Tyrrells Potato Crisps Ltd

Planning Permission Application No DNMW/10013/F

Odour Impact Assessment to Support the Proposal for a 26m High Stack

AMEC Environment & Infrastructure UK Limited

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Report for

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Executive Summary

Non Technical Summary

Tyrrells Potato Crisps ('Tyrrells') has commissioned AMEC to undertake an odour monitoring and modelling assessment of their Stretford Bridge plant at Tyrrells Court Farm near Leominster.

Retrospective planning permission was granted on 24 December 2010 to regularise the operational activities of Tyrrells at Tyrrells Court Farm (App ref DMNW/100313/F). The planning permission is subject to 17 planning conditions. Condition 8 of the permission firstly requires an assessment of existing ventilation and extraction systems used in connection with crisp frying activities (i.e. an odour assessment) and, based on the results of the assessment, secondly the submission of details for a scheme of improvement. Further to this planning condition and an associated breach of condition noticed which served on 03 April 2012, a report was prepared and submitted on 01 May 2012 to seek to satisfy the second part of the condition and to comply with a breach of condition notice which was served on 03 April 2012. The report concluded that, in order to satisfactorily address odour concentrations at receptor locations, a combined ducting system to be dispersed by a chimney stack should be submitted

This assessment has been prepared to accompany the chimney stack planning application, updating the report submitted on 01 May 2012. It is conducted in accordance with a previous odour assessment conducted by AMEC in November 2011 which predicted the odour effect based upon monitored odour emissions in September 2011. Since this 2011 baseline assessment, Tyrrells has put in place an infrastructure and equipment upgrade programme to improve the extraction regime. The following improvements have been made which have had a beneficial impact on reducing odour effects:

- Fitting of new burner air intake ducting enabling an increase in air extraction from the fryer hoods;
- Refurbishment of the extraction fans;
- Full clean of extraction hoods;
- Replacement of contaminated ductwork;
- Increased ventilation fan extraction rates generally; and
- Increased rate of extraction through Phase 2 of the frying process.

This assessment was conducted to evaluate the future odour impact of the current site upon completion of these modifications. Monitoring was conducted on the 15 and 16 of February 2012, comprising a detailed evaluation of emissions from the two stacks which had, at that time, been fully modified in line with the aforementioned improvements. All eight stacks had been fully modified by April 2012.

This odour assessment has considered the impact of the Tyrrells factory based on refurbishment and replacement of the existing extraction system. Based on odour monitoring conducted on the 15 and 16 February 2012, the future impact of the Tyrrells site after these improvements have been completed has been predicted. This concludes that odour concentrations will be improved compared to the pre modification baseline assessment in 2011, but that predicted odour concentrations at receptor locations will still exceed the adopted odour criterion of 5 $ou_E\ m^{-3}$ as the 98^{th} percentile of hourly averages criterion.

In order to address the elevated odour concentrations at receptor locations, AMEC has proposed an odour mitigation system to improve odour dispersion from the Tyrrells site. This comprises of ducting all of the current stacks into a combined duct which is emitted from a stack in the area between Building 3 and Store 7. The exact position of this stack will be formalised in the outline and detailed design process which is to be conducted in June and July 2012. This new system will result in the removal of all of the existing roof-mounted fans.

The odorous airflow from the cooking area at Tyrrells contains an amount of fat carried forward from the cooking process. This is known to hamper traditional abatement systems and any such system would require a series of trials and tests to assess whether it could be a workable solution. Such trials and tests would be a medium term project and any investment decision by the business could not be made until later in the year/early next year. As such, the optimum solution, in terms of being able to e delivered in the short term and with certainty of effectiveness, is to provide a chimney stack to disperse odour and reduce the impact at the receptor.

In summary, the proposed odour mitigation system has been carefully considered and assessed and it represents the only proven solution currently available to Tyrrells to ensure that the odour levels can be compliant with the adopted odour criterion at all receptor locations and that odour levels can be reduced within a short timescale.

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1. Introduction

1.1 Background, Aims and Objectives

Tyrrells Potato Crisps ('Tyrrells') has commissioned AMEC to undertake an odour monitoring and modelling assessment of their Stretford Bridge plant at Tyrrells Court Farm near Leominster.

Retrospective planning permission was granted on 24 December 2010 to regularise the operational activities of Tyrrells at Tyrrells Court Farm. The planning permission is subject to 17 planning conditions. Condition 8 of the permission firstly requires an assessment of existing ventilation and extraction systems used in connection with crisp frying activities (i.e. an odour assessment) and, based on the results of the assessment, secondly the submission of details for a scheme of improvement. Further to this planning condition and associated breach of condition notice which was served 03 April 2012, a report was prepared and submitted 01 May 2012 to seek to satisfy the second part of the condition. The report concluded that, in order to address odour concentrations in a satisfactory manner at receptor locations, a combined ducting system to be dispersed by a chimney stack of 26m in height would be required.

Further to the report submitted 01 May 2012, Herefordshire Council responded in writing on 11 June 2012 confirming that the Council is unable to deal with such a proposal as a discharge of the planning conditions it would be required to consult a number of bodies that were not given the opportunity to comment on the original application and that as such, a planning application for the chimney stack should be submitted.

This assessment has been prepared to accompany the chimney stack planning application, updating the report submitted on 01 May 2012. It is conducted in accordance with a previous odour assessment conducted by AMEC in November 2011 which predicted the odour effect based upon monitored odour emissions in September 2011. Since this 2011 baseline assessment, Tyrrells has completed a scheme of infrastructure and equipment improvements to enable modification of the extraction regimes. The following improvements have been made which have had an impact on reducing odour effects:

- Fitting of new burner air intakes enabling an increase in air extraction from the fryer hoods;
- Refurbishment of the extraction fans;
- Full clean of extraction hoods;
- Replacement of contaminated ductwork;
- Increase ventilation fan extraction rates; and
- Increased rate of extraction through Phase 2 of the frying process.

This assessment has been conducted to evaluate the future odour impact of the current site upon completion of these modifications. Monitoring was conducted on the 15 and 16 of February 2012, comprising a detailed evaluation of emissions from the two stacks which had, at that time, been fully modified in line with the aforementioned improvements. All eight stacks had been fully modified by April 2012.

This report details the methodology, sampling results and results of the odour assessment of baseline emissions of odour from the Tyrrells facility. It also describes the detail of the proposed odour mitigation scheme.

1.1.1 Details of the Planning Approval and Condition 8

During March 2010 Tyrrells Crisps Ltd ('Tyrrells') applied for a retrospective planning permission (Application No. DMNW/100313/F) for change of use of four barns from agricultural to storage of crisps and associated products, the change of use of one barn from agricultural to mixed office and storage, a loading bay extension to Store 7 and temporary portacabins and various ancillary plant. Planning permission was granted on 24 December 2010 subject to 17 planning conditions.

A breach of the planning application notice was served upon Tyrrells on the 03 April 2012 with regards to emissions of odour detailed in Condition 8 and in particular, the need to provide a scheme of improvements to the extraction and ventilation systems. A report was submitted on 01 May 2012 to respond to Condition 8 specifically in relation to odour management. It also includes details provided by Tyrrells in relation to issues such as certain technical specifications and maintenance regimes connected with recent modifications and improvements and the overall timetable for the completion of upgrading of systems. As noted previously, this report updates that submitted on 01 May 2012, including in relation to reference the specific design of the odour mitigation scheme proposed (at the time of 01 May 2012, only details of the proposed chimney stack and associated infrastructure works had been worked up).

Condition 8 is as follows:

> Within 3 months of the date of this permission a detailed assessment of the the existing extraction and ventilation systems used in the production of crisp and potato crisps shall be submitted to and approved in writing by the local planning authority.
>
> Details of what will be included in this assessment, the method of assessment (including industry standards) shall be submitted to the local planning authority for approval prior to being undertaken.
>
> Within 5 months of the date of this permission a scheme of improvements to the extraction and ventilation systems shall be submitted to and approved in writing. This scheme shall include (as a minimum) the following:
>
> a) Details of replacement or upgraded systems (including detailed specifications)
> b) details of program of review/maintenance (e.g bi - annually) / improvement)
> c) Timbetable for replacement / upgrade
>
> Works shall be carried out in accordance with the approved details / timetable and the equipment shall be retained in perpetuity and maintained on a regular basis. Details of any replacement equipment shall be submitted to and approved by the local planning authority prior to its installation.
>
> Reason: To ensure that the extraction systems are sufficient having regard to the intensified use of the site and the amenities of the nearby residential properties and to comply with policies DR1, DR2, DR4 of the UDP.

Tyrrells has submitted two earlier responses to this condition. The report "*Tyrrells Potato Crisps Extraction and Ventilation Systems Assessment*", dated 12 May 2011, covered the detailed assessment of the existing extraction and ventilation systems and the submission of methods of assessment, subsequently approved by the Council in August 2011. An updated version of this report was submitted on 28 December 2011.

1.2 Site Description

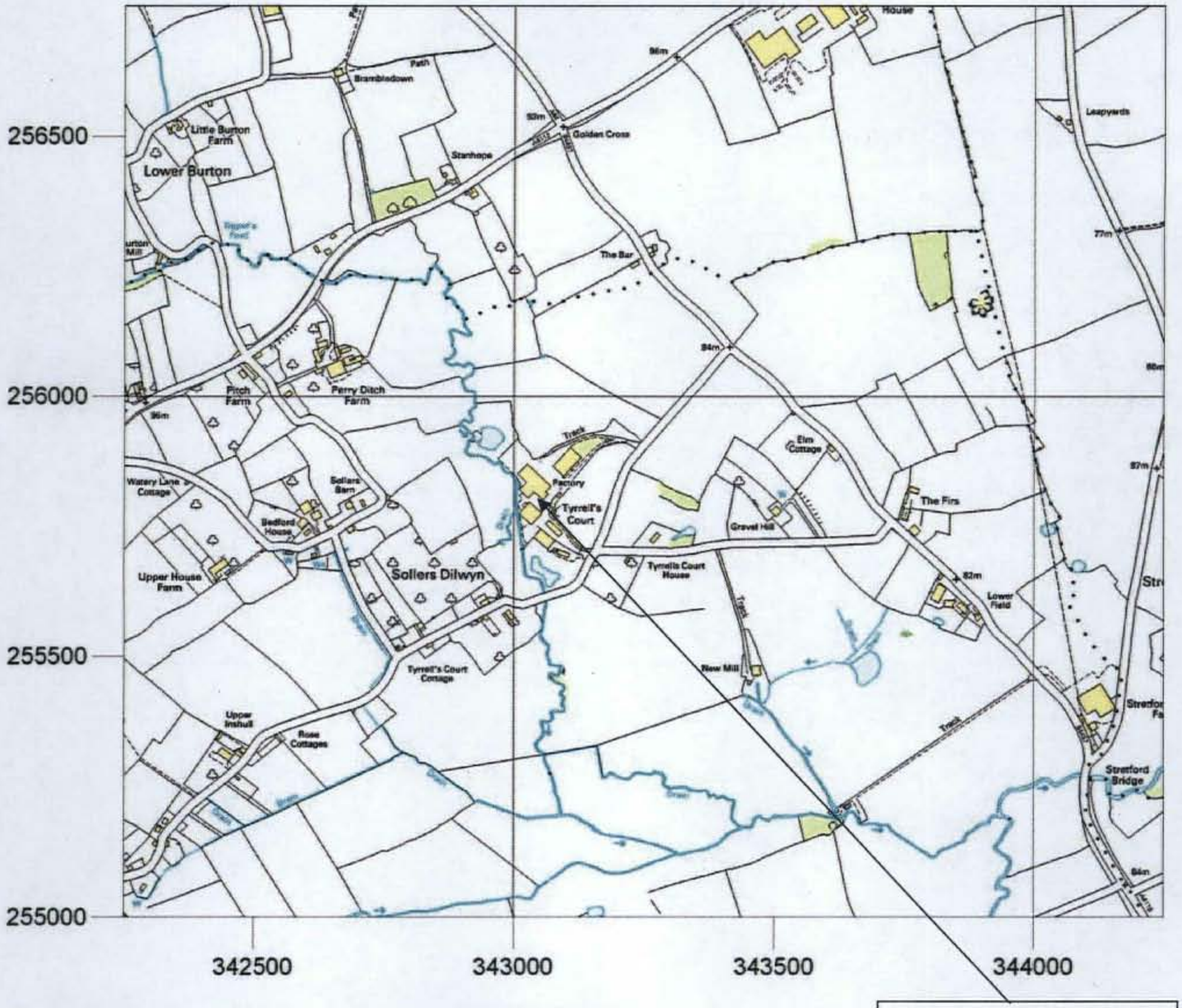
Tyrrells Court is located in a rural Herefordshire approximately 7km south-west of the town of Leominster. There are a small number of individual properties scattered around the facility in all directions, the closest being between 200m and 300m from the processing areas.

