ODOUR IMPACT ASSESSMENT

WKE (Middlesbrough) Ltd
Pelletising Facility

Prepared for:
WKE (Middlebrough) Ltd

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1. INTRODUCTION

1.1. Background

Sol Environment Ltd has been commissioned to undertake an assessment of the likely local odour impacts arising from a Pellet Manufacturing Facility (PMF) located at the Dawsons Wharf Industrial Estate off Riverside Park Road, Middlesbrough in Cleveland. The site is located to the south of the River Tees and is located in the administrative area of Middlesbrough Borough Council. The Site location is presented in Figure 1.1.

The installation will import solid recovered fuel (SRF) and pelletise it to create a pelletised product fuel. Part of the process includes the drying of the SRF on low temperature dryers which are heated directly via gas burners. There are three pelletising lines with emissions to air from nine individual stacks. There are two dryers with emissions from separate stacks. Emissions from the pelletising lines will comprise mainly fine particles. Emissions from the dryers will comprise combustion type pollutants (e.g. oxides of nitrogen and carbon monoxide).

There is the potential for the SRF to be odorous and for odours to be emitted from the dryer stacks during the drying process. However, it is considered that the SRF will have a low odour potential and there are no proposals to provide odour abatement for the dryer stacks. An odour assessment is provided to determine what the maximum odour release could be from the dryer stacks to prevent off-site annoyance.

1.2. Potential Sources of Odour

There is the potential for the SRF to be odorous and for odours to be emitted from the dryer stacks during the drying process. However, it is considered that the SRF will have a low odour potential and there are no proposals to provide odour abatement for the dryer stacks. An odour assessment is provided to determine what the maximum odour release could be from the dryer stacks to prevent off-site annoyance.

An odour management plan for the PMF is also being submitted to the Environment Agency as part of the permit application process. This details the fundamental design of the installation and includes a hierarchy of odour control and abatement measures to ensure that the potential for odour impacts are eliminated.

A glossary of common air quality and odour terminology is provided in Appendix A.

OS Licence Number (100062750)

Figure 1.1 Site location

2.1. Odour Legislation and Guidance

The following legislation and guidance has been used in this assessment:

- H4: Odour Management, Environment Agency, April 2011;
- Odour Guidance for Local Authorities, Department for Environment, Food and Rural Affairs (Defra), 2010;
- Environmental Permitting (England and Wales) Regulations (2010); and,
- Defra Code of Practice on Odour Nuisance from Sewage Treatment Works, 2006.

2.2. Odour Definition

Defra guidance defines odour as:

> *"An odour is the organoleptic attribute perceptible by the olfactory organ on sniffing certain volatile substances. It is a property of odorous substances that make them perceptible to our sense of smell. The term odour refers to the stimuli from a chemical compound that is volatilised in air. Odour is our perception of that sensation and we interpret what the odour means. Odours may be perceived as pleasant or unpleasant. The main concern with odour is its ability to cause a response in individuals that is considered to be objectionable or offensive.*
>
> *Odours have the potential to trigger strong reactions for good reason. Pleasant odours can provide enjoyment and prompt responses such as those associated with appetite. Equally, unpleasant odours can be useful indicators to protect us from harm such as the ingestion of rotten food. These protective mechanisms are learnt throughout our lives. Whilst there is often agreement about what constitutes pleasant and unpleasant odours, there is a wide variation between individuals as to what is deemed unacceptable and what affects our quality of life."*

2.3. Odour Impacts

The magnitude of odour impact depends on a number of factors and the potential for adverse impacts varies due to the subjective nature of odour perception. The FIDOR acronym is a useful reminder of the factors that can be used to help determine the degree of odour pollution:

- Frequency of detection - frequent odour incidents are more likely to result in adverse impacts;
- Intensity as perceived - intense odour incidents are more likely to result in adverse impacts;
- Duration of exposure - prolonged exposure is more likely to result in adverse impacts;
- Offensiveness - more offensive odours have a higher risk of resulting in adverse impacts; and,
- Receptor sensitivity - sensitive areas are more likely to have a lower odour tolerance.

It is important to note that even infrequent emissions of odours may cause loss of amenity if odours are perceived to be particularly intense or offensive.

The FIDOR factors can be further considered to provide the following issues with respect to the potential for an odour emission to cause adverse impacts:

- The rate of emission of the compound(s).
- The duration and frequency of emissions.
- The time of the day that this emission occurs.
- The prevailing meteorology (wind direction, wind speeds etc.).
- The sensitivity of receptors to the emission i.e. whether the odorous compound is more likely to cause annoyance, such as the sick or elderly, who may be more sensitive.
- The odour detection capacity of individuals to the various compound(s) in odours.
- The individual perception of the odour (i.e. whether the odour is regarded as unpleasant). This is quite subjective, and may vary significantly from individual to individual. For example, some individuals may consider some odours as pleasant, such as petrol, paint and creosote, whilst others find them less tolerable.

2.4. Odour Measurement

The concentration at which an odour is just detectable to a human nose is referred to as the detection threshold. This concept of a threshold concentration is the basis of olfactometry in which a quantitative sensory measurement is used to define the concentration of an odour. Standardised methods for measuring and reporting the detectability or concentration of an odour sample have been defined by European standard BS:EN 13725:2003. The concentration at which an odour is just detectable by a panel of selected human odour assessors is defined as the detection threshold and has an odour concentration of 1 European odour unit per cubic metre ($1ou_E/m^3$).

At the detection threshold, the concentration of an odour is so low that it is not recognisable as any specific odour at all, but the presence of some, very faint, odour can be sensed when the "sample" odour is compared to a clean, odour-free sample of air.

For a simple, single odorous compound such as hydrogen sulphide (H_2S), the concentration of odour present in a sample of air can be expressed in terms of ppm, ppb or mg/m^3. More usually, odours are complex mixtures of many different compounds and the concentration of the mixture can be expressed in ou_E/m^3.

