is considered to result in a **very low** residual risk of impact occurring

Source	Probability of Exposure	Harm	Magnitude of Risk	Control Measures	Residual Risk	Justification for Residual Risk
Air expelled from the vents serving the leachate storage tanks	**Very low** due the distance between source and receptors and the low release potential	**Medium**	**Low**	Leachate is likely to have a low release potential due to associated moisture content The low volume of air displaced from the tank during filling will limit mass emissions	**Very low**	The low release potential of leachate is considered to result in a **very low** residual risk of impact occurring
Air released from the common stack serving the Centriair abatement system	**Very low** due the distance between source and receptors and the limited residual release potential	**Medium**	**Low**	The proposed abatement system is likely to provide beneficial reductions in bioaerosol concentrations between inlet and outlet air due to the use of UV radiation and thermally assisted catalytic oxidation. In addition, impaction of microorganisms onto carbon media housed within the ColdOx units is likely to contribute to reductions Discharge or treated air to atmosphere via a 14m stack will help to promote effective dilution and dispersion of any residual components	**Very Low**	Full application of the proposed control measures is considered to result in a **very low** residual risk of impact occurring
Air expelled from the upgrading unit CO_2 vent	**Very low** due the distance between source and receptors and the limited release potential	**Medium**	**Low**	The carbon filter serving the gas upgrading system is likely to provide beneficial reductions in bioaerosol concentrations between inlet and vented air due to the impaction of microorganisms onto the media during operation. It is anticipated that the residual release potential will be limited	**Very Low**	Full application of the proposed control measures is considered to result in a **very low** residual risk of impact occurring

Source	Probability of Exposure	Harm	Magnitude of Risk	Control Measures	Residual Risk	Justification for Residual Risk
Solid digestate generated by the Crop AD process below the separator	**Very low** due the distance between source and the receptors, the limited quantity of solid digestate below the separator, containment provided by the cover fitted to the trailer and minimal disturbance of material during storage	**Medium**	**Low**	Solid digestate will remain covered within the trailer during storage in order to reduce the exposed surface area of material and limit the potential for surface wind stripping of microorganisms Solid digestate will be removed from site daily to avoid storage of significant amounts and associated emissions The material will remain static during storage with minimal mechanical agitation All reasonable measures will be undertaken to minimise disturbance of the material during loading	**Very Low**	Full application of the proposed control measures is considered to result in a **very low** residual risk of impact occurring

Source	Probability of Exposure	Harm	Magnitude of Risk	Control Measures	Residual Risk	Justification for Residual Risk
Fugitive emissions from the covered liquid digestate storage lagoons	**Low** at R1 to R3 due to the separation distance between the receptors and source, the frequency of winds blowing towards the receptors and containment of emissions **Very Low** at R4 to R18 due to the separation distance between the receptors and source and containment of emissions	**Medium**	**Medium** or **Low**	Both lagoons will feature floating covers. These are expected to provide effective containment of materials and limit any associated bioaerosol emissions to atmosphere	**Low**	Containment provided by the floating covers is considered to result in a **low** residual risk of impact occurring
Fugitive emissions from the covered dirty water lagoon	**Very low** due the distance between source and receptors and the limited release potential	**Medium**	**Low**	The water will not be agitated during storage in order to reduce the potential for atomisation of microorganisms The lagoon will feature a cover. This is expected to provide effective containment of materials and limit any associated bioaerosol emissions to atmosphere	**Very low**	Containment provided by the cover is considered to result in a **very low** residual risk of impact occurring

Source	Probability of Exposure	Harm	Magnitude of Risk	Control Measures	Residual Risk	Justification for Residual Risk
Air expelled from the liquid digestate tankers	**Very low** due the distance between source and receptors and the short duration of tanker filling operations	**Medium**	**Low**	The infrequent nature and short duration of tanker filling events is likely to limit the potential for impacts	**Very Low**	The short duration of filling operations as well as the low release potential of residual material within the tanker is considered to result in a **very low** residual risk of impact occurring

6.1.2 As shown in Table 6, the results of the assessment indicated residual risk from all sources was determined as **very low** or **low**. As such, it is concluded that no further control measures, other than those specified, are required in order reduce the potential for impacts at sensitive locations in the vicinity of the site.

7.0 CONCLUSION

7.1.1 Redmore Environmental Ltd was commissioned by Earthcare Technical Ltd to undertake a Bioaerosol Risk Assessment in support of a Substantial Variation Environmental Permit Application for Attleborough AD plant, Ellingham Road, Attleborough, Norfolk, NR17 1AE.

