REPORT

Odour impact assessment of the permitted installation at Afan WwTW

Client:
Dwr Cymru Welsh Water

Report Number:
DCWW22E_EPR_04_Afan

Project Code:
DCWW22E

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Executive Summary

Dŵr Cymru Welsh Water (DCWW) are currently applying to Natural Resource Wales (NRW) for an EPR[1] permit for the sludge digestion operations at Afan WwTW. The permit is required following reinterpretation of the Industrial Emissions Directive (IED) which brings such processes into the Environmental Permitting regulatory regime.

To support the permit application, an odour impact assessment was conducted to evaluate the risk of odour impact of the permitted activities on nearby sensitive receptors. The impact assessment was conducted in accordance with the requirements of odour guidance published by Natural Resource Wales (NRW)[2], using dispersion modelling techniques which have an established history of application for assessing odour impact in the UK. The dispersion model included all sources of odour associated with the permitted operations which have the potential to travel offsite. Odour emissions from each source were defined using a combination of site-specific survey data (olfactometry) and library data collected from other waste-water treatment processes by Olfasense.

The results of the survey and impact assessment were then used to identify improvement measures which are required to mitigate any impact risk identified and achieve compliance to the requirements of BATC for odour control, as defined in the Best Available Techniques (BAT) Reference Document for Waste Treatment, August 2018. These requirements are summarised below:

- BAT12 requires implementation and regular review of an Odour Management Plan (OMP).
- BAT14(A) requires '*minimisation of the number of diffuse (odour) emission sources*' (e.g. ensuring odorous materials which pose a risk of impact are contained or conducted within a building).
- BAT14(B) requires selection of high integrity equipment such as pipework, pumps and gaskets and to minimise leakage of odours or odorous materials.
- BAT14(D) requires containment, collection and treatment of diffuse emissions including control of odours by '*maintenance of an adequate pressure*' within buildings or enclosures and '*directing emissions to an appropriate abatement system'.*
- BAT34 requires a reduction in channelled *'emissions to air of dust, organic compounds and odorous compounds'* to meet specific Achievable Emission Levels (BAT-AELs). E.g. odour treatment systems.

The findings of the assessment are as follows:

1. The main contributors to odour from the permitted area which have the potential to travel offsite are as follows:

[1] Environment Permitting Regulations (England and Wales) 2016
[2] H4 Odour Management, Environment Agency, March 2011

   a. Intermittent emissions released during regeneration of the Siloxane filter,
   b. Intermittent diffuse emissions during delivery of imported sludge cake.
   c. Emissions from the digested sludge cake storage pad and export activities.

   The odours released from all of the above sources except the digested sludge cake are classified as highly offensive.

2. The odour exposure levels predicted by the dispersion model outside the site boundary fall below the level that is expected to pose a risk of odour impact due to the low sensitivity of the industrial receptors immediately surrounding the site. It is likely that intermittent high concentration odours released from the importation of raw sludge and periodic regeneration of the siloxane filter could lead to elevated short term exposure levels which pose a risk of impact beyond the area indicated in by the model. However, no odour complaints are understood to have been linked to the site in within the last 3 years.

3. The low level of risk posed by the site in terms of offsite impact implies that further enhancements to odour control are unlikely to be necessary from a risk management perspective. However, the following improvements are required to achieve full compliance to the requirements of BATc. It is recommended that DCWW consult with NRW to assess whether all such measures are required in this case due to low risk profile of the site.

   a. Prepare and implement an Odour Management Plan (OMP) for the permitted operations.
   b. Change the carbon media of OCU 1 so that the unit achieves the BAT-AEL of 1,000 ou_E/m^3 (BATc34).
   c. Investigate the feasibility of enclosing the imported sludge delivery operation in a building to reduce diffuse emissions and maintain the building under negative pressure by extraction to an appropriate odour treatment system (BATc14A and BATc14D).
   d. Investigate the feasibility of installing an abatement system to treat odours from the siloxane filter during periodic regeneration (BATc34).

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1 Introduction and Scope

1.1 Background

Dŵr Cymru Welsh Water (DCWW) are currently applying to Natural Resource Wales (NRW) for an EPR[3] permit for the sludge digestion operations at Afan WwTW. The permit is required following reinterpretation of the Industrial Emissions Directive (IED) which brings such processes into the Environmental Permitting regulatory regime.

As part of the application, NRW have requested a quantitative odour impact assessment be conducted to assess the current risk of impact posed by the permitted processes on nearby sensitive receptors and whether further measures are required to minimise such risk, in keeping with the requirements of the NRW's odour guidance H4[4] and BAT as defined in the 2018 waste treatment BAT reference document (BREF).

Olfasense UK Ltd were commissioned to undertake the assessment

1.2 Odour control requirements under EPR

Under the Environmental Permitting Regulations 2016 (EPR), operators of permitted processes must ensure compliance to the odour condition contained within the permit. The typical form of this odour condition is as follows:

'Emissions from the activities shall be free from odour at levels likely to cause pollution outside the site, as perceived by an authorised officer of Natural Resources Wales, unless the operator has used appropriate measures, including, but not limited to, those in an approved odour management plan, to prevent or where that is not practicable to minimise the odour.'

The operator must therefore employ appropriate measures to prevent odour pollution (at nearby sensitive receptors) or minimise it where prevention is not practicable.

For wet anaerobic digestion processes, appropriate measures are defined in the form of BAT conclusions (BATC), which were published in the Waste Treatment BAT Reference Document (BREF) in August 2018[5]. In addition to implementation and regular review of an Odour Management Plan (OMP) the BAT conclusions which are relevant to odour are as follows:

- BAT14(A) requires '*minimisation of the number of diffuse (odour) emission sources'* (e.g. ensuring odorous materials which pose a risk of impact are contained or conducted within a building).
- BAT14(B) requires selection of high integrity equipment such as pipework, pumps and gaskets and to minimise leakage of odours or odorous materials.

