REVISED*
Site Specific Bioaerosols Risk Assessment

For the
Open Windrow Composting Site
at

Nantycaws
Carmarthen

December 2022

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***Revised…**
due to IVC no longer in use.
(all mention of IVC deleted, and recent sampling data included)

EXECUTIVE SUMMARY

This report gathers together the relevant information, reference data and description of the site and provides an updated **Site Specific Bioaerosols Risk Assessment** (SSBRA) of the impacts caused by carrying on the activities of composting at the site:

Open Windrow Composting Facility (Pad) **Nantycaws Recycling Centre** **Llanddarog Rd.** **Nantycaws** **Carmarthen SA 32 8BG**

The Risk Assessment takes account of and follows the guidance for undertaking such a SSBRA as described in the reference:

[Ref 1]: Guidance on the Evaluation of Risk Assessments for Composting Facilities, Cranfield University (G.H. Drew et al) published by the EA August 2009 and can be found on the web-address: http://publications.environment-agency.gov.uk/pdf/GEHO0809BQUO-e-e.pdf

Attention has been given to the previous measurements at this site and account has been taken of the approved methodology for undertaking such measurements, formerly contained within Ref 2…

[Ref 2]. A Standardised Protocol for the Monitoring of Bioaerosols at Open Composting Facilities, EA and The Association for Organic Recycling (AfOR), edited by Toni Gladding (Open University) available by order at the AfOR website [publications]: http://www.organics-recycling.org.uk/

And latterly superseded by Ref 3:

[Ref 3]. The Environment Agency M9 Technical Guidance Note (Monitoring) Environmental monitoring of bioaerosols at regulated facilities - Environment Agency January 2018 Version 2

Which has been used as the methodology employed during sampling sessions since 2018

The facilities provide a good measure of environmental protection as follows:

1. The undertaking of external operations at a large separation distance from sensitive receptors
2. The undertaking of external operations with due consideration for the wind direction and weather; in particular is the wind is blowing towards the sensitive receptors.
3. Provides the facility for a water-based damping down for increased control of airborne emissions such as dust and bioaerosols during material processing.
4. Using modern machinery and equipment to maximise efficiency and minimise the release of dust and bioaerosols.

The SSBRA considers the proximity of the nearest sensitive receptors, specifically the domestic dwellings within 250m of each the external windrow composting site.

<u>In Conclusion</u>: Taking into account the site location and wind directions; the data accumulated over the recent period 2018* to 2022; and with detailed attention to both the measured values and modelled values, there is a high degree of confidence that the activities at the composting site are unlikely to present an increased risk to the health of the nearest sensitive receptors, i.e. the persons resident or working at the nearest dwellings and workplaces as specified in this risk assessment.

The previous SSBRA considered the data from sampling up to 2018.

CONTENTS

QUALITY ASSURANCE for the RISK ASSESSMENT AND REPORTING

Recogen Ltd. Environmental Quality Reporting – An Independent Assessor

For the purposes of quality assurance in undertaking this risk assessment, Recogen Ltd. is a recognised organisation with appropriately trained, qualified and experienced personnel; *independent* to the composting site operator. This assessment was undertaken by D J Baldwin, BSc (Hons) CEnv. MCIWM, Technical Director with Recogen Ltd. who has over 40 years of waste and environmental management experience. David is FACTS (fertiliser advice certification) qualified and holds the Environmental Permit Operators Certificate (EPOC).

Recogen Ltd. is registered as a Quality Environmental Consultancy on the National Business Link Register and is a supplier of Technical Consultancy to DEFRA, The Waste and Resources Action Programme (WRAP) and to The REA Ltd (Organic Recycling Group) formerly known as AfoR /The Composting Association.

David has managed or contributed to many major projects on waste management for Government (**DEFRA, ETSU, DTI, WRAP, EA**) and The Waste Management Industry including Composting and Anaerobic Digestion processes, compost site design, product quality assurance (PAS100:2018 and PAS110:2014), The Compost Quality Protocol, ISO9001, ISO14001, COSHH and H&S Risk Assessments.

BIOAEROSOLS MONITORING - DEFINITIONS

Bioaerosols, composting and health effects
Bioaerosols are complex mixtures of airborne micro-organisms and their products, and are ubiquitous, particularly in rural environments. The most serious health problems appear to arise from *Aspergillus Fumigatus*, but there are other fungal spores and bacteria that cause problems. International studies have shown that there is a wide variability in individual susceptibility to bioaerosol exposure.

Commercial scale composting activities tend to generate large amounts of bioaerosols; and these are likely to contain human allergens and pathogens. They have potential effects on respiratory health and may cause headaches, nausea and fatigue. There has been very little investigation into the effects of community exposure to bioaerosols from composting, but there is some limited data that suggest that living close to a composting facility may be associated with an increased risk of adverse health effects. The consensus from various studies is that bioaerosols from composting activities decline rapidly within the first 100 metres from a site and generally decline to background levels within 250m.

Composting
Composting is the biological decomposition of biodegradable waste under conditions that are predominantly aerobic and that allow the development of thermophilic temperatures as a result of biologically produced heat. It may include associated waste storage and treatment operations carried out at the composting facility.

Operations
…likely to result in the uncontrolled release of high levels of bioaerosols
Include the shredding of waste and the turning of waste in the sanitisation, stabilisation and maturation stages of composting where these operations are not contained or are not subjected to exhaust ventilation and scrubbing/filtering.

Sensitive receptors (SR's)
'Sensitive receptors' refers to people likely to be within 250 metres of the composting operation for prolonged or frequent periods. This term would therefore apply to dwellings (including any associated gardens) and to workplaces where workers would frequently be present. It does not apply to the operators of composting facilities or their staff while carrying out the composting operation as their health is covered by Health and Safety legislation. M9 Technical Guidance Box 5.1 provides the following:

> **Box 5.1: definition of nearest sensitive receptor for composting and anaerobic digestion for standard rules permits**
>
> '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 too 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 anaerobic digestion facility.

Acceptable levels at the sensitive receptors
Refers to the concentrations of bioaerosols (as predicted or as derived from direct measurements) at the sensitive receptors that are attributable to the composting operations. EA Policy documents have determined that the acceptable (appropriate) levels (given as colony forming units per cubic metre of air) are:

Bioaerosol type	total bacteria	*Aspergillus Fumigatus*
Threshold value	1000 cfu m^{-3}	500 cfu m^{-3}

M9 Sampling and This Site
In 2018 the EA published M9 which provides guidance on more detailed standardised methods for the sampling of bioaerosols. Specifically, the guidance describes the use of a 'fan-shaped' downwind array for sampling station arrangement. The **M9 methodology** describes the need for sampling at a distance downwind that equates to that to the Nearest Sensitive Receptor from the centre of active operations.

A summary of M9 is provided at **Appendix 4**.

Recogen Ltd.
Environmental Quality Reporting
D. J. Baldwin (Technical Director)
MCIWM CEnv. Tel: 01743 340630

SECTION 1. INTRODUCTION

1.1 Composting and Bioaerosol generation

Composting is currently being encouraged by the UK Government as a means of converting and stabilising organic biodegradable waste materials such as “green waste”, and putrescible waste. The processes rely on biological activity, notably the utilisation of bacteria and fungi in order to bio-degrade the volatile material and convert it to more stable forms of humic substance.

The overall process relies on mechanical treatment in the preparation and handling of the material, as well as specialist facilities for controlling the processes involved.

It is recognised that when any agitation of organic material occurs, especially turning, screening or shredding, or when leachate is recirculated, elevated numbers of micro-organisms may be released into the air. Once released into the air they can remain airborne for long periods and form a ‘bioaerosol’ i.e. an aerosol of biological particles.

New systems and processes have been developed in order to minimise the disturbance of compost.

The ‘Natural Resources Wales’ (NRW) regulate the Permitting of Composting Facilities and have provided clauses with regard to Bioaerosols within the Industrial Emissions Directive (IED) Permit for this site. Furthermore, the IED Permit requires that Best Available Techniques (BAT) should be used to provide the most efficient and environmentally friendly processing of the green waste. BAT includes multiple statements of guidance. The guidance strongly recommends the enclosure of such facilities and aeration techniques that reduce the need for the ‘turning’ of the material as the means to introduce fresh air (oxygen) as this is recognised as being a key activity that releases bioaerosols. However, BAT includes guidance for external windrow composting where key activities are undertaken externally and the key theme is to be diligent in regard to wind and weather conditions; in particular wind direction and to avoid generating emissions when the wind is toward any nearby sensitive receptor.

1.2 Bioaerosols Risks to health

Bioaerosols are small particles of biologically active material that may be carried independently in the air or otherwise may become attached to other particles of dust or moisture. Consequently the minute particles may be inhalable and also respirable (deposited in the air sacs of the lungs where gases are exchanged).

During the course of daily activities, people inhale airborne microbes. This is as much a feature of normal everyday life as eating or drinking. Most individuals' bodies are perfectly capable of coping adequately with the presence of these 'invaders' and do not suffer any ill effects. It is only when airborne microbes, such as those generated during the composting process, are present in high concentrations that they may become harmful to human health.

Everyone reacts to bioaerosols in different ways. It depends upon a variety of factors and can never be predicted: some people have worked at composting sites for many years without apparently displaying any adverse health effects.

Factors, such as prior exposure to bioaerosols, individual susceptibility, bioaerosol concentration and composition (the numbers and types of microbes present) and the length of time and frequency to which people are exposed all contribute to the way in which their bodies react. There are three main types of response:

Allergy This is an immunological response that results in the body becoming 'sensitised' following exposure. Sensitisation does not usually occur immediately; rather it is a consequence of inhaling a substance over a period of months or even years.

Inflammation This is a response of body tissues to an injury. It typically results in swelling, redness and pain.

Toxic Poisoning which is a disturbance of the normal bodily functions by a specific substance known as a toxin.

Besides from these bodily reactions it is possible that bioaerosols may lead to skin infections (spots/ boils) or else are may cause stomach sickness.

1.3 The Approach to Bioaerosols Risk Assessment

The Risk Assessment is undertaken by reference to:

[Ref 1]: Guidance on the Evaluation of Risk Assessments for Composting Facilities, Cranfield University (G.H. Drew et al) published by the EA August 2009 and can be found on the web-address: http://publications.environment-agency.gov.uk/pdf/GEHO0809BQUO-e-e.pdf

[Ref 2 see Appendix 3]. A Standardised Protocol for the Monitoring of Bioaerosols at Open Composting Facilities, EA and The Association for Organic Recycling (AfOR), edited by Toni Gladding (Open University) available by order at the AfOR website [publications]: http://www.organics-recycling.org.uk/

[Ref 3 see Appendix 4]. The Environment Agency M9 Technical Guidance Note (Monitoring) Environmental monitoring of bioaerosols at regulated facilities - Environment Agency January 2018 Version 2

[Ref 4.]: Environment Agency PS031 ' **Composting and potential health effects from bioaerosols: our interim guidance for permit applicants' November 2010.**

The Risk Assessment considers the 'Source,' 'Pathway' and 'Receptor', methodology for assessing Risks, i.e.

The **Source** of the bioaerosols is considered, by examination of the various activities and points within the process where bioaerosols may be generated and released. This also includes consideration of various techniques and systems for minimising those releases.

The **Pathway**, is the route by which the bioaerosols travel from the source to the receptor. Generally this is aerial, but may include vehicles or even liquid transport systems, whereby dust or similar material is carried by one medium and then by drying or exposure to the wind, becomes air-borne and travels beyond the site boundary to the receptor. The dominant wind direction and speeds are taken into account and also 'barriers' (such as topography etc.) that may serve to attenuate the concentration of bioaerosols during travel.

The **Sensitive Receptors** are identified and consideration given to the degree of sensitivity, daily period of exposure and overall duration of exposure. The context and nature of the activities that the receptors undertake are also considered as this may affect their actual exposure to the bioaerosols (in-doors, protected areas), their rate of breathing, e.g. exercising and their sensitivity (asthmatic or with weakened respiratory system).

This Risk Assessment **supersedes the 2018 SSBRA**, it no longer includes In-Vessel Composting (IVC) activities that ceased in Autumn 2020; and includes the consideration of recently acquired data and information from site specific sampling. It takes into account the various process controls and management procedures.

While it is appreciated that seasonal factors and day-today site operations can cause change, this report gathers together a wide range of information, data and evidence, in regard to the site operation. The reference data includes some data acquired during the period when the IVC was in operation; but places more emphasis on the recent data relating to the external windrow system.

1.4 Risk Mitigation

Risk management techniques comprising technological and managerial systems are utilised at the site. Table 1. summarises the key features of these Risk Mitigation techniques.

Table 1: Risk Mitigation techniques include technological processes and operational procedures including:

Technological	Procedural
▪ The Open Windrow Composting Pad is >200m distant from the Nearest Sensitive Receptor (A48 dwelling) ▪ The Open Windrow process utilises water damping of the feedstock material; and clean water damping of dust and surfaces when required during the composting process. ▪ The Open Windrow activities including shredding, screening and windrow turning shall, if required, be paused if the wind is blowing directly toward the nearest sensitive receptor	o Controls over material type received o Received material processed within set timescales. o Management of material to maintain high moisture content o Clean water damping of hard surfaces to minimise dust. o Environmental Monitoring undertaken o Operator training, supervision and management o Site Cleanliness procedures o The actual compost windrowing activities at the Pad are distanced >250m away from the NSR

1.5 Risk Assessment Methodology

The Risks have been assessed (Section 9) using the 'Probability v Consequences' matrix published in Ref 1. Guidance on the Evaluation of Risk Assessments for Composting Facilities, Cranfield University (G.H. Drew et al) published by the EA August 2009 at page 18, (Box 1):

Box 1 Risk Assessment Matrix

Probability					
	H	L	M	**H**	**H**
	M	L	M	M	**H**
	L	L	L	M	M
	VL	VL	L	L	M
		VL	**L**	**M**	**H**

Consequences

SECTION 2. INTRODUCTION TO THE COMPOSTING FACILITY

2.1 Site Location

The Site is located at the site of the Landfill, Nantycaws, Carmarthen as shown in figure 1 and 2.