The concept of odour concentrations, as ou_E/m^3, is based on a correlation between a physiological response when odour is detected by the nose and exposure to a particular sample at a specific concentration. The results of this assessment are expressed in terms of a single number. The odour sample assessed can be one of many individual odorous substances or a complex mixture of many substances, and so the odour unit or concentration will vary between test samples. A defined measurement standard for the odour unit is prescribed in the BS:EN standard on olfactometry using n-butanol. This gas is used to select and calibrate odour panel members.

An odour at a strength of $1ou_E/m^3$ is the concentration at which 50% of the population can detect the odour and 50% cannot within the controlled environment of an odour laboratory. As an odour becomes more concentrated, then it gradually becomes more apparent. Some guidance as to concentrations when this occurs can be derived from laboratory measurements of intensity. The following guideline values have been stated by Defra to provide some context for discussion about exposure to odours:

- $1ou_E/m^3$ is the point of detection;
- $5ou_E/m^3$ is a faint odour; and,
- $10ou_E/m^3$ is a distinct odour.

It is important to note that these values are based on laboratory measurements and in the general environment other factors affect the sense of odour perception, such as the following.

- The population is continuously exposed to a wide range of background odours at a range of different concentrations, and usually people are unaware of there being any background odours at all due to normal habituation. Individuals can also develop a tolerance to background and other specific odours. In an odour laboratory the determination of detection threshold is undertaken by comparison with non-odorous air, and in carefully controlled, odour-free, conditions. Normal background odours such as those from traffic, vegetation, grass mowing etc., can provide background odour concentrations from 5 to $60ou_E/m^3$ or more.
- The recognition threshold may be about $3ou_E/m^3$, although it might be less for offensive substances or higher if the receptor is less familiar with the odour or distracted by other stimuli.
- An odour which fluctuates rapidly in concentration is often more noticeable than a steady odour at a low concentration.

2.5. Odour Benchmarks

There are no statutory odour annoyance criteria in the UK although the Environment Agency (the Agency) has published guidance for processes regulated under the Environmental Permitting Regulations (EPR) [1].

1 H4 Odour Management, How to Comply with your Environmental Permit, Environment Agency Horizontal Guidance

The guidance (H4) provides a range of benchmark levels for assessing odour annoyance depending on the perceived offensiveness of the process undertaken. These are all based on the 98th percentile of hourly mean concentrations modelled over a year. Expressing air quality standards as percentiles is common in the UK and has been applied to the odour offensiveness criteria as the Agency recognises that there are circumstances when it is difficult to avoid off-site odour (e.g. extreme meteorological conditions).

The Environment Agency benchmarks are as follows:

- 1.5 ou_E/m^3 for most offensive odours;
- 3.0 ou_E/m^3 for moderately offensive odours; and
- 6 ou_E/m^3 for less offensive odours.

Offensiveness of the odour takes into account the sensitivity of the receptor (e.g. residential receptors would be considered more sensitive). The Environment Agency provides examples of processes that fall within each of the offensiveness categories. For most offensive odours, these include: decaying animal or fish remains; processes involving septic effluent or sludge; and biological landfill odours. Less offensive odours include bakeries, coffee roasting, breweries etc. These criteria are not compliance limits as it would not be possible to monitor compliance with the criteria. Therefore, they may be used for assessing the acceptability of a process (where it is possible to model emissions) or for developing stack emission limits such that compliance with a criterion can be demonstrated.

There has been much debate about the most appropriate odour benchmark to be applied to industrial and other developments that may give rise to odours. Prior to publication of the H4 guidance, an assessment criterion of 5 ou_E/m^3 (as the 98th percentile of hourly values) had traditionally been applied to sewage treatment works. This was based on evidence presented at the Newbiggen-by-the-Sea public inquiry in 1993 on behalf of Northumbrian Water. The evidence was derived from a Dutch study which concluded that odour concentrations of between 5 and 10 ou_E/m^3 (as the 98th percentile of hourly values) would be acceptable and would not result in justifiable complaints. It is considered that the Dutch study referred to Dutch odour standards where one dutch odour unit is equivalent to a half European odour unit. Therefore, the Newbiggen-by-the-Sea criterion would be equivalent to 2.5 to 5 ou_E/m^3.

In 2001, UK Waster Industry Research (UKWIR) published a study on the correlation between modelled odour impacts and human response. The study was based on a review of the correlation between reported odour complaints and modelled odour impacts at nine wastewater treatment works with on-going odour complaints. The findings of the study indicated the following:

- At modelled exposure of less than 5 ou_E/m^3 (98th percentile of hourly values) complaints are relatively rare at only 3% of the total registered.

- At modelled exposures of between 5 and 10 ou_E/m^3 a significant proportion of total registered complaints occur (38% of the total).
- The majority of complaints occur in areas of modelled exposure of greater than 10 ou_E/m^3 (59% of the total).

The Chartered Institution of Water and Environmental Management (CIWEM) has published a policy position statement (PPS) relating to the control of odour [2]. The purpose of the PPS is:

'to outline the main issues relating to odours arising from industrial premises, wastewater treatment plants, sewers and pumping stations, waste management facilities and agricultural activity, taking account of legislation, regulators, the public and other stakeholders and emerging best practice, particularly in a UK context.'

The CIWEM considers the following framework is the most reliable that can be defined on the basis of limited research in the UK (all expressed as the 98th percentile of hourly means):

- > 10 ou_E/m^3 – complaints are highly likely and odour exposure at these levels represents an actionable nuisance;
- > 5 ou_E/m^3 – complaints may occur and depending on the sensitivity of the locality and nature of the odour this level may constitute a nuisance;
- <3 ou_E/m^3 – complaints are unlikely to occur and exposure below this level are unlikely to constitute significant pollution or significant detriment to amenity unless the locality is highly sensitive or the odour highly unpleasant in nature.