The two earlier reports submitted by Tyrrells in response to Condition 8 highlighted the fact that only 4 out of 15 responding neighbours complained about odour emissions/smell in the residents' survey carried out in January 2011.

Currently, the Tyrrells Court Site uses eight batch fryer units, each being fitted with its own individual extraction hood, which vents air out through individual stacks on the roof. The crisp frying process operates on a 10 minute cycle, the first 2 minutes of which require a higher level of extraction due to water in the potatoes being fried off and creating steam ("first phase/stage"). Frying of the crisps during the remaining 8 minutes of the cycle ("second phase/stage") does not produce any steam and under the previous regime the extraction level was automatically reduced. This has now been amended so that a consistent flow rate is provided through both frying phases.

Figure 1.1 provides a site location map, indicating the location of the site in relation to the local area.

Figure 1.1 Site Location Map



1.3 Sources of Information

The information used to assess air quality includes:

- Odour analysis data provided by Silsoe Odours Ltd;
- Flow rates measured during the odour monitoring survey on site;

- Ordnance Survey (OS) maps of the local area; and
- Meteorological data supplied by Atmospheric Dispersion Modelling Ltd.

1.4 Report Structure

The remainder of the report is set out as follows.

Table 1.1 Report Structure

Section	Aims and Objectives
Section 2	Describes the dispersion model, assessment methodology, model inputs and assumptions used in the assessment.
Section 3	Presents detail of the results of the sampling to establish baseline emissions.
Section 4	Presents an assessment of the predicted odour impact arising from the site emissions.
Section 5	Presents an assessment of the proposed odour mitigation scenario including a stack height assessment.
Section 6	Contains a summary and conclusions of the assessment
Section 7	Response to the specific requirements of Condition 8 and details of the proposed odour mitigation scheme.

2. Assessment Methodology

2.1 Odour and Assessment Criteria

The issue of malodours from industrial sources has gained increased public recognition over the last 20 years, along with growing expectations of quality of life and a reduced tolerance towards adverse environmental effects of business and utilities upon public amenity.

Odours are not generally additive in the same way as other nuisance parameters such as decibels for noise[1]. This reflects the way in which the brain responds to odour. The human brain has a tendency to screen out those odours which are always present or those that are in context to their surroundings. The human brain will also develop a form of acceptance to a constant background of local odours.

Odour assessments in the UK and overseas use the odour unit as its standard reference figure. A European Odour Unit ($ou_E\ m^{-3}$) is a term used to describe the amount of odour that, when evaporated into a cubic metre of clean air, is sufficient to reach the detection threshold of a panel of screened and selected human subjects. The process of measuring odour is called olfactometry. A description of olfactometry and the odour unit is provided in Appendix A.

Limited research is available into what constitutes an appropriate and workable odour standard. *The Concise Guide*[2] considers that odours at five times their detection threshold (effectively 5 $ou_E\ m^{-3}$) can be considered as having the potential to cause annoyance. Although this is not directly aimed at the food industry, it provides for a common guideline as to the historical approaches that have been adopted in food production, industrial, utilities and other applications.

In the Industrial, Food and Utility sectors modelling output has been assessed against an odour annoyance criterion whereby no critical receptor shall be exposed to a concentration of more than 5 $ou_E\ m^{-3}$ 98th percentile of hourly averages as a result of emissions from an odorous facility[3,4]. This criterion has its origins in the Miedema et al study[5] from the Netherlands. The study was based upon the 5 $ou_E\ m^{-3}$ as the 98th percentile criterion at residential receptors locations. The application of the criterion indicates that an odour annoyance occurs when the odour concentration exceeds 5 $ou_E\ m^{-3}$ for a time period exceeding 2% (7.2 days) of a year. Although this criterion has been generally accepted in the planning arena, certain circumstances have arisen where the population may be especially sensitive to odour emissions, namely through prolonged exposure and encroachment.

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[1] Environment Agency (2002) DRAFT Horizontal Guidance for Odour Part 1 - Regulation and Permitting

2Valentin, F.H.H and North, A.A. (1980).Odour Control - a concise guide. Department of the Environment.

[3] McGovern, JE, Clarkson, CR (1994). The Development of Northumbrian Waters Approach to Odour Abatement for Sewage Facilities.

[4] Department of the Environment (1993).Report by the Inspector on a Public Enquiry in to the Appeal by Northumbrian Water Limited for Additional Sewage treatment Facilities on Land Adjacent to Spital Burn, Newbiggin by the Sea, Northumberland.DoE APP/F2930/A/92/206240.

5Miedema., H.M.E., Walpot, J.I., Vos, H., Steunenberg, C.F. (2000). Exposure-annoyance relationships for odour from industrial sources. Atmospheric Environment 34, 2927-2936.

Research in the Netherlands[6] has highlighted the complexity of the assessment of odours. It states that situations exist where 5 $ou_E\ m^{-3}$ has been achieved and no complaints have been received, yet cases also exist where 1 $ou_E\ m^{-3}$ has been achieved and complaints are still received. The conclusion is that an appropriate nuisance criteria could lie anywhere between 1 $ou_E\ m^{-3}$ and 10 $ou_E\ m^{-3}$ as the 98th percentile of hourly averages at a critical receptor[7].

AMEC's extensive experience of applying and designing to this criterion over the last 15 years for many different schemes, including food preparation, pet food manufacturing, industrial applications and wastewater treatment indicates that, where compliance occurs, complaints with respect to odour are unlikely.

As the Tyrrells site does not require an environmental permit under the Environmental Permitting Regulations (EPR), the adopted odour annoyance criterion of 5 $ou_E\ m^{-3}$ as the 98th percentile of hourly averages has been used to determine the likelihood of an odour annoyance at a receptor location.

2.2 Assessment of Odour Impact

In order to assess the impact of the changes upon odour effects at receptor locations, Tyrrells commissioned a second odour monitoring and dispersion modelling assessment. This assessment was conducted on the 15 and 16 February 2012 and consisted of detailed odour sampling at two of the fully upgraded extraction units. This monitoring assessment follows the full baseline survey conducted on 20 September 2011.

The monitoring data was used to provide inputs to a dispersion modelling assessment to predict the odour baseline of the facility after the improvements had been implemented on all extraction units, work which has now been completed.

Sampling was conducted using the rigid lung method where air is evacuated from a sampling barrel in order to draw a representative air sample into an inert sampling bag. Odour Samples were taken from representative stacks during both high and low flow conditions alongside air flow measurements using a rotating vane anemometer.

As the dimensions of each stack are known an odour emission rate can be derived from the odour sample and the measured air flow rate. Olfactometry analysis of the samples was conducted by Silsoe Odours Ltd in order to determine the odour concentration at each source.

The assessment of odour impact was undertaken using the ADMS 4.2 dispersion model. This dispersion model has been extensively used to predict odour impacts, both in the UK and overseas and, as such, was considered appropriate for the odour assessment. The dispersion model was run using five years of meteorological data from Hereford Weather Station, located approximately 15km to the south-east of the facility.

Wherever possible, this assessment has used worst-case scenarios, which will over estimate the impact of the emissions on the surrounding area, including meteorology and surface roughness. This assessment has therefore

[6] Information Centre for the Environment (2001).*Netherlands Emission Guidelines for Air*.InfoMil.

[7] Hall, D. L., McIntyre, A. E., (2004). The Derivation of Odour Standards and their Role and the Foundation of Odour Management Plans for Planning Regulation.*In Proceedings of the Second National Conference Volume Two September 2004. Ed N. J. Horan.*

considered five years of meteorological data, and based the proposal on the single year yielding the greatest 98th percentile figures. The assessment has been based upon a 3km x 3km Cartesian grid centred upon the site with a resolution of less than 30m.

2.3 The Dispersion Model

The model used in this assessment is the ADMS 4.2 atmospheric dispersion model that has been developed and validated by Cambridge Environmental Research Consultants (CERC). The model has been used extensively throughout the UK for regulatory compliance purposes and is accepted as an appropriate air quality modelling tool by the Environment Agency and local authorities.

ADMS 4.2 parameterises stability and turbulence in the Atmospheric Boundary Layer (ABL) by the Monin-Obukhov length and the boundary layer depth. This approach allows the vertical structure of the ABL to be more accurately defined than by the stability classification methods of earlier dispersion models such as R91 or ISCST3. In ADMS, the concentration distribution follows a symmetrical Gaussian profile in the vertical and crosswind directions in neutral and stable conditions. However, the vertical profile in convective conditions follows a skewed Gaussian distribution to take account of the inhomogeneous nature of the vertical velocity distribution in the Convective Boundary Layer (CBL).

A number of complex modules, including the effects of plume rise, complex terrain, coastlines, concentration fluctuations, radioactive decay and buildings effects, are also included in the model, as well as the facility to calculate long-term averages of hourly mean concentration, dry and wet deposition fluxes, and percentile concentrations, from either statistical meteorological data or hourly average data.

2.3.1 Meteorology

For meteorological data to be suitable for dispersion modelling purposes, a number of meteorological parameters need to be measured on an hourly basis. These parameters include wind speed, wind direction, cloud cover and temperature. There are only a limited number of sites where the required meteorological measurements are made. The year of meteorological data that is used for a modelling assessment can also have a significant effect on ground level concentrations.

This assessment has utilised meteorological data recorded at Hereford Meteorological Station during the period 2006-2010. Hereford Meteorological Station is located approximately 15km to the south-east of the site and, therefore, likely to produce data representative of conditions at the site. The following figures illustrate the frequency of wind directions and wind speeds for the years considered.