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[3] Environment Permitting Regulations (England and Wales) 2016
[4] H4 Odour Management, Environment Agency, March 2011
[5] Best Available Techniques (BAT) Reference Document for Waste Treatment Industrial Emissions Directive 2010/75/EU (Integrated Pollution Prevention and Control) Antoine Pinasseau, Benoit Zerger, Joze Roth, Michele Canova, Serge Roudier 2018

- BAT14(D) requires containment, collection and treatment of diffuse emissions including control of odours by '*maintenance of an adequate pressure*' within buildings or enclosures and 'directing emissions to an appropriate abatement system'.
- BAT34 requires a reduction in channelled '*emissions to air of dust, organic compounds and odorous compounds, including H2S and NH3*' to meet specific Achievable Emission Levels (BAT-AELs). E.g. odour treatment systems.
- A general requirement to provide an equivalent level of environmental protection by demonstrating compliance to odour exposure benchmarks at nearby sensitive receptor(s), as determined through odour dispersion modelling**.**

Determining what measures are appropriate is also dependent upon site specific circumstances and should take cost and benefits into account. In some circumstances, it may be necessary to apply additional measures that go beyond BATC if risk of offsite pollution is high. Conversely, if it can be demonstrated that the risk of impact of a given odour source is low, a lower level of control may be justified.

Odour dispersion modelling is a key tool to establish the risk of impact and inform this decision making process, as referenced in Appendix 3 of H4. The general concept behind modelling is to establish what combination of measures provides an equivalent level of protection to no offsite odour pollution, by reference to odour exposure benchmarks which are published in H4 and in other informative guidance by third parties e.g. the institute of Air Quality Management (IAQM).

1.3 Scope

The scope of the assessment was as follows:

1. Review of the operations undertaken within the permitted area and identify the activities within the area which are likely to generate odour emissions.
2. Measure the odour emissions from the key elements of the site and estimate the odour emissions generated from each of the identified sources under normal operating conditions.
3. Assess the exposure levels that are likely to occur offsite and at nearby sensitive receptors using a dispersion model and evaluate the risk of impact using the most appropriate odour exposure benchmark defined in H4 and other relevant guidance.
4. Identify the measures that are likely to be required to minimise odour impact and comply with the requirements of BATC.

Full details of each stage and the assumptions applied are presented in the remainder of this report.

1.4 Approach

1.4.1 Overview

The first stage of the study involved a review of the site operations to identify activities and processes that have the potential to generate odour emissions. This was followed by an odour survey using 'at-source' sampling and analysis techniques to measure the odour emissions from each element of the sewage treatment process and evaluate the performance of the existing Odour Control systems. Where relevant, smoke testing was also used on selected sources to assess the containment effectiveness of buildings containing odorous plant.

The data collected during the survey was used in combination with reference data from Olfasense's odour emission database to estimate the odour emissions generated from each odour source and define a site odour emission inventory. In defining the emission estimates, consideration was given to the following influencing factors where relevant:

- Liquid turbulence.
- The frequency and duration of release of intermittent activities.

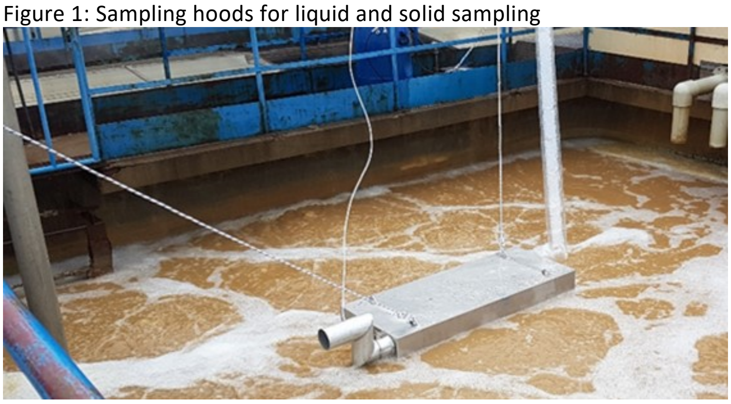
The emission inventory was input into an odour dispersion model and used to assess the odour exposure levels which may occur around the site under current operational conditions. The model used for the study was the US EPA BREEZE AERMOD dispersion model which was established in accordance with relevant guidance issued by the US Environmental Protection Agency (EPA) and other relevant authorities.

The results of the modelling were presented in the forms of maps identifying the areas around the site that are exposed to odour levels that correspond to relevant odour impact criteria.

1.4.2 Samling and analysis techniques

Air samples from each source were collected using standardised techniques based on the European Standard for Olfactometry BSE EN 13725[6]. For liquid and solid sources, a ventilated sampling hood was used to isolate the source from the atmosphere as indicated in Figure 1.

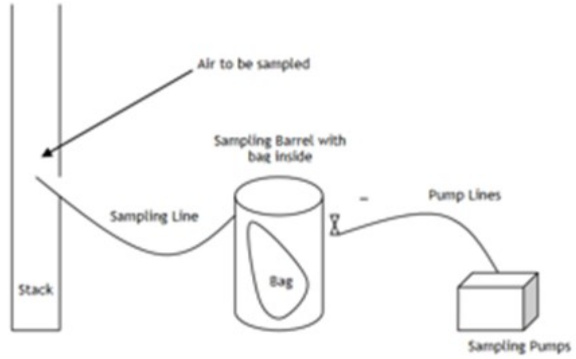
Figure 1: Sampling hoods for liquid and solid sampling



For duct sources, samples were collected using the 'lung principal' as illustrated in Figure 2 below.

[6] BS EN 13725: 2003 - Air Quality: Determination of odour concentration by dynamic olfactometry.