Cwm Environmental Composting Site
C/o Nantycaws Landfill Site Office
Llanddarog Rd.
Nantycaws
Carmarthen SA 32 8BG
OS Grid Reference (Entry point to CA Site) SN 47393 17563

Figure 1: Nantycaws CA Site Location Map

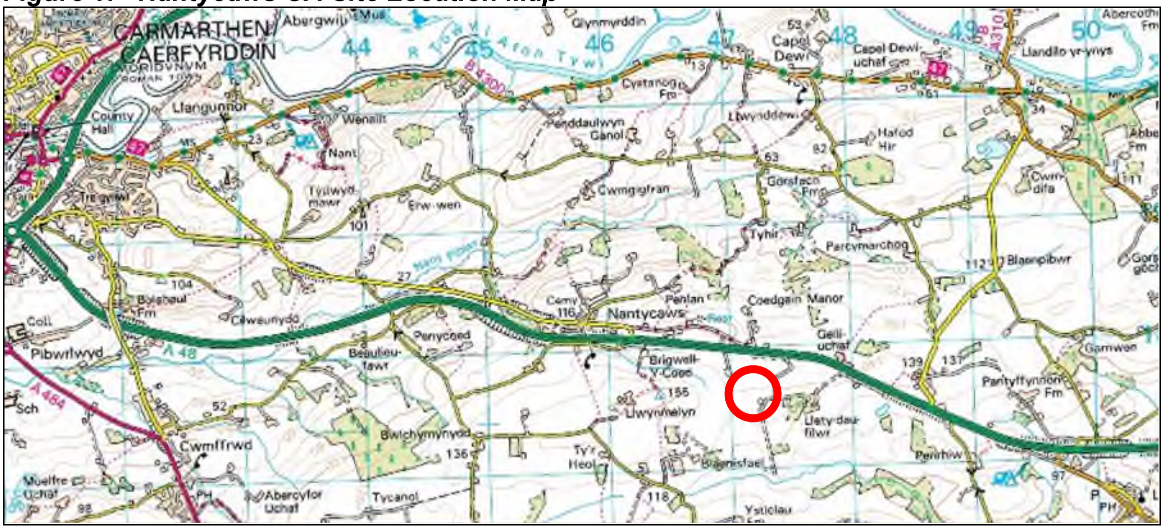
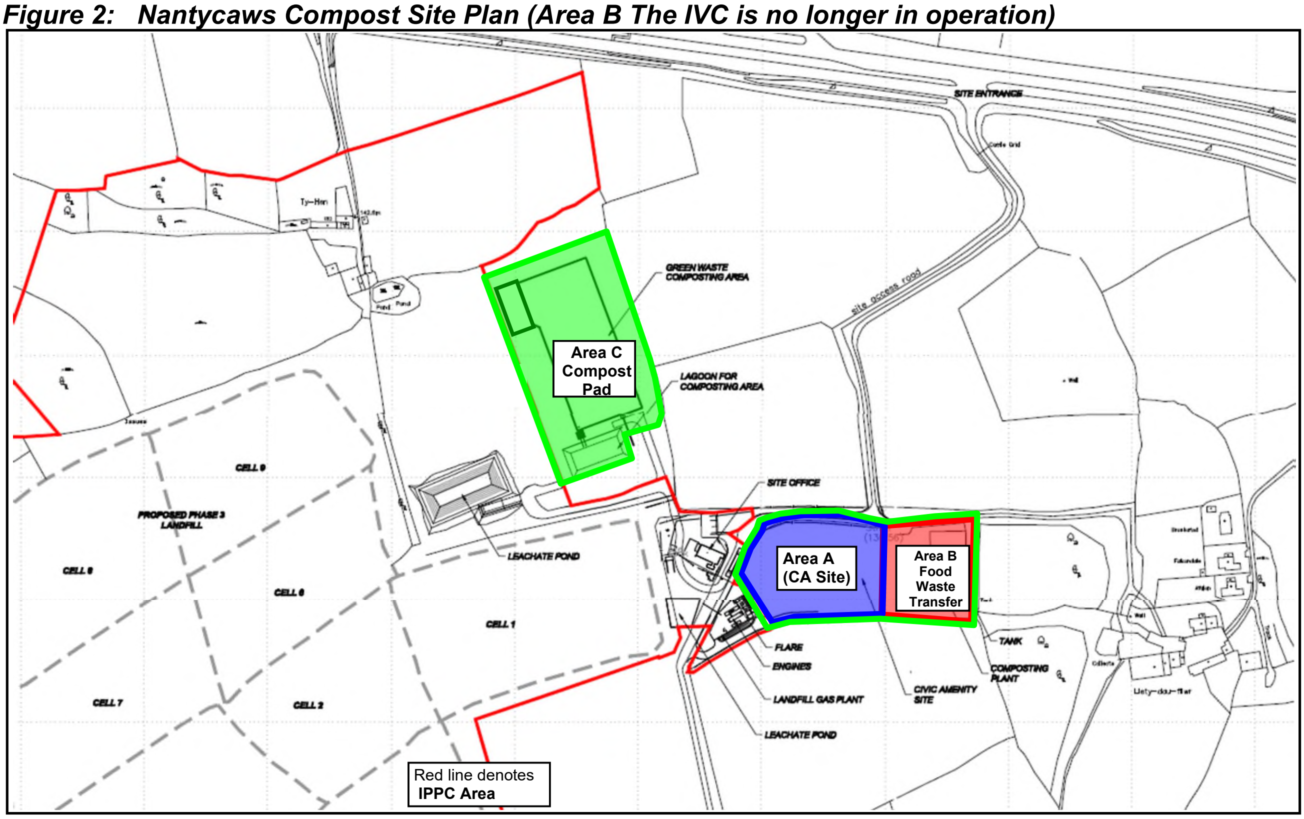


Figure 2: Nantycaws Compost Site Plan (Area B The IVC is no longer in operation)



2.2 Site Context

In order to maintain clarity and for the convenience of structuring this Risk Assessment, the following terms are being used:

The **'CA Site'** is located on **'Area A'**. This is shown in blue at Figure 2.

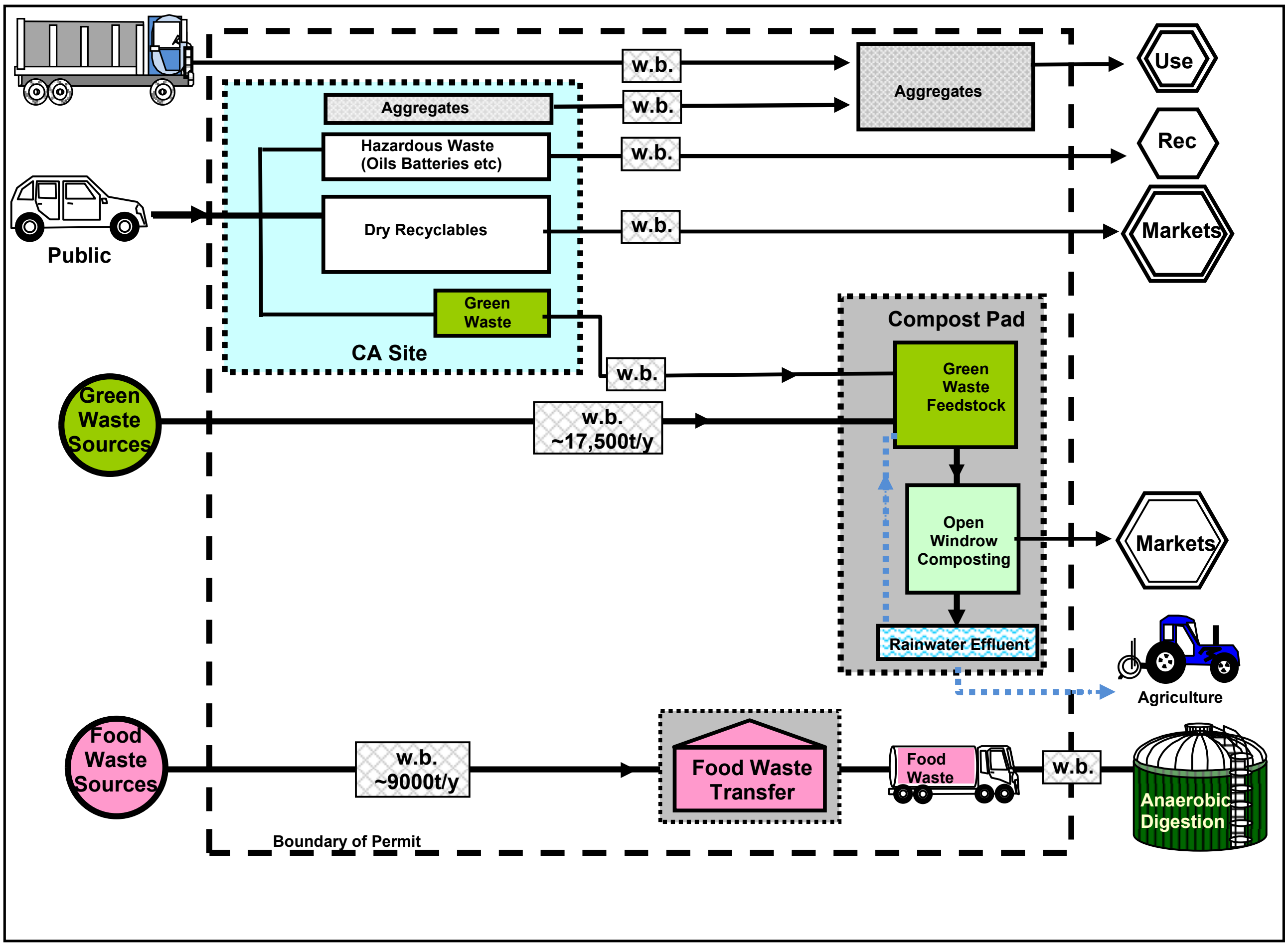
The In-Vessel Composting activity **has ceased**. Food (Catering Waste) is currently transferred within the **'Area B'**; and is shown in Figure 2 marked as 'Food Waste Transfer' within the red line and shaded red colour.

The External, Open Windrow Composting activity is referred to as **'The Composting Pad'** is located at **'Area C'**; and is shown within a green line and with green colour at Figure 2.

The CA site does not include any composting, but does provide the location for the drop-off point for green waste and therefore being only for the 'Transfer' of green waste is mentioned but is not required to be included in this risk assessment.

In order to appreciate the movement of waste between the sites the following flow diagram is considered useful. This provides an appreciation for where and to what scale the material undergoes the main processes of composting.

Figure 3 Waste Movement between the C A Site, Composting Pad and outputs. (w.b. = weighbridge used)



2.3.1 The CA Site

The general public arrive at the CA Site, deposit their green-waste over the wall into a bunker built into the wall of the CA Site-Lower yard area. The Green-waste that is deposited into the bunker is loaded to a trailer and taken to be weighed at the weighbridge and then is taken for composting at the external windrow pad.

2.3.2 The Food Waste Reception

The throughput of the facility is approx. 9000 tonnes per year. This is delivered in the collection vehicles or else wagons that deliver it in from the outlying transfer stations; and then it is bulked up into large sealed haulage vehicles that take it to the Anaerobic Digestion Facility. There are 8 loads out per week, meaning at least one load per day and so the material does not remain in the holding bay for any more than 24 hours. No processing is undertaken and the material is not there long enough to start composting. There is no composting related bioaerosols risk. The facility is cleaned down after it is emptied after each lorry load.

2.3.3 The Composting Pad

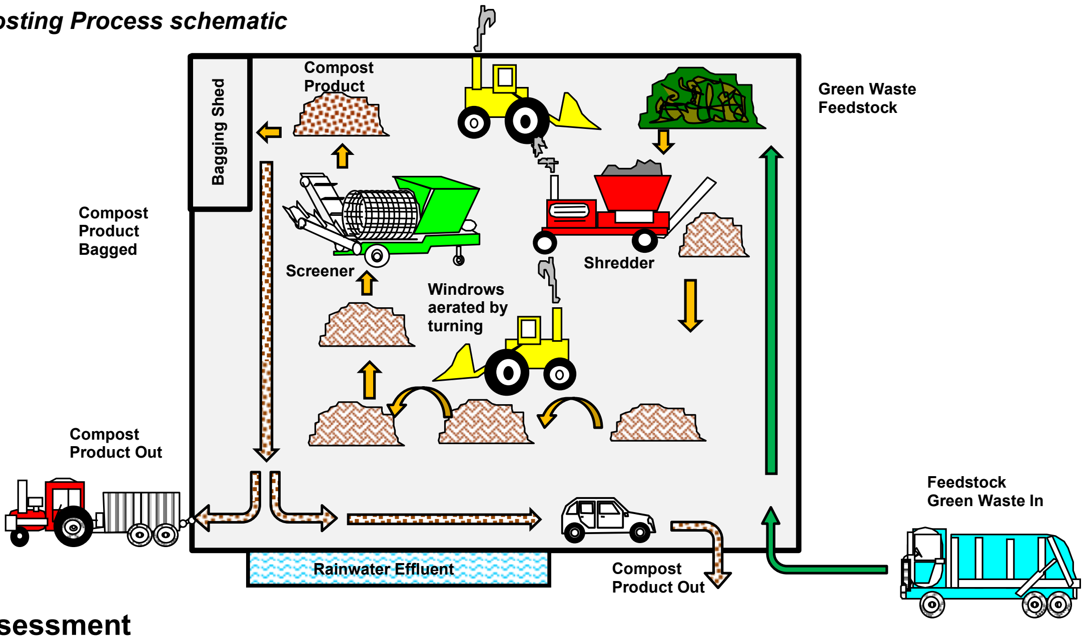
Green waste is received from Carmarthenshire and some other Local Authority Areas including Swansea and Neath & Port Talbot (depending on the contracts arranged in a given year). The Green Waste from the CA Site also is transferred via the weighbridge, into the Green Waste reception area. The Green Waste is kept segregated from other waste to maintain ‘organic’ status.

The Green Waste is checked, sorted if required and arranged in a stock-pile ready for shredding. Shredding is done so that typically one Batch is formed of shredded material each fortnight. This equates to 600 -750 tonnes of material, subject to seasonality. The throughput is ~17,500t/year.

The process follows a standard PAS100 quality assured system that includes daily monitoring and measurement of key parameters (temperature, moisture, aeration) and is turned regularly in order to maintain its aerobic condition. Ultimately it is screened to obtain the desired graded particle size.

The process from batch formation to product completion takes 8 weeks.

Figure 4 Composting Process schematic



2.4 Risk Assessment

For the purpose of the Risk Assessment, further detail of the process is provided at Section 5.