Figure 2.1 2006 Wind Rose

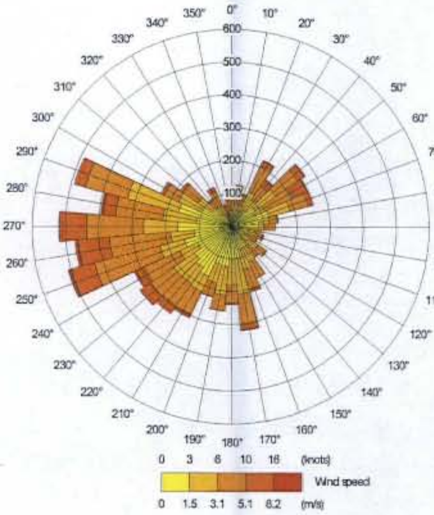


Figure 2.2 2007 Wind Rose

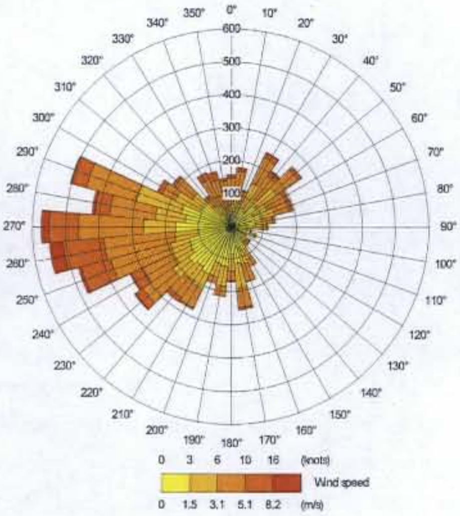


Figure 2.3 2008 Wind Rose

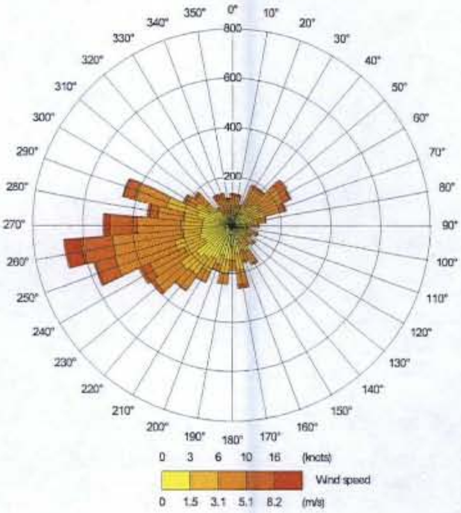


Figure 2.4 2009 Wind Rose

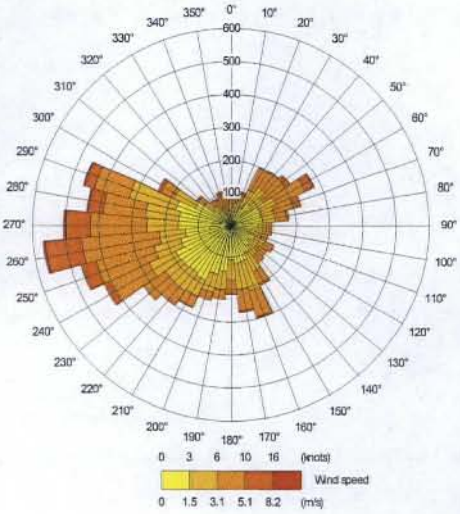
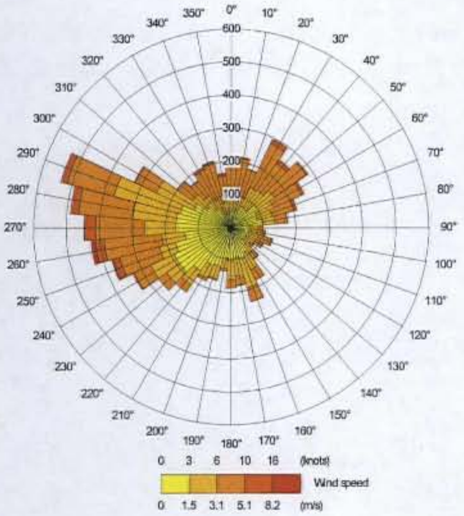


Figure 2.5 2010 Wind Rose



2.3.2 Surface Characteristics

The predominant surface characteristics and land use in a model domain have an important influence in determining turbulent fluxes and, hence, the stability of the boundary layer and atmospheric dispersion. Factors pertinent to this determination are detailed below. Consideration to these impacts is explained in more detail in Appendix C.

2.3.3 Surface Roughness

The overall impact on ground level concentration is, therefore, strongly correlated to the distance and orientation of a receptor from the emission source. This assessment has used a value of 0.3m to represent the agricultural nature of the surrounding area.

2.3.4 Buildings

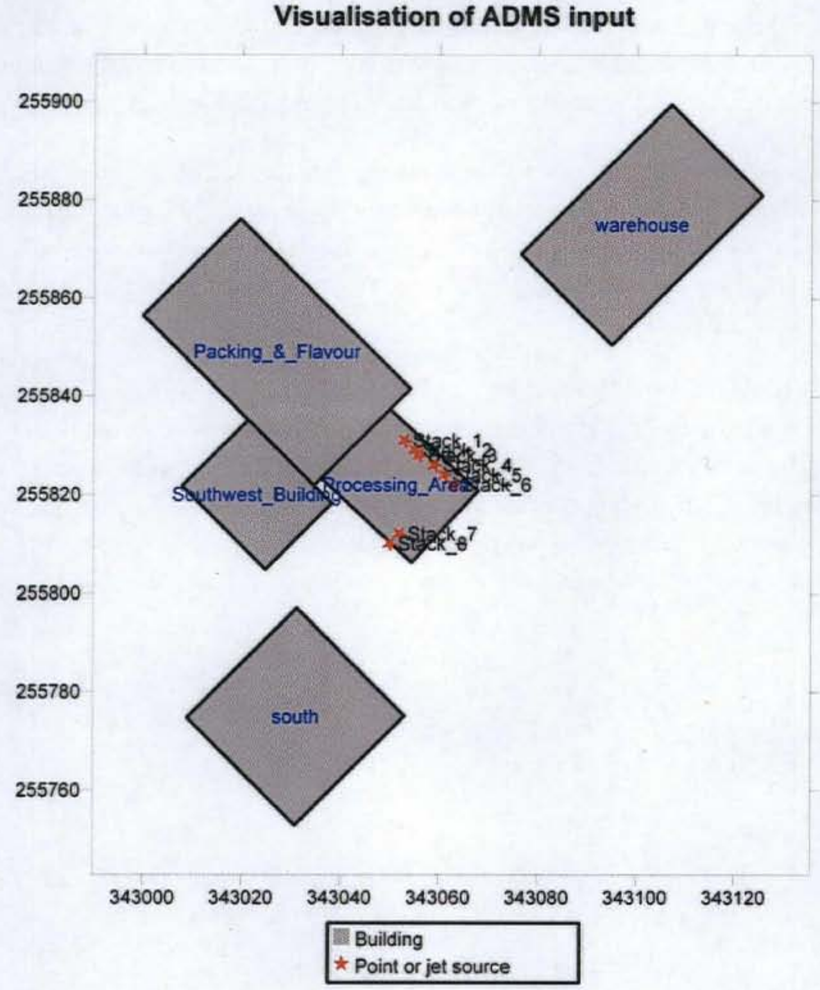
Any large, sharp-edged object has an impact on atmospheric flow and air turbulence within the locality of the object. This can result in maximum ground level concentrations that are significantly different (generally higher) from those encountered in the absence of buildings. The building 'zone of influence' is generally regarded as extending a distance of 5L (where L is the lesser of the building height or width) from the foot of the building in the horizontal plane and three times the height of the building in the vertical plane.

Table 2.1 and Figure 2.6 detail the generic buildings that have been assumed to be present at the site and, consequently, included in the model. With the exception of the main processing building, the ridge height has been used as the building height. As some of the existing stacks are below the ridge height of the processing building, a height of 9.7m has been used, 1m below the ridge height of the building.

Table 2.1 Buildings Modelled

Building	X (m)	Y (m)	Height (m)	Length (m)	Width (m)	Angle (°)
Processing Area	343052	255822	9.7	25	19.8	132.8
Packing & Flavour	343027	255849	10.7	49	27.8	315
South-west building	343023	255820	10.7	24	19	315
South Building	343031	255775	10.7	31	31.5	315
Warehouse	343101	255875	10.7	26.2	43.1	315

Figure 2.6 Generic Building and Emission Point Visualisation - 2012 Baseline Scenario



2.3.5 Terrain

As the terrain in the area is generally flat and does not exceed the modelling guidance of a scoping gradient criteria of 10% change, terrain has not been included in the model.

2.3.6 Modelled Domain and Receptors

Modelled Domain

A 3km x 3km square grid centred on the site was modelled, with an approximate receptor resolution of 30m, to assess the impact of atmospheric emissions from the site on local air quality.

2.3.7 Sensitivity Analysis and Uncertainty

Dispersion modelling is inherently uncertain, but is nonetheless a useful tool in plume footprint visualisation and prediction of ground level concentrations. The use of dispersion models has been widely used in the UK for both regulatory and compliance purposes for a number of years and is an accepted approach for this type of assessment.

This assessment has incorporated a number of worst-case assumptions, as described above, which will result in an overestimation of the predicted ground level concentrations from the process. Therefore, the actual predicted ground level concentrations would be expected to be lower than this and, in some cases, significantly lower. This assessment has considered the years predicting the highest ground-level concentrations at the nearest sensitive receptor for comparison with the AQS.

The model is well validated with observed concentrations for a number of scenarios; however, as the complexity of the modelled domain increases, modelled concentrations deviate from observed concentrations. For this modelling assessment, it was not considered suitable to scope out the inclusion of buildings in the model due to the nature of the site. However, the inclusion of buildings in the model introduces a further element of uncertainty but provides a better representation of plume dispersion and downwash. Terrain effects have been scoped out of the assessment whilst a surface roughness value of 0.3, representing an agricultural land use, has been used.

3. Sampling of Existing Odour Emissions

3.1 Odour Sampling

Odour sampling was conducted at the Tyrrells facility on 15 and 16 February 2012. Sampling was conducted on an overcast day with an ambient temperature of approximately 10°C. Odour samples were collected during both the first and second stages of frying from the two fully refurbished stacks; Stacks 5 and 6. Two flow rate options were considered, a 50 Hz scenario representing current emissions from the site and a 60 Hz scenario representing the maximum future extraction rate using the current fans.

The results of this odour monitoring assessment are detailed in Table 3.1.

Table 3.1 Olfactometry Results

Operating Conditions	Odour Concentration (ou_E m^{-3})				Geometric mean (ou_E m^{-3})
	Stack 5 Sample 1	Stack 5 Sample 2	Stack 6 Sample 1	Stack 6 Sample 2	
Phase 1 Frying - 50 Hz	21,690	18,410	32,050	29,370	24,761
Phase 2 Frying - 50 Hz	12,040	11,530	8,820	13,600	11,360
Phase 1 Frying - 60 Hz	19,890	31,590	20,650	28,770	24,718
Phase 2 Frying - 60 Hz	13,040	10,880	15,690	16,620	13,869

* single samples taken to best represent emissions from the frying and non frying phases.

The odour analysis showed that odour concentrations during the first frying phase were approximately double that what was measured during the second phase of frying. Flow temperatures varied between 40 and 45°C across the stacks. As a conservative assumption, a stack flow temperature of 40°C has been assumed in the model.

3.2 Quantification of Emission

Table 3.1 details the efflux velocities, calculated volumetric flow rates and comparable odour emission rates used in the dispersion modelling assessment. The assessment has used measured flow rates from February 2012 for Stacks 1 to 6, whilst flow rates from the remaining stacks were based on monitoring conducted in September 2011 monitoring. The 60 Hz flow rates have been factored using the results from measurements from Stacks 5 and 6. Stack 5 exhibited a proportion increase of 1.127 between the 50 Hz and 60 Hz measurements and this factor has been applied to Stacks 4, 7 and 8 which use the larger type fans. Stack 6 exhibited a proportion increase of 1.158

between the 50 Hz and 60 Hz measurements and this factor has been applied to Stacks 1, 2 and 3 which use the smaller fans.

