Bioaerosol Risk Assessment

Herriad Anaerobic Digestion Plant, Herriad

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1.0 INTRODUCTION

1.1 Background

1.1.1 Redmore Environmental Ltd was commissioned by Herriad Bio Power to undertake a Bioaerosol Risk Assessment in support of the anaerobic digestion (AD) plant operated by the company on land off Bushywarren Lane, Herriad.

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 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 Herriad AD plant is located on land off Bushywarren Lane, Herriad, at National Grid Reference (NGR): 465480, 146626. Reference should be made to Figure 1 for a map of the site and surrounding area.

1.2.2 The site operates as a biological treatment facility under an Environmental Permit (No. AB3807KW/A001) issued by the Environment Agency (EA). The following types of input materials are accepted and processed at the plant:

- Liquid and solid food wastes; and,
- Energy crops.

1.2.3 An Environmental Permit Variation Application has recently been submitted to the EA in order to authorise a number of changes to operations at the facility. These include the installation of two new digester tanks, two new covered liquid digestate storage lagoons,

a biogas upgrade plant, a carbon dioxide (CO_2) recovery unit and a biofilter to treat extract air from the waste reception building prior to discharge to atmosphere.

1.2.4 The operation of the facility 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 the AD process is provided in the following Sections. It should be noted that the description incorporates all activities which will be undertaken at the site following implementation of the proposed changes.

2.2 Management

2.2.1 The overall management responsibility for the plant will lie with Herriard Bio Power 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 A summary of the feedstock delivery and storage procedures is provided in the following Sections.

Solid Food Waste

2.3.2 Unpackaged and packaged solid food waste will be transferred to the facility in enclosed Heavy Goods Vehicles (HGVs). These will drive directly into the reception building on the western section of the site and deposit loads within dedicated storage areas.

2.3.3 A fast-acting roller shutter door will be used to allow delivery vehicle entry and exit to/from the building. This will remain closed at all times except for when access is required in order to maintain a sealed environment as far as practicable and limit the potential for fugitive bioaerosol emissions to the external atmosphere.

2.3.4 Air will be extracted from the building at a rate equivalent to 3 air changes per hour (ac/hr) and transferred to a biofilter abatement system for treatment prior to discharge to atmosphere. The proposed extraction arrangements will help to promote negative pressure within the building and reduce the potential for fugitive bioaerosol emissions when the roller shutter door is opened to allow vehicle access.

Liquid Food Waste

2.3.5 Liquid wastes will be delivered to the site in vacuum tankers. Following arrival, the feedstocks will be transferred directly into a buffer tank on the northern section of the site using a mechanical pumping system. The arrangement is a closed system and therefore the feedstocks will not be exposed to atmosphere.

2.3.6 Air displaced from the tank during filling will vent directly to the headspaces of the digesters via sealed pipework. As such, there will be no bioaerosol release to atmosphere as a result of liquid waste delivery.

Energy Crops

2.3.7 Energy crops including maize 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 a storage clamp located on the southern section of the site.

2.3.8 Following delivery, the crops will be compacted and covered with protective 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 bioaerosol emissions.

2.3.9 The clamp cover will remain slightly open at one end to allow access to the crops for transportation to the AD plant.

2.4 Preliminary Processing of Feedstocks

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

Solid Food Waste

2.4.2 Solid food waste will be removed from the storage areas and deposited into feed hoppers located within the building using a front-end loading shovel. These will remove any packaging and macerate the material prior to transfer via sealed pipework to the buffer tank on the northern section of the site. The pumping arrangement is a closed system and therefore the feedstocks will not be exposed to atmosphere during transfer to the tank.

Crop Feedstocks

2.4.3 Crop feedstocks will be transferred directly from the clamp to an open top hopper to the west of primary digester 1 using a bucket loader or similar. This will macerate and blend the material prior to processing within the AD plant. It is anticipated that transfer of crops and loading of the feed hopper will take place over a period of approximately 2-hours each working day.

2.5 AD Plant Operation

2.5.1 The feedstocks will be digested within four sealed AD tanks. These 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 within the digestion process (a mixture of methane (CH_4) and CO_2) will be combusted within a Combined Heat and Power (CHP) unit in order to generate electricity and heat. Exhaust gases from the CHP unit will be dispersed to atmosphere via a dedicated stack.