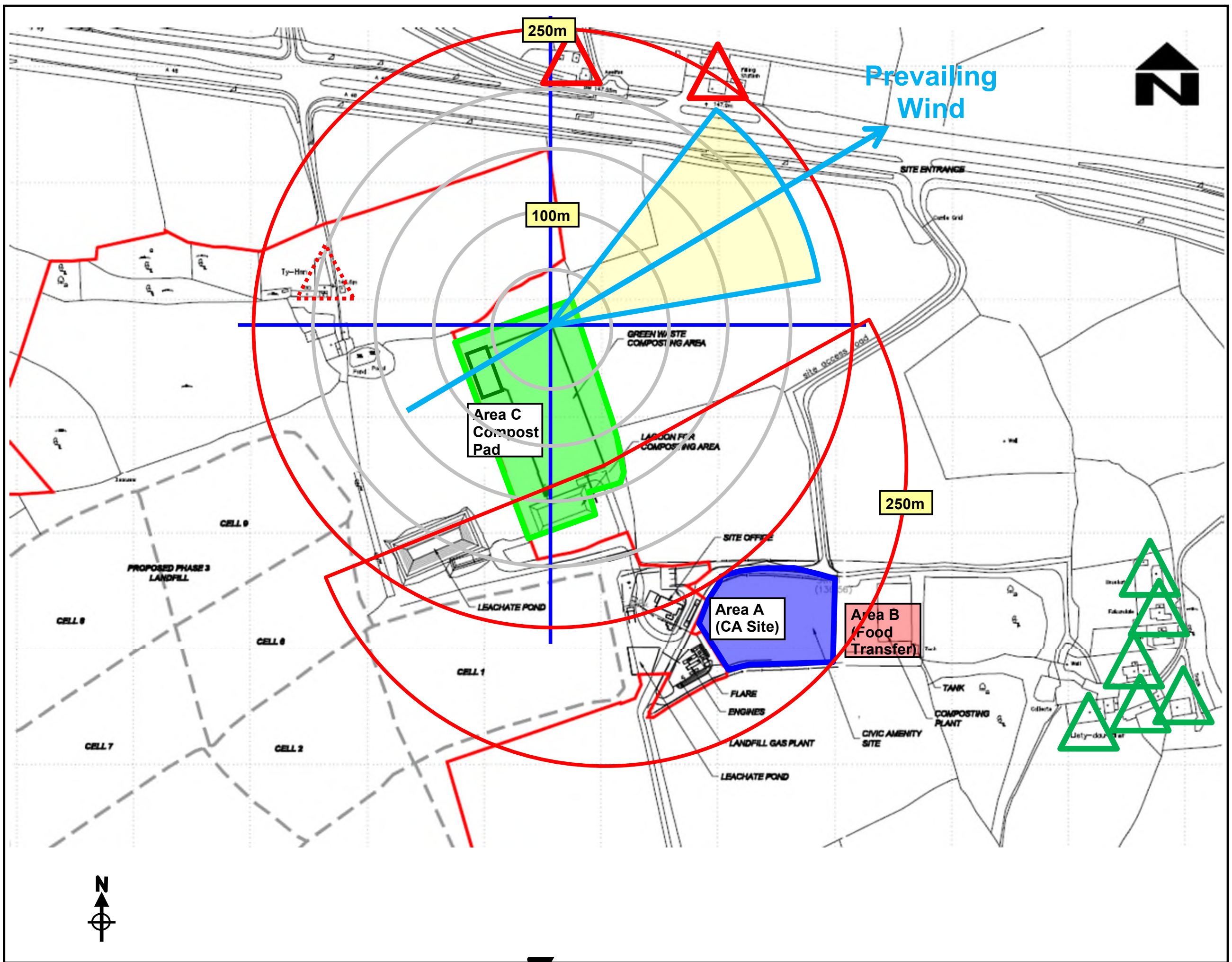
SECTION 3. SENSITIVE RECEPTORS

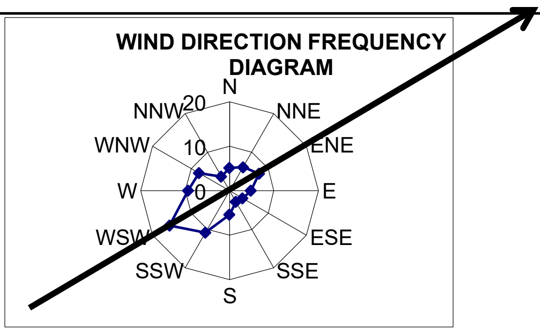
3.1 Site Situation with Site Situation with Regard to Nearest Sensitive Receptors (NSR's)

The Composting Facility Location at Nantycaws is in close proximity to dwellings and 'workplace' type sensitive receptors being: The Garage/filling station and nearby properties on the north side of the A48. These are shown as red triangles at Figure 5. However, there are also 'non-workplace' type receptors within 250m of the site including transient persons that may be using the civic amenity site or roadways within the site or on the A48 dual carriageway, or else may be involved with deliveries or other services to the Materials Reclamation Facility units or offices.

There are Domestic dwellings identified (green triangles) in figure 5. that were previously within 250m of the composting activity at the In-Vessel Composting facility. Now that the composting process has ceased, these are not within 250m and no longer deemed to be 'sensitive receptors'.

Figure 5. Map showing location of nearest domestic type receptors





SECTION 4. METEOROLOGICAL CONDITIONS FOR THE SITE

The National Agrometeorology Unit, at Wolverhampton, have supplied the following data that has been accumulated over a long time period and is representative of the wind strength and direction averages for this area.

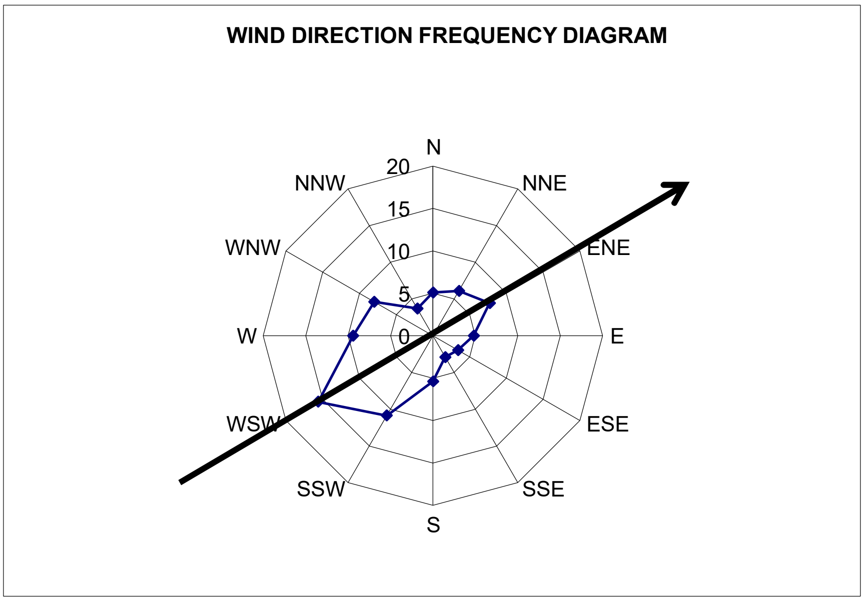
4.1 Background

The dominant wind directions in the UK normally blow from between South and West. However, the direction of the prevailing winds can be modified by local topography. In general the more pronounced the topography, then the greater the potential influence upon local wind directions.

Table 2. Percentage Frequency of Wind Directions at Shobdon : 1991-2000

	N	NNE	ENE	E	ESE	SSE	S	SSW	WSW	W	WNW	NNW
Apr	7.4	8.0	7.7	5.4	5.7	4.3	6.5	9.1	12.3	7.9	7.2	4.5
May	7.8	16.0	14.3	5.4	3.1	3.0	5.1	10.1	9.2	5.0	5.7	2.8
Jun	5.6	4.5	5.5	4.6	3.3	2.7	4.7	13.0	15.0	10.4	12.1	3.8
Jul	3.3	5.5	6.6	4.6	2.1	2.3	4.5	9.6	19.0	12.7	10.0	2.7
Aug	4.8	4.5	6.8	5.2	3.3	2.0	4.4	11.8	15.5	9.1	9.9	3.2
Sep	5.5	6.6	8.3	5.3	4.7	2.8	4.6	9.2	11.8	9.1	8.8	4.1
Year	5.1	6.1	7.7	4.8	3.4	2.9	5.4	10.9	15.6	9.4	8.0	3.7

Figure 6. wind direction Frequency Diagram for Wind Directions at Shobdon : 1991-2000



Notes:-

- The above table shows the directions FROM which the winds blow.
- The NNE sector covers directions from 15 to 45 degrees and so on in 30 degree sectors.
- 100% of hours in a 30 day month = 720 ; 10%= 72 hours etc.
- Calm winds in the area are generally around 17% of hours.

The main features in Table 1 are:

- Over the whole year the prevailing winds are from the SSW to W with the most frequent winds being from the WSW (15.6%).
- Winds from ESE (3.4%) and SSE (2.9%) are relatively infrequent .

SECTION 5. BIOAEROSOL CONTROL POINTS

Tables that previously held information regarding the IVC process and associated IVC windrows have now been deleted.

5.1 Nantycaws Open Windrow Composting of Green Waste Material

Table 3: Nantycaws Composting Facility's FIVE Bioaerosol Control Points

1.	**RECEPTION and GREEN WASTE STORAGE**	Material arrives on sites in high sided lorries that minimise the release of dust or bioaerosols in transit. Feedstock deliveries shall be compliance checked. The offloading of material shall be supervised by experienced personnel. Green waste is not disturbed until required.
2.	**GREEN WASTE SHREDDING**	To control the output/emissions from the shredder a water spray can be added to suppress dust if required.
3.	**OPEN WINDROW COMPOSTING**	The output/emissions during block windrow turning may be mitigated by the addition of a water spray to suppress dust if required. The size and quantities of the material are kept low in order to minimise the extent of any emissions.
4.	**COMPOST SCREENING**	The compost material is retained damp. The wind direction is checked and the screening shall take place to avoid times when the wind is directly north-wards towards the A48. The compost may be screened directly into the building.
5.	**COMPOST DESPATCH**	The compost material is moved into a specialist open sided building for bagging and stacked to pallets.

SECTION 6. BIOAEROSOL PUBLISHED REFERENCE DATA

6.1 Reference Data

Various research projects have been commissioned by the EA some of which have been joint with the H&SE and the 'The Composting Association' (now AfOR). The following summarises some of the relevant key points from these research.

6.2 HSE Reference Regarding Occupational Exposures from Composting and Agriculture

[Ref 1] Useful information is taken from the HSE reference: **'Occupational and environmental exposure to bioaerosols from composts and potential health effects - A critical review of published data'.** RESEARCH REPORT 130 Prepared by The Composting Association and Health and Safety Laboratory for the Health and Safety Executive 2003. The HSE report provides information at section 8.3 as follows [Box 2]:

Box 2: Extract from Reference- Research Report 130

8.3 BIOAEROSOLS GENERATED BY OTHER INDUSTRIES A wide range of industries may give rise to exposure of workers to bioaerosols, either through workplace activities purposefully involving the handling of micro-organisms, e.g., biotechnology, or through incidental exposure while working with contaminated materials. Both factory- based and agricultural activities have been investigated, mostly with respect to potential respiratory sensitisation or irritation in exposed workers. Reviews of bioaerosol exposure levels in various industries are given by Crook (1995), Eduard (1997) and Crook and Swan (2001). (These are re-presented here at Table 9).	HSE Health & Safety Executive

The following Table 4, presents data from that report. It is immediately obvious that bioaerosols are ubiquitous and present in many industrial processes and in the background air. Activities that involve either livestock (manure/bedding or fodder) or vegetable matter (crops/plants/vegetation) are identified as having much greater levels of bioaerosols in their working environment. These values are potentially 10 or 100 times greater than the thresholds that the EA have advised for Total bacteria (1000 cfu m^{-3}) and Aspergillus Fumigatus (500 cfu m^{-3}) although it will be noted that the levels shown are for Fungi, not just Aspergillus Fumigatus.

Table 4. Airborne bacteria and fungi cfu/m3 and endotoxin (ng/m3) in various workplaces - agriculture (from Crook, 1995, Eduard, 1997 and Crook and Swan, 2001)

Work activity	Bacteria	Fungi	Endotoxin (where measured)	Predominant organisms
Grain stores on farms	10^5	10^4	10^3	Fungi including *Aspergillus*
Handling mouldy hay, grain on farms	10^8	10^8		*Aspergillus fumigatus*, actinomycetes
Grain harvesting	10^7– 10^8	10^5- 10^7		Fungi including *Aspergillus,* Gram positive bacteria
Animal feed mills	-	10^3	10^1-10^2	Fungi including *Aspergillus*
Cattle sheds	10^3 - 10^5	10^4– 10^5	10^3- 10^4	Fungi including *Aspergillus*
Horse stables	10^5	10^3- 10^4	10^1- 10^3	Fungi including *Aspergillus*
Pig houses	10^4- 10^6	10^4– 10^5	10^2-10^4	Gram positive and negative bacteria
Poultry houses	$\mathbf{10^5}$	$\mathbf{10^3}$	$\mathbf{10^2}$	**Fungi including *Aspergillus***
Handling mushroom compost	10^7	10^5		Actinomycetes
Picking mushrooms	10^3	10^5		Fungi (*Trichoderma*)
Wood bark composting	10^4- 10^5	10^6– 10^7		Fungi (*Paecilomyces*)

6.3 EA Cranfield University Reference Regarding Assessment of Bioaerosol Risks from Composting

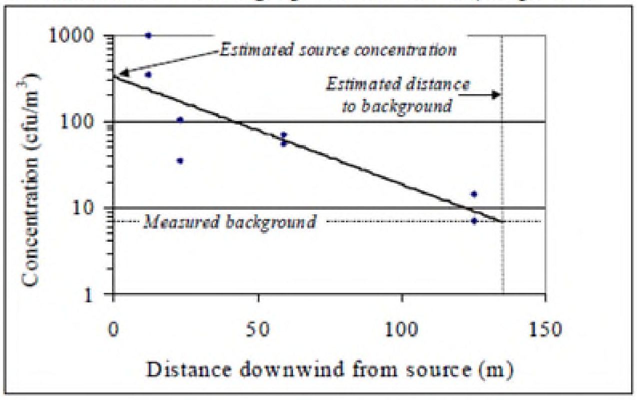
[Ref 2] Similar Data has been presented in the EA/ Cranfield University Reference: Guidance on the Evaluation of Risk Assessments for Composting Facilities, Cranfield University (G.H. Drew et al) published by the EA August 2009 and can be found on the web-address: http://publications.environment-agency.gov.uk/pdf/GEHO0809BQUO-e-e.pdf

6.4 The 'Health & Safety' and Composting Association Report

This Report considers the recent joint research findings of the **Health and Safety Executive (HSE)** and **The Composting Association (TCA).** The HSE/TCA report summarises the evidence that bioaerosols are widely present in agricultural activities as a norm; it reveals that bioaerosol levels reduce (much as dust levels reduce) with distance from the source; and concludes that the bulk of evidence suggests that bioaerosol levels reduce to background within a distance of 200m.

A review of many research and scientific articles, provided trial results data that revealed that concentrations of both culturable mesophilic bacteria and *A. fumigatus* downwind of source activities decreased **approximately exponentially with distance** from the source, and generally attained background levels (measured and estimated from the median sampled throughout the study period) within 200 m of the source activities. The summary of this is depicted in Figure 7: and shows the rapid reduction of bioaerosol concentration in air with increased separation distance.

Figure 7: **Concentrations of culturable *Aspergillus fumigatus* measured at distances downwind from a 'turning' operation at Site A (sample code**



6.5 The Health Risks Assessment undertaken by Enviros on behalf of DEFRA. Report

The scientific reference - **Health Risks Assessment undertaken by Enviros on behalf of DEFRA,** shows there is no evidence of a link of ill health between Composting Sites and third parties. [See Box 3.]