Table 3.2 Calculated Odour Emission Rates

Process Source	Stack	Measured Efflux Velocity (ms^{-1})	Volumetric flow Rate ($m^3 s^{-1}$)	Odour Concentration ($ou_E m^{-3}$)		Odour Emission Rate ($ou_E s^{-1}$)		Hourly Averaged Emission ($ou_E s^{-1}$)
				Phase 1	Phase 2	Phase 1	Phase 2	
Stack 1 - 50 Hz	10.2	8.54	2.28	24,761	11,360	56,450	25,898	32,008
Stack 2 - 50 Hz	10.7	10.30	2.75	24,761	11,360	68,103	31,244	38,616
Stack 3 - 50 Hz	11.3	8.56	2.28	24,761	11,360	56,565	25,951	32,074
Stack 4 - 50 Hz	11.4	10.21	7.62	24,761	11,360	188,659	86,553	106,974
Stack 5 - 50 Hz	10.6	8.09	6.04	24,761	11,360	149,522	68,598	84,783
Stack 6 - 50 Hz	9.9	13.79	3.68	24,761	11,360	91,162	41,823	51,691
Stack 7 - 50 Hz	10.1	8.40	6.27	24,761	11,360	155,252	71,226	88,032
Stack 8 - 50 Hz	10.1	6.67	4.98	24,761	11,360	123,216	56,529	69,866
Total 50 Hz			**35.90**			**888,929**	**407,823**	**504,044**
Stack 1 - 50 Hz	10.2	9.88*	2.64	24,718	13,869	65,242	36,606	42,333
Stack 2 - 50 Hz	10.7	11.92*	3.18	24,718	13,869	78,710	44,163	51,073
Stack 3 - 50 Hz	11.3	9.90*	2.64	24,718	13,869	65,376	36,681	42,420
Stack 4 - 50 Hz	11.4	11.50*	8.58	24,718	13,869	212,195	119,059	137,687
Stack 5 - 50 Hz	10.6	9.12	6.80	24,718	13,869	168,176	94,361	109,124
Stack 6 - 50 Hz	9.9	15.96	4.26	24,718	13,869	105,361	59,117	68,366
Stack 7 - 50 Hz	10.1	9.46*	7.06	24,718	13,869	174,620	97,977	113,306
Stack 8 - 50 Hz	10.1	7.51*	5.61	24,718	13,869	138,588	77,759	89,925
Total 60 Hz			**40.79**			**1,008,268**	**565,724**	**654,233**

* Calculated using the 50 Hz to 60 Hz conversions factors.

The dispersion modelling assessment has assumed constant operation based on a 10 minute cycle comprising of 2 minutes of Phase 1 frying and 8 minutes of Phase 2 frying. The odour emission rates have been weighted in order to calculate an hourly averaged odour emission rate for dispersion modelling purposes.

4. Baseline Odour Impacts

4.1 Baseline Assessment

The baseline assessment has been based on the 50 Hz operating condition which best represents emissions from the plant after completion of the first phase of stack improvements and refurbishments. All scenarios use the worst case assumption that all of the fryers will be running in either the first or second frying modes at full capacity for 24 hours a day, 365 days a year. This worst case assumption is likely to overestimate results as there will be periods where fryers are between processing batches and periods when fryers are not operational. This assumption also discounts routine weekly cleaning of the fryers, a period where no odour will be emitted from the associated extraction hood.

The odour emission rates, stack properties and efflux velocities which form the basis of the modelled baseline scenario are taken from the 50 Hz scenario as indicated in Table 3.2. The worst case meteorological year was selected by selecting the year which predicted the highest odour concentration at the worst case receptor location. The results of all five assessment years are provided in Table 4.1.

Table 4.1 Baselines Scenario - Worst Case Odour Concentration at a Receptor Location

Meteorological Year	Predicted odour Concentration ($ou_E m^{-3}$ as the 98th percentile of hourly averages)
2006	19.8
2007	20.8
2008	17.6
2009	18.5
2010	23.2

The dispersion modelling assessment predicted that odour concentrations at receptor locations exceeded the adopted odour annoyance criterion of 5 ou_E m^{-3} as the 98th percentile of hourly averages for the baseline scenario. Although the adopted odour annoyance criterion is breached, the modifications have reduced odour concentrations when compared to the 2011 pre modification baseline odour assessment. Concentrations at the worst case receptor for the 2011 baseline assessment were in excess of 30 ou_E m^{-3} as the 98th percentile of hourly averages for the worst performing scenario.

The predicted odour contour plot for the worst case year, 2010, has been provided in Figure 4.1 whilst all other assessment years are presented in Appendix D.

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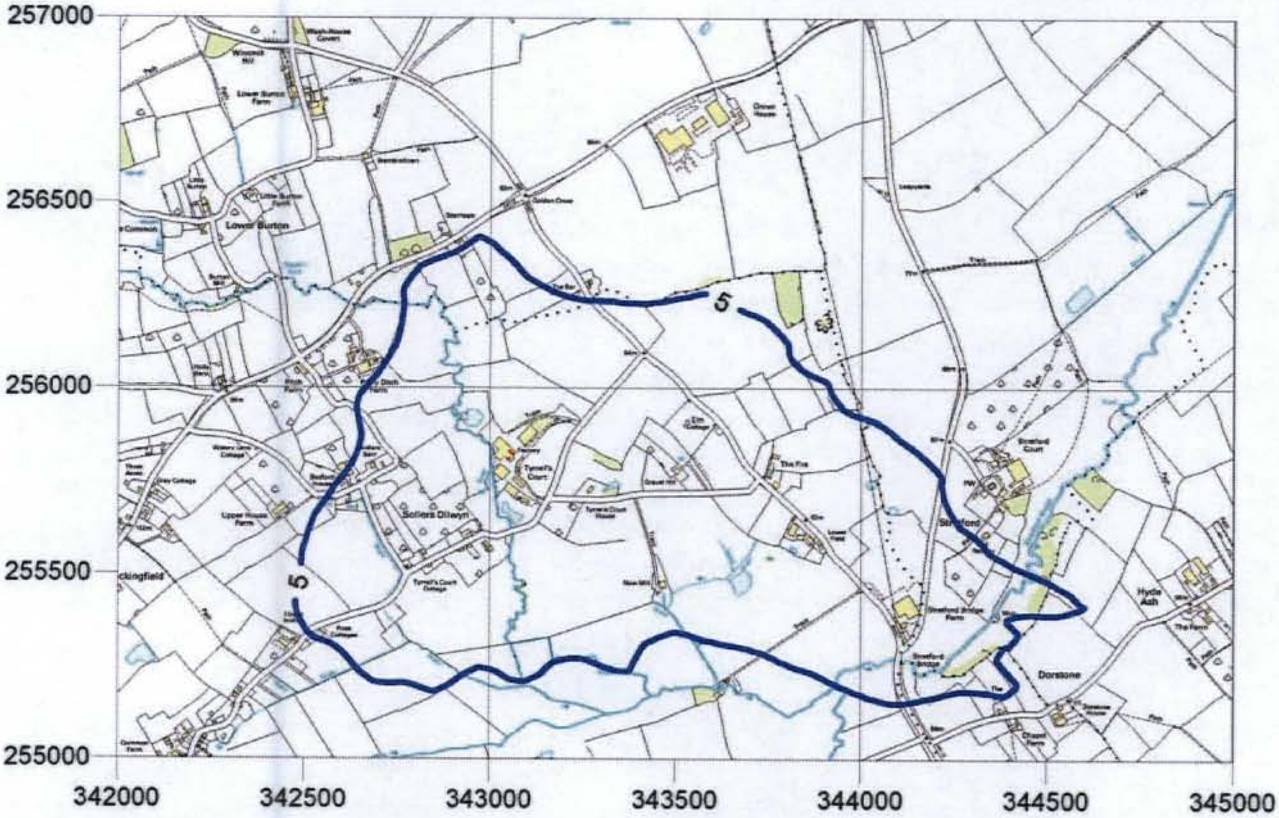
Figure 4.1 Predicted Baseline Odour Concentrations - $ou_E\ m^{-3}$ as the 98[th] percentile of hourly averages (2010)



5. Proposed Odour Mitigation Scenario

As the baseline assessment predicted that odour concentrations at receptor locations exceeded the odour annoyance criterion at receptor locations, Tyrrells has put in place further proposals to improve dispersion from the Leominster Site.

AMEC has proposed a design to combine the eight extraction systems into a single system which would be emitted via a ground based stack. A number of stack locations are currently under consideration with the stack likely to be constructed in the space between the current warehouse (Store 7) and the current processing area (Building 3). This assessment has considered one of these options, a location to the north-west of the warehouse to demonstrate the feasibility of using an odour extraction stack as a viable odour mitigation method.

This scenario has been assessed using dispersion modelling to evaluate the benefit of the modifications with respect to odour. The preferred height of the new combined emission point has been determined by a stack height assessment, details of which are provided in this report.

5.1 Quantification of Emissions

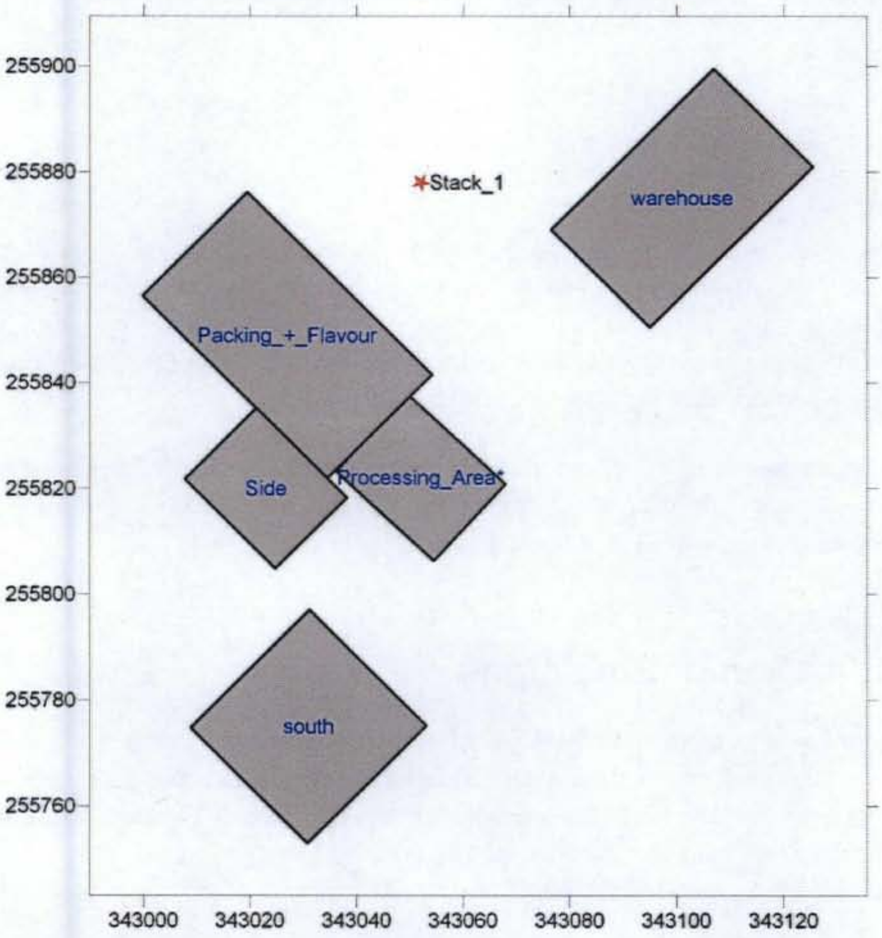
The modelled odour emission parameters for the Odour Mitigation Scenario are presented in Table 5.1. The assessment has assumed that the future extraction rates are equivalent to the maximum flow rates achievable by the existing fan system, as represented by the 60 Hz scenario. As shown in Table 3.2, the worst case future flow rate will be 40.79 m^3s^{-1} which would emit odour at a rate of 654,233 $ou_E\,s^{-1}$. To achieve an efflux velocity of 20 ms^{-1} the stack will be reduced at the stack tip to an outlet diameter of 1.61m.

