

EVALUATION OF COMPOSTING BIOAEROSOLS AT:

**CRUGMORE FARM COMPOSTING FACILITY
PENPARC
CARDIGAN
CEREDIGION
SA43 1QY**

9th DECEMBER 2021

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23rd December 2021

1. BACKGROUND & SITE DESCRIPTION:

D&F Associates Ltd has been commissioned by MD Recycling Ltd to evaluate bioaerosols at an open windrow composting (OWC) facility situated at Crugmore Farm, Penparc, Ceredigion SA43 1QY. The facility receives green waste from local sources including landscape gardeners and grounds maintenance contractors.

The composting facility is surrounded by open farmland to the North, South and West. Wood and demolition/construction waste recycling areas are situated to the East of the composting area. A neighbouring anaerobic digestion (AD) facility (operated independently of MD Recycling Ltd) is located 60m Southeast. Sensitive receptors identified within 250m of the composting facility include the AD plant and a residential dwelling situated 220m North Northwest.

2. SAMPLING PROTOCOL & SAMPLING POINTS:

The Environment Agency Technical Guidance Note M9 (Environmental monitoring of bioaerosols at regulated facilities, version 2, 2018) offers guidance about sampling ambient bioaerosol emissions from composting sites. The guidance suggests strategies for sampling at open facilities using a fan-like shape arrangement to measure bioaerosols upwind and downwind of an emissions plume, however, the sampling strategy can be amended or modified if wind direction, topography or site layout prevent a fan-like arrangement, or if sampling at the same distance downwind as the distance to the nearest sensitive receptor cannot be undertaken.

The guidance is designed to assess the potential bioaerosol level at the nearest sensitive receptor to the site. It cannot determine if a composting facility presents a risk to the health of people who may live or work near to a site or to assess the occupational exposure of workers who may be engaged in composting activities because satisfactory dose-response data is not available.

2.1 Samples

Sample points are dependent on weather conditions and are chosen with respect to the direction of the wind on the day of monitoring. The sample points used for this evaluation are given in Table 1. Sample locations and relevant wind directions are illustrated on the site map attached as Appendix 1 (Page 10). Deviations from TGN M9 are summarised in Appendix 2 (Page 11).

Table 1: Samples Evaluated (09/12/2021)

Sample Ref.	Position	Distance & Location	Grid Reference
SP1	Upwind	10m SSE of composting pad, 50m SSE of centre of the operational area.	SN 20285 47202
SP2	Downwind 1	Central Traverse, 60m NNW of composting pad, ~80m NNW of centre of the operational area.	SN 20314 47401
SP3	Downwind 2	-30° from Central Traverse 60m WNW of composting pad, ~80m WNW of centre of the operational area.	SN 20282 47387
SP4	Downwind 3	+30° from Central Traverse 60m N of composting pad, ~80m N of centre of the operational area.	SN 20347 47401

2.2 Sampling, Transportation & Storage

Concurrent sampling was carried out in triplicate at each point using personal air sampling pumps calibrated to operate at 2 L/min and SKC IOM samplers containing sterile 25mm 0.8µm polycarbonate filters. The samplers were mounted in a fixed vertical (forward facing) position on tripods 1.6m high and the start and stop times for each pump were recorded.

The exposed filters were aseptically removed from the samplers and placed into 10ml aliquots of sterile physiological saline. Two unexposed filters were aseptically transferred into 10ml of sterile saline solution to form control samples. An electrically controlled coolbox operating at 4°C was used to transport the samples to D&F Associates laboratories where they were placed in a refrigerator and processed the following day.

2.3 Laboratory Enumeration

The samples were shaken and allowed to stand for 10-15 minutes to equilibrate to room temperature. 0.5ml aliquots (BS EN ISO 7218:2007 + A1:2013) were plated onto prepared agar plates containing half strength Nutrient Agar (NA for the enumeration of mesophilic bacteria) and Malt Extract Agar (MEA for the enumeration of *Aspergillus sp.*). Plates to evaluate mesophilic bacteria were inverted and incubated at 37°C. Plates to evaluate *Aspergillus fumigatus* were inverted and incubated at 45°C. All plates were counted after 48 hours.