Figure 2: Sampling from ductwork and enclosed tanks/buildings

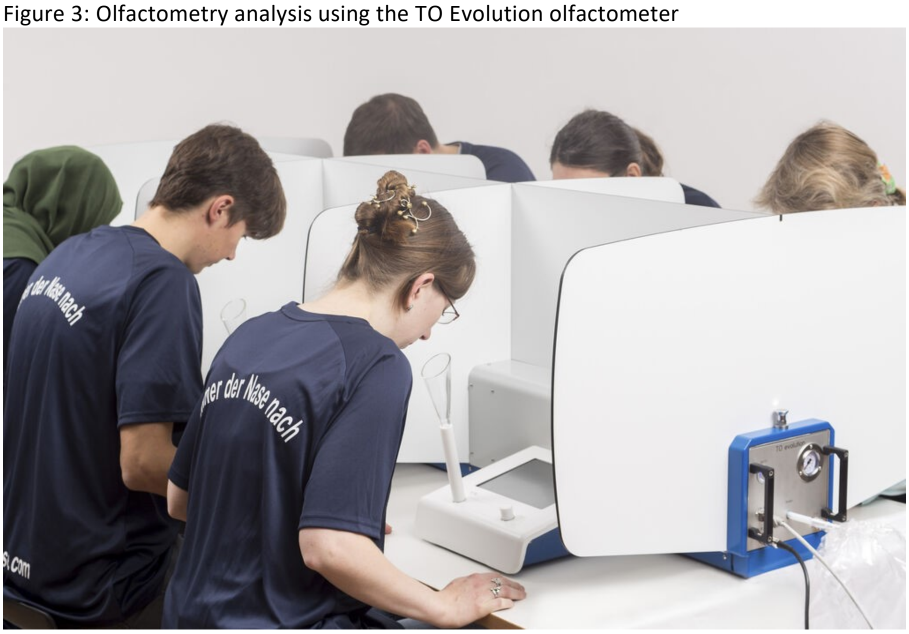


Air flow measurements were also conducted for duct or stack type sources using anemometers or pitot tubes in accordance with the standard ISO 10780[7], where possible.

1.4.3 Analysis Techniques

Odour analysis was conducted by olfactometry using a state of the art TO-Evolution™ olfactometer in full accordance with the procedures defined in BS EN 13725, using 4 to 6 No. qualified and trained odour panellists. In addition, hydrogen sulphide and ammonia were measured using a Jerome gold film analyser (H_2S) and colorimetric detector tubes (H_2S & NH_3), on select odour sources an assessment of the character and relative offensiveness of the odour was conducted using in house sensory assessment techniques.

Figure 3: Olfactometry analysis using the TO Evolution olfactometer



1.5 Quality Control and Assurance

The study was conducted by experienced odour assessment specialists and in accordance with quality management procedures that are certified to ISO 9001 (Certificate No. A13725). Odour

[7] Stationary Source Emissions: Measurement of velocity and volume flow rate of gas streams in ducts.

sampling and olfactometry analysis was undertaken using UKAS accredited procedures (UKAS Testing Laboratory No. 2430) which comply fully with the requirements of the international quality standard ISO 17025:2017[8] and the European standard for olfactometry BS EN 13725:2003[9]. Opinions and interpretations expressed herein are outside the scope of UKAS accreditation.

[8] ISO 17025:2017 – General requirements for the competence of testing and calibration laboratories.
[9] BS EN 13725:2003 – Air quality. Determination of odour concentration by dynamic olfactometry.

2 Site details

2.1 Site location

Afan Wastewater Treatment Works (WwTW) is located within the Port Talbot Steelworks area to the south of the Port Talbot urban area. The works is bounded to the north and east by Port Talbot Steelworks, with Magam Sands and Swansea Bay to the south and west.

The nearest potentially odour sensitive receptors to the site are isolated industrial premises which are located to the north and west of the works, and the Associated British Ports Port Talbot land to the west northwest. Due to the nature of the activities conducted in these areas, their sensitivity to odour emissions from the WwTW is likely to be low.

The nearest residential properties are located approximately 2.5 Km to the north northwest in Aberavon, and to the north northeast and northeast in Taibach (2 Km) and Margam (2 Km) respectively, both located along the A48.

The site location in relation to the nearby sensitive receptors is illustrated in **Error! Reference s ource not found.** below. Residential receptor areas are shaded in blue and the industrial receptors in orange.

Figure 4: Site location

2.2 Overview of site operations

The site treats a combination of domestic and trade sewage flows from the Port Talbot catchment area with a population equivalent of approximately 12,500 pe. The site also receives imports of sludge cake from other DCWW Wastewater treatment sites in South Wales. The incoming sewage flows are conveyed to the works via a number of offsite pumping stations and rising mains.

The WwTW treats a flow to full treatment (FTFT) of 1,250 l/s and broadly comprises the following: preliminary treatment plant including screens and grit removal which is followed by a Sequential Batch Reactor (SBR) primary/secondary treatment process. Treated sewage from the SBRs is discharged to the sea via the sea outfall. Surplus Activated Sludge from the SBR’S and imported sludges are treated in a Thermal Hydrolysis Plant (THP) prior to wet anaerobic digestion. The resultant digested sludge is then dewatered and conveyed offsite as sludge cake.

2.3 Permitted activities

2.3.1 Permit boundary

The area of the site that is to be included within the IED permit (green boundary) is outlined in Figure 5 below and includes sludge cake imports, storage and processing plant, plant associated with the wet anaerobic digestion process, including biogas storage, treatment and utilisation, digested sludge dewatering, storage and export, and 2 No. Odour Control Units (OCUs).

Figure 5: Location of permit boundary

2.3.2 Permitted process description

Imported sludge cake is delivered to the site by road and is received into the cake import centre, which comprises 2 No. enclosed hoppers, both of which are extracted to OCU1. The imported cake is then transferred to the Thermal Hydrolysis Plant (THP) feed silo where it combines with indigenous sludge cake previously held within the indigenous sludge cake silo. Both the indigenous and THP feed silos are also extracted to OCU1.

The mixed sludge cake within the THP feed silo is then conveyed through the THP and into 2 No. anaerobic digestors. The digested sludge is then pumped to an open aerated digested sludge holding tank prior to dewatering.

Dewatering is provided by 4 No. belt presses housed within the post THP belt press building, and the resultant dewatered sludge cake is discharged into 4 No. cake bays prior to transfer to the main cake pad and subsequently exported off site by road trailer. Each of the belt presses and the cake bays are extracted to OCU2.

Biogas generated from the wet Anaerobic Digestion process is stored in 2 No. dual membrane gas storage bags. The biogas is then transferred to the Combined Heat and Power (CHP) Engines where it is combusted in 2 No. spark ignition engines with a rated thermal input of 3.745 MW each (1.56 MW_e output). The CHP engines are used to generate electricity via an alternator and heat via the engine exhaust and cooling jacket. Electricity produced is used by the WwTW with any surplus transferred to the distribution network.

High grade heat is recovered from the CHP engine exhaust and used to generate low pressure steam, whilst low grade heat from the cooling jacket is used to generate hot water for reuse in the Advanced Digestion process. Additional heat demand is met by 2 No. supplementary fired waste heat boilers (3.9 MW_{th} each), which are fuelled by natural gas or biogas.

The biogas is treated prior to combustion by a dedicated Siloxane removal unit which regenerates daily for 4 No. hours starting at midnight.

A waste gas burner is also available to flare off excess biogas.