As a worst case assumption it has been assumed that crisp frying occurs 365 days a year on a 24 hour basis.

Table 5.1 Proposed Odour Mitigation Scenario, Modelled Parameters

Source	Grid Reference		Stack Height (m)	Odour Emission Rate (ou_Es^{-1})	Efflux Velocity (ms^{-1})
	x (m)	y (m)			
Combined Stack	343052	255878	14-32 m	654,233	20

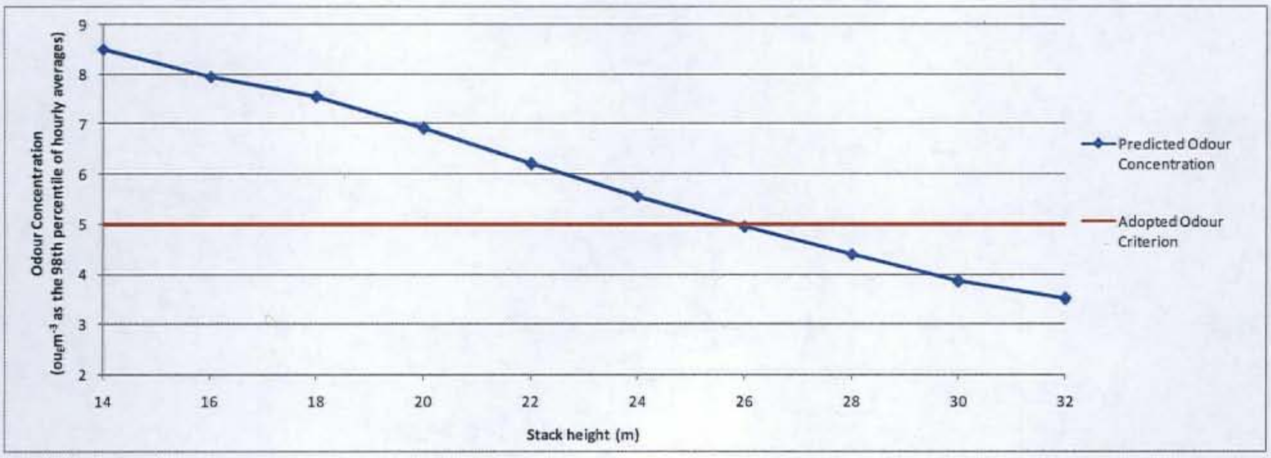
Figure 5.1 Proposed Location of the Combined Odour Mitigation Extraction Stack



5.2 Predicted Odour Concentrations - Stack Height Assessment

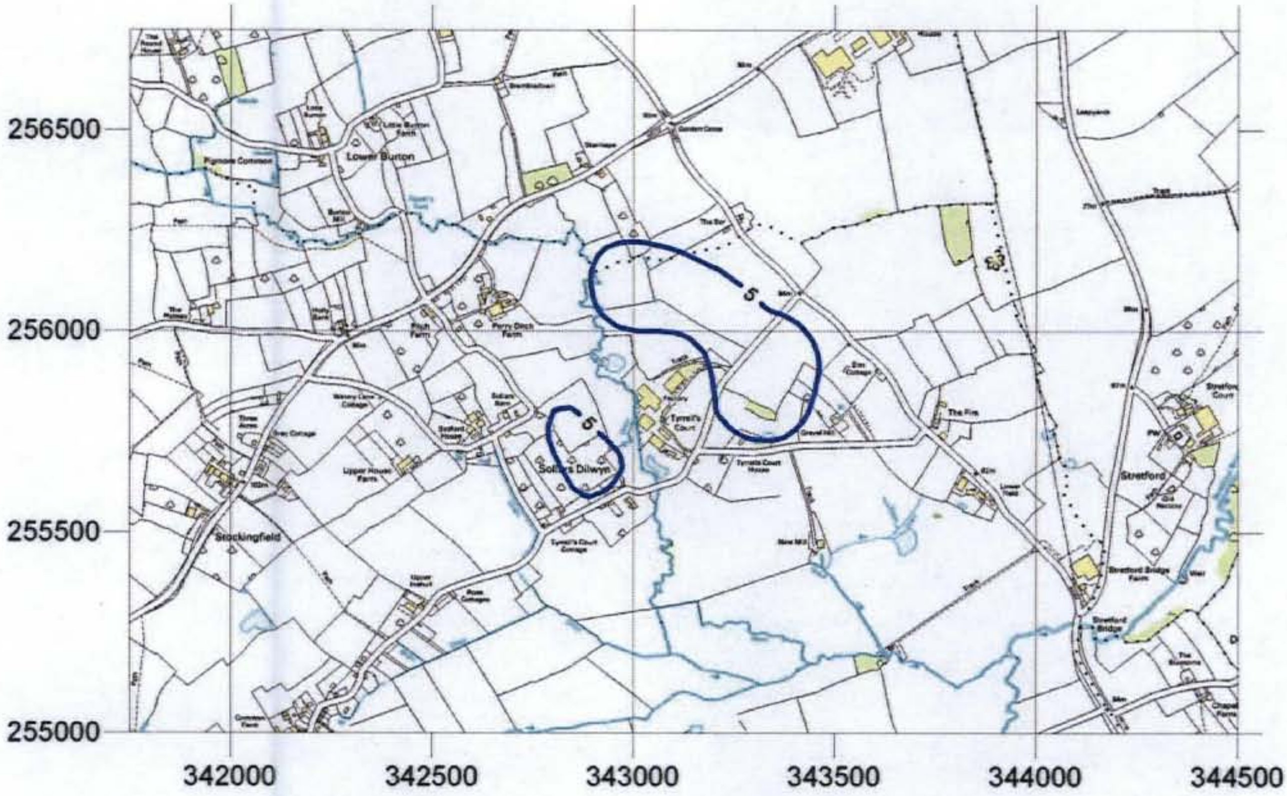
In order to determine the appropriate size of the new combined odour stack, a stack height assessment was conducted evaluating dispersion from stacks ranging from 14m to 32m at 2m intervals. The maximum odour concentration at a receptor location has been used to identify the stack height requirements for a scenario complaint with the adopted odour criterion. Figure 5.2 shows the maximum receptor concentration for all the stack heights considered in this assessment.

Figure 5.2 Stack Height Assessment - Predicted Odour Concentrations, 14-32m ($ou_E\ m^{-3}$ as the 98th percentile of hourly averages)



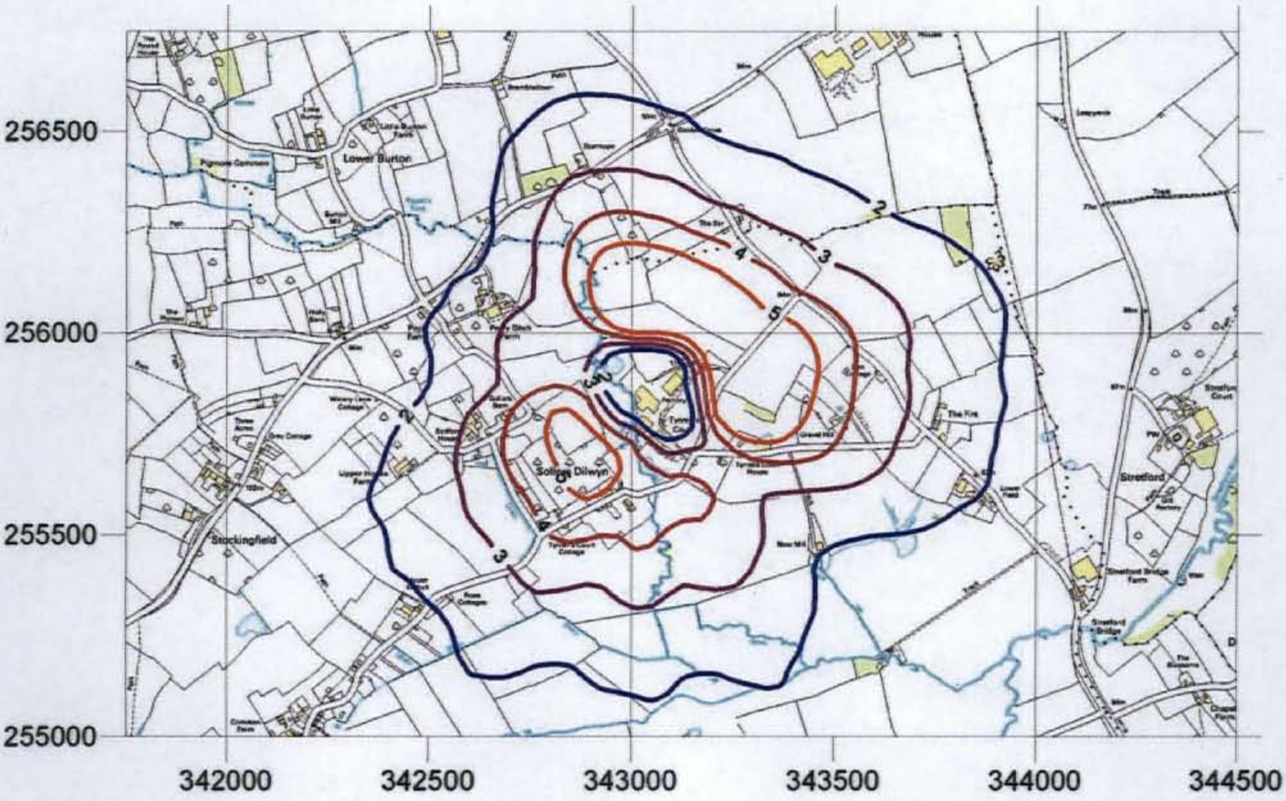
The stack height assessment predicted that a 26m stack would provide sufficient dispersion of odours to meet the odour criterion at all relevant receptor locations. The dispersion modelling contour plot for the compliant scenario is presented as Figure 5.3.

Figure 5.3 Predicted Odour Concentrations - Proposed 26m Combined Stack Scenario, 2010 ($ou_E\ m^{-3}$ as the 98th percentile of hourly averages)



A map with a more detailed isopleths is provided in Figure 5.4 to ensure that no receptor distanced from the Tyrrells site is predicted to be subjected to odour concentrations higher than the adopted odour annoyance criterion.