Therefore, there are a range of odour annoyance criteria that could be applied to the installation site as follows (all expressed as the 98th percentile of hourly values):

- 1.5 ou_E/m^3 based on the Environment Agency criterion for most offensive odours;
- 2.5 ou_E/m^3 as the lower end of the Newbiggen-by-the-Sea criterion as being acceptable and would not result in justifiable complaints;
- 3.0 ou_E/m^3 based on the Environment Agency criterion for moderately offensive odours taking into account the lack of septicity of the wastewater being treated and the waste acceptance criterion;
- 3.0 ou_E/m^3 based on the CIWEM policy position statement for complaints unlikely to occur;

2 Control of Odour, CIWEM Policy Position Statement (September 2012)

- 5 ou_E/m^3 based on the UKWIR correlation between modelled concentrations and complaints documented as being rare;

Given that the waste acceptance procedures exclude any excessively odorous waste, it is concluded that odour sources from the drying plant would be classified as 'moderately offensive'. Therefore, the 3.0 ou_E/m^3 benchmark is likely to be the most appropriate in accordance with the criteria provided in the EA's H4 guidance.

3.1. Introduction

The proposed drying plant may result in odour emissions during normal operations. However, no odour abatement will be provided due to the low odour potential of the SRF. Therefore, the assessment has used a dispersion model to predict the maximum odour emission that could arise to avoid an off-site annoyance. This is based on an odour annoyance criterion of 3 ou_E/m^3 as discussed In Section 2.5. Therefore, the dispersion modelling assessment has been used to derive an appropriate odour emission for the dryer stacks.

3.2. Odour Sources

This assessment identifies that the potential odour sources are the two drying plant stacks. The potential odour sources identified are summarised in Table 3.1. The two stacks are sufficiently close (less than three stack diameters) that they may be considered as a single source.

Table 3.1: Odour Sources Identified for the PMF

Source		Easting	Northing
A1 & A2 Combined	Dryer stacks	448921	521691

3.3. Dispersion Modelling

<u>The Dispersion Model</u>

The potential impact of odorous emissions from the installation has been assessed using a dispersion model to predict airborne ground level concentrations of odour emitted from the drying plant stacks from a nominal emission concentration. Based on the predicted odour concentrations from this emission an appropriate emission can be derived that would give rise to a predicted concentration that is below the odour benchmark.

The assessment has utilised the AERMOD dispersion model. AERMOD allows for the modelling of dispersion under convective meteorological conditions using a skewed Gaussian concentration distribution. It is able to simulate the effects of terrain and building downwash simultaneously. It can also calculate concentrations for direct comparison with odour annoyance criteria (i.e. hourly means expressed as the 98th percentile). It is used extensively in the UK for assessing the air quality and odour impacts of industrial and other polluting processes.

Emission Parameters

Emission parameters associated with the operation of the drying plant are derived from data issued by the technology provider. Process conditions were provided by Stela Ltd. The dispersion modelling inputs are summarised in Table 3.2.

Table 3.2: Emission Parameters for the Drying Plant (Combined Emissions for A1 and A2)

Parameter	Value	Unit
Volumetric flow rate (actual)	111.1	Am^3/s
Normalised volumetric flow rate (273K only)	95.4	Nm^3/s
Temperature	45	°C
Stack height	25	m
Internal stack diameter	2.83	m
Emission velocity	17.7	m/s

The likely odour emission for the dryer stack emissions is unknown. Therefore, the odour assessment will be used to determine an appropriate odour emission for the dryer emissions.

Local Meteorological Data

The dispersion modelling has utilised five years (2015-2019) of hourly sequential meteorological data in order to take account of inter-annual variability and reduce the effect of any atypical conditions. Data from the meteorological station at Teesside International Airport have been used for the assessment. Given the relatively industrial nature of the site location, a surface roughness value of 0.7 m has been assumed in the processing of the meteorological data.

Wind roses for each year of meteorological data are presented in **Appendix B.**

Topography

The presence of elevated terrain can significantly affect the dispersion of pollutants by increasing turbulence and reducing the distance between the plume centre line and the ground level.

Information relating to the topography of the area surrounding the proposed facility has been used in the dispersion modelling to assess the impact of terrain features on the dispersion of emissions.

Building Downwash / Entrainment

The presence of buildings close to emission sources can significantly affect the dispersion of pollutants by leading to a phenomenon called downwash. This occurs when a building distorts the wind flow, creating zones of increased turbulence. Increased turbulence causes the plume to come to ground earlier than otherwise would be the case and result in higher ground level concentrations closer to the stack.

Downwash effects are only significant where building heights are greater than 30 to 40% of the emission release height. The downwash structures also need to be sufficiently close for their influence to be significant. A summary of the buildings and structures that have been included in the model is presented in Table 3.3. For buildings with an eaves and an apex, the mean of the two has been used to characterise the building within the model.

Table 3.3: Building Downwash Structures

Description	Height (m)	X Length (m)	Y Length (m)	Angle
Main building (high section)	15.3	80	22	129
Main building (low section)	12.4	100	70	129
Adjacent off-site building	38	65	120	132

Sensitive Receptors

Details of the discrete sensitive receptors selected for the assessment of odour impacts are presented in Table 3.4 and the locations illustrated in Figure 3.1. Residential properties are around 500 m from the installation site. Therefore, the nearest industrial receptors have also been included. However, it should be noted that these will be less sensitive to odour impacts arising as a result of the installation emissions.