7.1.2 During the operation of the AD facility there is the potential for bioaerosol emissions and associated impacts at sensitive receptor locations in the vicinity of the site. A Risk Assessment has therefore been undertaken to identify potential emission sources and evaluate effects in the local area.

7.1.3 The following potential bioaerosol emission sources were identified:

- Exposed maize silage and rye during delivery and storage within the clamps;
- Exposed maize silage and rye during transfer to the feed hoppers;
- Exposed material within the feed hoppers;
- Fugitive emissions from the reception building;
- Air displaced from the leachate storage tanks;
- Air released from the common stack serving the Centriair abatement systems;
- Air released from the upgrade system CO_2 vent;
- Fugitive emissions from the covered solid digestate storage trailer serving the Crop AD plant;
- Fugitive emissions from the covered liquid digestate storage lagoons;
- Fugitive emissions from the covered dirty water lagoon; and,
- Air expelled from the liquid digestate tankers.

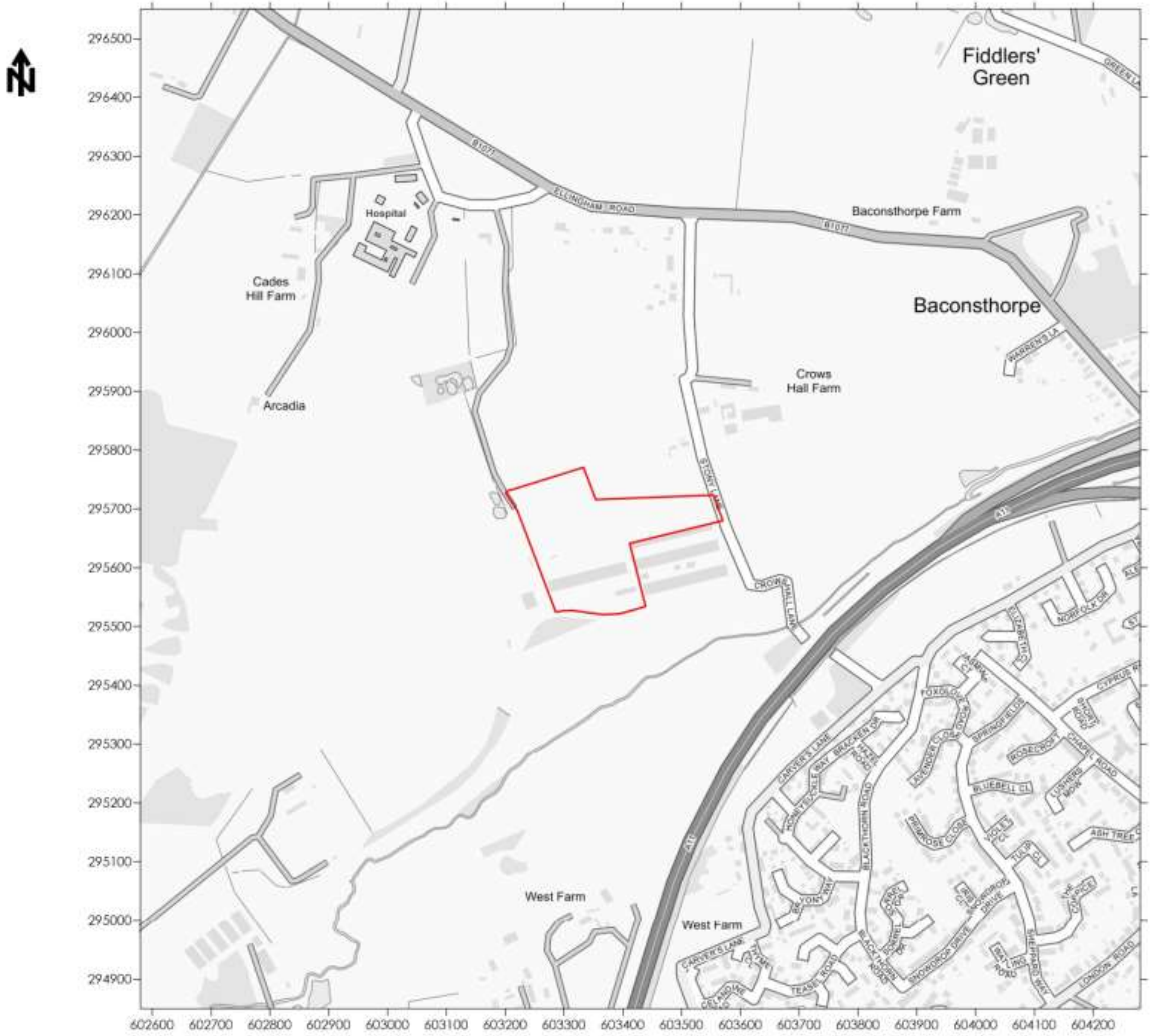
7.1.4 The risk of significant bioaerosol impact at sensitive locations in the vicinity of the site for each of the identified sources was assessed using a source - pathway - receptor approach. This considered the nature of the potential emission, any barriers to dispersion and the severity of harm.