Figure 5.4 Predicted Odour Concentrations - Proposed 26m Combined Stack Scenario, 2010 ($ou_E\ m^{-3}$ as the 98[th] percentile of hourly averages) - 1,2,3,4,5 $ou_E\ m^{-3}$ Isopleths



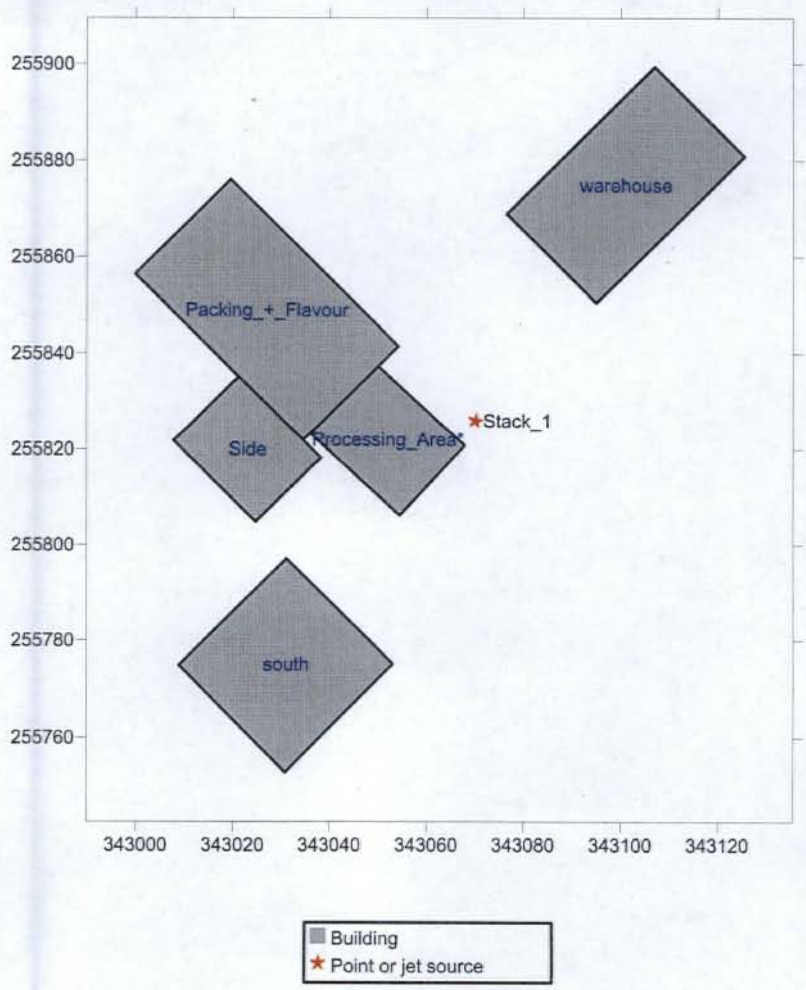
6. Revised Final Stack Position

6.1 Relocated Stack Position

As part of the detailed design process, the stack location has been revised so that it is located near to the easterly corner of the current processing building. As the position of the stack may have an affect on concentrations at receptor locations, odour dispersion modelling for the worst case year, 2010, has been conducted for the revised stack position. All other parameters remain the same as modelled in Section 5.

The revised position is shown in Figure 6.1

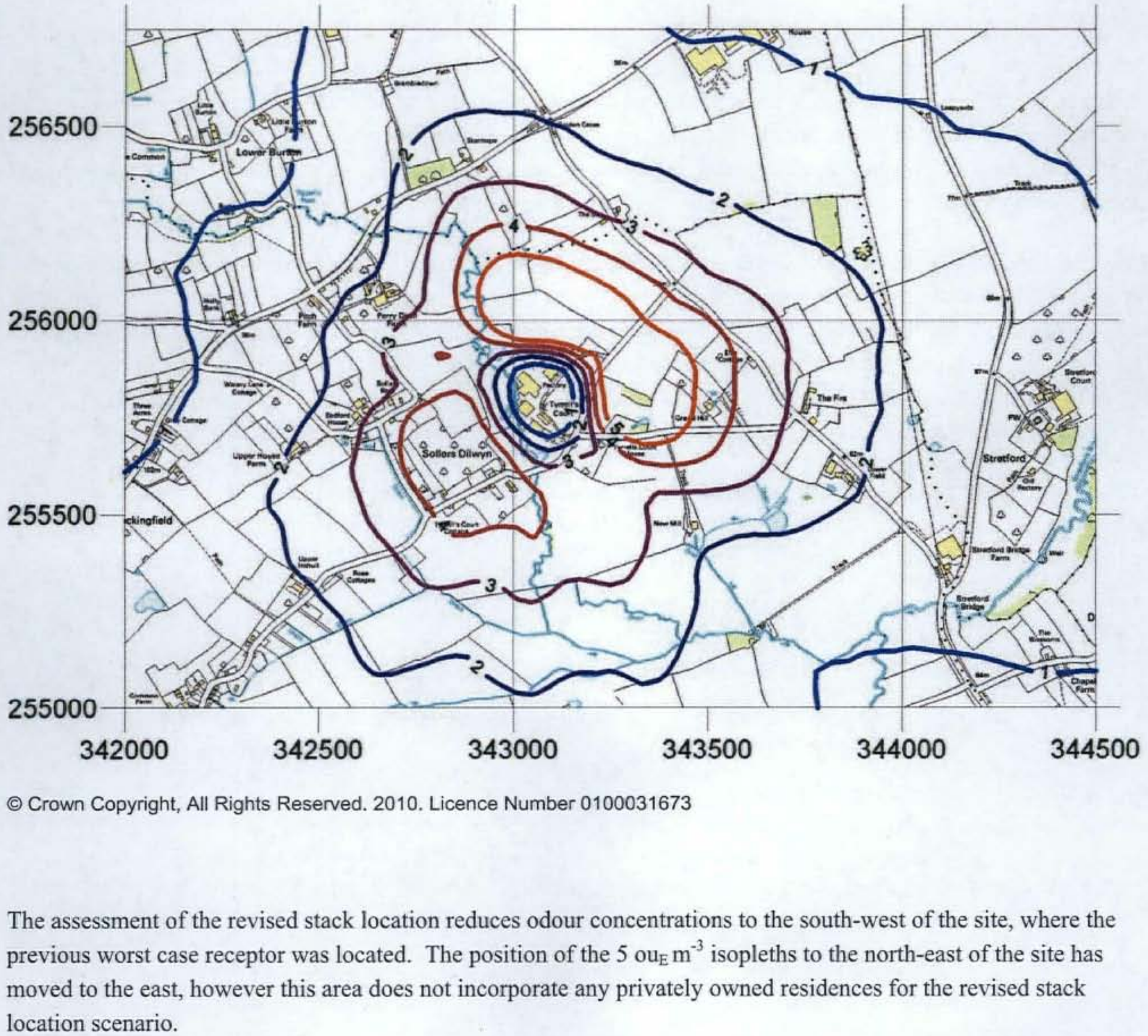
Figure 6.1 Revised Proposed Location of the Combined Odour Mitigation Extraction Stack



6.2 Odour Dispersion Modelling Results - Revised Stack Location

The predicted odour contour for the revised stack position for the worst case meteorological data is presented as Figure 6.2.

Figure 6.2 Revised Stack Location - Predicted Odour Concentrations - Proposed 26m Combined Stack Scenario, 2010 ($ou_E\,m^{-3}$ as the 98th percentile of hourly averages)



The assessment of the revised stack location reduces odour concentrations to the south-west of the site, where the previous worst case receptor was located. The position of the 5 $ou_E\,m^{-3}$ isopleths to the north-east of the site has moved to the east, however this area does not incorporate any privately owned residences for the revised stack location scenario.

7. Conclusions

This odour assessment has considered the impact of the Tyrrells factory based on refurbishment and replacement of the existing extraction system. Based on odour monitoring conducted on the 15 and 16 February 2012, the future impact of the Tyrrells site after these improvements have been completed has been predicted. Despite odour concentrations being improved compared to the pre modification baseline assessment in 2011, predicted odour concentrations at receptor locations exceeded the adopted odour criterion of 5 ou_E m^{-3} as the 98^{th} percentile of hourly averages criterion.

In order to address the elevated odour concentrations at receptor locations AMEC has proposed an odour mitigation system to improve odour dispersion from the Tyrrells site. This comprise of ducting all of the current stacks into a combined duct which is emitted from a stack in the area between Building 3 and Store 7. The exact position of this stack will be formalised in the outline and detailed design process. This new system will result in the removal of all of the existing roof-mounted fans. A stack height assessment concluded that a release point 26m from the ground would provide the required dispersion.

The odorous airflow from the cooking area at Tyrrells contains an amount of fat carried forward from the cooking process. This is known to hamper traditional abatement systems and any such system would require a series of trials and tests to assess whether it could provide a workable solution. Such trials and tests would be a medium term project and any investment decision by the business could not be made until next year. As such, the optimum solution, in terms of being able to be delivered in the short term and with certainty as to its effectiveness, is to provide a chimney stack to disperse odour and reduce the impact at the receptor.

In summary, the proposed odour mitigation system has been carefully considered and assessed and it represents the only proven solution currently available to Tyrrells to ensure that the odour levels can be compliant with the adopted odour criterion at all receptor locations and that odour levels can be reduced within a short timescale.

8. Details of the Proposed Odour Mitigation Scheme

A main purpose of this report is to provide a response to the requirements of Condition 8 attached to planning permission reference DMNW/100313/F and in particular, to respond to Section 5 of the breach of condition notice dated 03 April 2012(Council reference E/2012/001607/ZZ). In accordance with the planning condition, the notice requires the following:

The following paragraphs draw together details in relation to the overall scheme of improvements to extraction and ventilation systems in specific response to the requirements of criterion a) - c) listed in the condition. In response, regard is had to the various elements of the improvement scheme, including improvements already made to extraction and ventilation systems and those improvements still to be implemented. This section also includes details supplied by Tyrrells, such as in relation to technical specifications and maintenance programs associated with the improvements already implemented by the business.

8.1 Details of Replacement and Upgraded Systems

As part of the initial upgrade to the existing site infrastructure the following improvements have been made to each of the existing extraction systems:

- Fitting of new burner air intakes enabling an increase in air extraction from the fryer hoods;
- Refurbishment of the extraction fans;
- Full clean of extraction hoods;
- Replacement of contaminated ductwork;
- Increase ventilation fan extraction rates; and
- Increased rate of extraction through Phase 2 of the frying process.

This assessment has indicated that extraction via a combined odour extraction would be a viable odour mitigation methodology capable of meeting the adopted odour criterion at all receptor locations. The outline proposal for an odour extraction stack is based on the following requirements:

- Stack height of at least 26m (determined by this odour assessment);
- Appropriate stack diameter achieving an efflux velocity of 20 ms^{-1};
- Duty standby ground level fans; and
- Possibility of a below roof level support frame or spiral strengtheners.

The eight existing fans will be replaced with a duty standby fan configuration located at the base of the proposed stack. The new ducting system will also include non return dampeners with two isolation dampeners for the duty standby fan system. A cone at the top of the stack will be fitted to maintain the required efflux velocity of at least 20 ms^{-1}.

The layout drawings, building elevations and site plan of the proposed scenario will accompany the planning application for the construction of the chimney stack.

8.2 Timetable for Replacement/Upgrade

The following is the current working draft delivery programme for the new 26m stack. A separate planning application will be required for this stack and this is reflected in the program. This program would be subject to change dependent on the planning permissions and other potential delays. The planning authority would be made aware in writing of any delays in the schedule, with a discussion about the reasons for any delays.

Table 8.1 Delivery Timetable

Item	June	July	August	September	October	Nov.
Determination				♦		
Outline Design						
Detailed Design						
Fabrication						
Installation						

After completion of the construction, a full odour monitoring assessment and dispersion modelling will be used to assess the effect of the installed odour mitigation equipment.

8.3 Maintenance Detail

Cleaning and maintenance frequency is as follows:

- Deep cleaning and maintenance work on fryers - fortnightly;

- Deep cleaning of fryer cooker hoods - fortnightly;
- Deep cleaning of fryer extraction ducting - annually; and
- Cleaning and maintenance of new extraction fans and new stack - annually.

