Air Quality Assessment

Proposed Small Waste Incineration Plant

Marsh Farm, Melbourne, York

For H Barker & Son Limited

www.rpsgroup.com

Quality Management

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Executive Summary

This report details the air quality assessment undertaken to accompany the permit application for the proposed small waste incinerator at Marsh Farm, Melbourne, York.

The assessment has been undertaken based upon appropriate information on the Proposed Development provided by H Barker & Son Limited and its project team. In undertaking this assessment, RPS experts have exercised professional skills and judgement to the best of their abilities and have given professional opinions that are objective, reliable and backed with scientific rigour. These professional responsibilities are in accordance with the code of professional conduct set by the Institution of Environmental Sciences for members of the Institute of Air Quality Management (IAQM).

Regarding the operational phase, the most important consideration is stack emissions. This assessment predicts that ground-level concentrations will be within acceptable levels across the modelled grid and at sensitive receptors and will not give rise to any significant adverse effects.

The proposed development does not, in air quality terms, conflict with national or local policies. There are no constraints to the development in the context of air quality.

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1 Introduction

1.1 This report details the air quality assessment undertaken to accompany the permit application for the proposed Small Waste Incinerator Plant (SWIP) at Marsh Farm, Melbourne, York.

1.2 The Application Site is located within the administrative area of East Riding of Yorkshire Council (ERYC) which has not designated any Air Quality Management Area (AQMAs) and air quality in the area is generally quite good.

1.3 This report begins by setting out the policy and legislative context for the assessment. The methods and criteria used to assess potential air quality effects have then been described. The baseline air quality conditions have been established taking into account Defra estimates, local authority documents and the results of any local monitoring. The results of the assessment of air quality impacts have been presented. A conclusion has been drawn on the significance of the residual effects.

2 Policy and Legislative Context

Industrial Emission Directive Limits

2.1 The plant would be designed and operated in accordance with the requirements of the Industrial Emissions Directive (2010/75/EU) [1], known hereafter as the IED, which requires adherence to emission limits for a range of pollutants.

2.2 Emission limits in the IED are specified in the form of half-hourly mean concentrations; daily-mean concentrations; mean concentrations over a period of between 30 minutes and 8 hours; or, for dioxins and furans, mean concentrations evaluated over a period of between six and eight hours.

2.3 For the purposes of this assessment for those pollutants having only one emission limit (for a single averaging period), the facility has been assumed to operate at that limit. Where more than one limit exists for a pollutant, the facility has been assumed to operate at the short-term emission limit for short-term averaging periods and the daily-mean emission limits for long-term averaging periods. The IED emission limit values are provided in Table 2.1.

Table 2.1 Relevant Industrial Emission Directive Limit Values

Pollutant	Short-Term Emission Limits ($mg.Nm^{-3}$)	Daily-Mean Emission Limits ($mg.Nm^{-3}$)
Particles	30	10
TOC	20	10
HCl	60	10
HF	4	1
SO_2	200	50
NOx	400	200
CO	-	50
Group 1 metals (a)	-	0.05 (d)
Group 2 metals (b)	-	0.05 (d)
Group 3 metals (c)	-	0.5 (d)
Dioxins and furans	-	0.0000001 (e)

Notes: All concentrations referenced to temperature 273 K, pressure 101.3 kPa, 11% oxygen, dry gas.
(a) Cadmium (Cd) and thallium (Tl).
(b) Mercury (Hg).
(c) Antimony (Sb), arsenic (As), lead (Pb), chromium (Cr), cobalt (Co), copper (Cu), manganese (Mn), nickel (Ni), and vanadium (V).
(d) All average values over a sample period of a minimum of 30 minutes and a maximum of 8 hours.
(e) Average values over a sample period of a minimum of 6 hours and a maximum of 8 hours. The emission limit value refers to the total concentration of dioxins and furans calculated using the concept of toxic equivalence (TEQ).

2.4 Ammonia (NH_3), polychlorinated biphenyls (PCBs) and polycyclic aromatic hydrocarbons (PAHs) are not specifically regulated under the IED. For the purposes of this assessment, the emission concentrations in Table 2.2 have been used for these pollutants.

Table 2.2 Modelled Emission Concentrations for non-IED Regulated Pollutants

Pollutant	Scenario 2 Emission Concentrations (mg.Nm^{-3})
NH_3	10
PCBs	8E-08
PAHs (as B[a]P equivalent)	0.00005

Notes: All concentrations referenced to temperature 273 K, pressure 101.3 kPa, 11% oxygen, dry gas.
Emission limits for *NH_3* and PCBs obtained from the Commission Implementing Decision (EU) 2019.2010 of 12 November 2019 establishing the best available techniques (BAT) conclusions, under Directive 2010/75/EU of the European Parliament and of the Council for waste incineration. Emission limit for PAHs (as B[a]P equivalent) taken from Figure 8.121 of the Best Available Techniques (BAT) Reference Document on Waste Incineration (2019). The maximum average measured emission concentration of 0.00015 µg.m^{-3} was not used as this was an outlier. The second highest measured emission concentration of 0.00005 µg.m^{-3} has been used.

Environmental Permitting Regulations

2.5 The Industrial Emissions Directive (IED) [2] applies an integrated environmental approach to the regulation of certain industrial activities. The Environmental Permitting Regulations (EPR) 2016 [3] implement the Directive relating to installations in England and Wales. The Regulations define activities that require an Environmental Permit from the Environment Agency (EA).

2.6 EPR is a regulatory system that employs an integrated approach to control the environmental impacts of certain listed industrial activities including the generation of energy from waste. The intention of the regulatory system is to ensure that Best Available Techniques (BAT), required by the IED, are used to prevent or minimise the effects of an activity on the environment, having regard to the effects of emissions to air, land and water via a single permitting process.

2.7 To gain a permit, Operators have to demonstrate in their applications, in a systematic way, that the techniques they are using or are proposing to use are the BAT for their installation and meet certain other requirements taking account of relevant local factors. The permitting process also places a duty on the regulating body to ensure that the requirements of the IED are included for permitted sites to which these apply.

2.8 The essence of BAT is that the techniques selected to protect the environment should achieve a high degree of protection of people and the environment taken as a whole. Indicative BAT standards are laid out in national guidance and where relevant, should be applied unless a different standard can be justified for a particular installation. The EA is legally obliged to go beyond BAT requirements where EU Air Quality Limit Values may be exceeded by an existing operator.

2.9 The Environment Agency's on-line guidance entitled '*Environmental management – guidance, Air emissions risk assessment for your environmental permit'* [4] provides guidelines for air dispersion modelling. The assessment of air quality effects for the proposed development is consistent with this guidance.

Air Quality Standards Regulations

2.10 The Air Quality Standards Regulations 2010 [5] sets limit values for ambient air concentrations for the main air pollutants: particulate matter (PM_{10} and $PM_{2.5}$), nitrogen dioxide (NO_2), sulphur dioxide (SO_2), ozone (O_3), carbon monoxide (CO), lead (Pb) and benzene, certain toxic heavy metals (arsenic, cadmium and nickel) and polycyclic aromatic hydrocarbons (PAHs). These limit values are legally binding on the Secretary of State. The Government and devolved administrations operate various national ambient air quality monitoring networks to measure compliance and develop plans to meet the limit values.

2.11 The statutory air quality limit values are listed in Table 2.3.

Table 2.3 Statutory Air Quality Limit Values

Pollutant	Averaging Period	Limit Values	Not to be Exceeded More Than
Nitrogen Dioxide (NO_2)	1 hour	200 µg.m^{-3}	18 times pcy
	Annual	40 µg.m^{-3}	-
Particulate Matter (PM_{10})	24 hour	50 µg.m^{-3}	35 times pcy
	Annual	40 µg.m^{-3}	-
Particulate Matter ($PM_{2.5}$)	Annual	25 µg.m^{-3}	-
Carbon Monoxide (CO)	Maximum daily running 8 hour mean	10,000 µg.m^{-3}	-
Sulphur Dioxide (SO_2)	15 minute	266 µg.m^{-3}	> 35 times pcy
	1 hour	350 µg.m^{-3}	> 24 times pcy
	24 hour	125 µg.m^{-3}	> 3 times pcy
Lead (Pb)	Annual	0.25 µg.m^{-3}	-
Arsenic (As)	Annual	0.006 µg.m^{-3}	-
Cadmium (Cd)	Annual	0.005 µg.m^{-3}	-
Nickel (Ni)	Annual	0.02 µg.m^{-3}	-

Non-Statutory Air Quality Objectives and Guidelines

2.12 The Environment Act 1995 established the requirement for the Government and the devolved administrations to produce a National Air Quality Strategy (AQS) for improving ambient air quality, the first being published in 1997 and having been revised several times since, with the latest published in 2007 [6]. The Strategy sets UK air quality standards♦ and objectives# for the pollutants in the Air Quality Standards Regulations plus 1,3-butadiene and recognises that action at national, regional and local level may be needed, depending on the scale and nature of the air quality problem. There is no legal requirement to meet objectives set within the UK AQS except where equivalent limit values are set within the Air Quality Standards Regulations.

2.13 Non-statutory air quality objectives and guidelines also exist within the World Health Organisation Guidelines [7] and the Expert Panel on Air Quality Standards Guidelines (EPAQS) [8]. The non-statutory objectives and guidelines are presented in Table 2.4.