The IED permit includes the following assets:

- 1 No. indigenous cake silo.
- 2 No. import hoppers.
- 1 No. THP feed silo.
- THP process including pulpers, reactors and flash tanks.
- 2 No. anaerobic digestors.
- 1 No. digested sludge holding tank.
- 4 No. digested sludge belt presses.
- 4 No. digested sludge cake bays.
- 1 No. digested sludge storage pad.
- 2 No. CHP engines.
- 2 No. dual membrane gas holders.
- 1 No. enclosed flare.
- 1 No. regenerative Siloxane filter.
- 2 No. Odour Control Units (OCUs)

2.3.3 Odour control systems

The following odour control systems are installed:

Table 1: Odour Control Units

Odour control unit reference	Technology	Processes served

OCU 1	2 stage system comprising a biofilter followed by a carbon adsorber.	Imported sludge hoppers, indigenous cake silo and THP feed silo.
OCU 2	1 stage system comprising an acid scrubber for ammonia removal.	Digested sludge belt presses, sludge cake bays.

2.1 Odour complaints

It is understood that no odour complaints have been linked to the site in the last three years.

3 Review of odour sources and estimation of emissions

3.1 Potentially significant odour sources

The following potential odour sources were identified within the permitted boundary during the site review and survey. No significant emissions were identified from any other elements of the site.

Table 2: Odour sources

Potential odour source	Odorous material	Control measures	Emission type	Frequency and duration of release
Imported sludge cake delivery	Raw sludge cake	None	Diffuse	Intermittent
Digested sludge holding tank	Digested sludge	None	Diffuse	Continuous
Post THP belt press building	Digested sludge	Enclosed belt presses extracted to OCU	Fugitive	Continuous
Digested sludge cake storage bays	Digested sludge cake	Semi-enclosed bays, extracted to OCU	Diffuse	Continuous
Digested sludge cake storage pad	Digested sludge cake	Semi-enclosed cake barn	Diffuse	Continuous
Digested sludge cake export	Digested sludge cake	None	Diffuse	Intermittent
Siloxane filter	Regeneration off-gas	Dispersion stack	Channelled	Intermittent
OCU 1 (sludge)	Odorous process air	2 stage treatment	Channelled	Continuous
OCU 2 (Acid scrubber)	Odorous process air	1 stage treatment	Channelled	Continuous

Source types: Diffuse: emissions released direct to atmosphere; fugitive: leakage from tanks or buildings; Channelled: emissions released through a vent or stack.

No other significant odour sources were identified. The other raw sludge holding tanks, anaerobic digestors and gas storage systems appeared to be well contained and the emissions from the CHPs and boilers were not considered to be odorous. No significant emissions were detected in the centrifuge building.

It is possible that incidental emissions from other areas may also occur from time to time in the event of process failure or plant breakdown. However, such emissions will be minimised through adoption of the measures as described in the site Odour Management Plan (OMP) and hence have not been included in the impact assessment.

3.2 Odour composition and offensiveness

The odours generated from sewage sludge comprises a wide range of odorous organic and inorganic volatile compounds. The precise composition can vary depending upon the type of sludge, age and level of decomposition, but generally include aldehydes, ketones, fatty acids, esters, alcohols, amines, and reduced sulphur compounds, as well as hydrogen sulphide and ammonia. Raw sludge odours are generally considered to be highly offensive and have a sulphidic and faecal character. Aerobic activated sludge and digested sludges tend to be considered moderately offensive with a more earthy and ammonia like character.

3.3 Site odour emission hierarchy

A breakdown of the estimated 'time weighted' odour emissions from the permitted area is presented in the table below. Further details of the sources, survey data and the specific odour emission assumptions are presented in Annex B.

Table 3: Contribution of time weighted emissions from each aspect of the permitted treatment process

Source	Odour emission [ou_E/s]	Contribution to total site emissions [%]	Offensiveness
Imported cake delivery	1,125	8.0%	High
Digested sludge holding tank	329	2.3%	Moderate
Post THP belt press building	1,084	7.7%	Moderate
Sludge cake storage bays (inc. cake agitation)	623	4.4%	Moderate
Sludge cake storage and export	1,991	14.2%	Moderate
Siloxane filter regeneration	7,466	53.3%	High
OCU 1 (Sludge)	744	5.3%	High
OCU 2 (Acid scrubber)	649	4.6%	Moderate
Total	**14,011**	**100.0%**	**-**

Review of the table above indicates that the total time-weighted odour emission rate from the permitted sludge processing operations is estimated at approximately 14,000 ou_E/s.

The main contributors to the site emissions are as follows:

- Diffuse emissions of highly offensive odour during the importation of raw sludge cake. Since this activity is intermittent, the time weighted figures in Table 3 above understate their potential importance in terms of contribution. On average, the instantaneous emissions from this activity are estimated to be in the region of 21,000 ou_E/s and potentially contribute significantly to offsite exposure when the operations occur.
- Emissions of highly offensive odours during the siloxane filter regeneration which occurs for around 4 hours per day. The contribution of these emissions when they occur is also understanded in the table above for the same reasons stated for imported sludge delivery. The instantaneously emission rate is in the order of 50,000 ou_E/s.
- Diffuse emissions of moderately offensive odours associated with the storage and export of digested sludge cake, held within the individual storage bays and the main cake pad.

Highly offensive odours are also generated from OCU 1 as the carbon media has reached the end of its operational life and has started to desorb odorous VOCs back into the airstream.