Table 3.6: Location of Sensitive Receptors				
ID	Receptor	Type	Easting	Northing
D1	Commercial/Industrial	Commercial/Industrial	448995	521623
D2	Commercial/industrial	Commercial/Industrial	448958	521789
D3	Commercial/industrial	Commercial/Industrial	448819	521688
D4	Cambridge Terrace	Residential	449267	522143
D5	Port Clarence School	Educational	449476	521974
D6	Police Headquarters	Commercial	449423	520830
D7	Beaufort Street	Residential	449048	520191
D8	Limetrees Close	Residential	449078	522390
D9	Saltholme Close	Residential	449125	522277
D10	Palm Terrace	Residential	449366	522074

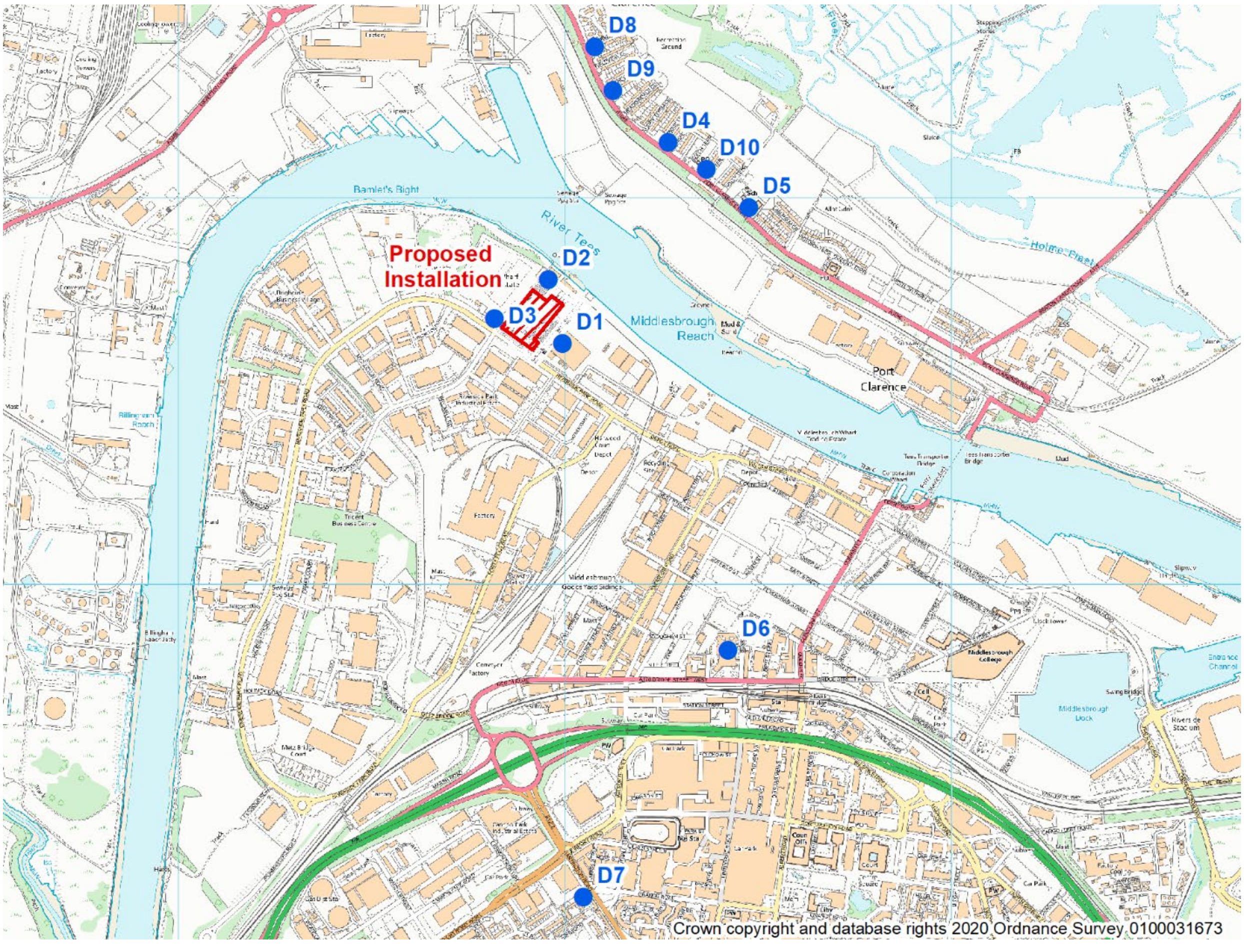

Figure 3.1: Sensitive Receptor Locations

Pollutant concentrations have been predicted at both discrete receptor locations and over a 4 km by 4 km Cartesian grid of 25 m resolution. These are used to provide contour plots of odour concentration for the on-site sources.

Modelling Uncertainty

Uncertainty in dispersion modelling predictions can be associated with a variety of factors, including:

- model uncertainty - due to model limitations;
- data uncertainty - due to errors in input data, including emission estimates, land use characteristics and meteorology; and
- variability - randomness of measurements used.

Potential uncertainties in model results have been minimised as far as practicable and worst-case inputs used in order to provide a robust assessment. This included the following:

- Choice of model - AERMOD is a commonly used atmospheric dispersion model and results have been verified through a number of studies to ensure predictions are as accurate as possible.
- Meteorological data - modelling was undertaken using five-years of annual meteorological data sets from the most appropriate observing station to the facility to take account of local conditions. In addition, for each receptor the maximum for the five years is presented.
- Plant operating conditions - plant operating conditions were provided by Stela Ltd. As such, these are considered to be representative of operating conditions.
- Emission rates – odour emission rates were calculated taking into account worst-case assumptions (e.g. assuming continuous operation).
- Receptor locations - a Cartesian Grid was included in the model in order to calculate maximum predicted concentrations throughout the assessment extents. Receptor points were also included at sensitive locations to provide additional consideration of these areas.
- Variability - all model inputs are as accurate as possible and worst-case conditions were considered as necessary in order to ensure a robust assessment of potential odour impact.