NA and MEA plates showing fewer than 100 colonies were returned to their respective incubators. Growth for *Aspergillus fumigatus* was rechecked after 3-days and growth for mesophilic bacteria was rechecked after 5-days.

Microbiological growth media was prepared in accordance with BS EN ISO 11133:2014+A2-2020: Microbiology of food, animal feed and water - Preparation, production, storage and performance testing of culture media. Following sterilisation and cooling to 47°C, MEA was treated with Penicillin G Sodium Salt (20 units/ml) and Streptomycin sulphate (40 units/ml), and NA was supplemented with 0.01% w/v cycloheximide (dissolved in <2.0ml acetone). Prepared plates were pre-incubated and quality checked before use.

2.4 Calculation of Results

Exposed filters placed into 10ml aliquots of sterile physiological saline produce microbial suspensions in which the micro-organisms have been diluted by a factor of 10 (*i.e.* 1:10 or 10⁻¹). Dilution allows the number of viable cells in a microbial suspension to be quantified as colony forming units per millilitre (cfu/ml). The number of colonies that develop on microbiological growth media are therefore multiplied by a factor of 10 to estimate the number of organisms captured on a filter (*i.e.* cfu/filter).

The number of colony forming units in one cubic metre of air (cfu/m³) is calculated by dividing 1m³ (or 1000 litres) by the volume of air sampled as m³ (or litres) to provide a calculation adjustment factor. The number of micro-organisms enumerated on a filter is multiplied by the adjustment factor to produce results as cfu/m³. This is shown in the following equation:

$$\text{cfu/m}^3 = \frac{1\text{m}^3}{v\text{m}^3} \times (n \times 10)$$

where,

n = the mean number of cfu quantified in 1.0ml of the filter suspension as received (*i.e.* cfu/ml).

v = the volume of air sampled as m³.

The minimum level of detection (LOD) for airborne micro-organisms is determined by the volume of air sampled. Results that are lower than the minimum LOD are given as <*x* cfu/m³ (*i.e.* less than *x* colony forming units per cubic metre of air where *x* is the minimum LOD based on the volume of air sampled).

2.5 Other Considerations

Equipment, consumables and microbiological growth media were assessed in the laboratory for quality assurance before use or release. Results and records of QA and QC checks are maintained as part of Good Laboratory Practice procedures. IMS was used to sterilise equipment in the field and procedures are followed to prevent external contamination during filter transfer.

3. METEOROLOGICAL/WEATHER CONDITIONS:

Wind speed, wind direction, air temperature and relative humidity were logged at 1-minute intervals using Kestrel 4500 portable weather stations mounted on the sample tripods. There is no weather station at the composting facility.

4. SITE ACTIVITIES:

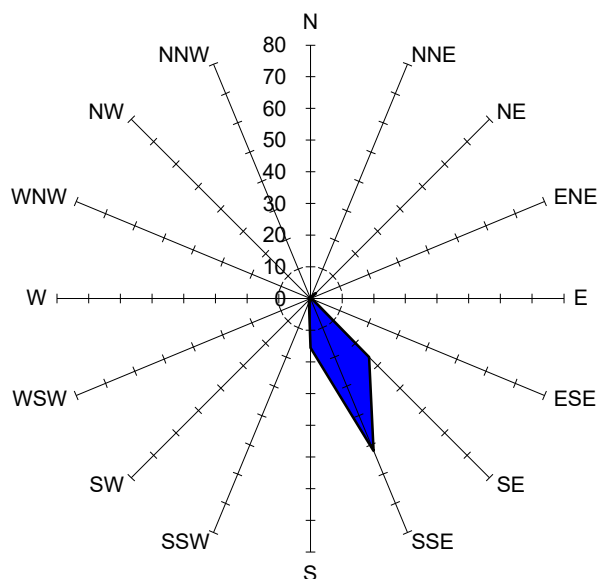
Material movement and product loading operations were in progress during the assessment.