2.5.3 A proportion of the biogas produced from the AD process will be upgraded 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 a dedicated vent.

2.5.4 The site has an automatic back-up flare that burns gas in a controlled manner if the CHP unit or upgrade system stops temporarily, or if the plant maintenance is required. Should the flare fail for any reason the 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.

2.1 Pasteurisation

2.1.1 The plant will produce digestate as a by-product of the process which can be used as a biofertiliser. Many types of AD feedstocks, including crops, are rich in plant nutrients. These remain within the material throughout the process, making digestate a valuable biofertiliser. By making the best possible use of digestate as a biofertiliser, nutrients are returned to the land through natural cycles to replace the input of inorganic fertiliser. Recycling in this way closes a loop to create more sustainable agricultural production systems.

2.1.2 The digestate generated by the process will be heated to a minimum of 70.5°C for at least 1-hour in a pasteurisation unit before being pumped to a screening buffer tank. Air displaced from the pasteuriser and screening buffer tank during filling will vent directly to the headspaces of the digesters via sealed pipework. As such, there will be no bioaerosol release to atmosphere from these sources during normal operation.

2.2 Digestate Separation

2.2.1 Following pasteurisation, the digestate will be separated into solid and liquid fractions using a Börger Bioselect unit. The whole digestate will remain completely enclosed within the plant during separation and there will be no associated bioaerosol emissions to atmosphere as a result of the process.

2.2.2 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 one of two lagoons located on the southern section of the facility. Both lagoons will feature impermeable membrane covers in order to prevent rain ingress and provide containment of the material. Any gases displaced from the headspace between the liquid surfaces of the digestate and the covers will be vented directly to the digesters via sealed pipework.

2.2.3 The liquid digestate will be pumped from the lagoons to the local estate for land application. The pumping arrangement is a closed system and therefore the materials will not be exposed to atmosphere during transfer.

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 organic 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[1]. 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

[1] 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'[2] 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'[3] 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'[4] 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

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

[3] Bioaerosol Monitoring and Dispersal from Composting Sites, ADAS, 2005.

[4] 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'[5] 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'[6] 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:

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

6 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'[7]; 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'[8] 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'[9] 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.

7 M9: environmental monitoring of bioaerosols at regulated facilities, EA, 2017.

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

9 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 Potential hazards from bioaerosols are summarised in the conceptual model in Table 1.

Table 1 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 2.2
Transport Mechanism	Airborne
Medium of Exposure	Inhalation, ingestion, absorption, injection
Receptor	Human receptors at the proposed site as outlined in Section 4.4

4.3 Sources

4.3.1 The operation of the AD plant may result in bioaerosol emissions from a number of activities. A review of the proposed operations was undertaken in order to identify relevant emissions sources for inclusion in the assessment. This identified the following:

- Exposed crop feedstocks within the clamps;
- Exposed crop feedstocks during transfer to the hopper;
- Exposed crop feedstocks within the hopper;
- Fugitive emissions from the covered solid digestate trailer;
- Fugitive emissions from the covered liquid digestate storage lagoons; and,
- Emissions from the proposed biofilter.

4.3.2 Reference should be made to Figure 2 for a visual representation of the source locations.

4.3.3 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.

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

4.3.5 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. As such, the risk of impact from residual emissions is not considered to be significant and they have not been evaluated further in the context of this assessment.

4.3.6 As stated previously, emissions from other potential sources at the facility will be vented back to the headspaces of the digesters and there will be no associated bioaerosol release to atmosphere. The potential for bioaerosol emissions from each remaining source is considered further in the following Sections.

Exposed Crop Feedstocks During Delivery and Storage

4.3.7 Energy crops will be transferred to the facility using a tractor and trailer or HGVs during typical harvest periods. The feedstocks will be deposited within a storage clamp located on the southern 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.

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

4.3.9 The cover on the clamps will be slightly open at one end in order to allow access to the feedstock for removal and transportation to the AD plant feed hopper. The area of uncovered material will be kept to a minimum at all times in order to limit the potential for surface wind stripping of microorganisms.

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

4.3.11 Despite implementation of the stated controls, residual bioaerosol emissions may occur as a result of energy crop delivery and storage activities. As such, potential releases have been considered further as part of the assessment.