Appendix A
Olfactometry and Odour Units

An odour unit is defined as the number of times a sample needs to be diluted with odour free air to reach a point at which half of the panel can detect the odour. The European odour unit (ou_E) is the amount of odorant that when evaporated into $1m^3$ at standard conditions, elicits a physiological response from a panel (detection threshold) equivalent to that elicited by one European Reference Odour Mass (EROM) evaporated in $1m^3$ of neutral gas at standard conditions.

One EROM, evaporated into $1m^3$ of neutral gas at standard conditions, is the mass of substance that will elicit the 50% detection threshold (D_{50}) physiological response assessed by an odour panel in conformity with this standard and has by definition a concentration of 1 ou_E/m^3.

For n-butanol (CAS-Nr. 71-36-3) one EROM is 123μg. Evaporated in $1m^3$ of neutral gas, at standard conditions, this produces a concentration of 0.040μmol/mol (equal to 40 ppb by volume).

The relationship between ou_E for the reference odorant and that for any mixture of odorants at the D_{50} concentration;

$$1 \text{ EROM} \equiv 123 \ \mu g \text{ n-butanol} \equiv 1 ou_E \text{ (for a mixture of odorants)}$$

By definition odour units are expressed as n-butanol mass equivalents.

Measurement of Odour Concentration Using Olfactometry

Odour concentration of a gaseous sample of odorants is determined by presenting a panel of selected and screened human subjects (Figure C1[8]) with that sample, varying the concentration by diluting with neutral gas in order to determine the dilution factor at D_{50}.

At that dilution factor the odour concentration is 1 ou_E/m^3 by definition. The odour concentration of the sample is then expressed as a multiple (equal to the dilution factor at 1 ou_E/m^3) of one European odour unit per cubic metre at standard conditions for olfactometry.

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[8] Photo courtesy of Silsoe Odours

The measurement of odour concentration is the subject of British Standard BS EN 13725:2003(E)[9]. Odour laboratories used by AMEC are UKAS accredited.

[9] British Standards Institute (2003) Air Quality - Determination of Odour Concentration by Dynamic Olfactometry. BS EN 13725:2003 (E)

Appendix B
ADMS 4.2

The model used in this assessment is the ADMS 4.2 atmospheric dispersion model that has been developed and validated by Cambridge Environmental Research Consultants (CERC). The model has been used extensively throughout the UK for regulatory compliance purposes and is accepted as an appropriate air quality modelling tool by the Environment Agency and local authorities.

ADMS 4.2 parameterises stability and turbulence in the atmospheric boundary layer (ABL) by the Monin-Obukhov length and the boundary layer depth. This approach allows the vertical structure of the ABL to be more accurately defined than by the stability classification methods of earlier dispersion models such as R91 or ISCST3. In ADMS, the concentration distribution follows a symmetrical Gaussian profile in the vertical and crosswind directions in neutral and stable conditions. However, the vertical profile in convective conditions follows a skewed Gaussian distribution to take account of the inhomogeneous nature of the vertical velocity distribution in the Convective Boundary Layer (CBL).

A number of complex modules, including the effects of plume rise, complex terrain, coastlines, concentration fluctuations, radioactive decay and buildings effects, are also included in the model, as well as the facility to calculate long-term averages of hourly mean concentration, dry and wet deposition fluxes, and percentile concentrations, from either statistical meteorological data or hourly average data.

A range of input parameters is required including, among others, data describing the local area, meteorological measurements, emissions data and stack flow rate parameters.

Appendix C
Dispersion Modelling Parameters

Surface Roughness

Roughness length, z_0, represents the aerodynamic effects of surface friction and is physically defined as the height at which the extrapolated surface layer wind profile tends to zero. This value is an important parameter used by meteorological pre-processors to interpret the vertical profile of wind speed and estimate friction velocities which are, in turn, used to define heat and momentum fluxes and, consequently, the degree of turbulent mixing.

The surface roughness length is related to the height of surface elements; typically, the surface roughness length is approximately 10% of the height of the main surface features. Thus, it follows that surface roughness is higher in urban and congested areas than in rural and open areas. Oke (1987) and CERC (2003) suggest typical roughness lengths for various land use categories (Table C.1).

Table C.1 Typical Surface Roughness Lengths for Various Land Use Categories

Type of Surface	z_0 (m)
Ice	0.00001
Smooth snow	0.00005
Smooth sea	0.0002
Lawn grass	0.01
Pasture	0.2
Isolated settlement (farms, trees, hedges)	0.4
Parkland, woodlands, villages, open suburbia	0.5-1.0
Forests, cities, industrialised areas	1.0-1.5
Heavily industrialised areas	1.5-2.0

Increasing surface roughness increases turbulent mixing in the lower boundary layer. This can often have conflicting impacts in terms of ground level concentrations:

- the increased mixing can bring portions of an elevated plume down towards ground level, resulting in increased ground level concentrations closer to the emission source; however; and
- the increased mixing increases entrainment of ambient air into the plume and dilutes plume concentrations, resulting in reduced ground level concentrations further downwind from an emission source.

Surface Energy Budget

One of the key factors governing the generation of convective turbulence is the magnitude of the surface sensible heat flux. This, in turn, is a factor of the incoming solar radiation. However, not all solar radiation arriving at the Earth's surface is available to be emitted back to atmosphere in the form of sensible heat. By adopting a surface energy budget approach, it can be identified that, for fixed values of incoming short and long wave solar radiation, the surface sensible heat flux is inversely proportional to the surface albedo and latent heat flux.

The surface albedo is a measure of the fraction of incoming short-wave solar radiation reflected by the Earth's surface. This parameter is dependent upon surface characteristics and varies throughout the year. Oke (1987) recommends average surface albedo values of 0.6 for snow covered ground and 0.23 for non-snow covered ground, respectively.

The latent heat flux is dependent upon the amount of moisture present at the surface. The Priestly-Taylor parameter can be used to represent the amount of moisture available for evaporation:

$$\alpha = \frac{1}{S(B+1)}$$

Where:

α = Priestly-Taylor parameter (dimensionless)

$$S = \frac{s}{s+\gamma}$$

$$s = \frac{de_s}{dT}$$

e_s = Saturation specific humidity (kg H_2O / kg dry air)

T = Temperature (K)

$$\gamma = \frac{c_{pw}}{\lambda}$$

c_{pw} = Specific heat capacity of water (kJ kg^{-1} K^{-1})

λ = Specific latent heat of vaporisation of water (kJ kg^{-1})

B = Bowen ratio (dimensionless)

Areas where moisture availability is greater will experience a greater proportion of incoming solar radiation released back to atmosphere in the form of latent heat, leaving less available in the form of sensible heat and, thus, decreasing convective turbulence. Holstag and van Ulden (1983) suggest α values of 0.45 and 1.0 for dry grassland and moist grassland respectively.

Selection of Appropriate Surface Characteristic Parameters Facility

A detailed analysis of the effects of surface characteristics on ground level concentrations by Auld et al. (2002) led them to conclude that, with respect to uncertainty in model predictions:

> *"...the energy budget calculations had relatively little impact on the overall uncertainty"*

In this regard, it is not considered necessary to vary the surface energy budget parameters spatially or, temporally, and annual averaged values have been adopted throughout the model domain for this assessment.

As snow covered ground is only likely to be present for a small fraction of the year, the surface albedo of 0.23 for non-snow covered ground advocated by Oke (1987) has been used whilst the model default α value of 1.0 has also been retained.

From examination of 1:10,000 Ordnance Survey maps, it can be seen that within the immediate vicinity of the site, land use is predominately industrial with some areas of open land and suburbia. Consequently, a composite surface roughness length of 0.7m has been used to take account of the respective land use categories in the model domain.

Terrain

The concentrations of an emitted pollutant found in elevated, complex terrain differ from those found in simple level terrain. There have been numerous studies on the effects of topography on atmospheric flows. A summary of the main effects of terrain on atmospheric flow and dispersion of pollutants are summarised below.

- Plume interactions with windward facing terrain features:
  - plume interactions with terrain features whereby receptors on hills at a similar elevation to the stack experience elevated concentrations;
  - direct impaction of the plume on hill slopes in stable conditions; and

- flow over hills in neutral conditions can experience deceleration forces on the upwind slope, reducing the rate of dispersion and increasing concentrations.

- Plume interactions with lee sides of terrain features:

  - regions of recirculation behind steep terrain features can rapidly advect pollutants towards the ground culminating in elevated concentrations; and

  - releases into the lee of a hill in stable conditions can also be re-circulated, resulting in increased ground level concentrations.

- Plume interactions within valleys:

  - Releases within steep valleys experience restricted lateral dispersion due to the valley sidewalls. During stable overnight conditions, inversion layers develop within the valley essentially trapping all emitted pollutants. Following sunrise and the erosion of the inversion, elevated ground level concentrations can result during fumigation events.

  - Convective circulations in complex terrain due to differential heating of the valley side walls can lead to the impingement of plumes due to cross flow onto the valley sidewalls and the subsidence of plume centrelines, both having the impact of increasing ground level concentrations.

Appendix D
Dispersion Modelling Results

Figure D.1 Predicted Baseline Odour Concentrations - $ou_E\ m^{-3}$ as the 98th percentile of hourly averages (2006)

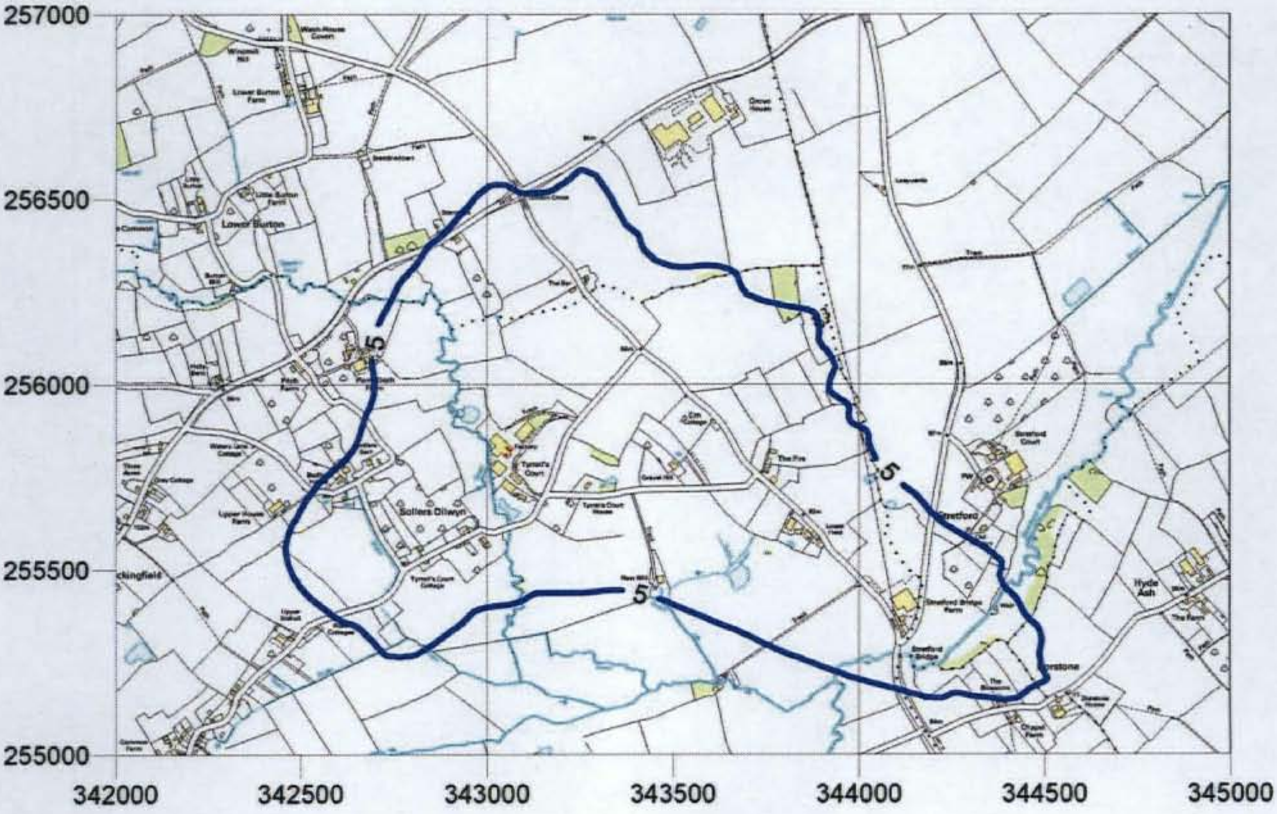

Figure D.2 Predicted Baseline Odour Concentrations - $ou_E\ m^{-3}$ as the 98th percentile of hourly averages (2007)