Table 2.4 Non-Statutory Air Quality Objectives and Guidelines

Pollutant	Averaging Period	Guideline
Particulate Matter ($PM_{2.5}$)	Annual	Target of 15% reduction in concentrations at urban background locations
	Annual	25 µg.m^{-3}
PAHs (as B[a]P equivalent)	Annual	0.00025 µg.m^{-3}
Sulphur Dioxide (SO_2)	Annual (a)	50 µg.m^{-3}
Hydrogen Chloride	1 hour (b)	750 µg.m^{-3}
Hydrogen Fluoride	1 hour (b)	160 µg.m^{-3}

Notes:
(a) World Health Organisation Guidelines
(b) EPAQS recommended guideline values

Environmental Assessment Levels

2.14 The Environment Agency's on-line guidance entitled '*Environmental management – guidance, Air emissions risk assessment for your environmental permit'* [4] provides further assessment criteria in the form of EALs.

♦ Standards are concentrations of pollutants in the atmosphere which can broadly be taken to achieve a certain level of environmental quality. Standards, as the benchmarks for setting objectives, are set purely with regard to scientific evidence and medical evidence on the effects of the particular pollutant on health, or on the wider environment, as minimum or zero risk levels.

Objectives are policy targets expressed as a concentration that should be achieved, all the time or for a percentage of time, by a certain date.

2.15 Table 2.5 presents all available EALs for the pollutants relevant to this assessment.

Table 2.5 Environmental Assessment Levels (EALs)

Pollutant	Long-term EAL, $\mu g.m^{-3}$	Short-term EAL, $\mu g.m^{-3}$
Carbon monoxide (CO)	-	30,000 (1 hour mean)
Hydrogen chloride (HCl)	-	750
Hydrogen fluoride (HF)	16 (monthly average)	160
Antimony (Sb)	5	150
Cadmium (Cd)	0.005	-
Chromium (Cr)	5	150
Chromium VI ((oxidation state in the PM_{10} fraction)	0.00025	-
Cobalt (Co)	0.2 (a)	6 (a)
Copper (Cu)	10	200
Manganese (Mn)	0.15	1500
Mercury (Hg)	0.25	7.5
Thallium (Tl)	1 (a)	30 (a)
Vanadium (V)	5	1
PAHs (as B[a]P equivalent)	0.00025	-
PCBs	0.2	6
Ammonia (NH_3)	180	2500

Note: (a) EALs have been obtained from the EA's earlier Horizontal Guidance Note EPR H1 guidance note as no levels are provided in the current guidance.

2.16 Within the assessment, the statutory air quality limit and target values (as presented in Table 2.3) are assumed to take precedent over objectives, guidelines and the EALs. In addition, for those pollutants which do not have any statutory air quality standards, the assessment assumes the lower of either the EAL or the non-statutory air quality objective or guideline where they exist.

3 Assessment Methodology

Approach

3.1 This air quality assessment includes the key elements listed below:

- Establishing the background Ambient Concentration (AC) from consideration of Air Quality Review & Assessment findings and assessment of existing local air quality through a review of available air quality monitoring and Defra background map data in the vicinity of the proposed site.
- Quantitative assessment of the operational effects on local air quality from stack emissions utilising a "new generation" Gaussian dispersion model, ADMS 5. Assessment of Process Contributions (PC) from the facility in isolation, and assessment of resultant Predicted Environmental Concentrations (PEC), taking into account cumulative impacts through incorporation of the AC.

3.2 Air quality guidance advises that the organisation engaged in assessing the overall risks should hold relevant qualifications and/or extensive experience in undertaking air quality assessments. The RPS air quality team members involved at various stages of this assessment have professional affiliations that include Fellow and Member of the Institute of Air Quality Management, and Chartered Environmentalist and have the required academic qualifications for these professional bodies. In addition, the Director responsible for authorising all deliverables has over 17 years' experience.

Pollutant Concentrations

3.3 In urban areas, pollutant concentrations are primarily determined by the balance between pollutant emissions that increase concentrations, and the ability of the atmosphere to reduce and remove pollutants by dispersion, advection, reaction and deposition. An atmospheric dispersion model is used as a practical way to simulate these complex processes; such a model requires a range of input data, which can include emissions rates, meteorological data and local topographical information. The model used and the input data relevant to this assessment are described in the following sub-sections.

3.4 The atmospheric pollutant concentrations in an urban area depend not only on local sources at a street scale, but also on the background pollutant level made up of the local urban-wide background, together with regional pollution and pollution from more remote sources brought in on the incoming air mass. This background contribution needs to be added to the fraction from the modelled sources, and is usually obtained from measurements or estimates of urban background concentrations for the area in locations that are not directly affected by local emissions sources. Background pollution levels are described in detail in Section 4.

Dispersion Model Selection

3.5 A number of commercially available dispersion models are able to predict ground level concentrations arising from emissions to atmosphere from elevated point sources. Modelling for this study has been undertaken using ADMS 5, a version of the ADMS (Atmospheric Dispersion Modelling System) developed by Cambridge Environmental Research Consultants (CERC) that models a wide range of buoyant and passive releases to atmosphere either individually or in combination. The model calculates the mean concentration over flat terrain and also allows for the effect of plume rise, complex terrain, buildings and deposition. Dispersion models predict atmospheric concentrations within a set level of confidence and there can be variations in results between models under certain conditions; the ADMS 5 model has been formally validated and is widely used in the UK and internationally for regulatory purposes.

3.6 ADMS comprises a number of individual modules each representing one of the processes contributing to dispersion or an aspect of data input and output. Amongst the features of ADMS are:

- An up-to-date dispersion model in which the boundary layer structure is characterised by the height of the boundary layer and the Monin-Obukhov length, a length scale dependent on the friction velocity and the heat flux at the surface. This approach allows the vertical structure of the boundary layer, and hence concentrations, to be calculated more accurately than does the use of Pasquill-Gifford stability categories, which were used in many previous models (e.g. ISCST3). The restriction implied by the Pasquill-Gifford approach that the dispersion parameters are independent of height is avoided. In ADMS the concentration distribution is Gaussian in stable and neutral conditions, but the vertical distribution is non-Gaussian in convective conditions, to take account of the skewed structure of the vertical component of turbulence;
- A number of complex modules including the effects of plume rise, complex terrain, coastlines, concentration fluctuations and buildings; and
- A facility to calculate long-term averages of hourly mean concentration, dry and wet deposition fluxes and radioactivity, and percentiles of hourly mean concentrations, from either statistical meteorological data or hourly average data.

Model Inputs

Meteorological Data

3.7 The most important meteorological parameters governing the atmospheric dispersion of pollutants are wind direction, wind speed and atmospheric stability as described below:

- Wind direction determines the sector of the compass into which the plume is dispersed;
- Wind speed affects the distance that the plume travels over time and can affect plume dispersion by increasing the initial dilution of pollutants and inhibiting plume rise; and
- Atmospheric stability is a measure of the turbulence of the air, and particularly of its vertical motion. It therefore affects the spread of the plume as it travels away from the source. New generation dispersion models, including ADMS, use a parameter known as the Monin-Obukhov length that, together with the wind speed, describes the stability of the atmosphere.

3.8 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.

3.9 The year of meteorological data that is used for a modelling assessment can have a significant effect on source contribution concentrations. Dispersion model simulations have been performed using five years of data from Linton-on-Ouse between 2015 and 2019.

3.10 Wind roses have been produced for each of the years of meteorological data used in this assessment and are presented in Figure 1.

Stack Parameters and Emissions Rates used in the Model

3.11 Flue gases are emitted from an elevated stack to allow dispersion and dilution of the residual combustion emissions. The stack needs to be of sufficient height to ensure that pollutant concentrations are acceptable by the time they reach ground level. The stack also needs to be high enough to ensure that releases are not within the aerodynamic influence of nearby buildings, or else wake effects can quickly bring the undiluted plume down to the ground.

3.12 A stack height determination has been undertaken to establish the height at which there is minimal additional environmental benefit associated with the cost of further increasing the stack. The Environment Agency removed their detailed guidance, Horizontal Guidance Note EPR H1 [4], for undertaking risk assessments on 1 February 2016; however, the approach used here by RPS is consistent with that EA guidance which required the identification of "*an option that gives acceptable environmental performance but balances costs and benefits of implementing it.*"

3.13 The stack height determination has focused on identifying the stack height required to overcome the wake effects of nearby buildings. This involved running a series of atmospheric dispersion modelling simulations to predict the ground-level concentrations with the stack at different heights: starting at 7 metres and extending up in 1 metre increments, until a height of 13 metres was reached. The results of the stack height determination are provided in Appendix A. The stack height determination indicated a 9 m stack height was appropriate.

3.14 Stack emissions characteristics modelled are provided in Table 3.1 and the mass emissions are provided in Table 3.2. The stack location is shown in Figure 2.

Table 3.1 Stack Characteristics

Parameter	Unit	Value
Stack height	m	9
Internal diameter	m	0.4
Efflux velocity	$m.s^{-1}$	12
Efflux temperature	^{o}C	180
Actual O_2	%	7
Actual H_2O	%	13
Actual volumetric flow	$m^3.s^{-1}$	1.51
Normalised volumetric flow (Dry, 0°C, 11% O_2)	$m^3.s^{-1}$	1.11

Table 3.2 Mass Emissions of Released Pollutants

Pollutants	Mass Emission Rate ($g.s^{-1}$)
Particles	0.011 (0.033 for short-term)
CO	0.111
SO_2	0.055 (0.222 for short-term)
HCl	0.067
HF	0.001 (0.004 for short-term)
NOx	0.222 (0.444 for short-term)
Group 1 Metals Total (a)	5.55E-05
Group 2 Metals (b)	5.55E-05
Group 3 Metals Total (c)	5.55E-04
Dioxins and furans	1.11E-10
PCBs	8.88E-11
PAHs – B[a]P (d)	5.55E-08
NH_3	0.011
TVOCs	0.022

Notes:
(a) Cadmium (Cd) and thallium (Tl)
(b) Mercury (Hg)
(c) Antimony (Sb), Arsenic (As), Lead (Pb), Chromium (Cr), Cobalt (Co), Copper (Cu), Manganese (Mn), Nickel (Ni), and Vanadium (V)
(d) Based on a PAHs (as B[a]P equivalent) emission concentration of 0.00005 $mg.Nm^3$. Taken from the Figure 8.121 of the Best Available Techniques (BAT) Reference Document on Waste Incineration (2019).