Results were considered in the context of the relevant odour benchmark level. It is considered that the use of the stated measures to reduce uncertainty and the use of worst-case assumptions when necessary has resulted in model accuracy of an acceptable level.

4.1. Introduction

Predicted ground level concentrations of odour as the maximum off-site and at sensitive receptors has been provided. For each receptor, these are the maximum predicted for the five years of meteorological data and represent worst-case conditions.

4.2. Predicted Concentrations for a Nominal Emission Concentration

Predicted ground level odour concentrations as the 98th percentile of hourly means for the dryers with an emission concentration of 1,000 ou_E/Nm^3 (emission rate of 95,390 ou_E/s) is presented in Table 4.1.

Table 4.1: Predicted Odour Concentration as the 98th Percentile of Hourly Means –Emission Concentration of 1,000 ou_E/Nm^3

ID	Receptor	Type	Odour (ou_E/m^3)
Maximum predicted			2.9
D1	Commercial/Industrial	Commercial/Industrial	1.0
D2	Commercial/industrial	Commercial/Industrial	1.0
D3	Commercial/industrial	Commercial/Industrial	0.1
D4	Cambridge Terrace	Residential	0.3
D5	Port Clarence School	Educational	0.3
D6	Police Headquarters	Commercial	0.3
D7	Beaufort Street	Residential	0.1
D8	Limetrees Close	Residential	0.3
D9	Saltholme Close	Residential	0.3
D10	Palm Terrace	Residential	0.3

Predicted concentrations at the most sensitive locations are 0.3 ou_E/m^3 or less. At the industrial receptors highest concentrations are predicted at D1 and D2 immediately adjacent to and downwind of installation. The predicted odour concentration at this location is 1.0 ou_E/m^3. The maximum predicted concentration is 2.9 ou_E/m^3 and is less than the odour benchmark of 3 ou_E/m^3.

4.3. Odour Concentration to Achieve the Odour Benchmark

For the maximum predicted and for each receptor, the odour emission concentration resulting in compliance with the odour benchmark of 3 ou_E/m^3 at each location is provided in Table 4.2.

Table 4.2: Odour Emission that Results in Compliance with the Odour Benchmark of 3 ou_E/m^3 as the 98th Percentile of Hourly Means			
ID	Receptor	Type	Odour Emission (ou_E/Nm^3)
Maximum predicted			1,021
D1	Commercial/Industrial	Commercial/Industrial	3,214
D2	Commercial/industrial	Commercial/Industrial	2,927
D3	Commercial/industrial	Commercial/Industrial	25,694
D4	Cambridge Terrace	Residential	11,012
D5	Port Clarence School	Educational	13,449
D6	Police Headquarters	Commercial	17,093
D7	Beaufort Street	Residential	45,721
D8	Limetrees Close	Residential	14,811
D9	Saltholme Close	Residential	11,954
D10	Palm Terrace	Residential	11,900

The odour benchmark of 3 ou_E/m^3 would be achieved at any off-site locations for an odour emission of 1,021 ou_E/Nm^3. At any of the discrete receptors the benchmark would be achieved for an emission of around 3,000 ou_E/Nm^3 (commercial and industrial receptors) and for more sensitive receptors for less than around 12,000 ou_E/Nm^3.

Therefore, it is proposed that 3,000 ou_E/Nm^3 would be an appropriate odour emission concentration for the dryers.

4.4. Predicted Odour Concentrations for a 3,000 ou_E/Nm^3 Emission Concentration

Predicted concentrations of odour as the 98th percentile of hourly means for an emission concentration of 3,000 ou_E/Nm^3 are presented in Table 4.3.

A contour plot of the 98th percentile of hourly means for the dryer emissions at 3,000 ou_E/Nm^3 is presented in Figure 4.1. Results are presented for the 2015 meteorological year which gives rise to the highest concentrations. The 1.5, 3.0 and 6.0 ou_E/m^3 contours are highlighted in red.

Table 4.3: Predicted Odour Concentration as the 98th Percentile of Hourly Means –Emission Concentration of 3,000 ou_E/Nm^3			
ID	Receptor	Type	Odour (ou_E/m^3)
Maximum predicted			8.8
D1	Commercial/Industrial	Commercial/Industrial	2.9
D2	Commercial/industrial	Commercial/Industrial	3.1
D3	Commercial/industrial	Commercial/Industrial	0.4
D4	Cambridge Terrace	Residential	1.0
D5	Port Clarence School	Educational	0.9
D6	Police Headquarters	Commercial	0.8
D7	Beaufort Street	Residential	0.3
D8	Limetrees Close	Residential	0.9
D9	Saltholme Close	Residential	1.0
D10	Palm Terrace	Residential	0.9