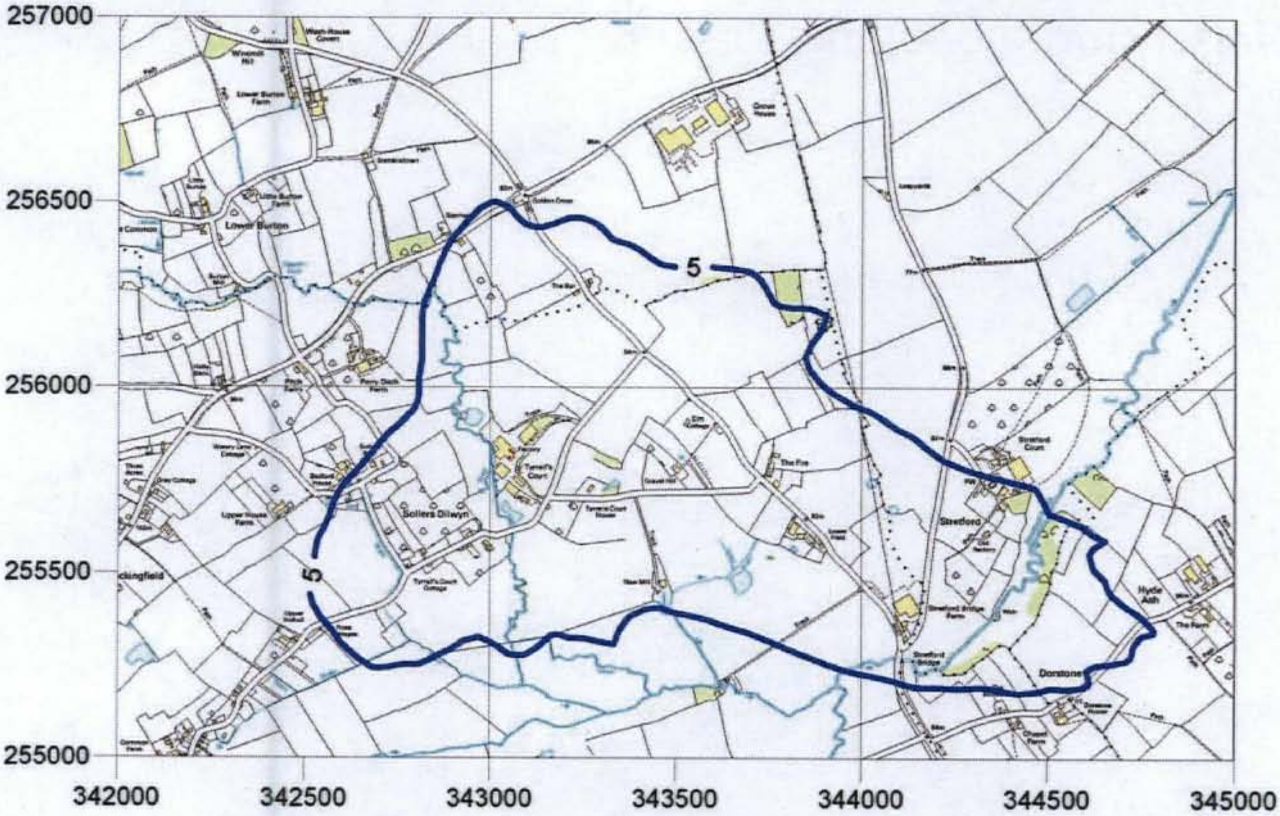

Figure D.3 Predicted Baseline Odour Concentrations - $ou_E\ m^{-3}$ as the 98th percentile of hourly averages (2008)

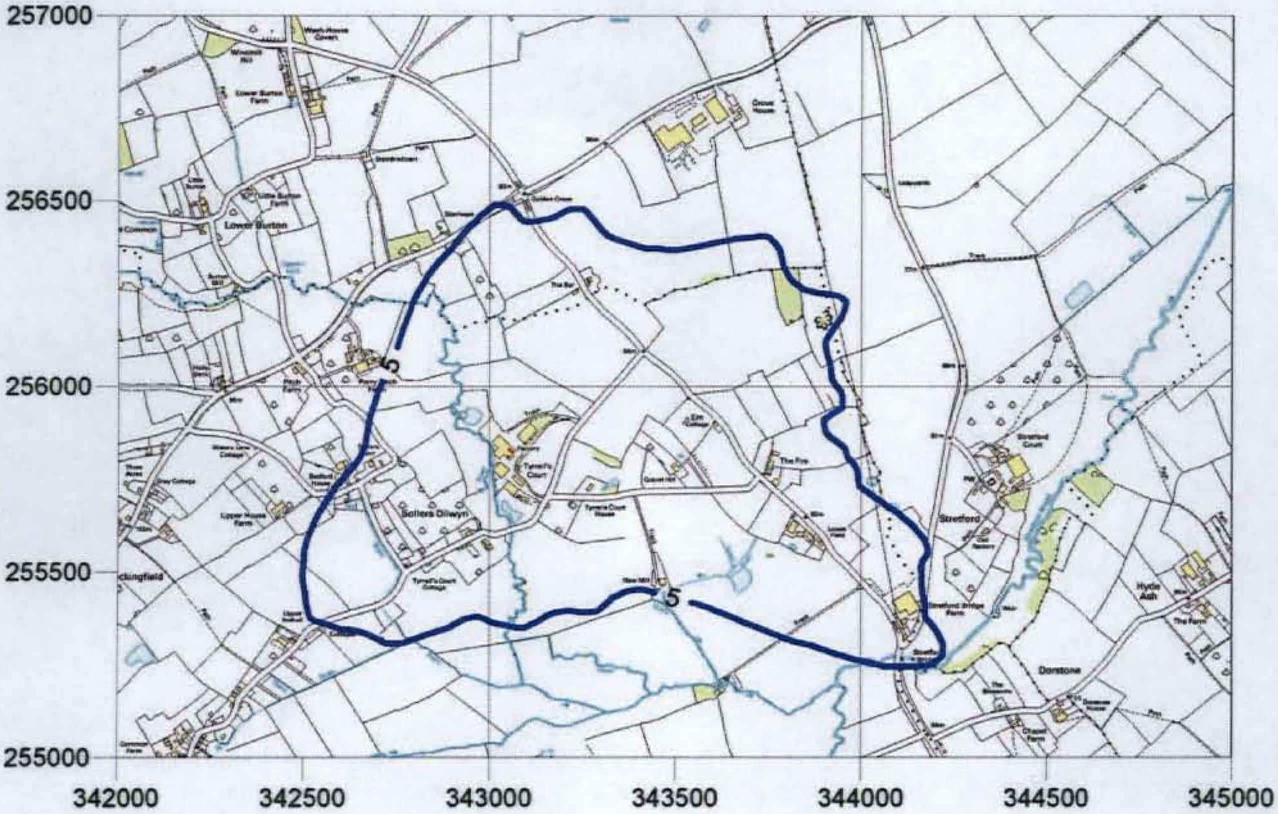

Figure D.4 Predicted Baseline Odour Concentrations - $ou_E\ m^{-3}$ as the 98th percentile of hourly averages (2009)

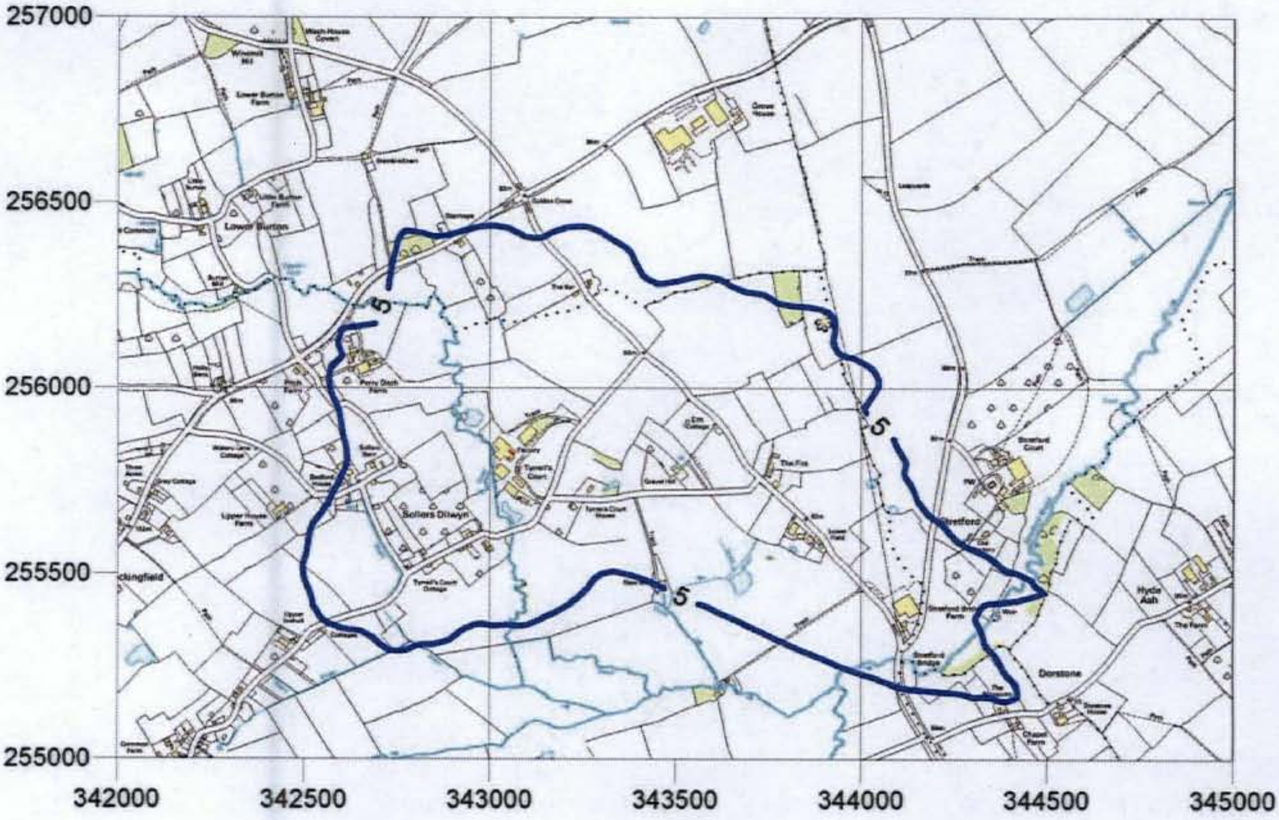

Figure D.5 Predicted Baseline Odour Concentrations - $ou_E\ m^{-3}$ as the 98th percentile of hourly averages (2010)