3.15 Emission limits in the IED are provided for total particles. For the purposes of this assessment, all particles are assumed to be less than 10 µm in diameter (i.e. PM_{10}). Furthermore, all particles are also assumed to be less than 2.5 µm in diameter (i.e. $PM_{2.5}$). In reality, the PM_{10} and $PM_{2.5}$ concentrations will be a smaller proportion of the total particulate emissions and the $PM_{2.5}$ concentration will be a smaller proportion of the PM_{10} concentration. Therefore, this can be considered a conservative estimate of the likely particulate emissions in each size fraction.

Terrain

3.16 The presence of elevated terrain can significantly affect (usually increase) ground level concentrations of pollutants emitted from elevated sources such as stacks, by reducing the distance between the plume centre line and ground level and by increasing turbulence and, hence, plume mixing. A complex terrain file has been used within the model.

Surface Roughness

3.17 The roughness of the terrain over which a plume passes can have a significant effect on dispersion by altering the velocity profile with height, and the degree of atmospheric turbulence. This is accounted for by a parameter called the surface roughness length.

3.18 A surface roughness length of 0.2 m, which the software developer recommends for use in agricultural areas, has been used within the model to represent the average surface characteristics across the study area.

Building Wake Effects

3.19 The movement of air over and around buildings generates areas of flow circulation, which can lead to increased ground level concentrations in the building wakes. Where building heights are greater than about 30 - 40% of the stack height, downwash effects can be significant. The dominant structures (i.e. with the greatest dimensions likely to promote turbulence) included within the model are listed in Table 3.3.

Table 3.3 Dimensions of Buildings Included Within the Dispersion Model

ID	Name	Approx Centre Location		Height (m)	Length (m)	Width (m)	Angle (Degrees)
		X (m)	Y (m)				
1	Boiler Building	473938	444420	6.1	14	18	108
2	Shed 1	473956	444469	4.5	19	78	289
3	Shed 2	473936	444476	4	19	78	108
4	Shed 3	473910	444485	4	18	77	110
5	Shed 4	473876	444382	4.2	19	107	106
6	Shed 5	473903	444373	4.2	20	107	106

Model Outputs

Receptors

3.20 The air quality assessment predicts the impacts at locations that could be sensitive to any changes. Such sensitive receptors should be selected where the public is regularly present and likely to be exposed over the averaging period of the objective. LAQM.TG16 [9] provides examples of exposure locations and these are summarised in Table 3.4.

Table 3.4: Example of Where Air Quality Objectives Apply

Averaging Period	Objectives should apply at:	Objectives should generally not apply at:
Annual-mean	All locations where members of the public might be regularly exposed. Building façades of residential properties, schools, hospitals, care homes.	Building façades of offices or other places of work where members of the public do not have regular access. Hotels, unless people live there as their permanent residence. Gardens of residential properties. Kerbside sites (as opposed to locations at the buildings façades), or any other location where public exposure is expected to be short-term.
Daily-mean	All locations where the annual-mean objective would apply, together with hotels. Gardens of residential properties.	Kerbside sites (as opposed to locations at the building façade), or any other location where public exposure is expected to be short-term.
Hourly-mean	All locations where the annual and 24-hour mean would apply. Kerbside sites (e.g. pavements of busy shopping streets). Those parts of car parks, bus stations and railway stations etc which are not fully enclosed, where members of the	Kerbside sites where the public would not be expected to have regular access.

Averaging Period	Objectives should apply at:	Objectives should generally not apply at:
	public might reasonably be expected to spend one hour or more. Any outdoor locations to which the public might reasonably be expected to spend 1-hour or longer.	

3.21 The ground level concentrations have been modelled at locations across a grid of 3 km by 3 km, with a spacing of 30 m, centred on the stack.

3.22 In addition, the effects of the proposed development have been assessed at the façades of a representative selection of discrete local existing receptors. All human receptors have been modelled at a height of 1.5 m, representative of typical head height. The locations of these discrete receptors are listed in Table 3.5 and illustrated in Figure 2.

Table 3.5: Modelled Sensitive Receptors

ID	Description	National Grid Reference	
		X(m)	Y(m)
1	Main Street 1	474007	444515
2	Main Street 2	474131	444455
3	Main Street 3	474318	444472
4	Main Street 4	474448	444316
5	Gamekeepers Cottage	474399	443871
6	Melbourne Grange	474259	443667
7	Ross Moor Park	473343	443695
8	Rossmoor 1	473787	444237
9	Rossmoor 2	473796	444408
10	Main Street 5	473824	444571
11	Westfield Farm	473856	444694

Note: Receptors have been modelled at 1.5m above ground level, representative of typical head height

3.23 The AQS NO_2 objectives for all the different averaging periods apply at the façades of the modelled sensitive receptors.

NO_x to NO_2 Relationship

3.24 The NOx emissions will typically comprise approximately 90-95% nitrogen monoxide (NO) and 5-10% nitrogen dioxide (NO_2) at the point of release. The NO oxidises in the atmosphere in the presence of sunlight, ozone and volatile organic compounds to form NO_2, which is the principal concern in terms of environmental health effects.

3.25 There are various techniques available for estimating the proportion of NOx converted to NO_2 by the time it has reached receptors. The methods used in this assessment are discussed below.

NOx to NO_2 Assumptions for Annual-Mean Calculations

3.26 Total conversion (i.e. 100%) of NO to NO_2 is sometimes used for the estimation of the absolute upper limit of the annual mean NO_2. This technique is based on the assumption that all NO emitted is converted to NO_2 before it reaches ground level. However, in reality the conversion is an equilibrium reaction and even at ambient concentrations a proportion of NOx remains in the form of NO. Total conversion is, therefore, an unrealistic assumption, particularly in the near field [10]. While this approach is useful for screening assessments, it is not appropriate for detailed assessments.

3.27 Historically, the Environment Agency has recommended that for a 'worse case scenario', a 70% conversion of NO to NO_2 should be considered for calculation of annual average concentrations. If a breach of the annual average NO_2 objective/limit value occurs, the Environment Agency requires a more detailed assessment to be carried out with operators asked to justify the use of percentages lower than 70%.

3.28 Following the withdrawal of the Environment Agency's H1 guidance document, there is no longer an explicit recommendation; however, for the purposes of this detailed assessment, a 70% conversion of NO to NO_2 has been assumed for annual average NO_2 concentrations in line with the Environment Agency's historic recommendations.

NOx to NO_2 Assumptions for Hourly-Mean Calculations

3.29 An assumed conversion of 35% follows the Environment Agency's recommendations [11] for the calculation of 'worse case scenario' short-term NO_2 concentrations.

Modelling of Long-term and Short-term Emissions

3.30 Long-term (annual-mean) NO_2 has been modelled for comparison with the relevant annual mean objectives.

3.31 For short-term NO_2, the objective is for the hourly-mean concentration not to exceed 200 µg.m^{-3} more than 18 times per calendar year. As there are 8,760 hours in a non-leap year, the hourly-mean concentration would need to be below 200 µg.m^{-3} in 8,742 hours, i.e. 99.79% of the time. Therefore, the 99.79th percentile of hourly NO_2 has been modelled.

Monthly-Mean Calculations

3.32 ADMS does not allow an averaging period of a month to be modelled so a factor has been derived to convert the annual-mean to a monthly mean using the dispersion factors in the on-line EA guidance entitled '*Environmental management – guidance, Air emissions risk assessment for your environmental permit'* [4] shown in the table below.

Table 3.6 Dispersion Factors

Effective height of release in metres*	Monthly Dispersion Factor	Annual Dispersion Factor
0	529	148
10	33.7	32
20	6.2	4.6
30	2.3	1.7
50	0.68	0.52
70	0.31	0.24
100	0.13	0.11
150	0.052	0.048
200	0.026	0.023

*where the stack is less than 3 m above any surrounding buildings, the effective height of release is 0m.

3.33 Monthly and annual-mean dispersion factors for a stack height of 9 m have been derived using interpolation. The monthly dispersion factor of 83.2 is 1.9 times higher than the annual dispersion factor of 43.6. Therefore, the monthly mean has been derived by multiplying the annual mean by a conversion factor of 1.9.

Significance Criteria

3.34 The on-line EA guidance entitled '*Environmental management – guidance, Air emissions risk assessment for your environmental permit'* [4] has been used. This guidance provides details for screening out substances for detailed assessment. In particular, it states that:

"*To screen out a PC for any substance so that you don't need to do any further assessment of it, the PC must meet both of the following criteria:*

- *the short-term PC is less than 10% of the short-term environmental standard*
- *the long-term PC is less than 1% of the long-term environmental standard*

If you meet both of these criteria you don't need to do any further assessment of the substance.

If you don't meet them you need to carry out a second stage of screening to determine the impact of the PEC."

3.35 It continues by stating that:

"You must do detailed modelling for any PECs not screened out as insignificant."

3.36 It then states that further action may be required where:

- *"your PCs could cause a PEC to exceed an environmental standard (unless the PC is very small compared to other contributions – if you think this is the case contact the Environment Agency)*
- *The PEC is already exceeding an environmental standard"*

3.37 The EA online guidance '*Environmental permitting: air dispersion modelling reports'* [12] states:

"For a detailed modelling assessment PCs are insignificant where they are less than:

- *10% of a short-term environmental standard*
- *1% of a long-term environmental standard*

At the detailed modelling stage there are no criteria to determine whether:

- *PCs are significant*
- *PECs are insignificant or significant*

You must explain how you judged significance and base this on the site specific circumstances."