Exposed Crop Feedstocks During Transfer

4.3.12 Feedstocks will be transferred from the clamp to the hopper for maceration prior to incorporation into the AD process.

4.3.13 There is the potential for bioaerosol release during removal of feedstocks from the clamp and loading into the hopper. 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.

4.3.14 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.

4.3.15 Despite implementation of the stated controls, residual bioaerosol emissions may occur as a result of crop transfer activities. As such, potential releases have been considered further as part of the assessment.

Crop Feedstock Hopper

4.3.16 The feed hopper will macerate and blend the crop feedstocks prior to processing within the AD plant.

4.3.17 There is the potential for bioaerosol release during loading and operation of the hopper. As such, all reasonable measures will be undertaken to minimise disturbance of the

material during loading and the operational periods of the plant.

4.3.18 Training in the use of relevant equipment will be provided to all staff. Any spilled material will be cleared by a site operative within the working day.

4.3.19 Despite implementation of the stated controls, residual bioaerosol emissions may occur as a result of operation of the feedstock hopper. As such, potential releases have been considered further as part of the assessment.

Solid Digestate

4.3.20 Digestate will be divided into solid and liquid fractions using a Börger Bioselect unit. The whole digestate will remain completely enclosed within the plant during separation and there will be no associated bioaerosol emissions to atmosphere as a result of the process.

4.3.21 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[10], there is the potential for emissions from this part of the process.

4.3.22 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. However, residual emissions may occur and have therefore been considered further as part of the assessment.

Liquid Digestate

4.3.23 The liquid fraction will be transferred to one of two lagoons located on the southern section of the facility. Both lagoons will feature impermeable membrane covers in order to prevent rain ingress and provide containment of the material. Any gases displaced from the headspace between the liquid surfaces of the digestate and the covers will be vented directly to the digesters via sealed pipework.

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

4.3.24 It is anticipated that the lagoon covers will provide effective containment of bioaerosols. However, residual emissions may occur and have therefore been considered further as part of the assessment.

4.3.25 The liquid digestate will be pumped from the lagoons to the local estate for land application. The pumping arrangement is a closed system and therefore the materials will not be exposed to atmosphere during transfer. As such, there will be no associated bioaerosol emissions to atmosphere and releases as a result of liquid digestate transfer off-site and releases have not been considered further as part of the assessment.

Biofilter

4.3.26 Air extracted from the reception building will be vented through a woodchip biofilter located on the north-western of the site.

4.3.27 There is currently limited scientific evidence in regards the effectiveness of biofilters in reducing bioaerosol emissions. However, the SNIFFER document 'Understanding biofilter performance and determining emission concentrations under operational conditions'[11] indicates that biofilters have the capacity to remove large concentrations of bioaerosols, which is thought to be facilitated through physical impaction of microorganisms onto the media. However, it is also noted within the report that biofilters can act as emitters of bioaerosols, particularly bacteria, which naturally populate the media.

4.3.28 In accordance with EA guidance[12], the proposed biofilter will provide a minimum air residence time of 30s in order to promote effective capture and treatment of emissions. In addition, the biofilter will be maintained in accordance with the supplier's instructions and EA guidance[13] to ensure optimum performance. However, there is the potential for residual bioaerosol emissions from the system. As such, potential releases have been considered further as part of the assessment.

[11] Understanding biofilter performance and determining emission concentrations under operational conditions, Sniffer, 2014.

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

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

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.

4.4.2 The AD plant is located immediately to the west of the Veolia UK Little Bushywarren open windrow composting facility. As detailed in Section 3.3, it is well established that composting operations have the potential to result in bioaerosol emissions. However, it should be noted that the stated facility operates under an Environmental Permit issued by the EA. In accordance with the provisions of the Environmental Permitting (England and Wales) Regulations (2016) and subsequent amendments, this should include appropriate conditions in order to restrict the potential for environmental impacts as a result of emissions and therefore the potential for cumulative bioaerosol effects at sensitive locations in the vicinity of the sites.

4.5 Receptors

4.5.1 EA guidance 'M9: environmental monitoring of bioaerosols at regulated facilities'[14] 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."

[14] M9: environmental monitoring of bioaerosols at regulated facilities, EA, 2017.

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 2.