5. RESULTS OF EVALUATION:

5.1 Meteorological Information

Meteorological data recorded at each sample location is summarised in the Meteorological Conditions Table (Page 7). The mean wind direction for the assessment was calculated from 154° (South Southeast), *i.e.* blowing to 334° (North Northwest) using data from the Kestrel portable stations (*i.e.* the conditions 1.6m above ground). Mean wind speeds at a height of 10m have been calculated using the method described on Page 39 of TGN M9. Wind influences were recorded from the North Northeast, Northeast, East Southeast, Southeast, South Southeast, South and South Southwest (Figure 1, Page 4).

Figure 1: Wind Rose Illustrating Mean Direction from the South Southeast.

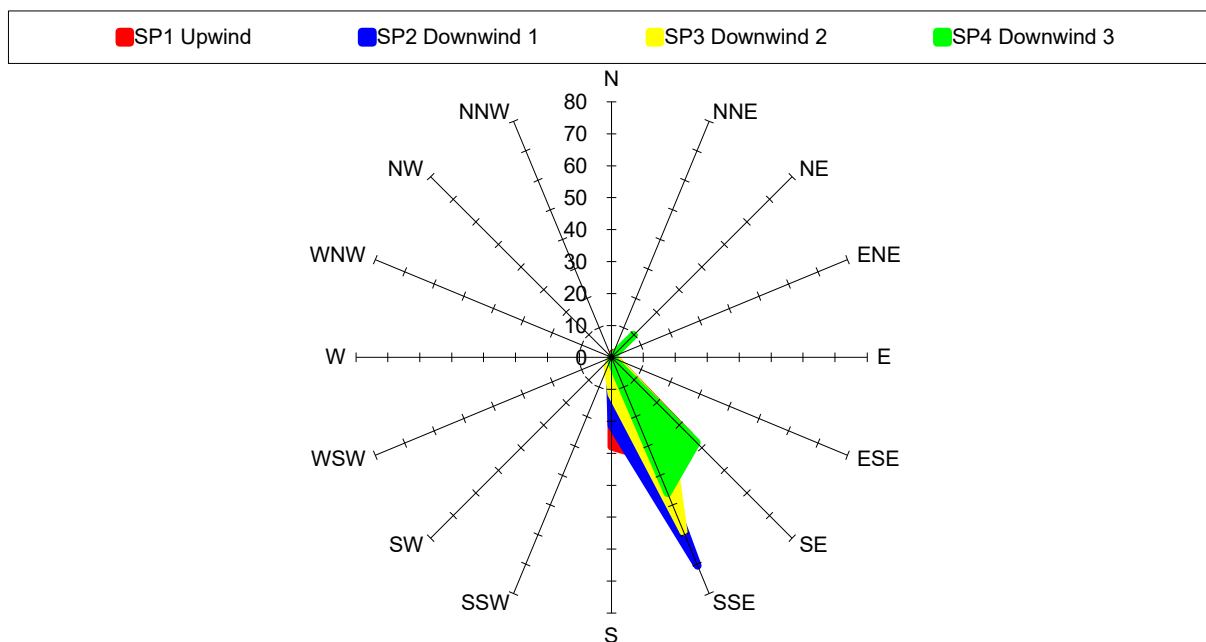


Note: Units in Percentage Contribution. Wind speed ranged from 0.0-4.4 m/s.

Figure 2 illustrates the wind patterns experienced at the sample locations during the sampling periods. The mean wind bearings given in the Meteorological Conditions Table have been calculated using the method described on Page 38 of TGN M9.

Kestrel weather stations record the direction the wind has blown from. The mean wind directions have been converted into the direction the wind blows to by adding or subtracting 180° as described on Page 15 of TGN M9. The mean wind bearing at each sample point may not reflect the bearing calculated for the whole of the assessment. It should be noted that the mean bearing calculated for the assessment may be different than the predominant wind direction. This can be due to the influence of landscape, topography and nearby structures on air movement at the sample location and this should be considered if wind direction patterns at different sampling locations are compared. The calculated mean wind directions are illustrated on the site diagram attached as Appendix 1 (Page 10).

Figure 2: Wind Rose Illustrating Wind Patterns at Sample Locations SP1 - SP4.



The mean wind direction at SP1 (Upwind) was calculated from 152° (South Southeast) and blowing to 332° (North Northwest). Wind influences were recorded from the North Northeast, East Southeast, Southeast, South Southeast and South. Wind speeds were measured within the range 0.6-4.1 m/s with an average wind speed of 2.0 m/s calculated.