3.38 On that basis, the results of the detailed modelling presented in this report have been used as follows:

- The effects are not considered significant if the short-term PC is less than 10% of the short-term Environmental Assessment Level (EAL) or the PEC is below the EAL; and
- The effects are not considered significant if the long-term PC is less than 1% of the long-term EAL or the PEC is below the EAL.

Uncertainty

3.39 All air quality assessment tools, whether models or monitoring measurements, have a degree of uncertainty associated with the results. The choices that the practitioner makes in setting-up the model, choosing the input data, and selecting the baseline monitoring data will decide whether the final predicted impact should be considered a central estimate, or an estimate tending towards the upper bounds of the uncertainty range (i.e. tending towards worst-case).

3.40 The atmospheric dispersion model itself contributes some of this uncertainty, due to it being a simplified version of the real situation: it uses a sophisticated set of mathematical equations to approximate the complex physical and chemical atmospheric processes taking place as a pollutant is released and as it travels to a receptor. The predictive ability of even the best model is limited by how well the turbulent nature of the atmosphere can be represented.

3.41 Each of the data inputs for the model, listed earlier, will also have some uncertainty associated with them. Where it has been necessary to make assumptions, these have mainly been made towards the upper end of the range informed by an analysis of relevant, available data.

3.42 The main components of uncertainty in the total predicted concentrations, made up of the background concentration and the modelled fraction, include those summarised in Table 3.7.

Table 3.7 Approaches to Dealing with Uncertainty used Within the Assessment

Concentration	Source of Uncertainty	Approach to Dealing with Uncertainty	Comments
Background Concentration	Characterisation of future baseline air quality (i.e. the air quality conditions in the future assuming that the development does not proceed)	The future background concentration used in the assessment is the same as the current background concentration and no reduction has been assumed. This is a conservative assumption as, in reality, background concentrations are likely to reduce over time as cleaner vehicle technologies form an increasing proportion of the fleet.	The background concentration is the major proportion of the total predicted concentration. The conservative assumptions adopted ensure that the background concentration used within the model contributes towards the results being towards the top of the uncertainty range, rather than a central estimate.
Model Input/ Output Data	Meteorological Data	Uncertainties arise from any differences between the conditions at the met station and the development site, and between the historical met years and the future years. These have been minimised by using meteorological data collated at a representative measuring site. The model has been run for 5 full years of meteorological conditions.	

Concentration	Source of Uncertainty	Approach to Dealing with Uncertainty	Comments
	Receptors	The model has been run for a grid of receptors. In addition, receptor locations have been identified where concentrations are highest or where the greatest changes are expected.	

3.43 The analysis of the component uncertainties indicates that, overall, the predicted total concentration is likely to be towards the top of the uncertainty range rather than being a central estimate. The actual concentrations that will be found when the development is operational are unlikely to be higher than those presented within this report and are more likely to be lower.

4 Baseline Air Quality Conditions

Overview

4.1 The background concentration often represents a large proportion of the total pollution concentration, so it is important that the background concentration selected for the assessment is realistic. EPUK/IAQM guidance highlight public information from Defra and local monitoring studies as potential sources of information on background air quality.

4.2 For this assessment, the background air quality has been characterised by drawing on information from the following public sources:

- Defra maps [13], which show estimated pollutant concentrations across the UK in 1 km grid squares;
- published results of local authority Review and Assessment (R&A) studies of air quality, including local monitoring and modelling studies; and
- results published by national monitoring networks.

4.3 A detailed description of how the baseline air quality has been derived for the proposed development is provided in Appendix B. The background concentrations used in the assessment are set out in Table 4.1.

Table 4.1 Summary of Assumed Background Concentrations

	Long-term	Short-term (a)	Data Source
Nitrogen dioxide (NO_2)	6.6 μg.m^{-3}	13.2 μg.m^{-3}	Defra mapped
Particulates (PM_{10})	12.6 μg.m^{-3}	25.2 μg.m^{-3}	Defra mapped
Carbon monoxide (CO)	200 μg.m^{-3}	400 μg.m^{-3}	5-year average (2016-2020) at Leeds Centre AURN
Sulphur dioxide (SO_2)	1.42 μg.m^{-3}	2.84 μg.m^{-3}	
Hydrogen chloride (HCl)	0.31 μg.m^{-3}	-	3-year average (2013-2015) at Caenby
Arsenic (As)	0.0008 μg.m^{-3}	-	Max of 5-year average (2016-2020) of Scunthorpe Low Santon and Scunthorpe Town
Cadmium (Cd)	0.0006 μg.m^{-3}	-	
Cobalt (Co)	0.0002 μg.m^{-3}	-	
Manganese (Mn)	0.0899 μg.m^{-3}	-	
Nickel (Ni)	0.0012 μg.m^{-3}	-	
Lead (Pb)	0.0174 μg.m^{-3}	-	
Chromium (Cr)	0.0038 μg.m^{-3}	-	

	Long-term	Short-term (a)	Data Source
Vanadium (V)	0.0094 µg.m^{-3}	-	
PAHs (as B[a]P equivalent)	0.0002 µg.m^{-3}	-	5-year average (2016-2020) at Leeds Millshaw
1,3-Butadiene	0.10 µg.m^{-3}	-	Max of 5-year average (2016-2020) of Auchencorth Moss, Chibolton Observatory, London Eltham and London Marylebone

Note:
(a) Short-term background data approximately equate to the 90th percentile, which is approximately equivalent to 2 x the annual mean.

5 Assessment of Air Quality Impacts

Stack Emissions

5.1 For each of the five years of meteorological data (2015 to 2019), the maximum predicted ground-level concentration across the modelled domain has been derived and are reported below. The maximum predicted ground-level concentrations at the selected sensitive receptors have also been predicted and these are summarised in Appendix C. The impacts at ecological receptors are assessed in Appendix D.

5.2 Table 5.1 summarises the maximum predicted PC across the modelled grid to ground-level concentrations. Where the PC cannot be screened out as insignificant, the resulting PECs have been calculated by adding the PC to the background AC.

5.3 For hexavalent chromium (CrVI), the measured concentrations in the Environment Agency '*Releases from waste incinerators – Guidance on assessing group 3 metal stack emissions from incinerators'* version 4 (undated), varies from 0.0005% to 0.03% of the IED emission concentration limit. Table 5.1 shows the predicted PC at these proportions.

5.4 A contour plot of the 99.79th percentile of hourly-mean PCs is shown in **Error! Reference source not found.**. A contour plot of the annual-mean PCs is shown in **Error! Reference source not found.**. The contours are for the year with the maximum PC across the grid.

Table 5.1 Predicted Maximum Process Contributions (µg.m^{-3})

Pollutant	Averaging Period	EAL (µg.m^{-3})	Max PC (µg.m^{-3})	Max PC as % of EAL	Criteria (%)	PC is Potentially Significant ?	AC (µg.m^{-3})	PEC (µg.m^{-3})	PEC as % of EAL	PEC is Potentially Significant ?
PM_{10}	24 hour (90.41st percentile)	50	2.8	6	10	No	-	-	-	-
	24 hour (annual mean)	40	0.32	1	1	No	-	-	-	-
$PM_{2.5}$	24 hour (annual mean)	25	0.32	1	1	No	-	-	-	-
HCl	1 hour (maximum)	750	30.3	4	10	No	-	-	-	-
HF	1 hour (maximum)	160	2.0	1	10	No	-	-	-	-
	1 hour (monthly mean)	16	0.1	0	1	No	-	-	-	-
SO_2	15 minute (99.90th percentile)	266	71.3	27	10	Yes	2.8	74.2	28	No
	1 hour (99.73th percentile)	350	50.8	15	10	Yes	2.8	53.7	15	No
	24 hour (99.18th percentile)	125	33.2	27	10	Yes	2.8	36.0	29	No
	1 hour (annual mean)	50	1.6	3	1	Yes	1.4	3.0	6	No
NO_2	1 hour (99.79th percentile)	200	37.7	19	10	Yes	13.2	50.9	25	No
	1 hour (annual mean)	40	4.5	11	1	Yes	6.6	11.1	28	No
CO	8 hour (maximum daily running)	10,000	15.7	0	10	No	-	-	-	-
	1 hour (maximum)	30,000	25.3	0	10	No	-	-	-	-
Cd	1 hour (annual mean)	0.005	0.0016	32	10	Yes	0.001	0.002	43	No
Tl	1 hour (maximum)	30	0.0253	0	10	No	-	-	-	-

Pollutant	Averaging Period	EAL (µg.m-3)	Max PC (µg.m-3)	Max PC as % of EAL	Criteria (%)	PC is Potentially Significant ?	AC (µg.m-3)	PEC (µg.m-3)	PEC as % of EAL	PEC is Potentially Significant ?
	1 hour (annual mean)	1	0.0016	0	1	No	-	-	-	-
Hg	1 hour (maximum)	7.5	0.0253	0	10	No	-	-	-	-
	1 hour (annual mean)	0.25	0.0016	1	1	No	-	-	-	-
Sb	1 hour (maximum)	150	0.2528	0	10	No	-	-	-	-
	1 hour (annual mean)	5	0.0162	0	1	No	-	-	-	-
As	1 hour (annual mean)	0.006	0.0162	270	1	Yes	0.001	0.017	283	Yes
Cr	1 hour (maximum)	150	0.2528	0	10	No	-	-	-	-
	1 hour (annual mean)	5	0.0162	0	1	No	-	-	-	-
Co	1 hour (maximum)	6	0.2528	4	10	No	-	-	-	-
	1 hour (annual mean)	0.2	0.0162	8	1	Yes	0.0002	0.016	8	No
Cu	1 hour (maximum)	200	0.2528	0	10	No	-	-	-	-
	1 hour (annual mean)	10	0.0162	0	1	No	-	-	-	-
Pb	1 hour (annual mean)	0.25	0.0162	6	1	Yes	0.017	0.034	13	No
Mn	1 hour (maximum)	1500	0.2528	0	10	No	-	-	-	-
	1 hour (annual mean)	0.15	0.0162	11	1	Yes	0.090	0.106	71	No
Ni	1 hour (annual mean)	0.02	0.0162	81	1	Yes	0.001	0.017	87	No
V	1 hour (maximum)	5	0.2528	5	10	No	-	-	-	-