Box 3: Summary Extract of Information taken from the Enviros - Health Risks Assessment

Composting on a major scale is a relatively new and rapidly expanding industry in the UK. There is little published evidence of serious/chronic disease in compost workers, although there is evidence of early ill health responses to prolonged bioaerosol exposure. e.g. there is evidence of raised antibody levels and inflammatory mediators, and evidence of progressive allergic respiratory disease in industries such as waste handling, **agriculture** and cotton mills, where similar exposure to bioaerosols may exist.

Only few published studies exist where the health of residents near to composting facilities has been investigated, **but where this has been done there is no evidence of significant ill health compared to unexposed controls**.

6.6 Published data in relation to Biofilter performance

As the IVC activity has now ceased, the data (previously shown in a table and figure) in relation to biofilters has now been deleted. It showed how Aspergillus Fumigatus concentrations were reduced by wet biofiltration. Refer to the previous SSBRA if reference to that data is required.

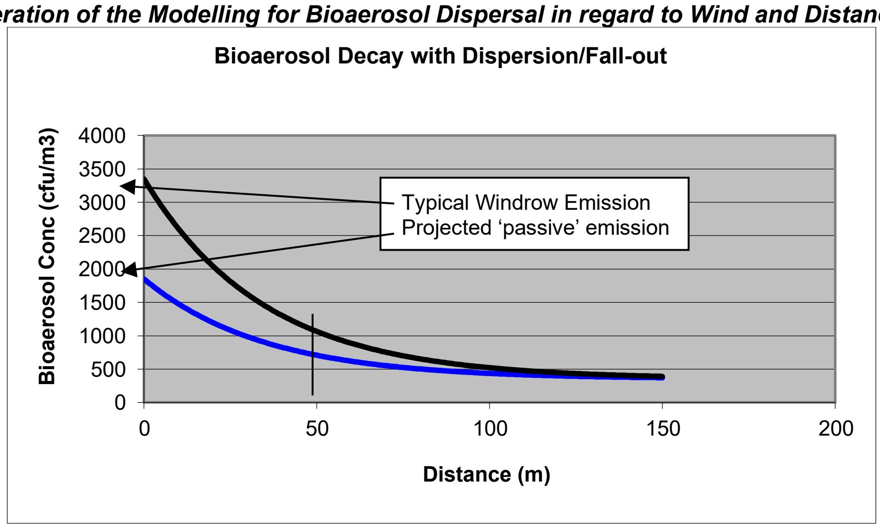
SECTION 7. BIOAEROSOL DISPERSAL

As with any other type of emission (smoke, odour or noise), the emission will disperse in a three dimensional pattern around the source and particulate emissions will be highly influenced by wind and local topography. With increasing distance from the source, the volume of air into which the emission becomes mixed, increases in a semi-cubic relationship. In high wind speeds there is a greater element of mixing, turbulence and vertical lift; however in low wind-speeds the emission is not well mixed and will form a more definite plume, drifting away from the source.

Factors such as ground rise, trees, hedges and buildings, have an effect on the shape of the plume, and weather conditions have an affect on the degree of vertical rise, mixing and attenuation e.g. in rain or moist air conditions.

Dispersions may be modelled, taking in to account these variables and local topography. Figure 8 illustrates this exponential decay in concentration:

Figure 8: Consideration of the Modelling for Bioaerosol Dispersal in regard to Wind and Distance.



The typical exponential dispersion of bioaerosols from a Typical Turned windrow system show that there is a strong likelihood that the bioaerosols will disperse and the concentration reduce to background within a distance of 250m.

In higher wind-speeds there is greater dispersal.
In lower wind-speeds there is reduced release.
For the nearest sensitive receptor (Dwelling / garage) near the Nantycaws Composting Pad Facility, there is a rise in land height and various hedges and cropped land that provide airflow resistance over the 250m distance from the activity to those nearest sensitive receptors.

The scientific projection would appear to indicate a strong probability that the bioaerosols levels at the sensitive receptors, when the wind is in that direction, would be returned to background levels.

Evidence based on monitoring and the sampling of bioaerosols at the site is provided in the **Section 8.** This data is now updated, a). to remove data that was specific to the IVC, b) to include data that now uses the M9 method, and c). to enable the more recent external windrow activity based data to become the basis of the assessment.

SECTION 8. SITE HISTORY BIOAEROSOL DATA 2011-2022

8.1 Data from when the IVC was operating 2011-2015

The site has been previously monitored to determine the bioaerosol levels under different operating conditions and at 4 times within each 12 month period. Details may be found in the previous version of the SSBRA and within the reports relating to each occasion of sampling.

8.2 Data from when the IVC was operating 2015-2017

The bioaerosol levels for the site during 2015 to 2017 are shown at table 5. Where there were replications the average has been shown. More details may be found in the previous version of the SSBRA and detailed information within the reports relating to each occasion of sampling.

Table 5 Historic Data Relating to the IVC Composting Process and the External Windrow Process 2015-2017

Location with regard to Site	*Date*	Total Bacteria cfu m^{-3}	Aspergillus fumigatus cfu m^{-3}
Upwind	*17/03/2015*	22	21
Downwind Of The Ivc	*17/03/2015*	22	43
25m DOWNWIND OF PAD	*17/03/2015*	69	77
Upwind At The (Farm) Nsr	10/06/2015	31	2
Downwind Of Ivc (Car Park)	10/06/2015	82	50
50m DOWNWIND Of The PAD (Screening)	10/06/2015	124	114
Upwind At The (Farm) Nsr	09/09/2015	89	1
Downwind At Ivc (Car Park)	09/09/2015	242	0
100m DOWNWIND OF PAD (Turning)	09/09/2015	185	24
Nsr Garage	09/09/2015	87	0
Upwind Of The Pad	04/12/2015	13	0
Downwind Of Ivc (Farm Track)	04/12/2015	62	0
Downwind Of Pad (Shred	04/12/2015	76	17
Nsr Garage	04/12/2015	16	0
Upwind	11/02/2016	5.5	2
Nsr Garage	11/02/2016	24	1
100m DOWNWIND OF PAD (Shredding)	11/02/2016	367	23
Upwind	14/04/2016	14.5	2
Downwind Of Pad 100m (Ene Wind)	14/04/2016	32	75
Nsr Farm	14/04/2016	10	1
Upwind Of Site	21/09/2016	23.5	0
Nsr Garage	21/09/2016	184	2
Downwind Of Pad 100m	21/09/2016	233	16
Downwind Nsr Farm	21/09/2016	136	0
Uw Nsr Garage/Farm	29/11/2016	75	4
Downwind Of Ivc 50m	29/11/2016	38	27
Carpark Uw	20/02/2017	7	2
Uw Landfill	20/02/2017	21.5	1
Downwind	20/02/2017	48	191
Downwind Of Ivc 50m	20/02/2017	27	40
Upwind Landfill	13/06/2017	48	16
Downwind Of Pad	13/06/2017	97	227
Downwind Of Pad (Rep)	13/06/2017	111	173
Downwind Of Ivc	13/06/2017	104	50
Downwind Nsr Garage	13/06/2017	70	27
Downwind Of Ivc	13/06/2017	104	50
Upwind Of Site 50m	15/08/2017	9	20
Downwind Of Pad	15/08/2017	126	53
Downwind Of Ivc 50m	15/08/2017	220	4
Downwind Nsr Garage	15/08/2017	51	2
Upwind Of Site 50m	16/11/2017	13	0
Downwind Of Pad	16/11/2017	311	0
Downwind Of Ivc 50m	16/11/2017	47	2
Downwind Nsr Garage	16/11/2017	82	9
Downwind Nsr Farm	16/11/2017	18	0

8.3 Data from when the IVC was operating 2018-2019

During this period the site was monitored using the Method based on the original Protocol; except when in one instance the M9 Method was used as a trial; however NRW advised that the Protocol Method should be used for the remainder of 2018 into 2019. Again the aim was to determine the bioaerosol levels under different operating conditions at 4 times within each 12 month period. Tables 6.1 – 6.6 provides a brief summary of the 2018-2019 data. More details may be found in the information within the report relating to each occasion of sampling.

Table 6.1 – Summary of results Nantycaws Composting Facility 25/4/18

Sampler location	Total Bacteria cfu/m³	Asp. Fumigatus cfu/m³
Overall Mean Upwind	7	0
Median Downwind	21	75
Overall Mean Downwind *	125	115
Max. of Median Downwind	489	311
Downwind NSR (Farm nr IVC)	0	43

Table 6.2 – Summary of results Nantycaws Composting Facility 24/07/2018

	Total Bacteria cfu/m³	Asp. Fumigatus cfu/m³
UPWIND of Site 50M	31	0
DOWNWIND NSR GARAGE	63	75
DOWNWIND of PAD	265	113
DOWNWIND of IVC 50M	68	2
DOWNWIND NSR FARM	38	0

Table 6.3 – Summary of results Nantycaws Composting Facility 8/10/2018

	Total Bacteria cfu/m³	Asp. Fumigatus cfu/m³
UPWIND of Site 50M	14	0
DOWNWIND of PAD	29	274
DOWNWIND NSR GARAGE	24	61
DOWNWIND of IVC 50M	20	13
DOWNWIND NSR FARM	4	4

Table 6.4 – Summary of results Nantycaws Composting Facility 19/02/19

	Total Bacteria cfu/m³	Asp. Fumigatus cfu/m³
UPWIND of Site 50M	12	0
DOWNWIND of IVC 50M	9	5
DOWNWIND NSR FARM	4	7
DOWNWIND of PAD	70	123
DOWNWIND NSR GARAGE	45	9

Table 6.5 – Summary of results Nantycaws Composting Facility 26/06/2019

	Total Bacteria cfu/m³	Asp. Fumigatus cfu/m³
UPWIND FARM TRACK NSR	45	0
DOWNWIND of PAD (TH Track)	546	51
DOWNWIND of PAD (LF Lag)	564	9
PAD NSR	218	0

Table 6.6 – Summary of results Nantycaws Composting Facility 25/09/2019

	Total Bacteria cfu/m³	Asp. Fumigatus cfu/m³
UPWIND Landfill Lagoon Track	132	4
DOWNWIND of PAD (Main Entrance Road)	411	7
DOWNWIND FARM TRACK NSR	100	0
DOWNWIND of PAD (Field to East)	148	102
PAD NSR near to Garage on A48	202	9

8.4 Data from the External Windrow Activities after the IVC ceased operating Nov. 2019

In the Autumn 2019, the In-Vessel Composting was stopped and the food/catering waste transferred to the Anaerobic Digester Facility. The opportunity was taken to switch the method used for bioaerosols sampling to the M9 Method. The M9 Method employs a ‘fan array’ of the samplers in the down wind locations, so that the stations account for small swings in the wind and

also the results are a good representation of what the Nearest sensitive Receptor would have received, if the wind had been towards the NSR.
The Maximum MEDIAN Value of the downwind results is used to compare to the Permit Values. Table 7 shows the typical levels as reported for the specific sampling sessions for the External windrow process in November 2019. Tables 8 to 10 show data for 2020 through to 2022.

Table 7 – Summary of results Nantycaws Composting Facility 28/11/2019 – No IVC

		Total Bacteria			Asp. Fumigatus	
	Activities	**Mean UW**	**Median DW**		**Mean UW**	**Median DW**
		cfu/m³	cfu/m³		cfu/m³	cfu/m³
Session 1	**Compost processing on the Pad**	**39**	**57**		**16**	**4**
Session 2	**Compost processing on the Pad**	**11**	**21**		**9**	**11**
Session 3	**Compost processing on the Pad**	**9**	**61**		**20**	**7**
Overall	**Mean UW and Median Downwind**	**17**	**57**		**23**	**7**
Maximum Median Downwind			**61**			**11**

Table 8 – Summary of results Cwm Environmental Composting Facility 2020

		Total Bacteria			Asp. Fumigatus	
		Mean UW	**Median DW**		**Mean UW**	**Median DW**
		cfu/m³	cfu/m³		cfu/m³	cfu/m³
25/3/2020	**Mean UW and Median Downwind**	**2**	**96**		**1**	**7**
25/3/2020	**Maximum Median Downwind**		**232**			**7**
14/5/2020	**Median UW and Downwind**	**96**	**168**		**0**	**4**
14/5/2020	**Maximum Median Downwind**		**614**			**4**
9/9/2020	**Median UW and Median Downwind**	**77**	**93**		**0**	**0**
9/9/2020	**Maximum Median Downwind**		**164**			**0**
30/11/2020	**Median UW and Median Downwind**	**7**	**36**		**4**	**36**
30/11/2020	**Maximum Median Downwind**		**71**			**36**

Table 9 – Summary of results Cwm Environmental Composting Facility 2021

		Total Bacteria			Asp. Fumigatus	
		Mean UW	**Median DW**		**Mean UW**	**Median DW**
		cfu/m³	cfu/m³		cfu/m³	cfu/m³
18/03/2021	**Mean UW and Median Downwind**	**34**	**32**		**0**	**32**
18/03/2021	**Maximum Median Downwind**	**48**	**50**		**2**	**171**
22/06/2021	**Median UW and Downwind**	**93**	**314**		**1**	**36**
22/06/2021	**Maximum Median Downwind**	**170**	**550**		**4**	**43**
27/07/2021	**Median UW and Median Downwind**	**116**	**311**		**16**	**29**
27/07/2021	**Maximum Median Downwind**	**163**	**361**		**30**	**29**
4/11/2021	**Median UW and Median Downwind**	**8**	**43**		**0**	**7**
4/11/2021	**Maximum Median Downwind**	**25**	**64**		**2**	**7**

Table 10 – Summary of results Cwm Environmental Composting Facility 2022

		Total Bacteria			Asp. Fumigatus	
		Mean UW	**Median DW**		**Mean UW**	**Median DW**
		cfu/m³	cfu/m³		cfu/m³	cfu/m³
15/03/2022	**Mean UW and Median Downwind**	**4**	**25**		**1**	**11**
15/03/2022	**Maximum Median Downwind**	**11**	**29**		**2**	**14**
5/05/2022	**Median UW and Downwind**	**55**	**93**		**0**	**7**
5/05/2022	**Maximum Median Downwind**	**61**	**164**		**2**	**14**
25/07/2022	**Median UW and Median Downwind**	**13**	**157**		**13**	**43**
25/07/2022	**Maximum Median Downwind**	**30**	**200**		**27**	**79**
30/11/2022	**Median UW and Median Downwind**	**5**	**18**		**2**	**42**
30/11/2022	**Maximum Median Downwind**	**7**	**24**		**4**	**54**

These data show that even at 250m downwind from the active processes at this site, the **Maximum** Medians remain <65% but more often **less than 30%** of the guideline thresholds and Permit values (1000 cfu/m^3 and 500 cfu/m^3) for Bacteria and Aspergillus Fumigatus respectively.