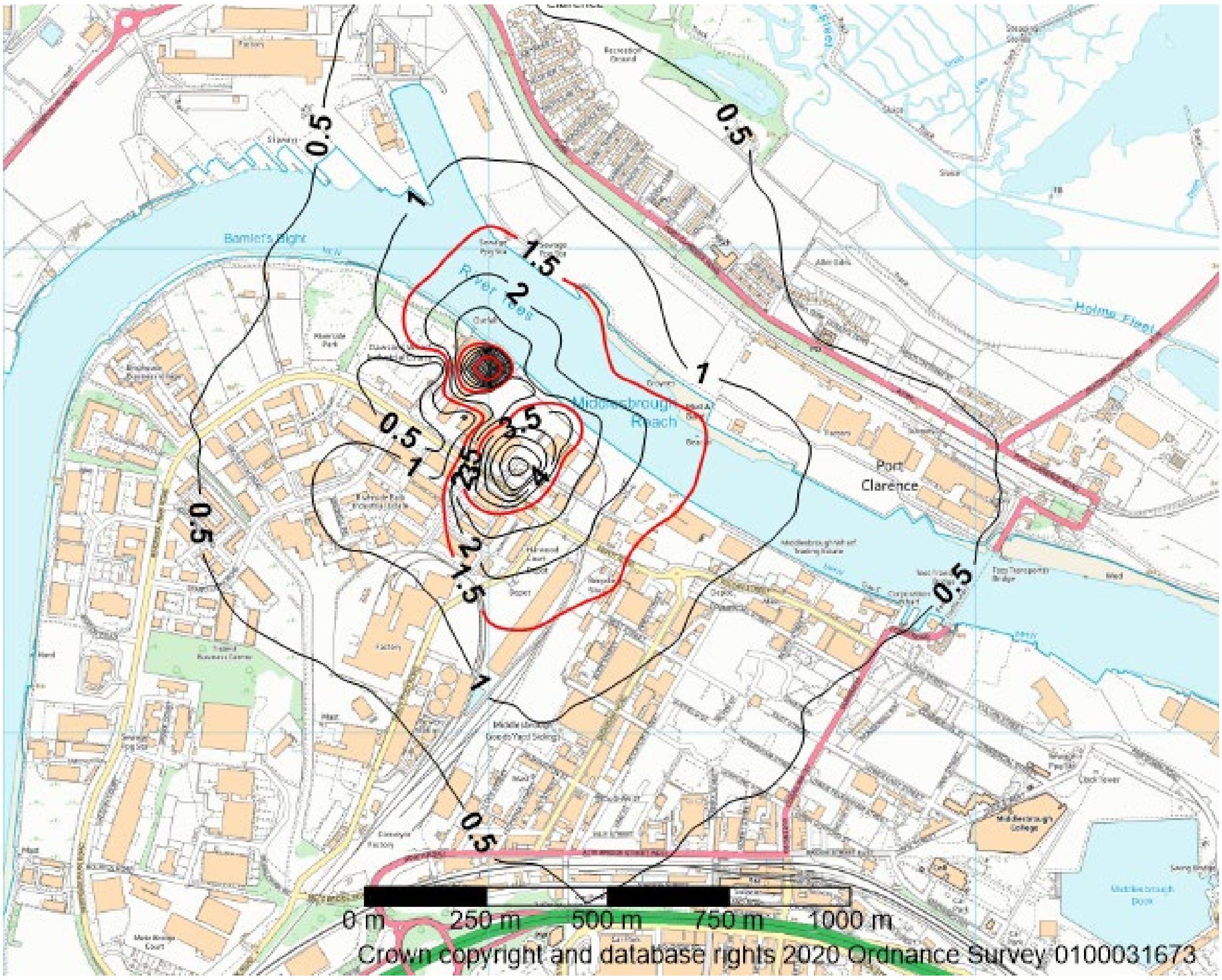

Figure 4.1: 99.8th Percentile of Hourly Mean Odour Concentrations for the Dryers (ou_E/m^3) – Emission Concentration of 3,000 ou_E/Nm^3

5. CONCLUSIONS

An Odour Impact Assessment has been provided to support a permit application for a Pellet Manufacturing Facility located at the Dawsons Wharf Industrial Estate off Riverside Park Road, Middlesbrough in Cleveland. The site is located to the south of the River Tees and is located in the administrative area of Middlesbrough Borough Council.

The installation will import solid recovered fuel (SRF) and pelletise it to create a pelletised product fuel. Part of the process includes the drying of the SRF on low temperature dryers which are heated directly via gas burners. There are three pelletising lines with emissions to air from nine individual stacks. There are two dryers with emissions from separate stacks. There is the potential for the SRF to be odorous and for odours to be emitted from the dryer stacks during the drying process. However, it is considered that the SRF will have a low odour potential and there are no proposals to provide odour abatement for the dryer stacks.

Due to the low odour potential of the waste material being dried, the dryers will operate without any abatement. Therefore, the assessment has been used to derive an appropriate odour emission level for the dryers. On this basis, an emission concentration for the dryers of 3,000 ou_E/m^3 is recommended. This would result in a negligible impact at residential locations with predicted concentrations of less than a third of the odour benchmark.

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Appendix A – Air Quality and Odour Terminology

Term	Definition
Accuracy	A measure of how well a set of data fits the true value.
Air quality objective	Policy target generally expressed as a maximum ambient concentration to be achieved, either without exception or with a permitted number of exceedances within a specific timescale (see also air quality standard).
Air quality standard	The concentrations of pollutants in the atmosphere which can broadly be taken to achieve a certain level of environmental quality. The standards are based on the assessment of the effects of each pollutant on human health including the effects on sensitive sub groups (see also air quality objective).
Ambient air	Outdoor air in the troposphere, excluding workplace air.
Annual mean	The average (mean) of the concentrations measured for each pollutant for one year. Usually this is for a calendar year, but some species are reported for the period April to March, known as a pollution year. This period avoids splitting winter season between 2 years, which is useful for pollutants that have higher concentrations during the winter months.
AQMA	Air Quality Management Area.
DEFRA	Department for Environment, Food and Rural Affairs.
Exceedance	A period of time where the concentrations of a pollutant is greater than, or equal to, the appropriate air quality standard.
Fugitive emissions	Emissions arising from the passage of vehicles that do not arise from the exhaust system.
LAQM	Local Air Quality Management.
NO	Nitrogen monoxide, a.k.a. nitric oxide.
NO_2	Nitrogen dioxide.
NO_x	Nitrogen oxides.
O_3	Ozone.
ou_E/m^3	European odour concentration
Percentile	The percentage of results below a given value.
PM_{10}	Particulate matter with an aerodynamic diameter of less than 10 micrometres.
ppb parts per billion	The concentration of a pollutant in the air in terms of volume ratio. A concentration of 1 ppb means that for every billion (10^9) units of air, there is one unit of pollutant present.
ppm parts per million	The concentration of a pollutant in the air in terms of volume ratio. A concentration of 1 ppm means that for every billion (10^6) units of air, there is one unit of pollutant present.
Ratification (Monitoring)	Involves a critical review of all information relating to a data set, in order to amend or reject the data. When the data have been ratified they represent the final data to be used (see also validation).
$\mu g/m^3$ micrograms per cubic metre	A measure of concentration in terms of mass per unit volume. A concentration of 1ug/m3 means that one cubic metre of air contains one microgram (millionth of a gram) of pollutant.
UKAS	United Kingdom Accreditation Service.
Uncertainty	A measure, associated with the result of a measurement, which characterizes the range of values within which the true value is expected to lie. Uncertainty is usually expressed as the range within which the true value is expected to lie with a 95% probability, where standard statistical and other procedures have been used to evaluate this figure. Uncertainty is more clearly defined than the closely related parameter 'accuracy', and has replaced it on recent European legislation.
USA	Updating and Screening Assessment.