7.1.5 The results of the assessment indicated residual risk from all sources was determined as **low** or **very low**. As such, it is concluded that no further control measures, other than those detailed in the assessment, are required in order reduce the potential for impacts at sensitive locations in the vicinity of the site.

8.0 ABBREVIATIONS

AD	Anaerobic Digestion
CH_4	Methane
CHP	Combined Heat and Power
CO_2	Carbon dioxide
DEFRA	Department for Environment, Food and Rural Affairs
EA	Environment Agency
HGV	Heavy Goods Vehicle
H_2S	Hydrogen sulphide
IVC	In-Vessel Composting
NGR	National Grid Reference
RPS	Regulatory Position Statement
SNIFFER	Scotland and Northern Ireland Forum for Environmental Research
UV	Ultra Violet
VOC	Volatile Organic Compound

Figures



Legend

Site Boundary

Title
Figure 1 - Site Location

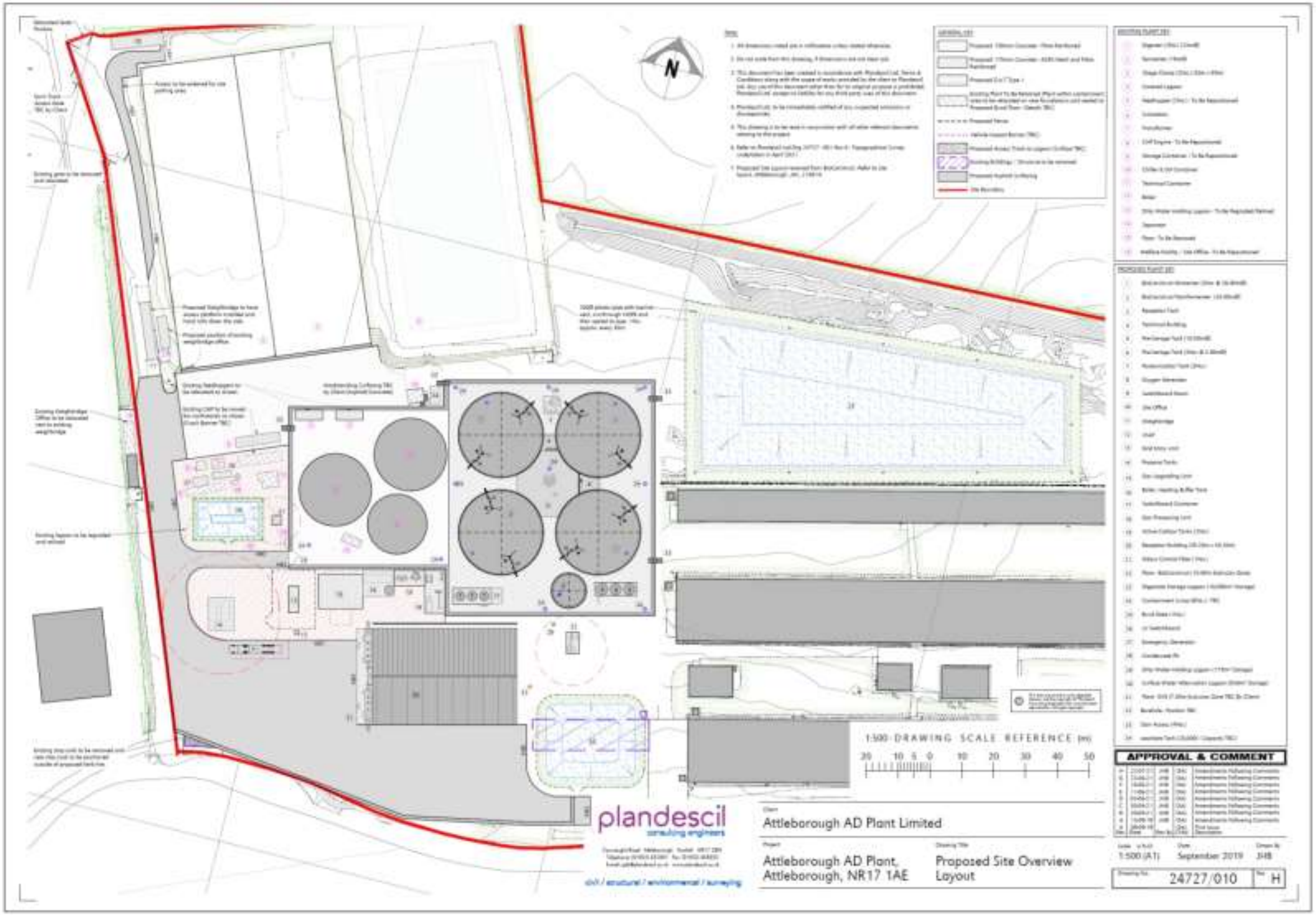
Project
Bioaerosol Risk Assessment
Attleborough AD Plant