SECTION 9a. BIOAEROSOL RISK CONSIDERATION – FOOD-WASTE RECEPTION AND TRANSFER

Table 11. Risk Consideration Table

Hazard		Hazard (Risk Potential)			Mitigation	RISK ASSESSMENT		
Critical Control Point		Hazard Description	Magnitude & Frequency	Pathway & Sensitive Receptors	Control Measures	Impact Magnitude (Consequences)	Probability	RISK
a.	**RECEPTION and TRANSFER OF FOOD WASTE**	Fresh material offloaded within enclosed space. Hazards may include bacteria, Fungi	Magnitude < 200t/wk Small tonnage Each working day.	Internal, therefore no direct emission. Potential emission via doorway during entry/exit.	Check Source and type of Feedstock. Only approved materials to be accepted. Dusty or spore laden materials not accepted.	Avoided high bioaerosol laden materials, but food waste is quite moist. Process enclosed hence Magnitude LOW	Probability of difficult materials arising at site is low, process enclosed so Probability is LOW	**LOW**
b.	**CA SITE - GREEN WASTE RECEPTION AND STORAGE**	Fresh material offloaded by public dropping material into small bunker. Hazards may include bacteria, Fungi. Material removed daily to keep it fresh.	Low magnitude and short period exposure time. <15mins by public	Open topped bunker but then at much lower level and away from persons potential to breath in.	Green waste bunker is kept clean and is emptied once material starts to build up, therefore keeping the waste away from people's faces. Fresh non-dusty green waste; material is not disturbed until needed.	Potential for some old or mould laden material delivered by public, but quantities are very low and height of bunker keeps material away from public, therefore Magnitude is LOW	Probability of public bringing very difficult material to the site in cars is very low; and time duration when public exposed is very short. Probability of risk materialising is LOW	**LOW**

SECTION 9b. BIOAEROSOL RISK ASSESSMENT - NANTYCAWS EXTERNAL COMPOSTING SITE

Table 12 Risk Assessment Table

Hazard		Hazard (Risk Potential)			Mitigation	RISK ASSESSMENT		
Critical Control Point		Hazard Description	Magnitude & Frequency	Pathway & Sensitive Receptors	Control Measures	Impact Magnitude (Consequences)	Probability	RISK
1.	**RECEPTION and GREEN WASTE STORAGE**	Fresh material offloaded from lorry. Hazards may include bacteria, Fungi.	Low magnitude and short period exposure time.	Material undisturbed until shredding.	Fresh non-dusty green waste is not disturbed until needed.	Minimal disturbance of material, arrives fresh; LOW Magnitude	Separation distance and wind direction <15%, hence LOW Probability	**LOW**
2.	**GREEN WASTE SHREDDING**	Shredding generates fragments and air movement. Hazards may include bacteria, Fungi	Magnitude approx 300t per week, may be undertaken over 2 days per week so that timing can be managed	Distance to NSR >220m; stockpile and high hedges in the pathway. Wind is toward the NSRs less than 15% of time	Shredder has enclosed drum and discharges via a grate and a conveyor belt to avoid particles becoming airborne. Shredding may be stopped if the wind is directly toward the NSR's. (from South or SSW)	Potentially elevated Magnitude of release; hence wind direction selection important to maintain LOW magnitude emission	Separation distance and wind direction <15%, but may need to pause if wind from S or SSW	**LOW**
3.	**OPEN WINDROW COMPOSTING**	Windrows turned in situ. One at a time. Hazards as 2.	Windrows in situ for 8 weeks, turned 4 times	Windrows are >250m from NSR	Material is maintained in moist condition to mitigate AF release. Irrigation type damping system available	Potentially elevated Magnitude of release when turning windrows. wind direction dependent	May need to pause if wind from S or SSW for LOW Probability	**LOW**
4.	**COMPOST SCREENING**	Hazards may include bacteria and Fungi	One Windrow screened /fortnight ~500t/fortnight	Screening adjacent to new building, west of pad, sheltered. >250m from NSR	Screener feed hopper is semi enclosed. Screener provides minimised agitation of material. Dust extraction. Spray damping system available	Damp material, protected screen with building available; Magnitude LOW	Ability to select when screening done, i.e. in wind direction hence LOW Probability	**LOW**
5.	**COMPOST DESPATCH**	Stabilised, cooled material is loaded to vehicles. Hazards may include bacteria, and Fungi	Low frequency	Semi contained vehicles or else material in bags.	Material is cooled screened and stabilised. Opportunity for damping down any dust.	Low Magnitude	LOW Probability	**LOW**

SECTION 10. SCIENTIFIC AND EVIDENCE BASED RISK ASSESSMENT

10.1 Summary of the Scientific Information

10.1.1 EA advised acceptable levels at the sensitive receptors

The original Position Statement PS031, the M9 guidance and the Permit advise that the concentrations of bioaerosols (as predicted or as derived from direct measurements) at the sensitive receptors which are attributable to the composting operations, that are deemed acceptable are as follows:

Table 13. The acceptable (appropriate) levels (given as colony forming units per cubic metre of air).

Bioaerosol type	Threshold value	units
total bacteria	1000	cfu m^{-3}
Aspergillus fumigatus	500	cfu m^{-3}

10.1.2 EA advised Separation Distance (PS031)
Sensitive receptors. Sensitive receptors refers to people likely to be within 250 metres of the composting operation for prolonged or frequent periods.

10.1.3 Separation Distance based on Research
The consensus from various studies is that bioaerosols from composting activities decline rapidly within the first 100 metres from a site and generally decline to background levels within 250m

The **Health and Safety Executive (HSE)** and **The Composting Association (TCA) report .** summarises the evidence that bioaerosols are widely present in agricultural activities as a norm; it reveals that bioaerosol levels reduce (much as dust levels reduce) with distance from the source; and concludes that the bulk of evidence suggests that bioaerosol levels reduce to background within **a distance of 200m**.

A review of many research and scientific articles, provided trial results data that revealed that concentrations of both culturable mesophilic bacteria and *A. fumigatus* downwind of source activities decreased **approximately exponentially with distance** from the source, and generally attained background levels (measured and estimated from the median sampled throughout the study period) within 200 m of the source activities. The summary of is depicted in Figure 6: and shows the rapid reduction of bioaerosol concentration in air with increased separation distance.

10.1.4 Background Levels of Bioaerosols in Rural Environments Section 7 Table 6.
Research shows that bioaerosols are ubiquitous and present in high concentrations in activities that involve either livestock (manure/bedding or fodder) or vegetable matter (crops/plants/vegetation) are identified as having much greater levels of bioaerosols in their working environment. These values are potentially as high as 10,000,000 cfu m^{-3} Total bacteria in grain harvesting or handling mouldy hay.

10.1.5 Dispersal Calculation
Based on the dispersion (dilution and decrease) shown in figure 8, the figure 9 below shows how bioaerosol dispersions may be modelled, and reveals that for elevated concentrations at the centre of activity at a site, then with increasing distance away from the activity, the concentrations are projected to decrease due to falling out of the air-stream and also due to dispersal into a much greater volume of air. It shows that the decrease will result in concentrations as high as ~3500 cfum^{-3} at the active source falling to below 1000 cfu m^{-3} within 100 metres.

The dispersion model uses meteorological data (Section 4) giving the prominent prevailing wind.

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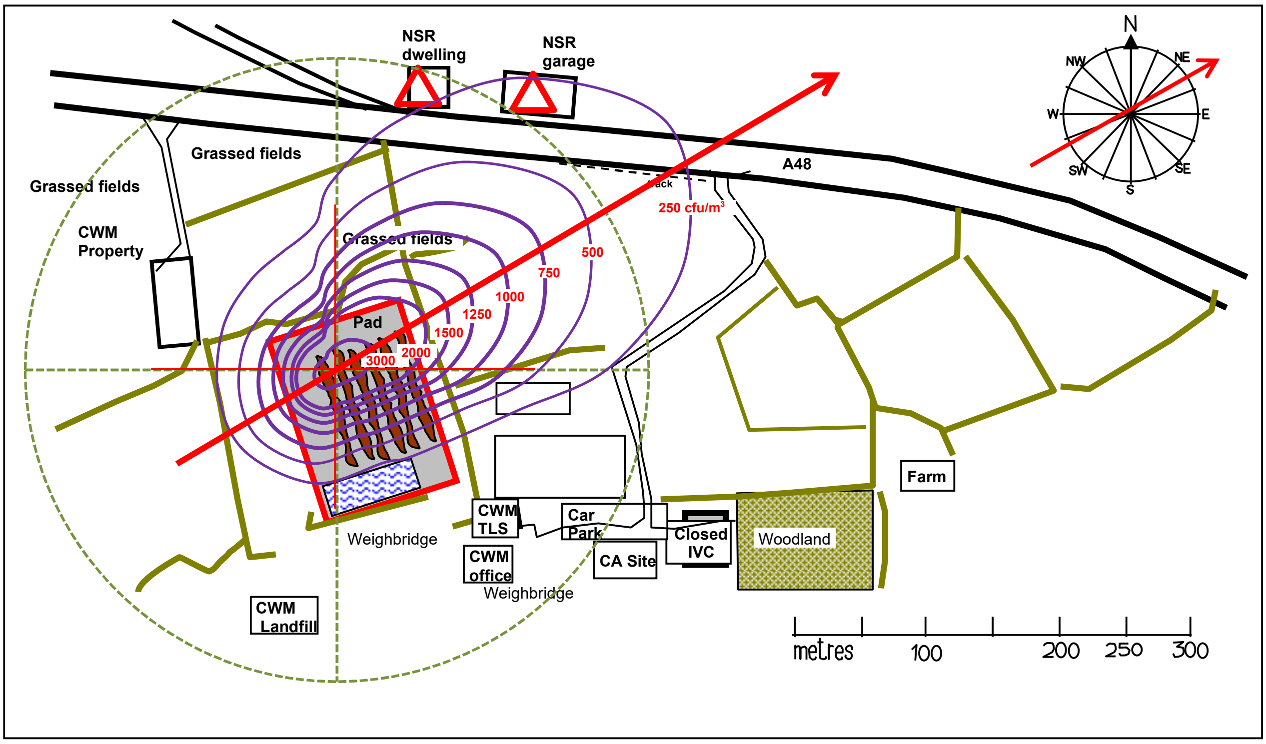
MCIWM CEnv. Tel: 01743 340630

Figure 9: Consideration of the Modelling for Bioaerosol Dispersal in regard to Prevailing Wind and Distance.



10.2 Summary of the Site Specific Monitoring Data

10.2.1 Summary of Data for 2015-2022

The data collected over several years is condensed and shown at Table 23.

Table 14: Summary of Bioaerosols Sampling Results Data 2015-19

		Total Bacteria cfu/m³			Asp. Fumigatus cfu/m³	
		Mean UW	Median DW		Mean UW	Median DW
	Mean Upwind 2015-2017	25			6	
	Mean Downwind (of IVC) 2015-2017		102			23
	Mean Downwind (of Pad) 2015-2017		136			73
	Mean Downwind (Farm) 2015-2017		83			32
	Mean Downwind (Garage) 2015-2017		92			6
	Mean Upwind 2018-2019	40			1	
	Mean Downwind (of IVC) 2018-2019		39			26
	Mean Downwind (of Pad) 2018-2019		236			88

Table 15: Summary of Bioaerosols Sampling Results Data 2019-22

		Total Bacteria cfu/m³				Asp. Fumigatus cfu/m³		
		Mean UW	**Median DW**	**MAX Med DW**		**Mean UW**	**Median DW**	**MAX Med DW**
	28/11/19	**17**	**57**	**61**		**23**	**7**	**11**
	25/03/2020	**2**	**96**	**232**		**1**	**7**	**7**
	14/05/2020	**96**	**168**	**614**		**0**	**4**	**4**
	9/9/2020	**77**	**93**	**164**		**0**	**0**	**0**
	30/11/2020	**7**	**36**	**71**		**4**	**36**	**36**
	18/03/2021	**34**	**32**	**50**		**0**	**32**	**171**
	22/06/2021	**93**	**314**	**550**		**1**	**36**	**43**
	27/07/2021	**116**	**311**	**361**		**16**	**29**	**29**
	04/11/2021	**8**	**43**	**64**		**0**	**7**	**7**
	15/03/2022	**4**	**25**	**29**		**1**	**11**	**14**
	05/05/2022	**55**	**93**	**164**		**0**	**7**	**14**
	25/07/2022	**13**	**157**	**200**		**13**	**43**	**79**
	30/11/2022	**5**	**18**	**24**		**2**	**42**	**54**

These data are not intended to be used as a scientific measure due to the range of circumstances, seasonal/weather etc.) and the data having been calculated from averages; however these values may aid the forming of simple comparisons.

The over-riding element is the Maximum Median Downwind Value in each instance; this being the Permit measure.

10.2.2 Discussion of Data for the External Composting Activity

The table 14 shows bioaerosols concentrations for the IVC and for the Pad; and in these data the maximum value downwind is 236 $cfum^{-3}$ (Bacteria) for the External Processing which at the same time was 88 $cfum^{-3}$ (AF).

The table 15 shows data obtained using the M9 Method and places focus on the Maximum Mean value. I n the 13 occasions these data are reported, on only two occasions were the 'Total Bacteria' Values over 500 $cfum^{-3}$ as maximum median; and only once was the Aspergillus Fumigatus over 100 $cfum^{-3}$ as maximum median at a value of 170 $cfum^{-3}$.

The M9 methodology is more thorough and takes account of deviations in the wind direction during sampling. In each case there were external activities being undertaken; and while these variations may give a bearing on the results; so too does the timing within each season and most importantly the weather at that time.

Together, these data, for this site show that the bioaerosols can be managed and maintained at levels well below the critical threshold (Permit) values.

The dispersion model is a useful representation of the typical levels in the downwind direction. The model shows that even with elevated bioaerosol concentrations at the source, the levels are moderated and reduced at the Permit Boundary and fall further due to dispersion away from the source.

10.2.3 Conclusions based on Data relating to the External Composting Activity

- The Upwind values vary with season
- The Downwind values vary with season, weather and activity being undertaken
- The results show evidence of increased bioaerosols downwind compared to the upwind
- The Total bacteria levels at the NSR's are within the limits required by the Permit
- For each bioaerosol type, the concentrations at the NSR are significantly less than the Permit or the NRW advised thresholds
- The data provide confidence to the assessment of risk as being LOW
- The data confirm the generalised output of the dispersion model.

SECTION 11. OVERALL RISK ASSESSMENT

11.1 Summary of the Risk Assessment Facts and Evidence

The Theoretical assessment comprises reference data and dispersion calculations and provides various relevant scientific facts that inform the assessment. The consensus from various studies is that bioaerosols from composting activities decline rapidly within the first 100 metres from a site and generally decline to background levels within 250m

The **Health and Safety Executive (HSE)** and **The Composting Association (TCA) report .** summarises the evidence that bioaerosols are widely present in agricultural activities as a norm; and concludes that bioaerosol levels reduce to background within **a distance of 200m**.