Term	Definition
Validation (modelling)	Refers to the general comparison of modelled results against monitoring data carried out by model developers.
Validation (monitoring)	Screening monitoring data by visual examination to check for spurious and unusual measurements (see also ratification).
Verification (modelling)	Comparison of modelled results versus any local monitoring data at relevant locations.

Appendix B – Wind Roses

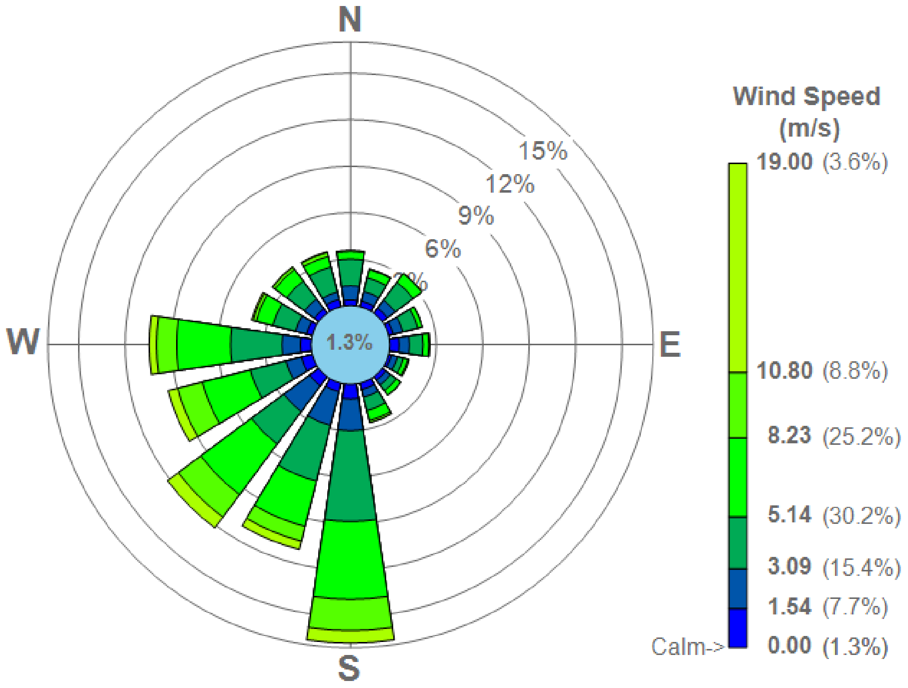

Figure B1: 2015

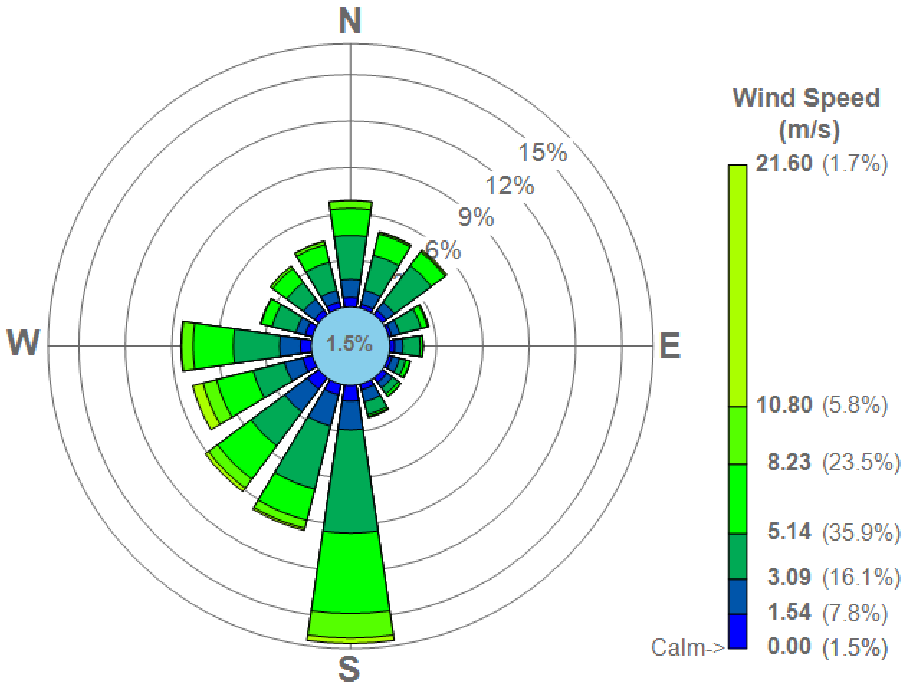

Figure B2: 2016

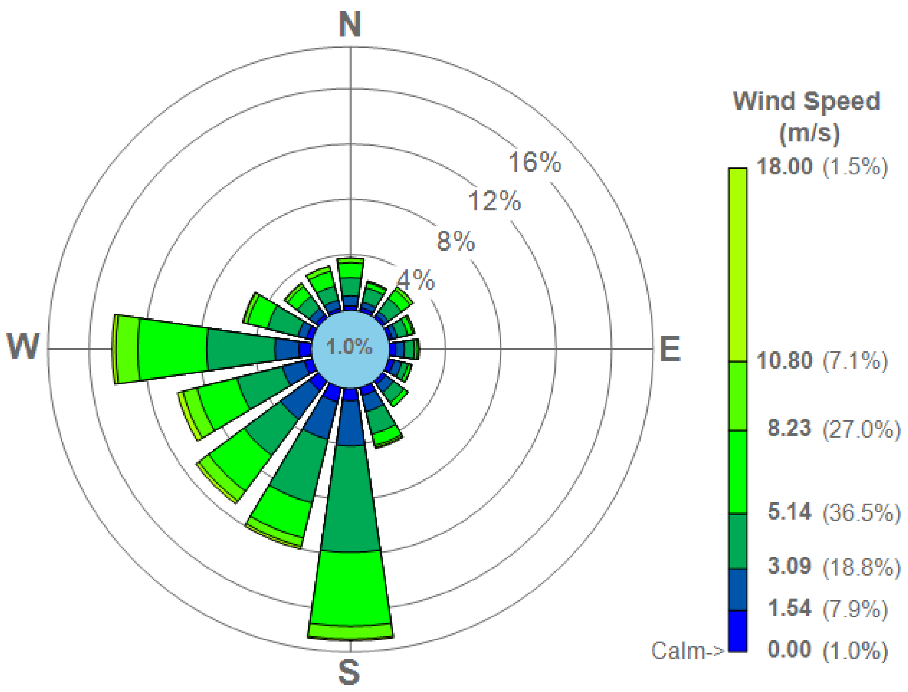

Figure B3: 2017

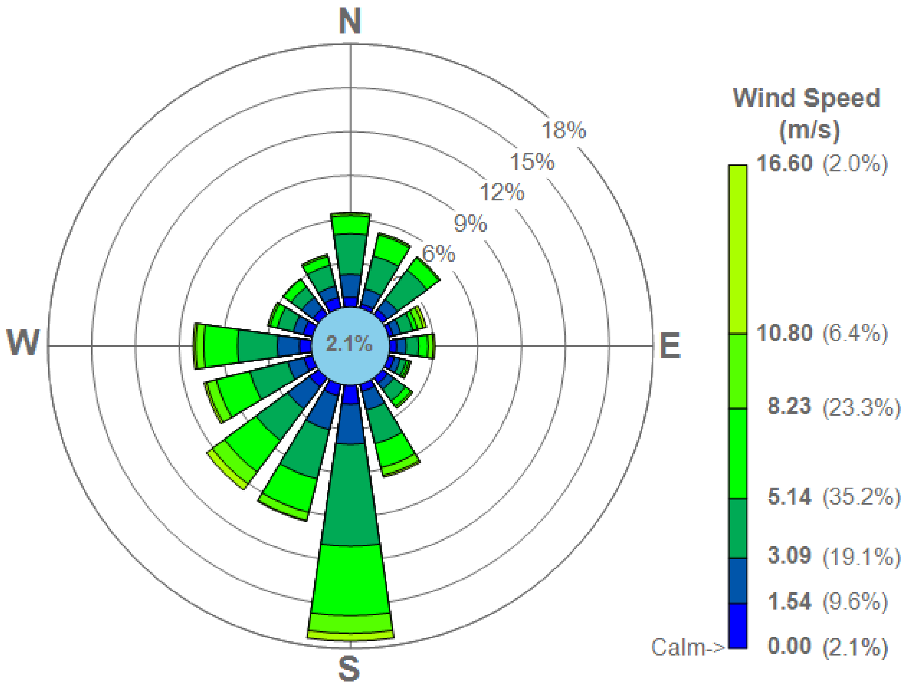

Figure B4: 2018

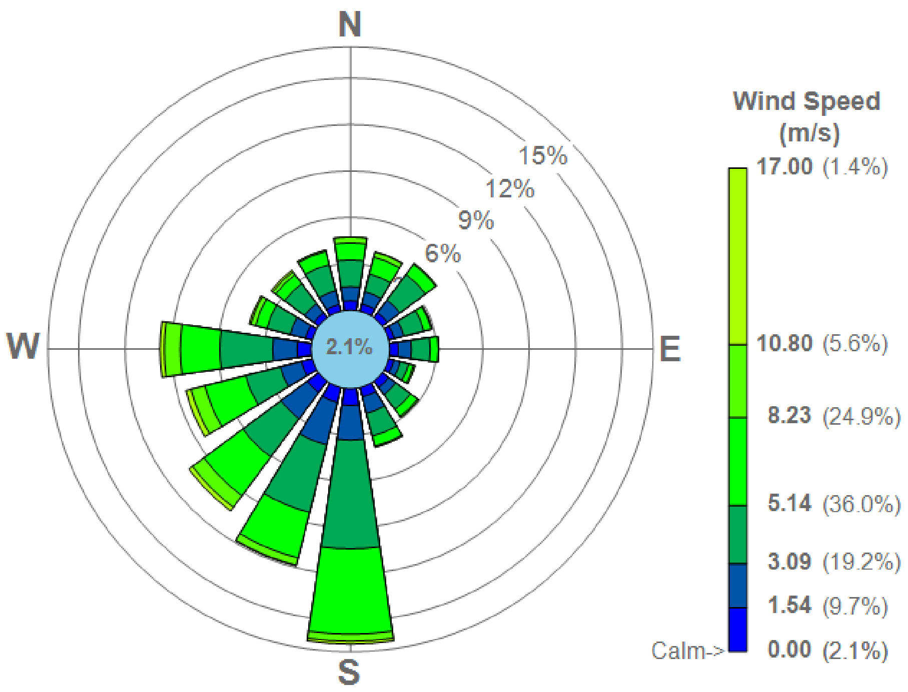

Figure B5: 2019