Pollutant	Averaging Period	EAL (µg.m^{-3})	Max PC (µg.m^{-3})	Max PC as % of EAL	Criteria (%)	PC is Potentially Significant ?	AC (µg.m^{-3})	PEC (µg.m^{-3})	PEC as % of EAL	PEC is Potentially Significant ?
	1 hour (annual mean)	1	0.0162	2	1	Yes	0.009	0.026	3	No
Dioxins & Furans	1 hour (annual mean)	-	3.24E-09	-	-	-	-	-	-	-
PAHs (as B[a]P equivalent)	1 hour (annual mean)	0.00025	1.62E-06	1	1	No	2.10E-04	2.11E-04	84	No
PCB	1 hour (annual mean)	0.2	2.59E-09	0	1	No	-	-	-	-
	1 hour (maximum)	6	4.05E-08	0	10	No	-	-	-	-
NH_3	1 hour (annual mean)	180	3.24E-01	0	1	No	-	-	-	-
	1 hour (maximum)	2500	5.06E+00	0	10	No	-	-	-	-
TVOCs	1 hour (annual mean)	2.25	6.47E-01	29	1	Yes	1.04E-01	7.51E-01	33	No
CR VI	1 hour (annual mean)	0.00025	4.86E-06	2	1	Yes	1.13E-06	5.99E-06	2	No

Table 5.2 Predicted Maximum Process Contributions (µg.m^{-3})

Pollutant	Averaging Period	EAL (µg.m^{-3})	Max PC (µg.m^{-3})	Max PC as % of EAL	Criteria (%)	PC is Potentially Significant ?	AC (µg.m^{-3})	PEC (µg.m^{-3})	PEC as % of EAL	PEC is Potentially Significant ?
As	1 hour (annual mean)	0.006	0.0008	13	1	Yes	0.0008	0.0016	27	No

5.5 The results presented in Table 5.1 show that the predicted PC is below 10% of the relevant short-term EAL and below 1% of the long-term EAL or the PEC is below 100% for all pollutants with the exception of As (arsenic).

5.6 For arsenic, the predicted PC is more than 1% of the EAL and the PEC is above the EAL. These predictions assume that arsenic individually comprises the total of the group 3 metals emissions. In reality, the IED emission limit applies to all nine of the group 3 metals. The Environment Agency 'Releases from waste incinerators – Guidance on assessing group 3 metal stack emissions from incinerators' version 4 (undated), provides a summary of 34 measured values for each metal recorded at 18 municipal waste and waste wood co-incinerators between 2007 and 2015. For arsenic, the measured concentration varies from 0.04% to 5% of the IED emission concentration limit.Table 5.2 shows the predicted PC if arsenic is 5% of the emission limit. i.e. maximum measured proportion of the IED emission concentration limit). In this case, the predicted PC remains more than 1% of the EAL; however, the PEC is below the EAL. The arsenic impacts are therefore not considered to be significant.

Significance of Effects

5.7 As set out in Section 3, it is generally considered good practice that, where possible, an assessment should communicate effects both numerically and descriptively. Professional judgement by a competent, suitably qualified professional is required to establish the significance associated with the consequence of the impacts.

5.8 Based on the predicted concentrations, the effects are deemed to be not significant, with no predicted exceedances of any objectives or standards at the modelled discrete receptors.

6 Mitigation

6.1 Predicted concentrations of pollutants have been demonstrated by the assessment to meet all relevant air quality standards, objectives and EALs. On that basis, no mitigation is proposed.

7 Conclusions

7.1 This assessment has considered the air quality impacts during the operational phase of the proposed small waste incinerator at Marsh Farm, Melbourne, York.

7.2 Emissions from the incinerator has been assessed through detailed dispersion modelling using best practice approaches. The assessment has been undertaken based on a number of conservative assumptions. This is likely to result in an over-estimate of the contributions that will arise in practice from the facility. The operational impact on receptors in the local area is predicted to be ‘negligible’ taking into account the changes in pollutant concentrations and the absolute levels. Using the criteria adopted for the assessment, together with professional judgement, the effects are not considered significant.

7.3 Overall, the effects of the incinerator are not considered to be significant.

Glossary

ADMS	Atmospheric Dispersion Modelling System
AQMA	Air Quality Management Area
AQS	Air Quality Strategy
Effect	The consequences of an impact, experienced by a receptor
EPUK	Environmental Protection UK
IAQM	Institute of Air Quality Management
Impact	The change in atmospheric pollutant concentration and/or dust deposition. A scheme can have an 'impact' on atmospheric pollutant concentration but no effect, for instance if there are no receptors to experience the impact
R&A	Review and Assessment
Receptor	A person, their land or property and ecologically sensitive sites that may be affected by air quality
Risk	The likelihood of an adverse event occurring

Figures

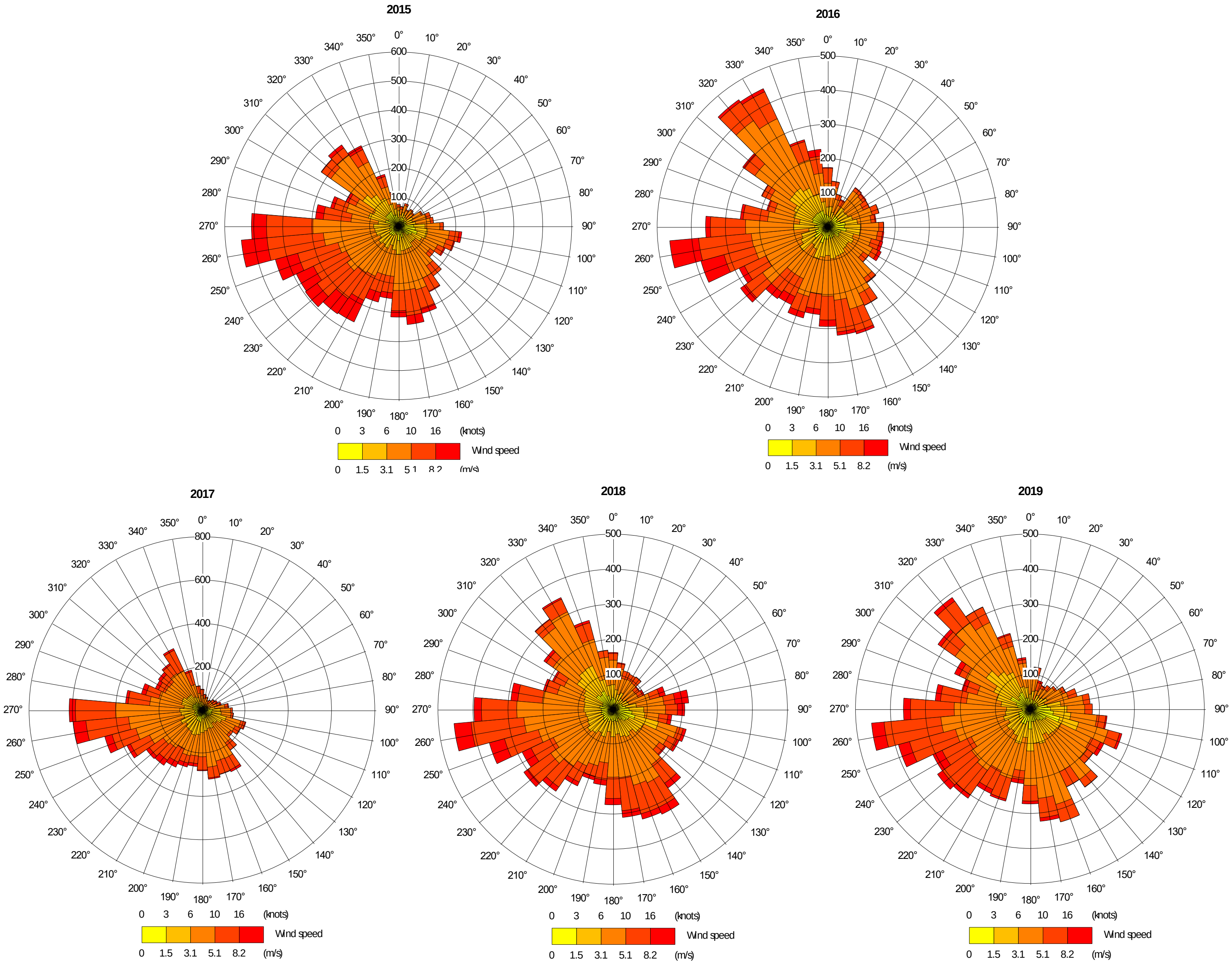

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Figure 1: Wind Roses – Linton-on-Ouse (2015 -2019)

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Figure 2: Stacks and Modelled Receptors