Project Reference
4820

Client
Earthcare Technical Ltd

Redmore environmental

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



Legend

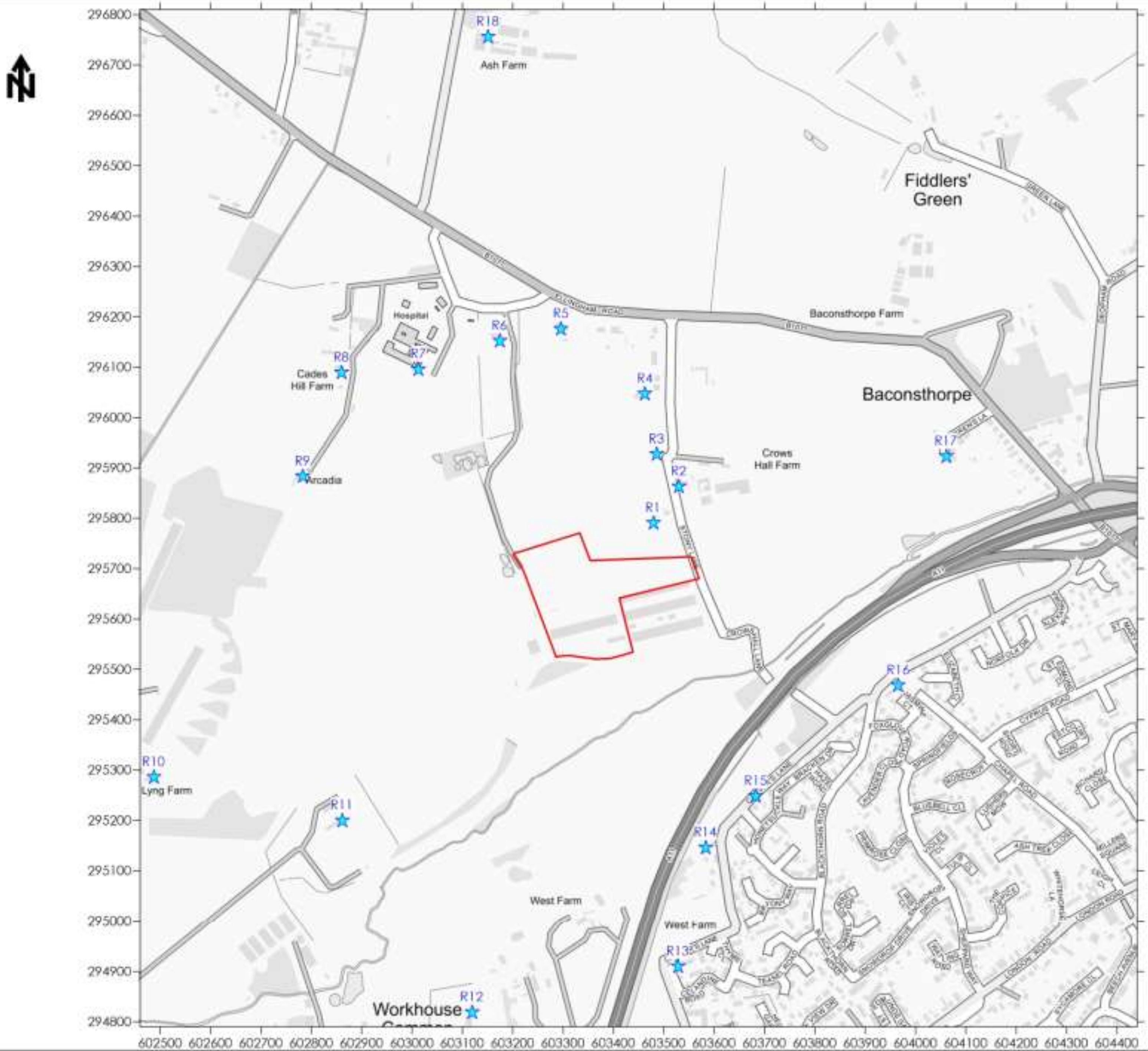
Title
Figure 2 - Site Layout

Project
Bioaerosol Risk Assessment
Attleborough AD Plant

Project Reference
4820

Client
Earthcare Technical Ltd

Redmore environmental



Legend

Site Boundary

Sensitive Receptor

Title
Figure 3 - Sensitive Receptor Locations