4 Dispersion modelling

4.1 Model assumptions and input data

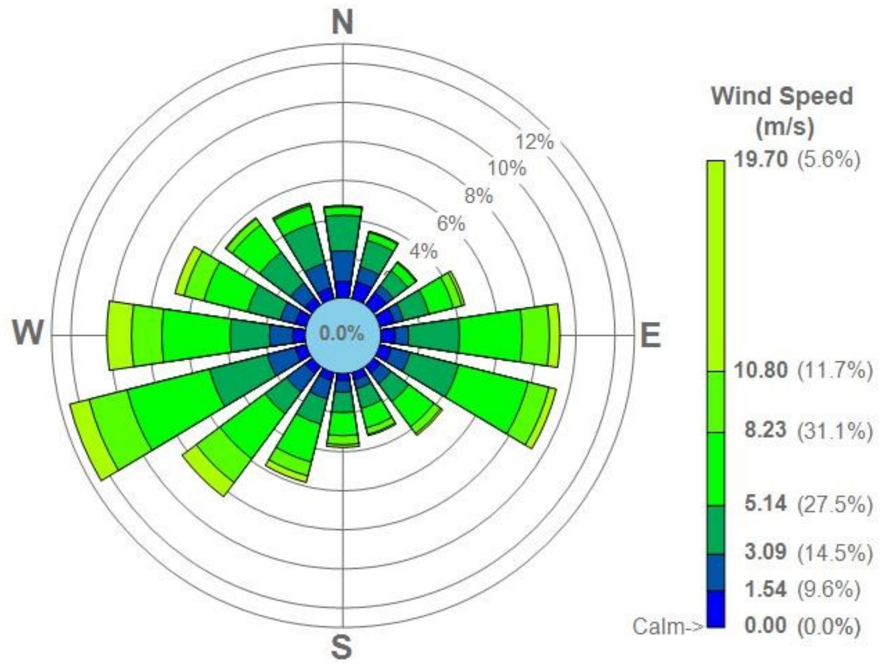
4.1.1 Metrological data

Sequential hourly average Numerical Weather Prediction (NWP) meteorological data for the years 2017-2021 was utilised for the study.

The data provided is provided by a specialist supplier[10] and is generated using the Weather Research and Forecasting Model (WRF), processed in accordance with the AERMOD implementation guide[11] issued by the US EPA.

The wind rose for the meteorological data utilised in the study is presented below.

Figure 6: NWP wind rose for Afan WwTW - 2017-2021 – AERMOD surface file



4.1.2 Receptor grid

Two uniform cartesian receptor grids were defined for the study area comprising a total of approximately 2,750 gridded receptors.

The main grid was approximately 2.3 x 2.6 km, comprising approximately 2,450 gridded receptors with a 50 m receptor spacing (southwest extent of 274600, 185600). The course grid for the wider domain area to the northeast was approximately 2.7 x 2.3 km, comprising approximately 300 gridded receptors, with a 150 m receptor spacing (southwest extent of 275150, 186850).

[10] Meteosim, S.L

[11] AERMOD Implementation Guide, Published by the US EPA, Last Revised: June 2022

All receptors were assigned a 1.5 m flagpole height.

In addition, specific (discrete) receptors were also included in the model at the nearest sensitive locations to the site as indicated in Figure 7 and Table 4.

Figure 7: Location of discrete receptors

Table 4: Details of discrete receptors included within dispersion model

Ref.	Nature of receptor	Land-use	Distance to site [m]	Sensitivity to odour
A	Associated British Ports	Commercial	1,500	Medium
B	Offices	Mixed commercial/industrial	450	Medium
C	Industry & supporting offices	Commercial/industrial	350	Low/medium
D	Sinter Plant (inc. offices)	Commercial/industrial	650	Low/medium
E	Industry & supporting offices	Commercial/industrial	850	Low/medium
F	Llewellyn's Road	Mixed commercial	1,700	Medium
G	West End Road	Residential	1,800	High
H	Tal-Y-Wern	Residential	1,800	High
I	Industry & supporting offices	Commercial/industrial	1,050	Low/medium

4.1.3 Model settings

The model was run without considering any urban heat island effects. A review of land use in the vicinity of Afan WwTW, in line with procedures detailed in the AERMOD Implementation Guide, indicated that the site is in a non-urban setting.

Data describing the topography of the area surrounding the works was obtained from Ordnance Survey in Landform Panorama™ format and processed through the AERMAP terrain processing module of AERMOD to define elevations and hill height data for all receptors, buildings, and emission sources within the model.

4.1.4 Buildings and stacks

The following buildings were included in the model. The AERMOD Building Profile Input Parameters (BPIPRPIME) subprogram was run to calculate the potential for building downwash on each emission source in each of the 36 wind direction sectors (10° width/sector). This data is used in AERMOD to calculate plume downwash (i.e. adjusted plume centreline due to building wake affects). The effect of building downwash is considered for point sources.

Table 5: Buildings included within the model

Building	Coordinate of corner or centre		Height above ground level [m]
	X	Y	
MCC and Centrifuge building	276146	187350	11
CHP building	276111	187349	19
Cake barn	276188	187312	9
Belt pressure building	276171	187301	16
SAS tank	276181	187368	2
Kiosk	276189	187356	2
THP plant	276144	187312	7
Cabin/office	276077	187315	2
Admin buildings	276067	187328	5
Tank	276193	187359	4
OCU 1 - Bioscrubber	276168	187355	6
OCU 1 - Carbon filter	276171	187351	2
OCU 2 - Scrubber tower	276175	187359	7
Indigenous cake silo	276145	187344	11
THP feed silo	276151	187335	15
Digested sludge holding tank	276135	187304	9
Primary digester	276120	187286	20
Primary digester	276100	187276	20
Gas holder	276088	187294	14

4.2 Odour impact criteria

The Environment Agency publication entitled H4 Odour management defines three indicative odour impact benchmarks that can be used to assess odour impact risk under EPR[12]. The criteria are expressed in terms of a modelled odour exposure at the 98th percentile of hourly average concentrations over a typical year (notation: $C_{98,\ 1\text{-hour}}$).

Table 6: Environment Agency odour impact risk benchmarks

Benchmarks	Modelled exposure level	Example
High or most offensive odours	$C_{98,\ 1\text{-hour}} \geq 1.5\ ou_E/m^3$	Rotten animal, septic sewage
Medium or moderately offensive odours	$C_{98,\ 1\text{-hour}} \geq 3\ ou_E/m^3$	Aerobic green waste composting
Low or least offensive odours	$C_{98,\ 1\text{-hour}} \geq 6\ ou_E/m^3$	Confectionery, bakery

Exceedance of these benchmarks indicates that there may be a risk of unacceptable pollution at odour sensitive receptors. Hence, the objective under EPR is to demonstrate that odour control measures at a given site are sufficient to prevent exceedance under normal operating conditions.

On the basis of Olfasense experience, odours from sludge treatment facilities are generally classified as highly offensive unless the sludge has undergone treatment such digestion, is very fresh and maintained in an aerobic state (e.g. fresh activated sludge), or the odours have been treated in an abatement system prior to release e.g. a biofilter or carbon adsorber.

However, it is also important to note the H4 criteria are designed for application to highly sensitive residential receptors. As a result, the use of the criteria for commercial/industrial receptors is likely to overstate the impact.