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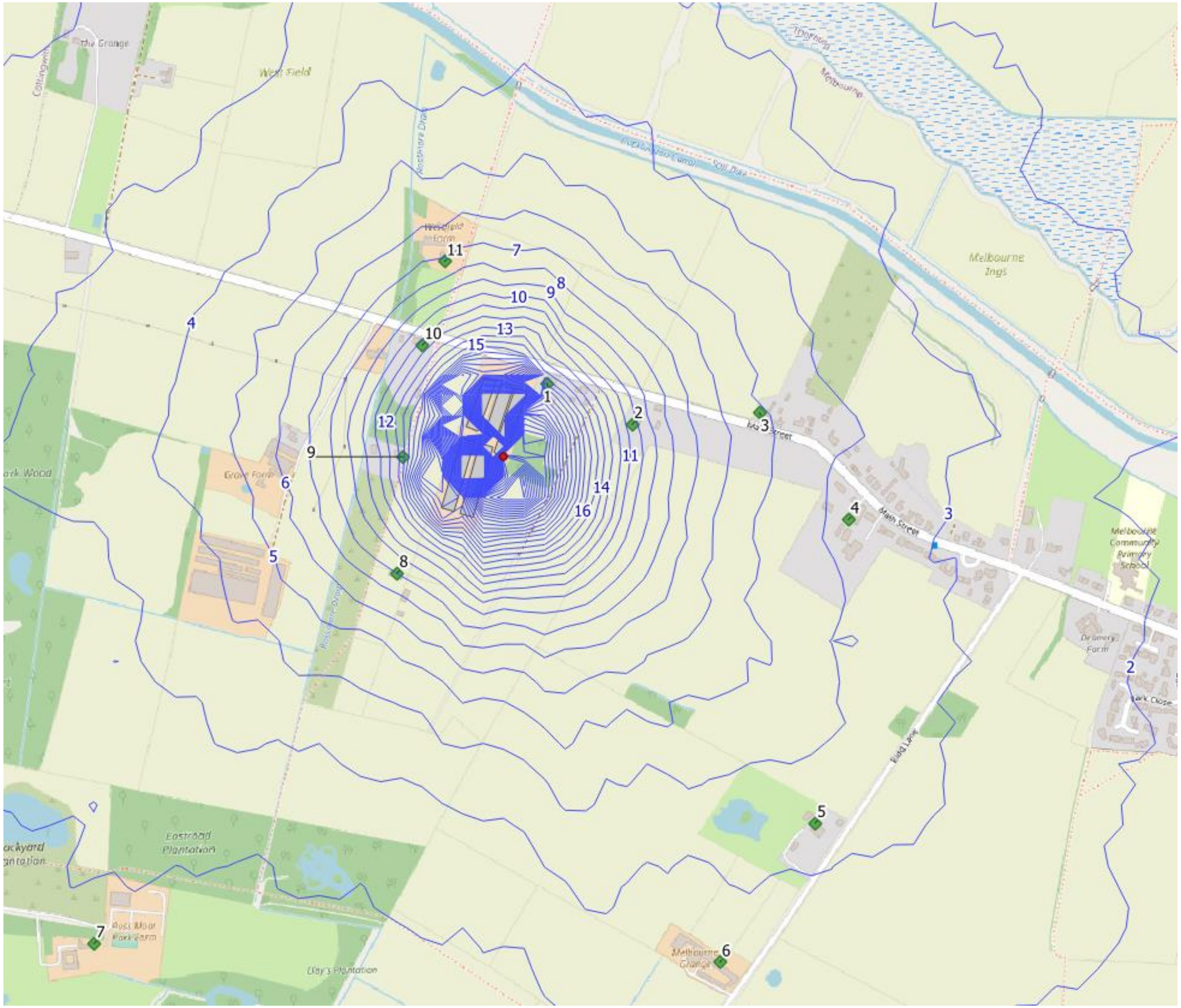
Figure 3: Annual-mean NO_2 PC ($\mu g.m^{-3}$)



- Modelled receptors
- Modelled stack
- Modelled buildings
- Contour

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Figure 4: 99.79th percentile of hourly-mean PC (μg.m^{-3})

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Appendices

Appendix A: Stack Height Determination

A.1 A stack height determination has been undertaken to establish the height at which there is minimal additional environmental benefit associated with the cost of further increasing the height of the stack. The Environment Agency removed their detailed guidance, Horizontal Guidance Note EPR H1 [14], for undertaking risk assessments on 1 February 2016; however, the approach used here is consistent with that EA guidance which required the identification of "*an option that gives acceptable environmental performance but balances costs and benefits of implementing it."*

Methodology

A.2 Model simulations have been run using ADMS 5 to determine what stack height is required to provide adequate dispersion/dilution and to overcome local building wake effects.

A.3 The stack height determination considers ground level concentrations over the averaging periods relevant to the air quality assessment, together with the full range of all likely meteorological conditions using five years (2015 to 2019) of hourly sequential meteorological data from Linton-on-Ouse. The model was run for a range of stack heights between 7 m and 13 m, in 1 m increments.

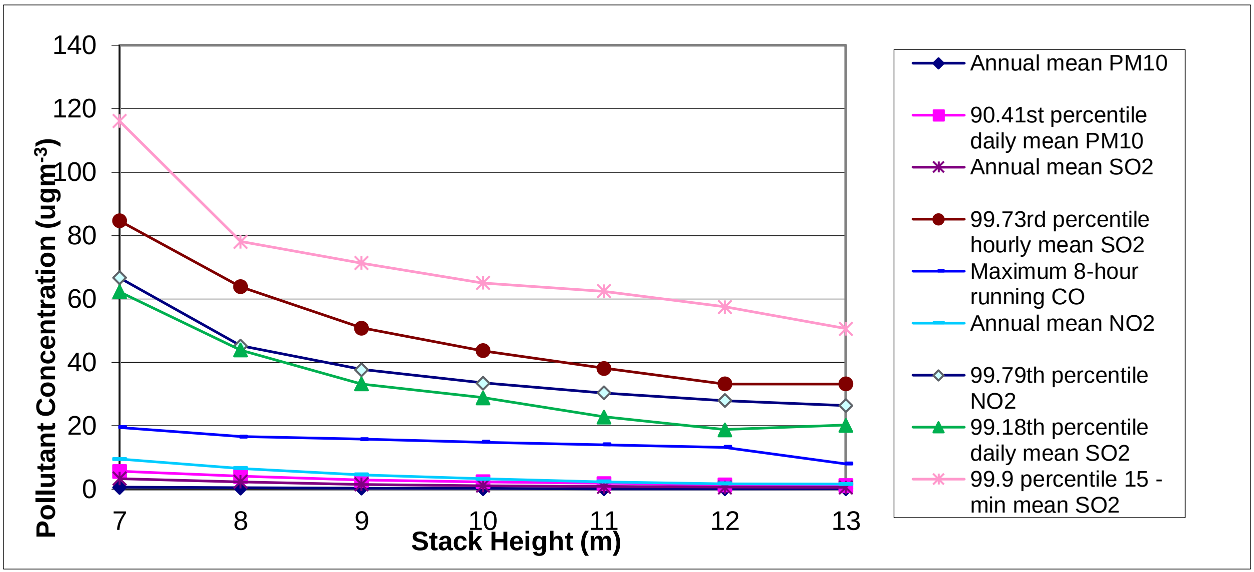
A.4 For the purposes of stack height determination, the modelled domain was 3 km by 3 km centred on the proposed development and with a grid spacing of 30 m. Results have been reported for the location where the highest concentration is predicted and for the worst-case meteorological conditions. Sensitive receptors have also been considered but concentrations were all below the highest concentration across the grid.

Stack Height Determination Results

A.5 The stack height modelling results have been analysed in two stages:

Stage 1 - The maximum predicted Process Contributions (PCs) have been plotted against height to determine if there is a height at which no benefit is gained from increases in stack heights.

Graph A: Maximum Predicted Process Contributions vs Stack Height



Stage 2 – The on-line EA guidance is for risk assessments and provides details for screening out substances for detailed assessment. In particular, it states that:

"*To screen out a PC for any substance so that you don't need to do any further assessment of it, the PC must meet both of the following criteria:*

- *the short-term PC is less than 10% of the short-term environmental standard*
- *the long-term PC is less than 1% of the long-term environmental standard*

If you meet both of these criteria you don't need to do any further assessment of the substance.

If you don't meet them you need to carry out a second stage of screening to determine the impact of the PEC."

A.6 It continues by stating that:

"You must do detailed modelling for any PECs not screened out as insignificant."

A.7 It then states that further action may be required where:

- *"your PCs could cause a PEC to exceed an environmental standard (unless the PC is very small compared to other contributions – if you think this is the case contact the Environment Agency)*
- *The PEC is already exceeding an environmental standard"*

A.8 The EA online guidance 'Environmental permitting: air dispersion modelling reports' [15] states:

"For a detailed modelling assessment PCs are insignificant where they are less than:

- *10% of a short-term environmental standard*
- *1% of a long-term environmental standard*

At the detailed modelling stage there are no criteria to determine whether:

- *PCs are significant*
- *PECs are insignificant or significant*

You must explain how you judged significance and base this on the site specific circumstances."

A.9 On that basis, the stack height has been determined as the height at which:

- The effects are not considered significant if the short-term PC is less than 10% of the short-term Environmental Assessment Level (EAL) or the PEC is below the EAL; and
- The effects are not considered significant if the long-term PC is less than 1% of the long-term EAL or the PEC is below the EAL.

A.10 Table A.1 provides the maximum predicted PC for a range of pollutants, covering a range of averaging periods, at each stack height modelled. Table A.2 provides the maximum predicted PC as a percentage of the EAL at each stack height modelled. Table A.3 provides the maximum predicted PEC as a percentage of the EAL at each stack height modelled.