The dispersion of bioaerosols is exponential and therefore significant reductions in concentration may be expected within close proximity to a site, but there-after the levels will only gradually decrease dependant upon the levels in the background.

The levels in the background of agriculture are ordinarily expected to be elevated

In Theory then, it may be concluded that given the separation distances and the topography surrounding Nantycaws; the increases in bioaerosols attributable to the composting operations may be expected to return to background or at least to well below (typically below 50% of) the Permit thresholds, prior to impacting upon the nearest sensitive receptors.

11.2 Summary of the Risk Assessment Evidence

The evidence from monitoring shows that the composting does promote an increase in the bioaerosol levels within the locality, but also shows that these levels are not unduly high beyond the boundary of the site and the samples taken to represent the nearest sensitive receptors, the sample bioaerosol concentrations are well within the NRW guidelines and Permit Values.

11.3 Summary of the Process using the Risk Assessment Matrix

Table 16. Composting Site - Risk Assessment Matrix Summary Table

Hazard		**RISK ASSESSMENT**		
Critical Control Point		**Impact Magnitude (Consequences)**	**Probability**	**RISK**
1.	**RECEPTION AND TRANSFER OF FOOD WASTE**	Low volume, Enclosed Low potential	Managed process. Low Probability	LOW RISK
2.	**GREEN WASTE STORAGE at CA Site**	Limited quantity Low potential	Regular removal. Low Probability	LOW RISK
1.	**RECEPTION and GREEN WASTE STORAGE**	Managed process Low potential	Low Probability	LOW RISK
2.	**GREEN WASTE SHREDDING**	250m separation Low potential *	Selected wind direction Low Probability	LOW RISK*
3.	**OPEN WINDROW COMPOSTING / TURNING**	250m separation Low potential ***	Selected wind direction for turning Maintained damp Low Probability	LOW RISK**/***
4.	**COMPOST SCREENING**	250m separation Low potential	Low Probability	LOW RISK
5.	**COMPOST DESPATCH**	250m separation Low potential	Low Probability	LOW RISK

*Carefully manage the shredding process. **Manage moisture to minimise emissions. *** Subject to Wind Direction

On the basis of the Keys for Minimising Risk, the scientific and technical evidence regarding the nearest receptor (dwelling or workplace)**, and given the evidence of the Background sampling;** it is determined that there is only a **LOW RISK** of bioaerosols arising from the composting site having any affect on the nearest receptors; and due to dispersal of the bioaerosols, these may be maintained **at appropriate levels** at the nearest receptors (ref. box 4ii).

Box 4. Definition of appropriate levels (see definitions at page iv)

i. Appropriate levels are defined as bioaerosol levels not exceeding:
i) those before the start of the composting process or
ii) bioaerosols levels no greater than 1,000 colony forming units (cfu) m^{-3} total bacteria, 500 cfu m^{-3} Aspergillus Fumigatus

SECTION 12. OVERALL CONCLUSIONS

1. **Bioaerosols formation (in particular Aspergillus Fumigatus) is managed by maintaining a moist composting process and managing the temperatures within the compost windrows.**

2. **Bioaerosol release from the composting site will be minimised by the use of water irrigation suppression over the windrows and hard ground surfaces, to mitigate the effect of dust.**

3. **Bioaerosol release from the composting Process will be minimised by care and attention to the processes and techniques utilised when material is moved; in order to minimise agitation, minimise undue fragmentation and by minimising the height when materials lifted or elevated by machinery.**

4. **The impact of bioaerosols on the nearest receptors is minimised by undertaking the key activities more than 250metres distant from the receptors; and, if necessary, curtailing activities if the wind is directly towards those receptors.**

5. **The data gathered over the years 2015 to 2022 serve to confirm that the bioaerosols levels downwind of the site under a range of conditions, activities and seasonal variations does not exceed the guidance or Permit thresholds. The evidence confirms that the bioaerosol levels can be adequately controlled during these activities.**

6. **The bioaerosol dispersal modelling, based on mathematical projections, shows that the residual concentrations of bioaerosols at the receptors are well below the threshold (Permit) levels and more likely to be less than 30% of these levels, most of the time.**

7. **With attention to both the measured values and modelled values, there is a high degree of confidence that the activities at the composting site are unlikely to present an increased risk to the health of persons resident or working at the nearest dwellings and workplaces as specified in this risk assessment.**

APPENDIX 1: CHECKLIST OF CONTENTS

Cranfield University / EA Bioaerosols Risk Assessment Checklist.

Taken from: Guidance on the Evaluation of Risk Assessments for Composting Facilities, Cranfield University (G.H. Drew et al) published by the EA August 2009

Essential attributes		Yes/No
1	Has the operator or consultant described Environment Agency policy on bioaerosols and risk assessment?	YES
2	Has the operator or consultant demonstrated that they understand what bioaerosols are	YES
3	Does the operator or consultant provide a summary of health risks from bioaerosols	YES
4	Has the operator or consultant described other sources of bioaerosols in vicinity	YES
5	Has the operator or consultant shown they understand the uncertainties and the lack of dose-response relationships associated with bioaerosols?	YES
6	Has the operator or consultant discussed any other potential emissions, e.g. odour, from their activities?	YES (separate Doc.)
7	Has the operator or consultant described the processing technology and equipment that is or will be used on the site?	YES
8	Has the operator or consultant described the feedstock that they will process and the tonnages?	YES
9	Has the operator or consultant described the site layout and included a scaled diagram?	YES
10	Does this description cover details of any screens, bunds, misting sprays or trees around the site?	YES
11	Has the operator or consultant described the pathways between the source and receptors, e.g. the prevailing winds?	YES
12	Has the operator or consultant provided local wind direction data?	YES
13	Has the operator or consultant described what is beyond the site boundaries?	YES
14	Does this include the location of and distance to sensitive receptors? Is there a scaled map that shows this?	YES O.S. Map copy with scale is included
	Desirable attributes	
16	Is all information site specific and relevant?	YES
17	Has the operator or consultant described their own competencies or qualifications for undertaking a bioaerosol risk assessment?	YES
18	Has the operator or consultant consulted any receptors (stakeholders)?	This has been done via Planning Local Liaison

Essential attributes	Yes/No
Has the operator or consultant described what is at risk (sensitive receptors, e.g. offices, schools homes)?	YES
Has the operator or consultant described what it is at risk from (the hazard)?	YES
Has the operator or consultant described what might happen (the consequences)?	YES
Has the operator or consultant described how it might happen (pathways)?	YES
Has the operator or consultant described how large the consequences might be?	YES by reference to case study information and inclusion of dispersion chart.
Has the operator or consultant described how probable the consequences are?	YES
Has the operator or consultant described the significance of the probabilities and consequences?	YES Appendix 4.
Has the operator or consultant described the criteria used to assess their significance?	YES reference to EA Cranfield matrix

Has the operator or consultant described the certainty of the assessment?	YES
Has the operator or consultant described the most significant risk?	YES
Has the operator or consultant described their assumptions and justified these?	YES
Is all information site specific and relevant?	YES

Checklist 3: Bioaerosols

Essential attributes		Yes/No
1	Has the operator or consultant listed the sources of bioaerosols from their composting process?	YES Section 4
2	Has the operator or consultant explained the causes of variation?	YES Section 4
3	Has the operator or consultant identified other sources of bioaerosols in the vicinity	YES
4	Has the operator or consultant discussed bioaerosol dispersal?	YES Figure 7 and references to EA Information
5	Has the operator or consultant used the Association for Organics Recycling standard protocol for sampling? If not, please contact the Human Health Advisory Service advice on alternative methods.	YES Appendices 2 & 3 and case study data Using The Composting Association Protocol 1999 & 2009
6	Has the operator or consultant monitored background concentrations?	YES
7	Is background either upwind for an existing site or pre-operations for a new site?	YES
8	How far upwind (greater than 25m)?	YES
9	Has the operator or consultant stated the local conditions during sampling (sampling location, including height and relationship to buildings, activities on-site, and weather conditions)?	YES
10	Has the operator or consultant taken these into account in designing their sampling strategy?	YES
11	Has the operator or consultant provided details of equipment used and sampling times	YES
12	Has the operator or consultant provided details of the calibration of equipment?	YES
13	Has the operator or consultant provided details of the storage of samples, transport method, time of transport, and any delays in analysis?	YES
14	Has the operator or consultant provided details of laboratory procedures, including agar used and culture techniques)	YES
15	Has the operator or consultant provided details of the laboratory certification?	YES
16	Has the operator or consultant provided details of the level of replication of sampling, variability between samples, or a statement of errors or error bars?	YES
17	Has the operator or consultant stated the uncertainties associated with the data?	YES
18	Is all information site specific and relevant?	YES

APPENDIX 2. The Composting Association Protocol (Contents list)

The Composting Association Protocol was used as a reference and basis of methodology within this study - **(Standardised Protocol for the Sampling and Enumeration of Airborne Micro-organisms at Composting Facilities 1999)** together with the updated version (July 2009) entitled:

A Standardised Protocol for the Monitoring of Bioaerosols at Open Composting Facilities

CONTENTS

The AfOR Protocol was used as the basis for the methodology during the reported sampling sessions.
It is available by order at the AfOR website [publications]:
http://www.organics-recycling.org.uk/

APPENDIX 3. The Sampling procedure Used: Andersen samplers

	A single Petri dish (with the lid removed) should be loaded into each sampler immediately prior to use, in accordance with the manufacturer's instructions. Due consideration must be given to potential sources of microbial contamination (Chapter 5.4) during this procedure. Once loaded, the sampler should be kept upright, to prevent the Petri dish from dislodging.	
	A *minimum* of two samples of *Aspergillus fumigatus* (two Petri dishes containing selective medium) should be collected in parallel at each of the specified locations (Chapter 7) using two single stage Andersen samplers. Samples are considered to have been collected in parallel if the onset and cessation of the sampling periods do not differ by more than 30 seconds. The same procedure should be repeated for mesophilic bacteria.	
	Additional replicate samples should be collected whenever possible. Samples should be considered replicates if they have been collected at the same location but in a different time frame. The start and stop times when the vacuum is applied and shut off should be recorded (Chapter 10.3) using the synchronised digital watch (Chapter 5.1).	
	The sampling times should be such that no more than 300 bacterial colonies grow on each Petri dish containing nutrient agar medium and no more than 300 colonies of *A. fumigatus* grow on each Petri dish containing malt extract agar medium. It is recommended that sampling times reflect the likelihood of overloading of the plates; initially a guideline of 20 minutes is suggested for the bacterial and *A. fumigatus* samples. However, shorter sampling times should be used if it is likely that local concentrations of airborne micro-organisms will be high and cause overloading of the plates (>399 colonies), as low as one minute in highly contaminated environments, for example (Swan *et al., 2003).*	
	Petri dishes should be stored in a refrigerated or cooled container (preferably at 4°C) following sampling, until the remaining samples have been collected.	
	In the laboratory, all dishes should then be inverted and placed in an appropriate microbiological incubator at the same time. This should be carried out no longer than 12 hours after sampling. The nutrient agar medium, selecting for total mesophilic bacteria, should be incubated at 37C; the malt extract medium, culturing A. *fumigatus,* should be incubated at 40°C. Colonies growing on both media should be enumerated after two days.	
	Control Petri dishes containing both types of media should also be included in the sampling programme. At least two Petri dishes containing both types of media should be kept in re-sealable bags in the work station during the entire working day. At least one Petri dish containing each of the sampling media should be placed in a sampler at the downwind location and exposed for the same time period as the respective samples, except the vacuum pump should not be switched on. All control dishes should be handled, incubated and enumerated in an identical manner to the samples collected with the pumps operational.	

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APPENDIX 4. The M9v2 Technical Guidance Note (Monitoring)

Technical Guidance Note (Monitoring) M9 Environmental monitoring of bioaerosols at regulated facilities

Environment Agency January 2018 Version 2

4.0 Sampling bioaerosols
Bioaerosols can be measured using a number of different techniques. This technical note describes the following techniques for sampling bioaerosols:

4.1 Impaction
The impaction method uses a single stage Andersen sampler, loaded with a Petri dish of appropriate media. This method uses inertial forces to collect microorganisms in the air. Air is drawn through the perforated holes in the sampling head at a constant rate, using a vacuum pump. The velocity of the air is determined by the diameter of the holes in the sampling head. When the air hits the collection surface it is forced to change direction. The inertia of the microorganisms prevents them from changing direction, which causes them to become impacted onto the Petri dish media. When a sufficient volume of air has been collected, the Petri dish is removed and incubated, without further treatment.

4.2 Sample location strategy
The principle of this specification is to compare the concentrations in air unaffected by the activities of the facility (that is the background air sampled upwind of the plant) with the concentration of <u>bioaerosols in air downwind of the plant</u>. This comparison enables an assessment of the plant related contribution over a specified area to be made. The difference between the upwind and downwind concentration caused by bioaerosol emissions from the site is <u>known as the process contribution</u>. It uses <u>sampling locations that form a fan like shape</u>, which helps to ensure that variable wind directions are taken account of during the sampling period.

4.2.2 Sample locations upwind of the site
Sampling should be carried out upwind of the site. Upwind data should provide information on the concentration of specified bioaerosols that are present in the air blowing onto the operational area of the site. This should reflect either the background concentration at that time, or the effects of neighbouring operations, such as agricultural activities.

Upwind data indicates the concentration of bioaerosols that would be present, irrespective of whether the facility was there or not. The sample location of the upwind concentration measurement should be measured at a distance of 50m from the centre of the active operational area.

Figure 5.2: Simplified fan like shape sampling arrangement for area sources (based on CEN TS 16115-2)

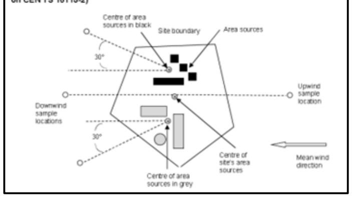
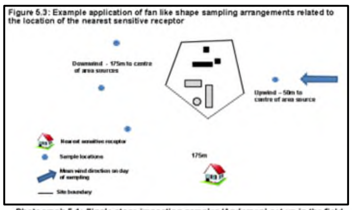


Figure 5.3: Example application of fan like shape sampling arrangements related to the location of the nearest sensitive receptor



Photograph 5.1: Single stage impaction sampler (Andersen) set up in the field

4.2.3 Sample locations downwind of the site
Sampling should be carried out downwind of the site, using a fan like shape arrangement to detect the position of the plume. The orientation of the measurement area is determined by the prevailing mean wind direction.

This approach is used to ensure that measurements are made in the emission plume, during the sampling campaign. If there are any buildings, installations or structures between the downwind location(s) and the centre of the active operational area, then sampling should be carried out *upwind of that structure or installation, at a distance greater than twice its height.*

<u>Figure 5.1 shows this approach applied to a facility with a single point source.</u> Topography or vegetation may restrict the line of sight required to locate sample traverses. This may make it difficult to determine the angle for locating the sample points. The restriction should be noted in the sample strategy and final monitoring report. For area sources, the orientation of the fan like shape sampling arrangement is selected by <u>determining the centre point of the sources in the site</u>.