The mean wind direction at SP2 (Downwind 1) was calculated from 161° (South Southeast) and blowing to 341° (North Northwest). Wind influences were recorded from the Southeast, South Southeast, South and South Southwest. Wind speeds were measured within the range 1.3-4.4 m/s with an average wind speed of 2.7 m/s calculated.

The mean wind direction at SP3 (Downwind 2) was calculated from 155° (South Southeast) and blowing to 335° (North Northwest). Wind influences were recorded from the East Southeast, Southeast, South Southeast, South and South Southwest. Wind speeds were measured within the range 1.3-3.8 m/s with an average wind speed of 2.5 m/s calculated.

The mean wind direction at SP4 (Downwind 3) was calculated from 142° (Southeast) and blowing to 322° (Northwest). Wind influences were recorded from the Northeast, Southeast, South Southeast and South. Wind speeds were measured within the range 0.0-4.2 m/s with an average wind speed of 2.0 m/s calculated.

5.2 Results for Airborne Micro-organisms

5.2.1 Current Limits (based on Open Windrow Composting Systems)

The Environment Agency considers acceptable bioaerosol levels as;

- i. Those before the start of the composting process, or,
- ii. Bioaerosol levels that are no greater than 1,000 cfu/m³ for total bacteria and 500 cfu/m³ for the thermophilic fungus *Aspergillus fumigatus*.

5.2.2 Microbiological Results

The microbiological results obtained for this assessment are given in the Estimated Concentrations of Airborne Micro-organisms Tables (Pages 8-9).

Upwind (SP1)

Sampling was undertaken 10m South Southeast of the composting pad boundary on an area of earthworks. SP1 was upwind of the composting facility. The median values for mesophilic bacteria and *Aspergillus fumigatus* were each calculated at less than 83 cfu/m³.

Downwind 1 – Central Traverse (SP2)

Sampling was undertaken 60m North Northwest of the composting pad boundary in an open field. SP2 was downwind of material movement and product loading operations. The median values for mesophilic bacteria and *Aspergillus fumigatus* were each calculated at less than 83 cfu/m³.

Downwind 2 – -30° from Central Traverse (SP3)

Sampling was undertaken 60m West Northwest of the composting pad boundary in an open field. SP3 was downwind of material movement and product loading operations. The median value for mesophilic bacteria was calculated at 83 cfu/m³ and at less than 83 cfu/m³ for *Aspergillus fumigatus*.

Downwind 3 – +30° from Central Traverse (SP4)

Sampling was undertaken 60m North of the composting pad boundary in an open field. SP4 was downwind of material movement and product loading operations. The median value for mesophilic bacteria was calculated at 83 cfu/m³ and at less than 83 cfu/m³ for *Aspergillus fumigatus*.

6. CONCLUSIONS & DISCUSSION:

1. Mesophilic bacteria and *Aspergillus fumigatus* were estimated below EA guidance levels upwind and downwind of the composting facility, i.e. SP1, SP2, SP3 and SP4.
2. The results suggest that the AD facility would not have been exposed to composting bioaerosols above EA guidance levels if it had been downwind on the day of the assessment. The AD facility was upwind of the composting facility on the day of the assessment and at very low risk of exposure to composting bioaerosols.

7. SUMMARY:

An assessment of bioaerosols was undertaken on 9th December 2021 at Crugmore Farm Composting Facility using the filter method described in TGN M9 during material movement and product loading operations.

Mesophilic bacteria and *Aspergillus fumigatus* were estimated at acceptable levels upwind and downwind of the composting facility. The maximum median result of the three downwind samples is used to assess the impact

of bioaerosols at the nearest receptor. The results suggest that the AD facility would not have been exposed to composting bioaerosols above EA guidance levels if it had been downwind on the day of the assessment.

8. DISCLAIMER:

Recommendations contained in this report are based on available information at the time of writing and are our opinions only. D&F Associates Limited is unable to take account of any future developments or changes in legislation. The interpretation or use of this report does not relieve the user of the responsibility of understanding the requirements of the appropriate legislation.