Table A.1 Maximum Predicted Process Contributions (µg.m^{-3}) at each Stack Height Modelled

Stack Height	Annual-mean PM_{10}	90.41st percentile daily mean PM_{10}	Maximum hourly HCl	Annual mean SO_2	99.73rd percentile hourly mean SO_2	Maximum 8-hour running CO	Annual-mean NO_2	99.79th percentile NO_2	99.18th percentile daily mean SO_2	99.9th percentile 15-minute mean SO_2
7	0.66	5.67	89.51	3.32	84.62	19.47	9.52	66.65	62.23	116.05
8	0.46	4.10	38.34	2.31	63.87	16.55	6.62	45.19	43.85	78.06
9	0.32	2.81	30.34	1.58	50.82	15.72	4.53	37.70	33.16	71.32
10	0.23	2.31	26.71	1.14	43.65	14.88	3.27	33.55	28.84	65.09
11	0.16	1.84	25.38	0.82	38.16	14.06	2.34	30.38	22.81	62.50
12	0.12	1.33	24.06	0.61	33.16	13.25	1.75	27.95	18.83	57.54
13	0.11	1.23	19.91	0.57	33.20	7.99	1.63	26.37	20.22	50.68

Table A.2 Maximum Predicted Process Contributions as a Percentage of the EAL at each Stack Height Modelled

Stack Height	Annual-mean PM_{10}	90.41st percentile daily mean PM_{10}	Maximum hourly HCl	Annual mean SO_2	99.73rd percentile hourly mean SO_2	Maximum 8-hour running CO	Annual-mean NO_2	99.79th percentile NO_2	99.18th percentile daily mean SO_2	99.9th percentile 15-minute mean SO_2
EAL	**40**	**50**	**750**	**50**	**350**	**10000**	**40**	**200**	**125**	**266**
7	1.7	11.3	11.9	6.6	24.2	0.2	23.8	33.3	49.8	43.6
8	1.2	8.2	5.1	4.6	18.2	0.2	16.6	22.6	35.1	29.3
9	0.8	5.6	4.0	3.2	14.5	0.2	11.3	18.8	26.5	26.8
10	0.6	4.6	3.6	2.3	12.5	0.1	8.2	16.8	23.1	24.5
11	0.4	3.7	3.4	1.6	10.9	0.1	5.8	15.2	18.2	23.5
12	0.3	2.7	3.2	1.2	9.5	0.1	4.4	14.0	15.1	21.6
13	0.3	2.5	2.7	1.1	9.5	0.1	4.1	13.2	16.2	19.1

Cells are shaded grey where the predicted process contribution is above 1% of EAL for long-term average periods and 10% for short-term average periods.

Table A.3 Maximum Predicted Environmental Concentration as a Percentage of the EAL at each Stack Height Modelled

Stack Height	Annual-mean PM_{10}	90.41st percentile daily mean PM_{10}	Maximum hourly HCl	Annual mean SO_2	99.73rd percentile hourly mean SO_2	Maximum 8-hour running CO	Annual-mean NO_2	99.79th percentile NO_2	99.18th percentile daily mean SO_2	99.9th percentile 15-minute mean SO_2
EAL	**40**	**50**	**750**	**50**	**350**	**10000**	**40**	**200**	**125**	**266**
7	33.2	61.8	12.0	9.5	25.0	2.2	40.2	39.9	52.1	44.7
8	32.7	58.6	5.2	7.5	19.1	2.2	33.0	29.2	37.4	30.4
9	32.3	56.1	4.1	6.0	15.3	2.2	27.8	25.4	28.8	27.9
10	32.1	55.1	3.6	5.1	13.3	2.2	24.6	23.4	25.3	25.5
11	31.9	54.1	3.4	4.5	11.7	2.1	22.3	21.8	20.5	24.6
12	31.8	53.1	3.3	4.1	10.3	2.1	20.8	20.6	17.3	22.7
13	31.8	52.9	2.7	4.0	10.3	2.1	20.5	19.8	18.4	20.1

Discussion

A.11 The results in Table A.2 indicate that there are no heights below 13 m at which the impacts can be screened-out as insignificant based on the PC alone. In particular, the maximum predicted PC for NO_2 and SO_2 is above 1% for long-term averaging periods and 10% for short-term averaging periods at the majority of heights modelled.

A.12 For PM_{10}, HCl and CO the PCs are below the 1% and 10% criteria at heights above 8 m.

A.13 The results in Table A.5 and Table A.6 indicate that for all pollutants and averaging periods the PECs are all well below the EAL at all heights.

A.14 On that basis, and using the significance criteria adopted for this assessment, the impacts would be considered not significant at all heights modelled.

A.15 The Her Majesty's Inspectorate of Pollution (HMIP) 1993 'Guidelines on Discharge Stack Heights for Polluting Emission. Technical Guidance Note D1 (Dispersion)' recommends that stack heights are at least 3 m above the building. Taking into account 3 m clearance between the roof of the building (6.1 m) and the tip of the stack, the optimum stack height for the assessment is considered to be 9 m.

Conclusion

A.16 Based on the results of the detailed stack height modelling and using professional judgement, the optimum stack height for the assessment is considered to be 9 m and the modelling undertaken in this report assumes a 9 m high stack.

Appendix B: Baseline

Nitrogen Dioxide and Particulate Matter

B.1 ERYC do not monitor PM_{10} and the Defra mapped background concentration estimate for the grid square containing the Application Site of 12.6 $\mu g.m^{-3}$ has been used in the assessment.

B.2 ERYC monitors NO_2 at a number of roadside and urban background locations. However, the nearest monitoring location is approximately 6.7 km from the site. Therefore, the Defra mapped background concentration estimate for the grid square containing the Application Site of 6.6 $\mu g.m^{-3}$ has been used in the assessment.

Sulphur Dioxide and Carbon Monoxide

B.3 The Automatic Urban and Rural Network (AURN) monitors ambient concentrations of, amongst others, SO_2 and CO.

B.4 The nearest monitoring location is at Leeds Centre AURN.

B.5 The concentrations monitored over recent years are provided in Table B.2.

Table B.1 Measured Annual-mean CO and SO_2 Concentrations

Pollutant	2016	2017	2018	2019	2020	Average
CO ($mg.m^{-3}$)	0.27	0.27	0.16	0.17	0.14	0.20
SO_2 ($\mu g.m^{-3}$)	1.48	1.46	1.40	1.44	1.32	1.42

B.6 The average concentrations have been used within the assessment.

Heavy Metals

B.7 The Heavy Metals Network monitors the concentrations in air for a range of metallic elements at urban, industrial and rural sites.

B.8 The nearest monitored concentrations are measured at the Scunthorpe Town and Scunthorpe Low Santon sites. The five-year average concentrations are shown in Table B.1. The maximum has been used in the assessment.

Table B.1 Measured Annual-mean Metal Concentrations ($\mu g.m^{-3}$)

Pollutant	Scunthorpe Low Santon 5-year average (2016-2020)	Scunthorpe Town 5-year average (2016-2020)	Max
Cd	0.0006	0.0003	0.0006

Pollutant	Scunthorpe Low Santon 5-year average (2016-2020)	Scunthorpe Town 5-year average (2016-2020)	Max
As	0.0008	0.0008	0.0008
Co	0.0002	0.0001	0.0002
Pb	0.0174	0.0135	0.0174
Mn	0.0899	0.0196	0.0899
Ni	0.0012	0.0010	0.0012
V	0.0094	0.0014	0.0094
Cr	0.0038	0.0027	0.0038

Polycyclic Aromatic Hydrocarbons

B.9 The polycyclic aromatic hydrocarbon (PAH) network monitors ambient concentrations of PAHs. The nearest monitoring location is at Leeds Millshaw where B[a]P is measured.

B.10 The concentrations monitored over recent years are provided in Table B.2.

Table B.2 Measured Annual-mean B[a]P Concentrations (ng.m^{-3})

Site Name	2016	2017	2018	2019	2020	Average
Leeds Millshaw	0.25	0.19	0.23	0.23	0.16	0.21

B.11 The average concentration of 0.21 ng.m^{-3} has been used within the assessment.

1,3 Butadiene

B.12 1,3-Butadiene is measured at four locations in the UK. The concentrations monitored over recent years are provided in Table B.3.

Table B.3 Measured Annual-mean 1,3-Butadiene Concentrations (ug.m^{-3})

Site Name	2016	2017	2018	2019	2020	Average
Auchencorth Moss	0.01	0.01	0.01	0.02	0.03	0.02
Chilbolton Observatory	0.12	0.16	0.09	0.09	0.06	0.10
London Eltham	0.09	0.06	0.05	0.06	0.06	0.07

Site Name	2016	2017	2018	2019	2020	Average
London Marylebone Road	0.07	0.10	-	0.05	-	0.07

B.13 The highest 5-year average concentration of 0.10 ug.m^{-3}, measured at Chilbolton Observatory, has been used within the assessment.

Hydrochloric Acid

B.14 Hydrochloric acid has not been measured since 2016. The concentrations monitored over the most recent years at the Caenby monitoring location are provided in Table B.3.

Table B.4 Measured Annual-mean 1,3-Butadiene Concentrations (ug.m^{-3})

Site Name	2013	2014	2015	Average
Caenby	0.46	0.32	0.16	0.31

B.15 The average concentration of 0.31 ug.m^{-3} has been used within the assessment.