Table 2 Sensitive Receptors

Receptor		NGR (m)		Distance from AD Plant (m)	Direction from AD Plant
		X	Y		
R1	Residential - Manor Court	466170.9	145956.3	800	South-east
R2	Residential - A339	466293.7	146152.2	780	South-east
R3	Residential - Winslade Lane	464477.9	145825.8	1,200	South-west
R4	Residential - Winslade Cottages	465348.4	147792.5	1,000	North

4.5.3 It should be noted that the Veolia UK Little Bushywarren open windrow composting facility has not been considered as a sensitive receptor in this assessment due to the nature of operations undertaken at the site which are likely to result in a higher potential for exposure of staff to bioaerosol emissions than releases associated with the Herriad AD plant.

4.5.4 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. Odiham meteorological station is located at NGR: 473411, 148391, which is approximately 8.7km east-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 Odiham meteorological station over the period 1st January 2014 to 31st December 2018 (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 3. Reference should be made to Figure 4 for a wind rose of the meteorological data.

Table 3 Wind Frequency Data

Wind Direction (°)	Frequency of Wind (%)
337.5 - 22.5	8.87
22.5 - 67.5	8.12
67.5 - 112.5	6.80
112.5 - 157.5	6.70
157.5 - 202.5	16.30
202.5 - 247.5	25.66
247.5 - 292.5	18.84
292.5 - 337.5	7.83
Sub-Total	99.12
Calms	0.26
Missing/Incomplete	0.62

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 3, the prevailing wind direction at the AD facility is from the south-west. Winds from the north and east are relatively infrequent, which is indicative of conditions throughout 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'[15]. 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 and included people, property, and the natural and physical environment.

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:

- Distance between source and receptor;

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

- 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 4.

Table 4 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 5.

Table 5 Risk Assessment

Source	Probability of Exposure	Harm	Magnitude of Risk	Control Measures	Residual Risk	Justification for Residual Risk
Exposed maize crop feedstocks during delivery and storage	**Low** 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 in order to limit the potential for surface wind stripping of microorganisms The clamp 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** risk of impact occurring

Source	Probability of Exposure	Harm	Magnitude of Risk	Control Measures	Residual Risk	Justification for Residual Risk
Exposed crop feedstocks during transfer to the feed hopper	**Very Low** 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**	**Low**	All reasonable measures will be undertaken to minimise disturbance of the feedstocks during removal from the clamp and transfer to the hopper 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	**Very Low**	The distance between source and receptors, limited duration of transfer operations, as well as and full implementation of the stated control measures, is considered to result in a **very low** risk of impact occurring
Exposed material within the feed hopper	**Low** due to the separation distance between the receptors and source and the frequency of winds blowing towards the receptors	**Medium**	**Medium**	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** risk of impact occurring

Source	Probability of Exposure	Harm	Magnitude of Risk	Control Measures	Residual Risk	Justification for Residual Risk
Solid digestate trailer	**Very low** due to the distance between source and the receptors, the frequency of winds blowing towards the receptors, the limited quantity of solid digestate 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 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 ow**	Full application of the proposed control measures is considered to result in a **very low** risk of impact occurring
Liquid digestate lagoons	**Very low** due to the distance between source and receptors and the prevailing meteorological conditions	**Medium**	**Low**	Liquid digestate will remain covered within the lagoons during storage in order to reduce the exposed surface area of material and limit the potential for surface wind stripping of microorganisms Any gases displaced from the headspace between the liquid surfaces of the digestate and the covers will be vented directly to the digesters via sealed pipework	**Very Low**	Full application of the proposed control measures is considered to result in a **very low** risk of impact occurring

Source	Probability of Exposure	Harm	Magnitude of Risk	Control Measures	Residual Risk	Justification for Residual Risk
Emissions from the biofilter	**Low** due to the distance between source and receptors and the prevailing meteorological conditions	**Medium**	**Medium**	The biofilter will provide a minimum air residence time of 30s in order to promote effective capture and treatment of emissions The biofilter will be maintained in accordance with the supplier's instructions and relevant best practice guidance. This will include irrigation of the media to ensure that sufficient moisture content is available and even air flow is maintained	**Low**	Biofilters have the capacity to remove large concentrations of bioaerosols, through physical impaction of microorganisms onto the media. Implementation of the stated control measures is considered to result in a **low** risk of impact occurring due to residual emissions

6.1.2 As shown in Table 5, 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 Herriad Bio Power to undertake a Bioaerosol Risk Assessment in support of the AD plant operated by the company on land off Bushywarren Lane, Herriad.