All laboratory documentation relating to sampling and testing will be retained for a minimum of 5-years. Measurements as colony forming units per cubic metre of air (cfu/m³) are representative only on the day on which the samples were taken. Concentrations of airborne micro-organisms can vary greatly depending on human and mechanical activities, quality and quantity of material received and processed, time of year and environmental conditions.

METEOROLOGICAL CONDITIONS

Site:	Crugmore Farm Composting Facility	Site Operator:	MD Recycling Ltd
Sampling Date:	09/12/2021	Commissioning Laboratory:	D&F Associates Ltd

Location	Sample Reference Number	Bearing of samplers from centre of operational area or turning/ screening operation (° from true North) Grid Reference	Mean wind direction the wind blows to during the sampling period (° from true North)	Difference in bearing between location of samplers from centre of operational area and mean direction wind blow to (°)	Mean wind speed during sampling		Arithmetic mean of air temperature (°C)	Arithmetic mean of relative humidity (%)	Prevailing weather conditions
					Measured at 1.6m height (m/s)	Calculated at 10m height (m/s)			
Upwind	SP1	150 SN 20285 47202	332	178	2.0 (Range 0.6-4.1)	3.2	6.6	78.1	Cloud cover = 8/8 Dry and overcast.
Downwind 1 Central Traverse	SP2	330 SN 20314 47401	341	11	2.7 (Range 1.3-4.4)	4.4	6.6	81.2	Cloud cover = 8/8 Dry and overcast.
Downwind 2 -30° from Central Traverse	SP3	300 SN 20282 47387	335	35	2.5 (Range 1.3-3.8)	4.1	6.5	77.1	Cloud cover = 8/8 Dry and overcast.
Downwind 3 +30° from Central Traverse	SP4	360 SN 20347 47401	322	38	2.0 (Range 0.0-4.2)	3.3	6.3	77.3	Cloud cover = 8/8 Dry and overcast.

Site Weather Station	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
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N/A = Not Available

ESTIMATED CONCENTRATIONS OF AIRBORNE MICRO-ORGANISMS

Site:	Crugmore Farm Composting Facility	Site Operator:	FCC Environment
Sampling Date:	09/12/2021	Commissioning Laboratory:	D&F Associates Ltd
Date Processed at Laboratory:	10/12/2021		
Estimated Mass of Materials:	1,000 Tonnes	Type of Material Processed:	Mixed Green Waste

Bioaerosol Type:	Mesophilic Bacteria	Site Activity:	Material Movement & Product Loading
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Location/ Sample point	Distance from centre of active area (m)	Sample ref. no.	Sampling start / end times	Concentration of bioaerosols (cfu/m ³)	Median of replicate field samples (cfu/m ³)	Activities affecting concentration of bioaerosols:
Upwind SP1	~50 (~10 boundary)	21L026	10:00:00 / 10:59:59	<83	<83	Location South Southeast of the composting pad on an area of earthworks. SP1 was upwind of the composting facility.
		21L027	10:00:00 / 10:59:59	<83		
		21L028	10:00:00 / 10:59:59	<83		
Downwind 1 SP2 Central Traverse	~80 (not visible) (60 boundary)	21L029	10:00:00 / 10:59:59	<83	<83	Location North Northwest of the pad in an open field. SP2 was downwind of material movement and product loading operations.
		21L030	10:00:00 / 10:59:59	<83		
		21L031	10:00:00 / 10:59:59	<83		
Downwind 2 SP3 -30° from Central Traverse	~80 (not visible) (60 boundary)	21L032	10:00:00 / 10:59:59	167	83	Location West Northwest of the pad in an open field earthworks. SP3 was downwind of material movement and product loading operations.
		21L033	10:00:00 / 10:59:59	<83		
		21L034	10:00:00 / 10:59:59	83		
Downwind 3 SP4 +30° from Central Traverse	~80 (not visible) (60 boundary)	21L035	10:00:00 / 10:59:59	<83	83	Location North of the pad in an open field. SP4 was material movement and product loading operations.
		21L036	10:00:00 / 10:59:59	1,167		
		21L037	10:00:00 / 10:59:59	83		
Control Filter 1	N/A	21L038	00:00:00 / 00:00:00	N/A	<10/filter	N/A
Control Filter 2	N/A	21L039	00:00:00 / 00:00:00	N/A	<10/filter	N/A