The H4 guidance provides provision to adjust criteria to reflect the lower sensitivity. However, no precise framework is defined. Research conducted on behalf of the EA in 2002 indicates that the difference in impact criteria between receptor sensitivity categories (e.g. from high to moderate) is likely to be in the region of a factor 2.

Odour impact criteria published in odour guidance prepared by the Institute of Air Quality Management (IAQM)[13] in July 2018 provides a more refined and explicit approach for determining the odour impact criteria for receptors with different sensitivities. Under this guidance, a stepped approach in impact criteria is applied to reflect odour offensiveness and receptor sensitivity as follows:

- For highly sensitive receptors such as residential properties the odour exposure criterion which is expected to result in a significant adverse impact are $C_{98,\ 1\text{-hour}} \geq 1.5$ for highly offensive odours and $C_{98,\ 1\text{-hour}} \geq 3\ ou_E/m^3$ for moderately offensive odours.
- For moderately sensitive receptors, such as offices, the odour exposure criterion which is expected to result in a significant adverse impact are $C_{98,\ 1\text{-hour}} \geq 3$ for highly offensive odours and $C_{98,\ 1\text{-hour}} \geq 5\ ou_E/m^3$ for moderately offensive odours.

[12] Environment permitting: H4 odour management. Published 2014.
https://www.gov.uk/government/publications/environmental-permitting-h4-odour-management
[13] Guidance for the assessment of odour for planning, IAQM, Version 1.1, July 2018.

- For low sensitivity receptors, such as industrial premises, the odour exposure criterion which is expected to result in a significant adverse impact are $C_{98,\ 1\text{-hour}} \geq 5$ for highly offensive odours, and $C_{98,\ 1\text{-hour}} \geq 10$ ou_E/m^3 for moderately offensive odours.

For the purposes of this assessment, it is assumed that all odours are highly offensive to provide a precautionary assessment.

5 Results of dispersion modelling

5.1 Model output

The results of the dispersion modelling are presented in Figure 8 below. The figure presents isopleths encompassing the area where odour exposure levels are predicted to exceed $C_{98,\ 1\text{-hour}}$ = 1.5, 3 and 5 ou_E/m^3 for greater than 2% of the hours in the year, for the meteorological years 2017-2021 under the current normal operational conditions.

Figure 8: Results of odour dispersion modelling under normal operational conditions

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Table 7: Exposure levels predicted at discrete receptors

Ref.	Land-use	Sensitivity to odour	Impact criterion [$C_{98,\ 1\text{-hour}}$, ou_E/m^3]	Predicted odour exposure level [$C_{98,\ 1\text{-hour}}$, ou_E/m^3]
A	Commercial	Medium	3	0.1
B	Mixed commercial/industrial	Medium	3	0.4
C	Commercial/industrial	Low/medium	5	1.1
D	Commercial/industrial	Low/medium	5	0.2
E	Commercial/industrial	Low/medium	5	0.2
F	Mixed commercial	Medium	3	0.1
G	Residential	High	1.5	0.1
H	Residential	High	1.5	0.1
I	Commercial/industrial	Low/medium	5	0.2

The results of the odour dispersion modelling indicates that under current operational conditions, predicted exposure levels at nearby receptors resulting from odours from the permitted areas of the site fall below the level that is expected to pose a risk of odour impact, based on the sensitivity of the nearest receptors.

It is possible that short term high intensity odour releases which could occur during importation of raw sludge cake and the daily regeneration of the siloxane filter could pose a risk beyond the area indicated by the model, since the model considered 98th percentiles. However, no compliant have been reported so this is likely to be low.

5.2 Assessment of uncertainties

The main factors that influence the uncertainty of the odour assessment are as follows:

- Model uncertainty.
- Meteorological data.
- Variation in emission rates.

5.2.1 Model uncertainty

The US EPA AERMOD model has been used extensively in the UK for undertaking odour impact assessments from a wide range of industries and source types. Whilst the model cannot be expected to fully reflect reality, its performance in terms of prediction of odour or pollutant exposure is considered to be good and the model is frequently used for regulatory purposes.

Since odour impact benchmarks applied in the UK are model derived, and have been tested extensively using the AERMOD model, the inherent uncertainties in the model predictions in comparison to real world conditions are not generally considered relevant.

5.2.2 Meteorological data

Meteorological data selection has a significant impact on model uncertainty and is arguably the most important factor to consider when assessing the outputs of odour dispersion modelling assessments.

In this case, Numerical Weather Prediction (NWP) meteorological data, derived from the Research and Forecasting Model (WRF) was used for the study. The model generated data is based upon a domain centred on the site with a 3x3 Km resolution and is considered to be the most representative dataset for the assessment.

5.2.3 Emission rates

Variations in the average source emission rates have a broadly proportional influence in terms of predicted offsite exposure. The odour emission rates used in the model have been selected on the basis of the odour survey at Afan WwTW and other DCWW sites, where relevant.

However, variations are possible, particularly in relation to the areas which handle raw sludges, which generate odours which pose the greatest risk of impact due to their high offensiveness. It is therefore possible that the impact area may change with time and that odours may be detectable and pose an impact beyond the area indicated by the model.

Where relevant, the improvement measures identified in the next section take this into account.

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6 Improvement measures

6.1 Recommendation for optimising odour control

The low level of risk posed by the site in terms of offsite impact implies that further enhancements to odour control are unlikely to be necessary from a risk management perspective. However, the following improvements are required to achieve full compliance to the requirements of BATc. It is recommended that DCWW consult with NRW to assess whether all such measures are required in this case due to low level of risk:

a. Prepare and implement an Odour Management Plan (OMP) for the permitted operations.

b. Change the carbon media of OCU 1 so that the unit achieves the BAT-AEL of 1,000 ou_E/m^3 (BATc34).

c. Investigate the feasibility of enclosing the imported sludge delivery operation in a building to reduce diffuse emissions and maintain the building under negative pressure by extraction to an appropriate odour treatment system (BATc14A and BATc14D).

d. Investigate the feasibility of installing an abatement system to treat odours from the siloxane filter during periodic regeneration. (BATc34).