7.1.2 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 was therefore 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 crop feedstocks within the clamps;
- Exposed crop feedstocks during transfer to the hopper;
- Exposed crop feedstocks within the hopper;
- Fugitive emissions from the covered solid digestate trailer;
- Fugitive emissions from the covered liquid digestate storage lagoons; and,
- Emissions from the proposed biofilter.

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, potential impacts as a result of bioaerosol emissions from the facility are considered to be **not significant** and no further control measures, other than those specified, are required in order reduce the potential for effects 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
VOC	Volatile Organic Compound

Figures

Legend

Site Boundary

Title
Figure 1 - Site Location Plan

Project
Bioaerosol Risk Assessment
Herriard AD Plant, Herriard

Project Reference
2256-7

Client
Herriad Bio Power

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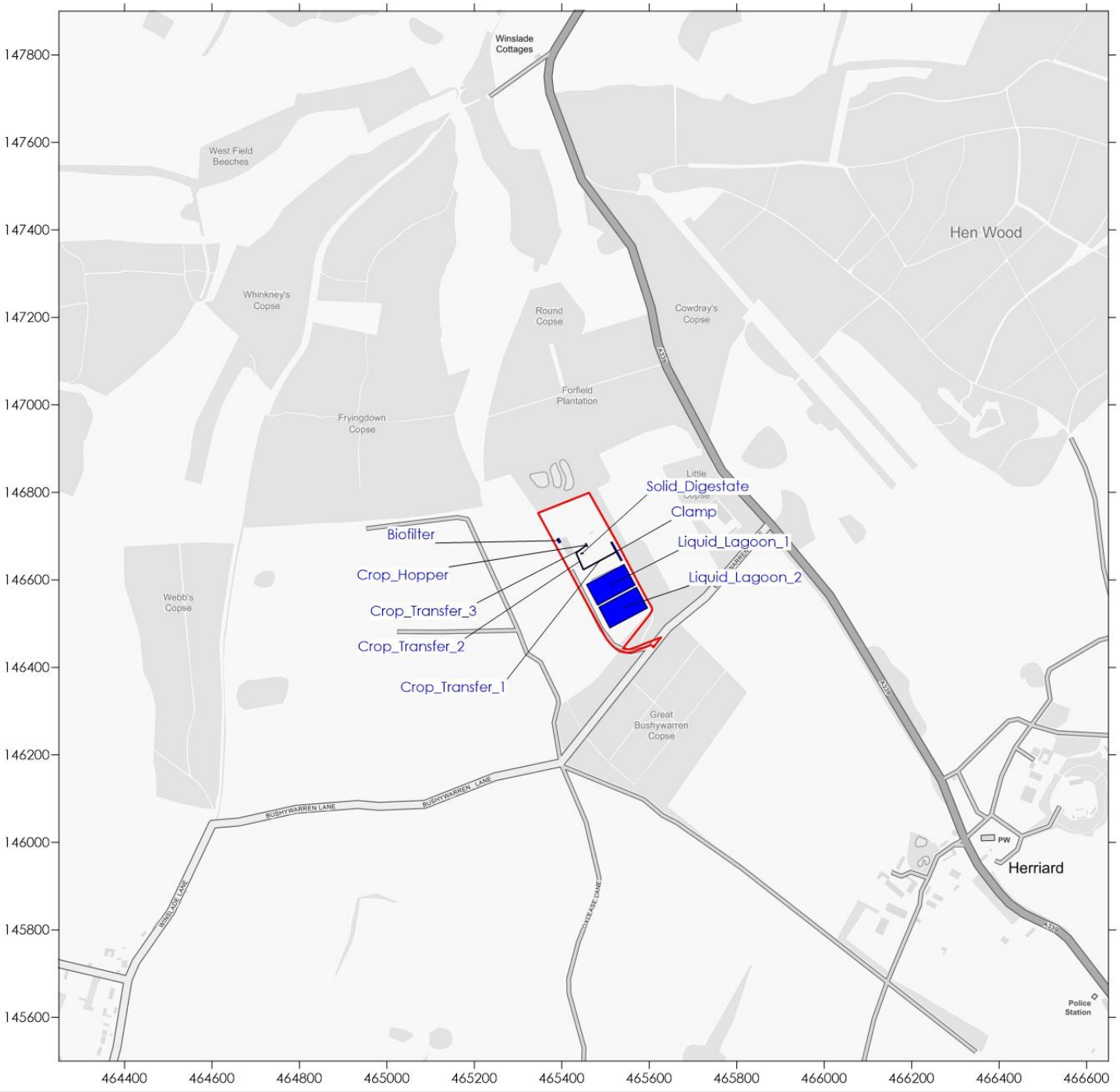