Each impaction sampler should be mounted onto a tripod, or other suitable structure, so that the top of the inlet cone is held <u>between 1.5 and 1.8m above the ground</u>. Each single stage impaction sampler fitted with a cone should be fitted with a <u>hemi-cylindrical baffle</u> extending in height at least 15 centimetres (cm) above the top of the inlet of the cone, to ensure stagnation point sampling.

4.6.2 Sampling procedure
A single Petri dish (with the lid removed) should be loaded into each sampler immediately prior to use, in accordance with the manufacturer's instructions. Once loaded, the sampler should be kept upright, to prevent the Petri dish from dislodging. A single sample of *Aspergillus fumigatus* (1 Petri dish containing selective medium) should be collected at each of the specified locations using a single stage impaction sampler. The same procedure should be repeated for mesophilic bacteria using Petri dishes containing selective medium specific for the culturing of mesophilic bacteria.

APPENDIX 5. Bioaerosol Types, Descriptions And Health Effects

A5.1 Description of Bioaerosol Types

Actinomycetes	A specific group of bacteria that are capable of forming very small spores, Actinomycetes are Gram-positive bacteria, but they are distinguished from other bacteria by their distinct role in decomposition. They have a filamentous (thread-like) morphology and grow slower than other bacteria, making them more of an intermediate between fungi and bacteria. Actinomycetes prefer moist and aerobic conditions, with a neutral to slightly alkaline pH. They are most easily seen in the early stages of composting, when the self heating process has begun. They form long grey strands that resemble spider webs and give the compost a soil-like odour. They are therefore a useful indication of the stage of the composting process.
Bacteria	A group of micro-organisms with a primitive cellular structure, in which the hereditary genetic material is not retained within an internal membrane (nucleus), Bacteria are usually between 1 and 5 µm in size, and are divided into Gram-negative bacteria (predominantly of animal origin) and Gram-positive bacteria (predominantly of plant origin).
Fungi	A group of micro-organisms with a more complicated cellular structure than bacteria, in which the hereditary genetic material is retained within an internal membrane forming a nucleus,
Micro-Organisms	Microscopic organisms that are capable of living on their own, Often called 'MICROBES',
Spore	A general term describing a bacterial or fungal cell that is in a dormant form, They are a potential risk to health because they can be inhaled.
Gram-Negative Bacteria	Gram-negative bacteria are more abundant in the mesophilic phases of composting. The pathogenic Gram-negative bacteria, *Salmonella* species and *Escherichia coli*, can also be found in composting facilities. However, adequate process control during composting should produce temperatures high enough to kill these bacteria. Sampling/Measurement of Gram-negative bacteria is not required under the M9 Methodology

A5.2 Health impacts

People who work with composting materials, or those who are in close proximity to the agitated compost, can potentially inhale significant concentrations of bioaerosols. The human respiratory system can adequately filter out larger dust particles through a combination of hairs that line the nose and specialised cells in the upper parts of our airways. Unfortunately, the smaller bioaerosol particles escape capture by these mechanisms and can penetrate deep into the lungs. As our lungs have a very large surface area and carry out a specialised function, they can easily be affected by bioaerosols.

During the course of daily activities, people inhale airborne microbes. This is as much a feature of normal everyday life as eating or drinking. Most individuals' bodies are perfectly capable of coping adequately with the presence of these 'invaders' and do not suffer any ill effects. It is only when airborne microbes, such as those generated during the composting process, are present in high concentrations that they may become harmful to human health.

Composting results in the formation of bioaerosols and utilises certain types of microbes that tend to produce very tiny spores. However without even being close to composting activities, third parties may continually encounter these same microbes in their everyday lives at low concentrations. They are present naturally and are essential in the 'recycling' of nutrients in our gardens, parks and countryside.

Everyone reacts to bioaerosols in different ways. It depends upon a variety of factors and can never be predicted: some people have worked at composting sites for many years without apparently displaying *any* adverse health effects.

Factors, such as prior exposure to bioaerosols, individual susceptibility, bioaerosol concentration and composition (the numbers and types of microbes present) and the length of time and frequency to which people are exposed all contribute to the way in which their bodies react. There are three main types of response:

Allergy

This is an immunological response that results in the body becoming 'sensitised' following exposure. The next time the body encounters the substance it 'over-reacts', even if the substance is present in extremely low concentrations. When such a substance affects a person's lungs in this way it is referred to as a 'respiratory sensitiser'.
Sensitisation does not usually occur immediately; rather it is a consequence of inhaling a substance over a period of months or even years.

Inflammation
This is a response of body tissues to an injury. It typically results in swelling, redness and pain.

Toxin Poisoning
This is a disturbance of the normal bodily functions by a specific substance known as a toxin. It differs from both the allergic and inflammatory responses.

These bodily reactions may manifest themselves in various ways. These conditions are not due to infections, which are caused by microbes that invade the body tissue and cause skin infections or else are ingested (such as E. Coli) and may cause stomach sickness.

APPENDIX 6: HISTORIC SAMPLING DATA

Table A6.1: Composting Pad – Bioaerosols Data Summary 25th June 2012

Sampler location	Sampling Station No.	Start time	Total Bacteria cfu m-3	Aspergillus fumigatus cfu m-3	Gram -ve bacteria cfu m-3
PAD Upwind	1	14:13	150	<1	<1
PAD Upwind	1		79	<1	<1
PAD Upwind	1	11:17	100	<1	<1
PAD Upwind	1		50	<1	<1
DW of Pad	2	10:42	1000	<1	<1
DW of Pad	2		339	<1	<1
DW of Pad	2	10:11	750	<1	<1
DW of Pad	2		893	<1	<1
DW OF PAD	4	14:41	875	<1	<1
DW OF PAD	4		750	<1	<1
NSR OF PAD	3	9:35	282	<1	<1
NSR OF PAD	3		232	<1	<1

Table A6.2: Summary of Bioaerosols Sampling Results – IVC Facility 12th September 2012

Sampler location	Sampling Station No.	Start time	Total Bacteria cfu m-3	Aspergillus fumigatus cfu m-3	Gram -ve bacteria cfu m-3
UW of IVC	4	12:35	643	<1	<1
UW of IVC	4		464	<1	<1
DW of IVC	5	16:29	893	21	<1
DW of IVC	5		857	14	<1
NSR of IVC	6	13:58	714	21	<1
NSR of IVC	6		857	<1	<1

Table A6.3: IVC Facility– Bioaerosols Data Summary 26th March 2013

Sampler location	Sampling Station No.	Start time	Total Bacteria cfu m-3	Aspergillus fumigatus cfu m-3	Gram -ve bacteria cfu m-3
IVC Upwind & NSR	2	11:12	18	0	0
IVC Upwind & NSR	2	11:12	11	0	0
UW of IVC	3	11:47	18	21	0
UW of IVC	3	11:47	18	11	0
DW of IVC	4	12:25	32	61	7
DW of IVC	4	12:25	46	64	4
DW OF IVC	4	13:02	14	7	0
DW OF IVC	4	13:02	21	11	4

Table A6.4: Composting Pad – Bioaerosols Data Summary 26th March 2013

Sampler location	Sampling Station No.	Start time	Total Bacteria cfu m-3	Aspergillus fumigatus cfu m-3	Gram -ve bacteria cfu m-3
PAD Upwind & NSR	1	10:30	29	0	4
PAD Upwind & NSR	1	10:30	29	0	4
UW of Pad	5	14:49	79	4	0
UW of Pad	5	14:49	86	0	0
UW of Pad	5	15:26	43	0	0
UW of Pad	5	15:26	43	0	0
50m DW of PAD	6	16:15	514	29	4
50m DW of PAD	6	16:15	436	25	4
100m DW of PAD	7	14:15	157	0	4
100m DW of PAD	7	14:15	143	0	7

Table A6.5: IVC – Bioaerosols Data Summary 6th June 2013

Sampler location	Sampling Station No.	Start time	Total Bacteria cfu m-3	Aspergillus fumigatus cfu m-3	Gram -ve bacteria cfu m-3
IVC Upwind & NSR	2	10:52	111	0	4
IVC Upwind & NSR	2		64	4	0
UW of IVC	3	11:32	39	0	7
UW of IVC	3		39	0	0
DW of IVC	4	12:36	18	0	0
DW of IVC	4		14	0	4
DW of IVC	4	13:11	21	0	0
DW of IVC	4		11	0	0

Table 6.6: IVC – Bioaerosols Data Summary 6th June 2013

Sampler location	Sampling Station No.	Start time	Total Bacteria cfu m-3	Aspergillus fumigatus cfu m-3	Gram -ve bacteria cfu m-3
PAD Upwind & NSR	1	10:14	32	0	0
PAD Upwind & NSR	1		32	0	0
UW of Pad	5	13:42	4	0	0
UW of Pad	5		7	0	0
DW of PAD	6	15:52	507	86	11
DW of PAD	6		611	68	7
100DW of PAD	7	15:11	382	93	7
100DW of PAD	7	15:11	561	86	11
150m DW of PAD	8	16:32	146	61	7
150m DW of PAD	8	16:32	107	46	11

Table A6.7: IVC – Bioaerosols Data Summary 5th September 2013

Sampler location	Sampling Station No.	Start time	Total Bacteria cfu m-3	Aspergillus fumigatus cfu m-3	Gram -ve bacteria cfu m-3
UW of IVC Office	1	12:31	61	4	11
UW of IVC Office	1	12:31	64	0	29
UW of IVC Yard	2	14:13	18	0	11
UW of IVC Yard	2	14:13	14	7	11
DW of IVC	3	10:49	614	0	18
DW of IVC	3	10:49	529	0	29
NSR OF IVC	4	9:56	171	0	18
NSR OF IVC	4	9:56	179	0	29

Table A6.8: Composting Pad Facility– Bioaerosols Data Summary 5th September 2013

Sampler location	Sampling Station No.	Start time	Total Bacteria cfu m-3	Aspergillus fumigatus cfu m-3	Gram -ve bacteria cfu m-3
UW of Pad	5	13:22	39	4	18
UW of Pad	5	13:22	39	0	0
DW of PAD EDGE	6	15:55	382	93	7
DW of PAD EDGE	6	15:55	561	86	11
DW of PAD	6	11:40	136	14	11
DW of PAD	6	11:40	132	7	18
DW of PAD = NSR	7	15:04	89	7	39
DW of PAD = NSR	7	15:04	93	0	25

Table A6.9: IVC – Bioaerosols Data Summary 10th December 2013

Sampler location	Sampling Station No.	Start time	Total Bacteria cfu m-3	Aspergillus fumigatus cfu m-3	Gram -ve bacteria cfu m-3
UW OF IVC	1	14:04	7	79	7
UW OF IVC	1	14:04	7	86	7
DW OF IVC	2	12:22	21	114	21
DW OF IVC	2	12:22	36	100	7
NSR OF IVC	3	10:38	114	57	14
NSR OF IVC	3	10:38	93	121	21

Table A6.10: Composting Pad Facility– Bioaerosols Data Summary 10th December 2013

Sampler location	Sampling Station No.	Start time	Total Bacteria cfu m-3	Aspergillus fumigatus cfu m-3	Gram -ve bacteria cfu m-3
UW OF PAD	4	14:55	14	114	14
UW OF PAD	4	14:55	29	121	7
DW OF PAD	5	13:13	29	214	14
DW OF PAD	5	13:13	29	86	7
NSR OF PAD	6	11:31	36	100	7
NSR OF PAD	6	11:31	36	79	14

Table A6.11: Bioaerosols Data Summary 19th March 2014

Sampler location	Sampling Station No.	Start time	Total Bacteria cfu m-3	Aspergillus fumigatus cfu m-3	Gram -ve bacteria cfu m-3
DOWNWIND IVC 25M	1	10:06	250	0	71
DOWNWIND IVC 25M	1	10:06	161	0	36
DOWNWIND IVC NSR	2	10:39	89	0	36
DOWNWIND IVC NSR	2	10:39	36	0	18
DW OF PAD	3	11:17	393	0	18
DW OF PAD	3	11:17	411	0	0
DOWNWIND PAD NSR	4	12:00	125	18	36
DOWNWIND PAD NSR	4	12:00	107	0	18
UPWIND IVC	5	12:33	89	0	0
UPWIND IVC	5	12:33	54	0	0
UPWIND PAD	6	13:26	54	0	0
UPWIND PAD	6	13:26	54	0	0

Table A6.12: Bioaerosols Data Summary 18th June 2014

Sampler location	Sampling Station No.	Start time	Total Bacteria cfu m-3	Aspergillus fumigatus cfu m-3	Gram -ve bacteria cfu m-3
DOWNWIND (Farm) NSR	1	9:37	154	0	14
DOWNWIND (Farm) NSR	1	9:37	186	0	11
DOWNWIND (Farm) NSR	1	10:04	111	0	11
DOWNWIND (Farm) NSR	1	10:04	211	0	7
UPWIND PAD/WHOLE SITE	2	10:31	64	0	14
UPWIND PAD/WHOLE SITE	2	10:31	104	4	0
NSR (GARAGE) UPWIND PAD	3	11:25	25	0	11
NSR (GARAGE) UPWIND PAD	3	11:25	14	0	7
DOWNWIND OF IVC / SE BOUNDARY	4	11:54	293	64	7
DOWNWIND OF IVC / SE BOUNDARY	4	11:54	239	68	36

Table A6.13: Bioaerosols Data Summary 16th September 2014

Sampler location	Sampling Station No.	Start time	Total Bacteria cfu m-3	Aspergillus fumigatus cfu m-3	Gram -ve bacteria cfu m-3
DOWNWIND OF IVC / New Car Park	1	12:28	346	11	104
DOWNWIND OF IVC / New Car Park	1	12:28	200	0	107
DOWNWIND of the COMPOSTING PAD	2	13:02	614	64	43
DOWNWIND of the COMPOSTING PAD	2	13:02	782	89	54
UPWIND and also THE (Farm) NSR	3	13:33	107	14	36
UPWIND and also THE (Farm) NSR	3	13:33	125	11	54

Table A6.14: Bioaerosols Data Summary 10th June 2015

Sampler location	Sampling Station No.	Start time	Total Bacteria cfu m-3	Aspergillus Fumigatus cfu m-3	Gram -ve bacteria cfu m-3
50m DOWNWIND OF PAD (turning)	1	11:14	93	282	43
50m DOWNWIND OF PAD (turning)	1	11:14	157	200	32
DOWNWIND of the IVC (Car Park)	2	11:48	107	0	21
DOWNWIND of the IVC (Car Park)	2	11:48	57	100	32
UPWIND and also THE (Farm) NSR	3	12:22	43	0	4
UPWIND and also THE (Farm) NSR	3	12:22	18	4	4
UPWIND and also THE (Farm) NSR	3	12:54	46	0	4
UPWIND and also THE (Farm) NSR	3	12:54	18	4	4
50m DOWNWIND of the PAD (screening)	4	13:25	100	82	18
50m DOWNWIND of the PAD (screening)	4	13:25	104	68	21
50m DOWNWIND of the PAD (screening)	4	13:49	111	18	14
50m DOWNWIND of the PAD (screening)	4	13:49	179	36	7