N/A = Not Available/ Not Applicable

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ESTIMATED CONCENTRATIONS OF AIRBORNE MICRO-ORGANISMS

Site:	Crugmore Farm Composting Facility	Site Operator:	FCC Environment
Sampling Date:	09/12/2021	Commissioning Laboratory:	D&F Associates Ltd
Date Processed at Laboratory:	10/12/2021		
Estimated Mass of Materials:	1,000 Tonnes	Type of Material Processed:	Mixed Green Waste

Bioaerosol Type:	<i>Aspergillus fumigatus</i>	Site Activity:	Material Movement & Product Loading
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Location/ Sample point	Distance from centre of active area (m)	Sample ref. no.	Sampling start / end times	Concentration of bioaerosols (cfu/m ³)	Median of replicate field samples (cfu/m ³)	Activities affecting concentration of bioaerosols:
Upwind SP1	~50 (~10 boundary)	21L026	10:00:00 / 10:59:59	<83	<83	Location South Southeast of the composting pad on an area of earthworks. SP1 was upwind of the composting facility.
		21L027	10:00:00 / 10:59:59	<83		
		21L028	10:00:00 / 10:59:59	<83		
Downwind 1 SP2 Central Traverse	~80 (not visible) (60 boundary)	21L029	10:00:00 / 10:59:59	<83	<83	Location North Northwest of the pad in an open field. SP2 was downwind of material movement and product loading operations.
		21L030	10:00:00 / 10:59:59	<83		
		21L031	10:00:00 / 10:59:59	<83		
Downwind 2 SP3 -30° from Central Traverse	~80 (not visible) (60 boundary)	21L032	10:00:00 / 10:59:59	<83	<83	Location West Northwest of the pad in an open field earthworks. SP3 was downwind of material movement and product loading operations.
		21L033	10:00:00 / 10:59:59	83		
		21L034	10:00:00 / 10:59:59	<83		
Downwind 3 SP4 +30° from Central Traverse	~80 (not visible) (60 boundary)	21L035	10:00:00 / 10:59:59	<83	<83	Location North of the pad in an open field. SP4 was material movement and product loading operations.
		21L036	10:00:00 / 10:59:59	<83		
		21L037	10:00:00 / 10:59:59	<83		
Control Filter 1	N/A	21L038	00:00:00 / 00:00:00	N/A	<10/filter	N/A
Control Filter 2	N/A	21L039	00:00:00 / 00:00:00	N/A	<10/filter	N/A