Project
Bioaerosol Risk Assessment Attleborough AD Plant

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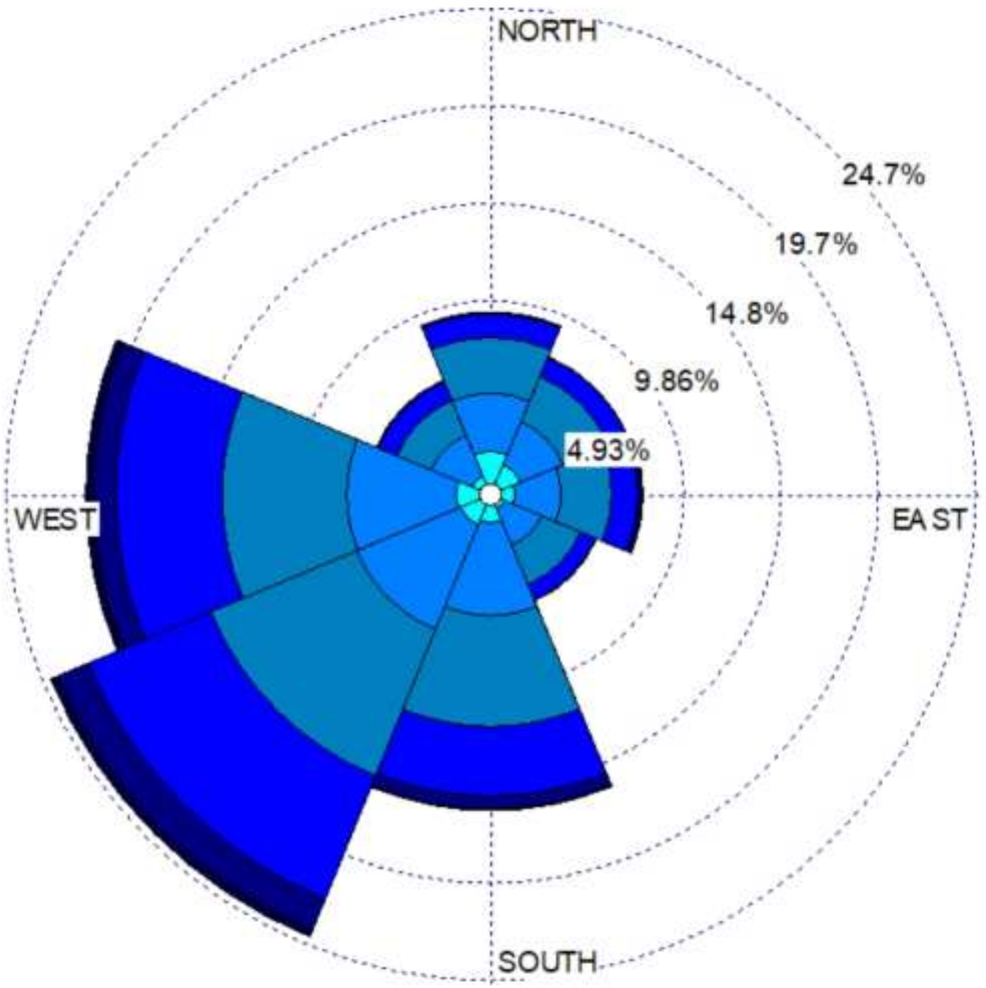

Legend

WIND SPEED (m/s)

- >= 11.10
- 8.80 - 11.10
- 5.70 - 8.80
- 3.60 - 5.70
- 2.10 - 3.60
- 0.50 - 2.10

Calms: 1.46%

Title
Figure 4 - Wind Rose of 2015 to 2019 Norwich Airport Meteorological Data

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