Table A6.15: Bioaerosols Data Summary 9th September 2015

Sampler location	Sampling Station No.	Start time	Total Bacteria cfu m^{-3}	Aspergillus Fumigatus cfu m^{-3}	Gram -ve bacteria cfu m^{-3}
DOWNWIND of the IVC (Car Park)	1	10:02	350	0	32
DOWNWIND of the IVC (Car Park)	1	10:02	136	0	7
DOWNWIND of the IVC (Car Park)	1	10:26	218	0	21
DOWNWIND of the IVC (Car Park)	1	10:26	264	0	25
100m DOWNWIND OF PAD (turning)	2	10:54	93	4	25
100m DOWNWIND OF PAD (turning)	2	10:54	225	0	32
100m DOWNWIND OF PAD (turning)	2	11:18	214	43	25
100m DOWNWIND OF PAD (turning)	2	11:18	207	50	32
UPWIND and also THE (Farm) NSR	3	11:49	79	4	71
UPWIND and also THE (Farm) NSR	3	11:49	86	0	54
UPWIND and also THE (Farm) NSR	3	12:12	68	0	18
UPWIND and also THE (Farm) NSR	3	12:12	121	0	46
NSR GARAGE	4	12:45	57	0	21
NSR GARAGE	4	12:45	175	0	32
NSR GARAGE	4	13:09	96	0	18
NSR GARAGE	4	13:09	21	0	29

Table A6.16: Bioaerosols Data Summary 4th December 2015

Sampler location	Sampling Station No.	Start time	Total Bacteria cfu m^{-3}	Aspergillus Fumigatus cfu m^{-3}	Gram -ve bacteria cfu m^{-3}
DOWNWIND of the IVC (Farm Track)	1	8:15	96	0	11
DOWNWIND of the IVC (Farm Track)	1	8:15	100	0	18
DOWNWIND of the IVC (Track nearer Farm)	2	8:41	18	0	11
DOWNWIND of the IVC (Track nearer Farm)	2	8:41	32	0	4
200m DOWNWIND OF PAD (shredding)	3	9:09	79	7	0
200m DOWNWIND OF PAD (shredding)	3	9:09	111	0	18
200m DOWNWIND OF PAD (shredding)	3	9:33	100	0	7
200m DOWNWIND OF PAD (shredding)	3	9:33	29	0	0
200m DOWNWIND OF PAD (turning)	3	9:57	43	43	4
200m DOWNWIND OF PAD (turning)	3	9:57	93	50	0
UPWIND of the PAD	4	10:26	21	0	4
UPWIND of the PAD	4	10:26	11	0	11
UPWIND of the PAD	4	10:50	7	0	18
UPWIND of the PAD	4	10:50	14	0	0
NSR GARAGE	5	11:21	18	0	4
NSR GARAGE	5	11:21	14	0	0

Table A6.17: Bioaerosols Data Summary 11th February 2016

Sampler location	Sampling Station No.	Start time	Total Bacteria cfu m^{-3}	Aspergillus Fumigatus cfu m^{-3}	Gram -ve bacteria cfu m^{-3}
100m DOWNWIND OF PAD (shredding)	1	10:29	400	14	21
100m DOWNWIND OF PAD (shredding)	1	10:29	386	18	14
100m DOWNWIND OF PAD (shredding)	1	10:54	386	4	32
100m DOWNWIND OF PAD (shredding)	1	10:54	396	11	14
100m DOWNWIND OF PAD (shredding)	1	11:18	318	43	4
100m DOWNWIND OF PAD (shredding)	1	11:18	318	50	7
NSR GARAGE	2	11:47	21	0	0
NSR GARAGE	2	11:47	32	4	4
NSR GARAGE	2	12:12	21	0	18
NSR GARAGE	2	12:12	21	0	4
UPWIND of the SITE (Farm)	3	12:43	7	0	7
UPWIND of the SITE (Farm)	3	12:43	4	4	7

Table A6.18: Bioaerosols Data Summary 14th April 2016

Sampler location	Sampling Station No.	Start time	Total Bacteria cfu m^{-3}	Aspergillus Fumigatus cfu m^{-3}	Gram -ve bacteria cfu m^{-3}
NSR FARM	1	8:45	14	4	0
NSR FARM	1	8:45	11	0	0
NSR FARM	1	9:10	18	0	0
NSR FARM	1	9:10	11	0	0
UPWIND	2	9:44	11	0	0
UPWIND	2	9:44	7	0	0
UPWIND	2	10:09	11	4	0
UPWIND	2	10:09	29	4	0
DOWNWIND of PAD 100M (ENE Wind)	3	10:46	39	43	4
DOWNWIND of PAD 100M (ENE Wind)	3	10:46	57	50	11
NSR GARAGE	4	11:22	7	0	0
NSR GARAGE	4	11:22	7	0	0
NSR GARAGE	4	11:47	4	0	18
NSR GARAGE	4	11:47	7	4	32
DOWNWIND of PAD 100M (NNE Wind)	5	12:26	14	61	18
DOWNWIND of PAD 100M (NNE Wind)	5	12:26	25	114	4

Table A6.19: Bioaerosols Data Summary 21st September 2016

Sampler location	Sampling Station No.	Start time	Total Bacteria cfu m^{-3}	Aspergillus Fumigatus cfu m^{-3}	Gram -ve bacteria cfu m^{-3}
UPWIND OF SITE	1	13:34	36	0	7
UPWIND OF SITE	1	13:34	54	0	7
UPWIND OF SITE	1	13:59	4	0	7
UPWIND OF SITE	1	13:59	0	0	4
NSR GARAGE	2	14:28	36	4	29
NSR GARAGE	2	14:28	104	0	18
NSR GARAGE	2	14:52	246	0	32
NSR GARAGE	2	14:52	350	4	25
DOWNWIND of PAD 100M	3	15:22	114	43	14
DOWNWIND of PAD 100M	3	15:22	264	50	32
DOWNWIND of IVC 50M	4	15:53	100	0	25
DOWNWIND of IVC 50M	4	15:53	121	0	32
DOWNWIND of IVC 50M	4	16:17	154	0	18
DOWNWIND of IVC 50M	4	16:17	646	0	36
DOWNWIND NSR FARM	5	16:44	207	0	29
DOWNWIND NSR FARM	5	16:44	64	0	36

Table A6.20: Bioaerosols Data Summary 29th November 2016

Sampler location	Sampling Station No.	Start time	Total Bacteria cfu m^{-3}	Aspergillus Fumigatus cfu m^{-3}	Gram -ve bacteria cfu m^{-3}
UW NSR GARAGE	1	11:12	71	4	32
UW NSR GARAGE	1	11:12	82	0	68
UW NSR GARAGE	1	11:35	79	4	43
UW NSR GARAGE	1	11:35	29	4	54
UW NSR FARM	2	12:06	71	7	18
UW NSR FARM	2	12:06	82	0	29
UW NSR FARM	2	12:30	104	7	21
UW NSR FARM	2	12:30	79	7	18
DOWNWIND of IVC 50M	3	12:59	64	43	29
DOWNWIND of IVC 50M	3	12:59	57	50	14
200m DOWNWIND as PROXY NSR	4	13:53	29	21	18
200m DOWNWIND as PROXY NSR	4	13:53	29	14	7
200m DOWNWIND as PROXY NSR	4	14:16	32	32	4
200m DOWNWIND as PROXY NSR	4	14:16	18	4	4

Table A6.21: Bioaerosols Data Summary 20th February 2017

Sampler location	Sampling Station No.	Start time	Total Bacteria cfu m^{-3}	Aspergillus Fumigatus cfu m^{-3}	Gram -ve bacteria cfu m^{-3}
UW LANDFILL	1	9:45	29	0	18
UW LANDFILL	1	9:45	18	4	0
UW LANDFILL	1	10:10	14	0	11
UW LANDFILL	1	10:10	25	0	0
DOWNWIND NSR GARAGE	2	10:45	11	54	29
DOWNWIND NSR GARAGE	2	10:45	7	43	14
DOWNWIND OF WINDROWS BACK OF MRF	3	11:14	93	361	25
DOWNWIND OF WINDROWS BACK OF MRF	3	11:14	82	304	50
DOWNWIND of IVC 50M	4	11:51	64	43	39
DOWNWIND of IVC 50M	4	11:51	18	50	39
DOWNWIND of IVC 50M	4	12:18	25	86	25
DOWNWIND of IVC 50M	4	12:18	29	57	29
DOWNWIND of IVC 75M NSR	5	12:47	18	4	18
DOWNWIND of IVC 75M NSR	5	12:47	7	0	0
CARPARK UW	6	13:18	7	0	7
CARPARK UW	6	13:18	7	4	0

Table A6.22: Bioaerosols Data Summary 13th June 2017

Sampler location	Sampling Station No.	Start time	Total Bacteria cfu m^{-3}	Aspergillus Fumigatus cfu m^{-3}	Gram -ve bacteria cfu m^{-3}
UPWIND LANDFILL	1	9:50	46	25	4
UPWIND LANDFILL	1	9:50	50	7	7
DOWNWIND of PAD	2	10:24	50	250	7
DOWNWIND of PAD	2	10:24	143	204	4
DOWNWIND NSR GARAGE	3	10:53	82	29	14
DOWNWIND NSR GARAGE	3	10:53	57	25	11
DOWNWIND NSR FARM	4	11:31	121	11	14
DOWNWIND NSR FARM	4	11:31	89	11	21
DOWNWIND of PAD (rep)	2	12:22	136	175	18
DOWNWIND of PAD (rep)	2	12:22	86	171	7
DOWNWIND of IVC	5	13:01	125	46	4
DOWNWIND of IVC	5	13:01	82	54	0

Table A6.23: Bioaerosols Data Summary 15th August 2017

Sampler location	Sampling Station No.	Start time	Total Bacteria cfu m^{-3}	Aspergillus Fumigatus cfu m^{-3}	Gram -ve bacteria cfu m^{-3}
DOWNWIND NSR GARAGE	1	10:16	21	7	11
DOWNWIND NSR GARAGE	1	10:16	86	0	11
DOWNWIND NSR FARM	2	10:45	64	0	7
DOWNWIND NSR FARM	2	10:45	32	0	11
DOWNWIND of IVC 50M	3	11:12	179	4	11
DOWNWIND of IVC 50M	3	11:12	261	4	14
UPWIND of Site 50M	4	11:46	7	29	14
UPWIND of Site 50M	4	11:46	11	11	11
DOWNWIND of PAD	5	12:23	264	25	18
DOWNWIND of PAD	5	12:23	175	18	7
DOWNWIND of PAD (rep)	5	12:49	7	79	4
DOWNWIND of PAD (rep)	5	12:49	57	89	7

Table A6.24: Bioaerosols Data Summary 16th November 2017

Sampler location	Sampling Station No.	Start time	Total Bacteria cfu m^{-3}	Aspergillus Fumigatus cfu m^{-3}	Gram -ve bacteria cfu m^{-3}
DOWNWIND of PAD	1	8:36	386	0	25
DOWNWIND of PAD	1	8:36	236	0	50
DOWNWIND NSR GARAGE	2	9:07	93	14	7
DOWNWIND NSR GARAGE	2	9:07	71	4	4
DOWNWIND of IVC 50M	3	9:37	61	0	0
DOWNWIND of IVC 50M	3	9:37	32	4	7
DOWNWIND NSR FARM	4	10:04	14	0	11
DOWNWIND NSR FARM	4	10:04	21	0	0
UPWIND of Site 50M	5	10:39	7	0	0
UPWIND of Site 50M	5	10:39	18	0	0

Table A6.25 – Summary of results Nantycaws Composting Facility March 2018

	Total Bacteria cfu/m^3	Asp. Fumigatus cfu/m^3
Overall Mean Upwind	13	1
Median Downwind	43	7
Overall Mean Downwind *	94	11
Max. of Median Downwind	236	21

* Mean value downwind is not required. Refer to Median Values. Mean value shown for interest.

Table A6.26 – Summary of results Nantycaws Composting Facility April 2018

	Total Bacteria cfu/m^3	Asp. Fumigatus cfu/m^3
Overall Mean Upwind	7	0
Median Downwind	21	75
Overall Mean Downwind *	125	115
Max. of Median Downwind	489	311
Downwind NSR	0	43

* Mean value downwind is not required. Refer to Median Values. Mean value shown for interest.

Table A6.27: Bioaerosols Data Summary 24th July 2018

Sampler location	Sampling Station No.	Start time	Total Bacteria cfu m^{-3}	Aspergillus Fumigatus cfu m^{-3}	Gram -ve bacteria cfu m^{-3}
DOWNWIND NSR GARAGE	1	11:19	54	50	18
DOWNWIND NSR GARAGE	1	11:19	71	100	14
UPWIND of Site 50M	2	11:58	50	0	25
UPWIND of Site 50M	2	11:58	11	0	11
DOWNWIND of PAD	3	12:34	393	161	18
DOWNWIND of PAD	3	12:34	136	64	11
DOWNWIND of IVC 50M	4	13:11	89	4	43
DOWNWIND of IVC 50M	4	13:11	46	0	32
DOWNWIND NSR FARM	5	13:40	50	0	14
DOWNWIND NSR FARM	5	13:40	25	0	11

Table A6.28: Bioaerosols Data Summary 8th October 2018

Sampler location	Sampling Station No.	Start time	Total Bacteria cfu m^{-3}	Asp. Fumigatus cfu m^{-3}	Gram -ve bacteria cfu m^{-3}
DOWNWIND of PAD	1	9:26	21	304	0
DOWNWIND of PAD	1	9:26	29	261	4
DOWNWIND of PAD	1	9:52	39	271	4
DOWNWIND of PAD	1	9:52	25	261	0
DOWNWIND NSR GARAGE	2	10:27	39	79	0
DOWNWIND NSR GARAGE	2	10:27	18	132	7
DOWNWIND NSR GARAGE	2	10:53	14	21	7
DOWNWIND NSR GARAGE	2	10:53	25	11	0
DOWNWIND of IVC 50M	3	11:28	25	7	4
DOWNWIND of IVC 50M	3	11:28	4	4	4
DOWNWIND of IVC 50M	3	11:53	32	21	4
DOWNWIND of IVC 50M	3	11:53	18	21	4
DOWNWIND NSR FARM	4	12:22	7	4	4
DOWNWIND NSR FARM	4	12:22	0	4	4
UPWIND of Site 50M	5	12:56	11	0	0
UPWIND of Site 50M	5	12:56	18	0	0
UPWIND of Site 50M	5	13:21	11	0	4
UPWIND of Site 50M	5	13:21	14	0	7