6.2 Assessment of the likely impact of implementing the recommended improvements

6.2.1 Changes to the model assumptions

The effect of the recommended improvements on offsite odour exposure and impact risk has been assessed using the dispersion model described in section 4 with the following modifications:

- Emissions from the odour control unit serving the new imported sludge delivery building (OCU 3) have been estimated assuming a building volume of 4,800 m^3 and an extraction rate of 3 air changes per hour. The emission parameters of the new OCU are defined in Table 8 below.

- It was assumed that all emissions from the siloxane filter during regeneration are eliminated.

- Remedial works on OCU 1 are assumed to result in a residual outlet odour concentration of 1,000 ou_E/m^3. The revised OCU 1 emission parameters are defined in Table 8 below.

Table 8: Emission assumptions for odour control units

Source	Emission point characteristics	Modelled Airflow [m^3/s]	Odour conc. [ou_E/m^3]	Emission rate [ou_E/s]	Stack height [m]	Diameter @ efflux point [m]
OCU 1	Vertical stack	0.3	1,000	300	6	0.26
OCU 3	Vertical stack	4.0	1,000	4,000	6	15 m/s

The emission hierarchy for the permitted area after these modifications is presented in Table 9 below and indicates that the improvements will reduce emissions from the permitted area by approximately 36%.

Table 9: Contribution of time weighted emissions from each aspect of the permitted treatment process – post mitigation

Stage of treatment	Source	Odour emission [ouE/s]	Contribution to total site emissions [%]
Sludge processing and handling	Imported cake delivery	-	-
	Digested sludge holding tank	329	3.7%
	Post THP belt press building	1,084	12.1%
	Sludge cake storage bays (inc. cake agitation)	623	6.9%
	Sludge cake storage and export	1,991	22.2%
	Siloxane filter regeneration	-	-
Odour control units	OCU 1 (Sludge)	300	3.3%
	OCU 2 (Acid scrubber)	649	7.2%
	OCU 3 (Imported sludge)	4,000	44.6%
Total		**8,976**	**100.0%**

6.2.2 Model outputs

The results of the modelling are presented in Figure 9 and

Table 10 below:

Table 10: Exposure levels predicted at named receptors

Ref.	Land-use	Sensitivity to odour	Impact criterion [$C_{98,\ 1\text{-hour}}$, ou_E/m^3]	Predicted odour exposure level [$C_{98,\ 1\text{-hour}}$, ou_E/m^3]
A	Commercial	Medium	3	<0.1
B	Mixed commercial/industrial	Medium	3	0.2
C	Commercial/industrial	Low/medium	5	0.5
D	Commercial/industrial	Low/medium	5	0.1
E	Commercial/industrial	Low/medium	5	0.1
F	Mixed commercial	Medium	3	<0.1
G	Residential	High	1.5	<0.1
H	Residential	High	1.5	<0.1
I	Commercial/industrial	Low/medium	5	0.1

Figure 9: Results of odour dispersion modelling under post-mitigation operational conditions

The modelling indicates that following application of the recommended control measures, the offsite odour exposure levels are predicted to fall below the most stringent exposure benchmark at all offsite sensitive receptors.

The impact risk associated with intermittent emissions, which aren't fully represented by 98th%ile dispersion models, have also been eliminated.

7 Conclusions

The findings of the assessment are as follows:

1. The main contributors to odour from the permitted area which have the potential to travel offsite are as follows:

    a. Intermittent emissions released during regeneration of the Siloxane filter,

    b. Intermittent diffuse emissions during delivery of imported sludge cake.

    c. Emissions from the digested sludge cake storage pad and export activities.

    The odours released from all of the above sources except the digested sludge cake are classified as highly offensive.

2. The odour exposure levels predicted by the dispersion model outside the site boundary fall below the level that is expected to pose a risk of odour impact due to the low sensitivity of the industrial receptors immediately surrounding the site. It is likely that intermittent high concentration odours released from the importation of raw sludge and periodic regeneration of the siloxane filter could lead to elevated short term exposure levels which pose a risk of impact beyond the area indicated in by the model. However, no odour complaints are understood to have been linked to the site in recent years.

3. The low level of risk posed by the site in terms of offsite impact implies that further enhancements to odour control are unlikely to be necessary from a risk management perspective. However, the following improvements are required to achieve full compliance to the requirements of BATc. It is recommended that DCWW consult with NRW to assess whether all such measures are required in this case due to low risk profile of the site.

    a. Prepare and implement an Odour Management Plan (OMP) for the permitted operations.

    b. Change the carbon media of OCU 1 so that the unit achieves the BAT-AEL of 1,000 ou_E/m^3 (BATc34).

    c. Investigate the feasibility of enclosing the imported sludge delivery operation in a building to reduce diffuse emissions and maintain the building under negative pressure by extraction to an appropriate odour treatment system (BATc14A and BATc14D).

    d. Investigate the feasibility of installing an abatement system to treat odours from the siloxane filter during periodic regeneration (BATc34).

Annex A Odour survey data

A.1 Survey results

Table 12: Odour survey results – area sources

Source	Average surface emission rate		
	Odour [$ou_E/m^2/s$]	H_2S [$ug/m^2/s$]	NH_3 [$ug/m^2/s$]
Secondary Digester	5.8	<LLOD	<LLOD
Cake Import	168.0	8.7	<LLOD
Digested Cake	16.0	0.05	40
Digested Cake	4.1	<LLOD	26

LLOD H2S = approximately 0.04 ug/m²/s
LLOD NH3 = approximately 3 ug/m²/s

Table 1311: Odour survey results – tanks and building sources

Source	Mean concentration		
	Odour [ou_E/m^3]	H_2S [mg/m^3]	Ammonia [mg/m^3]
Imported cake hopper enclosure	510	<LLOD	<LLOD

LLOD H2S = approximately 0.006 mg/m³
LLOD NH3 = approximately 0.4 mg/m³

Table 14: Odour survey results – odour control units

OCU	Locations	Mean concentration			Flow rate (m^3/s)[14]
		Odour [ou_E/m^3]	H_2S [mg/m^3]	NH_3 [mg/m^3]	
OCU 1	Inlet	207,361	13.0	0.7	0.3
	Mid-stage	1,534	0.23	<LLOD	
	Outlet	2,479	2.9*	<LLOD	
OCU 2	Inlet	541	0.05	5.3	1.2

*Cross interference with other reduced sulphur compounds suspected, see Annex B for further details.

[14] Airflow rate standardised to 101.3Kpa, 293K. Airflow measurement locations were not compliant with the requirements of ISO 10780 so the uncertainty of the results cannot be defined.