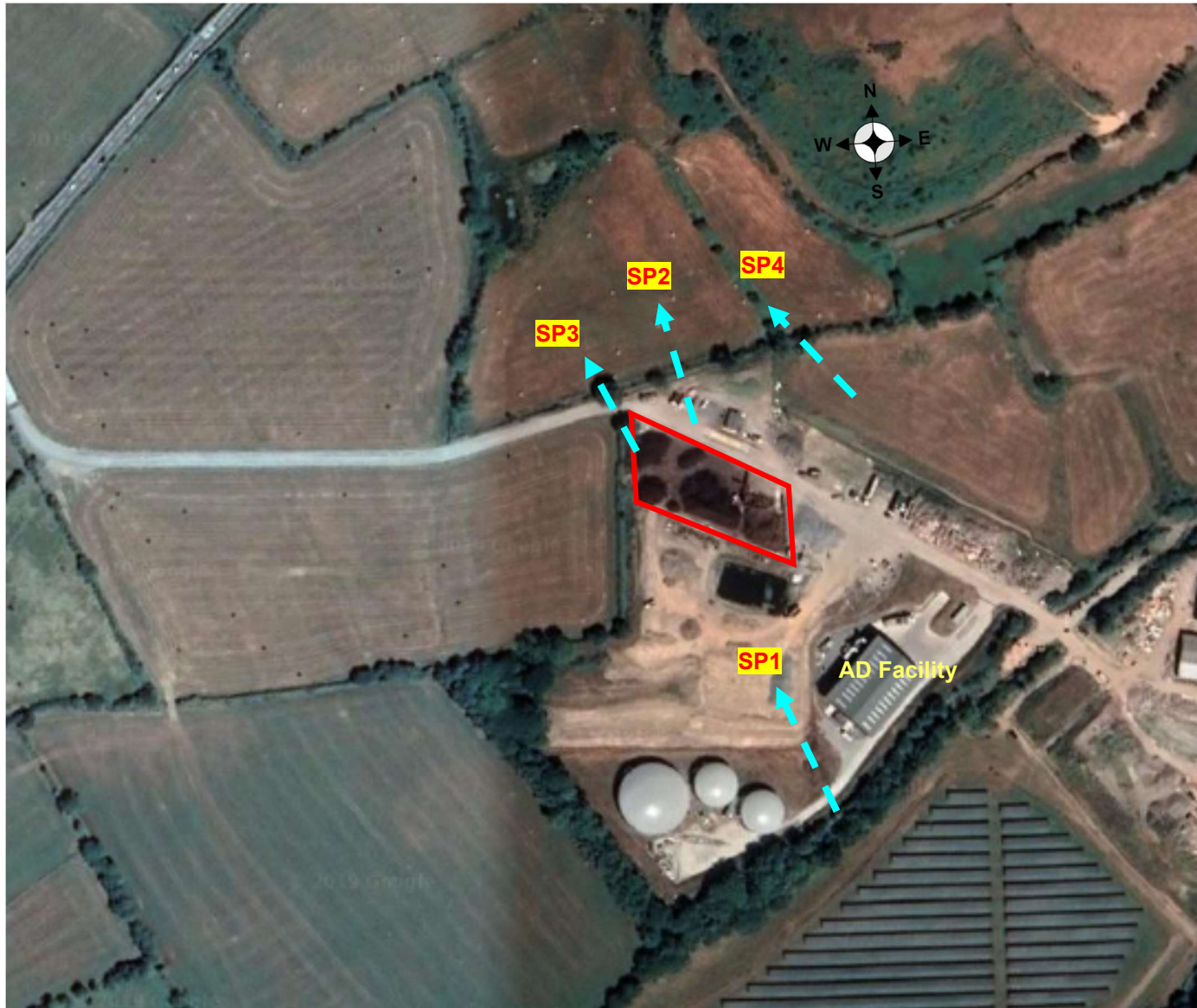
N/A - Not Available/ Not Applicable

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Appendix 1: Illustration of Sample Points Evaluated at Crugmore Farm Composting Facility on 9th December 2021



Illustrates Calculated Mean Wind Direction at Sample Point — — — — — Indicates Compost Pad Boundary — — — — —

Appendix 2: Summary of Deviations from the EA Technical Guidance Note M9

Deviation	Reason for the Deviation/Amendment
Sample points determined from wind direction upwind of site in an exposed position.	Weather Conditions – There is no site weather station. Wind direction was determined from the upwind sampling location at an exposed position.
Filters transferred into physiological saline prior to transportation.	Cell Viability - D&F Field Staff trained to carry out aseptic handling and filter transfer without loss or affect to bioaerosol sample. Filters are transferred to support the viability and recovery of stressed micro-organisms. Control filter samples generated during field transfer operations to confirm and qualify aseptic handling technique (TGN M9 section 6.2.2).
Two 0.5ml aliquots of filter suspension evaluated.	Cell Viability & Recovery - Agar plates are dried before use in accordance with D&F Associates Ltd GLP and QA procedures. 0.5ml aliquots are absorbed into the surface of agar plates within 15-minutes of spreading. The additional liquid volume prevents desiccation and splitting of the agar plate during extended incubation at 37°C and 45°C (TGN M9 section 6.2.4 and BS EN ISO 7218:2007 + A1:2013).
Mesophilic bacteria enumerated at 5-days.	Cell Viability & Recovery - Nutrient agar plates show signs of desiccation after incubation at 37°C for 5-days. This can influence the recovery of viable micro-organisms from samples. Plates counted at 5-days (TGN M9 section 6.3).
Measurement uncertainty.	Based on the technical specifications of the sampling and calibration equipment used for this assessment, the measurement uncertainty for each result is $\pm 7.5\%$.