Legend

Site Boundary

Bioaerosol Source

Title
Figure 2 - Bioaerosol Emission Sources

Project
Bioaerosol Risk Assessment
Herriard AD Plant, Herriard

Project Reference
2256-7

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Site Boundary

Sensitive Receptor

Title
Figure 3 - Sensitive Receptor Locations

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Bioaerosol Risk Assessment
Herriard AD Plant, Herriard

Project Reference
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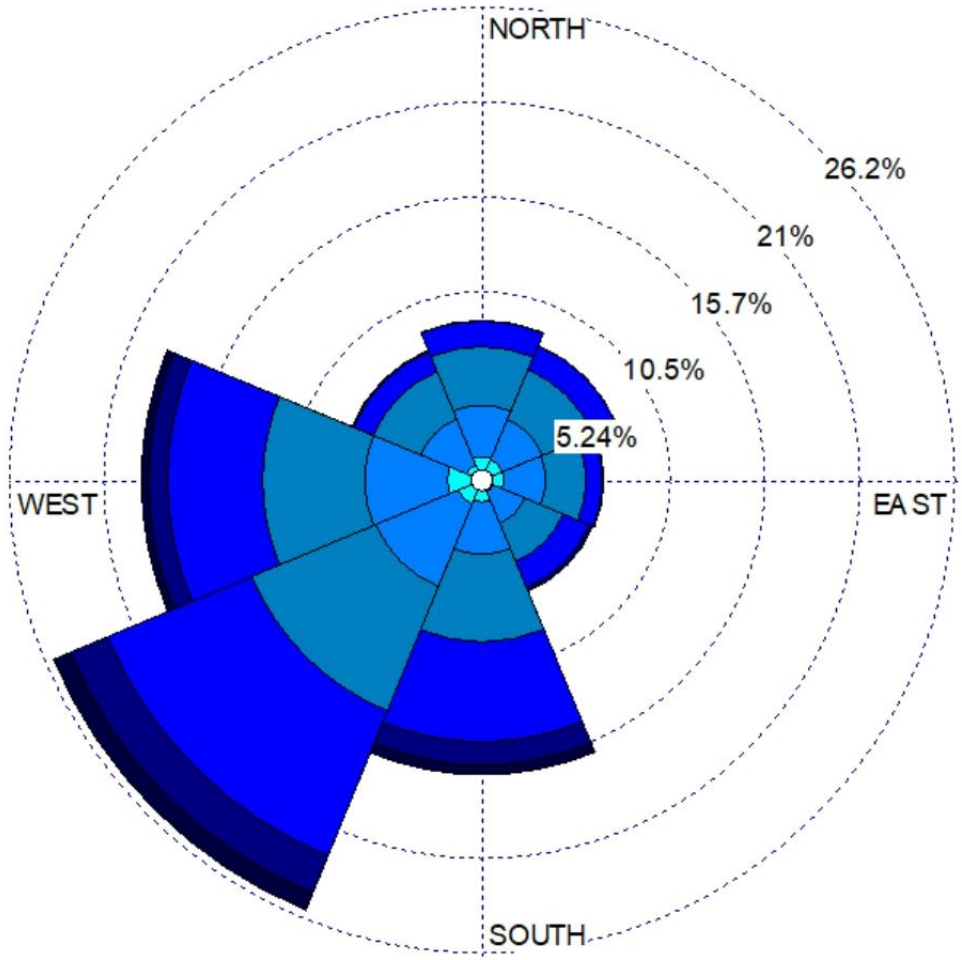

Legend

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: 0.26%

Title
Figure 4 - Wind Rose of 2014 to 2018 Odiham Meteorological Data

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