Annex B Description of odour sources and estimation of emissions

B.1 Sludge import centre

The sludge cake import centre comprises 2 No. hoppers, with each being enclosed by a permanent structure with roller doors which are only opened during importation. The hoppers are continuously extracted to OCU 1.

Emissions during intermittent sludge cake importation have been estimated on the basis of a diffuse emission from the open cake hopper at a rate of 1,500 $ou_E/m^2/s$ (defined on the basis of a 150 $ou_E/m^2/s$ [15] static surface emission multiplied by a 10x agitation factor[16]).

Table 12: Emission estimates for sludge cake import

Source	Duration	Odour emission rate [$ou_E/m^2/s$]	Surface area [m^2]	Estimated odour emission rate [ou_E/s]
Sludge cake importation	9 hours / week	1,500	14	21,000

B.2 Digested sludge holding tank

The digested sludge holding tank comprises 1 No. open tank downstream and directly adjacent to the 2 No. anaerobic digesters. The odour emission rate has been defined on the basis of the survey data.

Table 13: Emission estimates for the digested sludge holding tank

Source	Surface odour emission rate [$ou_E/m^2/s$]	Total tank emission rate [ou_E/s]
Digested sludge hold tank	5.8	305

B.3 Post THP belt press building

The post THP belt press building is located to the east of the site and comprises a building housing 4 No. belt presses which are enclosed and extracted to OCU 2. The building itself is actively ventilated by 4 No. high level wall mounted fans.

Emissions from the building have been estimated on the basis of the untreated odour concentration received by OCU 2 multiplied by the estimated ventilation rate of the building (defined from airflow measurements taken from the wall mounted fans). The emission parameters for the post THP belt press building are summarised in the table below.

[15] Defined from a combination of the Afan, Cog Moors and Five Fords odour survey results.

[16] Based on a comparison of data collected by Olfasense in the wastewater and waste sector.

Table 14: Emission estimates for the post THP belt press building

Source	Discharge point	Modelled airflow [m³/s]	Geomean odour conc. [ou_E/m^3]	Emission rate [ou_E/s]	Stack height [m]	Diameter @ efflux point [m]
Belt press building ventilation	4 No. horizontal vents*	0.5	541	271	14	0.35

*all values per vent

B.4 Sludge cake storage and export

Sludge cake is initially stored in one of 4 No. cake bays located below the belt presses and is periodically transferred to the main storage pad prior to exportation from site by road trailer.

The diffuse surface emission from the digested sludge cake during storage has been defined on the basis of the survey data. The typically prevailing area of digested sludge cake storage has been defined as 2 No. bays at 50% capacity (60 m^2 total) and the main storage pad at 50% capacity (243 m^2), based on information provided by the site operator.

Deposition and loading operations of sludge cake have been estimated assuming that the emissions during active handling of sludge cake are around 10x the surface emission rate from the static sludge cake.

Table 15: Emission estimates for sludge cake storage and export

Source	Duration	Odour emission rate [$ou_E/m^2/s$]	Surface area [m^2]	Estimated odour emission rate [ou_E/s]
Sludge cake dropping from belts	18 No. hours/day	81	2.25	182
Sludge cake storage	Continuous	8.1	303	2,454
Sludge cake export by road trailer	8 No. hours/week	81	6	486

B.5 Odour control units

The residual emissions from odour control units have been estimated on the basis of the survey data presented in the

Table 17 below. The OCU emission parameters are presented in Table 16.

Table 16: Emission estimates for odour control units

Source	Discharge point	Modelled airflow [m^3/s]	Geomean odour conc. [ou_E/m^3]	Emission rate [ou_E/s]	Stack height [m]	Diameter @ efflux point [m]
OCU 1	Vertical stack	0.3	2,479	744	6.0	0.26

OCU 2	Vertical stack	1.2	541	649	10.2	0.50

Table 17: Odour control system test results

OCU	Location	Measured concentration				% removal			Odour emission [ou_E/s]
		Odour [ou_E/m^3]	H_2S * [mg/m³]	NH_3 [mg/m³]	Airflow rate (m³/s)	Odour	H_2S	NH_3	
OCU 1	Inlet to stage 1	207,361	13.0	0.7	0.4	99%	98%	100%	82,944
	Inlet to stage 2	1,534	0.23	<LLOD		-62%	-1161%	-	614
	Outlet	2,479	2.9***	<LLOD		99%	78%	100%	992
OCU 2	Inlet*	541	0.05	5.3	1.2	-	-	-	479

*The acid scrubber associated with OCU 2 is not currently operational and is assumed to be providing no treatment of the airstream presented to it.
**Other sulphur-based compound can interfere with the readings from a Jerome gold film analyser
***Significant cross interference is suspected, potentially from other sulphur-based compounds.

The survey data indicates the following:

- OCU 1 was achieving removal efficiencies in excess of 98% for each measurement parameter showing a good overall system performance. However, the results suggest that a degree of preferential adsorption/desorption of volatiles was potentially occurring across the final carbon filtration stage of treatment. The available adsorption sites of the carbon media could be near to saturation meaning volatiles with a high affinity to the media such as H_2S are preferentially adsorbed over volatiles with a lower affinity to the media, such as a range of reduced sulphur compounds (e.g. dimethyl sulphide and dimethyl disulphide). The results are indicative of a carbon media at the end of its operational lifespan.
- OCU 2 was assumed to be providing no abatement of the considered measurement parameters.

B.6 Siloxane filter stack

Emissions from the siloxane filter stack occur during regeneration only. The regeneration of the unit occurs daily at midnight for 4 No. hours.

Emissions have been estimated directly form 2022 measurement data from Cardiff WwTW which has a similar system. The Siloxane filter emission parameters are presented in Table 18 below.

Table 18: Emission estimates for the siloxane filter regeneration

Source	Discharge odour conc. [ou_E/m^3]	Airflow rate (m³/s)	Odour emission rate [ou_E/s]	Discharge temperature [^oC]	Stack height (m)	Diameter @ efflux point

Siloxane filter stack (Hour 1)	281,306	0.2	56,261	Ambient	24	0.25
Siloxane filter stack (Hour 2)	204,882		40,976			
Siloxane filter stack (Hour 3)	204,882		40,976			
Siloxane filter stack (Hour 4)	204,882		40,976			