Appendix C: Impacts at Discrete Sensitive Receptors

Table C.4 Maximum Predicted Process Contributions (µg.m^{-3}) at each Modelled Receptor

Pollutant	Averaging Period	Receptor										
		1	2	3	4	5	6	7	8	9	10	11
PM_{10}	24 hour (90.41st percentile)	0.99	0.72	0.29	0.15	0.13	0.09	0.03	0.17	0.50	0.60	0.37
	24 hour (annual mean)	0.11	0.09	0.04	0.02	0.01	0.01	0.00	0.02	0.04	0.05	0.03
$PM_{2.5}$	24 hour (annual mean)	0.11	0.09	0.04	0.02	0.01	0.01	0.00	0.02	0.04	0.05	0.03
HCl	1 hour (maximum)	10.04	5.70	2.81	2.35	1.73	1.83	1.14	4.19	7.13	6.18	3.96
HF	1 hour (maximum)	0.67	0.38	0.19	0.16	0.12	0.12	0.08	0.28	0.48	0.41	0.26
	1 hour (monthly mean)	0.02	0.02	0.01	<0.005	<0.005	<0.005	<0.005	<0.005	0.01	0.01	0.01
SO_2	15 minute (99.90th percentile)	28.49	18.56	11.76	9.02	8.25	7.42	4.95	13.67	21.87	19.73	12.83
	1 hour (99.73th percentile)	24.26	16.13	7.67	5.44	4.78	4.11	2.82	11.89	19.52	16.27	10.36
	24 hour (99.18th percentile)	11.95	8.02	3.27	1.81	1.54	1.17	0.72	4.23	10.25	9.77	4.90
	1 hour (annual mean)	0.56	0.46	0.18	0.09	0.07	0.04	0.01	0.08	0.22	0.27	0.17

Pollutant	Averaging Period	Receptor 1	2	3	4	5	6	7	8	9	10	11
NO_2	1 hour (99.79th percentile)	17.58	11.36	5.60	3.98	3.49	3.03	2.00	8.43	13.74	11.55	7.34
	1 hour (annual mean)	1.57	1.29	0.51	0.24	0.18	0.12	0.04	0.21	0.62	0.74	0.49
CO	8 hour (maximum daily running)	5.77	3.32	1.37	1.33	0.95	0.90	0.40	2.30	4.25	3.91	2.26
	1 hour (maximum)	8.37	4.75	2.34	1.96	1.44	1.53	0.95	3.49	5.94	5.15	3.30
Cd	1 hour (annual mean)	5.62E-04	4.61E-04	1.84E-04	8.69E-05	6.53E-05	4.36E-05	1.25E-05	7.68E-05	2.22E-04	2.65E-04	1.74E-04
Tl	1 hour (maximum)	8.37E-03	4.75E-03	2.34E-03	1.96E-03	1.44E-03	1.53E-03	9.51E-04	3.49E-03	5.94E-03	5.15E-03	3.30E-03
	1 hour (annual mean)	5.62E-04	4.61E-04	1.84E-04	8.69E-05	6.53E-05	4.36E-05	1.25E-05	7.68E-05	2.22E-04	2.65E-04	1.74E-04
Hg	1 hour (maximum)	8.37E-03	4.75E-03	2.34E-03	1.96E-03	1.44E-03	1.53E-03	9.51E-04	3.49E-03	5.94E-03	5.15E-03	3.30E-03
	1 hour (annual mean)	5.62E-04	4.61E-04	1.84E-04	8.69E-05	6.53E-05	4.36E-05	1.25E-05	7.68E-05	2.22E-04	2.65E-04	1.74E-04
Sb	1 hour (maximum)	8.37E-02	4.75E-02	2.34E-02	1.96E-02	1.44E-02	1.53E-02	9.51E-03	3.49E-02	5.94E-02	5.15E-02	3.30E-02
	1 hour (annual mean)	5.62E-03	4.61E-03	1.84E-03	8.69E-04	6.53E-04	4.36E-04	1.25E-04	7.68E-04	2.22E-03	2.65E-03	1.74E-03
As	1 hour (annual mean)	5.62E-03	4.61E-03	1.84E-03	8.69E-04	6.53E-04	4.36E-04	1.25E-04	7.68E-04	2.22E-03	2.65E-03	1.74E-03
Cr	1 hour (maximum)	8.37E-02	4.75E-02	2.34E-02	1.96E-02	1.44E-02	1.53E-02	9.51E-03	3.49E-02	5.94E-02	5.15E-02	3.30E-02
	1 hour (annual mean)	5.62E-03	4.61E-03	1.84E-03	8.69E-04	6.53E-04	4.36E-04	1.25E-04	7.68E-04	2.22E-03	2.65E-03	1.74E-03
Co	1 hour (maximum)	8.37E-02	4.75E-02	2.34E-02	1.96E-02	1.44E-02	1.53E-02	9.51E-03	3.49E-02	5.94E-02	5.15E-02	3.30E-02
	1 hour (annual mean)	5.62E-03	4.61E-03	1.84E-03	8.69E-04	6.53E-04	4.36E-04	1.25E-04	7.68E-04	2.22E-03	2.65E-03	1.74E-03
Cu	1 hour (maximum)	8.37E-02	4.75E-02	2.34E-02	1.96E-02	1.44E-02	1.53E-02	9.51E-03	3.49E-02	5.94E-02	5.15E-02	3.30E-02

Pollutant	Averaging Period	Receptor 1	2	3	4	5	6	7	8	9	10	11
	1 hour (annual mean)	5.62E-03	4.61E-03	1.84E-03	8.69E-04	6.53E-04	4.36E-04	1.25E-04	7.68E-04	2.22E-03	2.65E-03	1.74E-03
Pb	1 hour (annual mean)	5.62E-03	4.61E-03	1.84E-03	8.69E-04	6.53E-04	4.36E-04	1.25E-04	7.68E-04	2.22E-03	2.65E-03	1.74E-03
Mn	1 hour (maximum)	8.37E-02	4.75E-02	2.34E-02	1.96E-02	1.44E-02	1.53E-02	9.51E-03	3.49E-02	5.94E-02	5.15E-02	3.30E-02
	1 hour (annual mean)	5.62E-03	4.61E-03	1.84E-03	8.69E-04	6.53E-04	4.36E-04	1.25E-04	7.68E-04	2.22E-03	2.65E-03	1.74E-03
Ni	1 hour (annual mean)	5.62E-03	4.61E-03	1.84E-03	8.69E-04	6.53E-04	4.36E-04	1.25E-04	7.68E-04	2.22E-03	2.65E-03	1.74E-03
V	1 hour (maximum)	8.37E-02	4.75E-02	2.34E-02	1.96E-02	1.44E-02	1.53E-02	9.51E-03	3.49E-02	5.94E-02	5.15E-02	3.30E-02
	1 hour (annual mean)	5.62E-03	4.61E-03	1.84E-03	8.69E-04	6.53E-04	4.36E-04	1.25E-04	7.68E-04	2.22E-03	2.65E-03	1.74E-03
Dioxins & Furans	1 hour (annual mean)	1.12E-09	9.23E-10	3.67E-10	1.74E-10	1.31E-10	8.71E-11	2.51E-11	1.54E-10	4.44E-10	5.30E-10	3.47E-10
PAHs (as B[a]P equivalent)	1 hour (annual mean)	5.62E-07	4.61E-07	1.84E-07	8.69E-08	6.53E-08	4.36E-08	1.25E-08	7.68E-08	2.22E-07	2.65E-07	1.74E-07
PCB	1 hour (annual mean)	8.99E-10	7.38E-10	2.94E-10	1.39E-10	1.04E-10	6.97E-11	2.01E-11	1.23E-10	3.55E-10	4.24E-10	2.78E-10
	1 hour (maximum)	1.34E-08	7.60E-09	3.75E-09	3.13E-09	2.30E-09	2.44E-09	1.52E-09	5.58E-09	9.51E-09	8.24E-09	5.29E-09
NH_3	1 hour (annual mean)	1.12E-01	9.23E-02	3.67E-02	1.74E-02	1.31E-02	8.71E-03	2.51E-03	1.54E-02	4.44E-02	5.30E-02	3.47E-02
	1 hour (maximum)	1.67E+00	9.50E-01	4.69E-01	3.91E-01	2.88E-01	3.05E-01	1.90E-01	6.98E-01	1.19E+00	1.03E+00	6.61E-01
TVOCs	1 hour (annual mean)	2.25E-01	1.85E-01	7.35E-02	3.47E-02	2.61E-02	1.74E-02	5.01E-03	3.07E-02	8.88E-02	1.06E-01	6.95E-02
CR VI	1 hour (annual mean)	1.69E-06	1.38E-06	5.51E-07	2.61E-07	1.96E-07	1.31E-07	3.76E-08	2.30E-07	6.66E-07	7.95E-07	5.21E-07

Appendix D: Impacts at Ecological Receptors

Scope

D.1 The EA guidance on 'Screening for protected conservations areas' (EA, 2020b) requires identification of:

- Special Protection Areas (SPAs), Special Areas of Conservation (SACs) and Ramsar sites (protected wetlands) within 10 km of the proposed development; and
- Sites of Special Scientific Interest (SSSIs) and Local Nature sites (ancient woods, local wildlife sites (LWSs) and national and local nature reserves) within 2 km of the proposed development.

D.2 As such, the assessment considers the impact of the development at the following designated sites:

- Lower Derwent Valley SAC, SPA, Ramsar and NNR;
- River Derwent SAC;
- Skipwith Common SAC; and
- Melbourne and Thornton SSSI.

Critical Levels

D.3 Critical levels are maximum atmospheric concentrations of pollutants for the protection of vegetation and ecosystems and are specified within UK air quality regulations. Where relevant, background concentrations at each designated site have been derived from the UK Air Pollution Information System (APIS) database [16].

Critical Loads

D.4 Critical loads refer to the quantity of pollutant deposited, below which significant harmful effects on sensitive elements of the environment do not occur, according to present knowledge.

Critical Loads – Nutrient Nitrogen Deposition

D.5 Percentage contributions to nutrient nitrogen deposition have been derived from the results of the ADMS dispersion modelling. Deposition rates have been calculated using empirical methods recommended by the Environment Agency, as follows:

- The dry deposition flux ($\mu g.m^{-2}.s^{-1}$) has been calculated by multiplying the ground level NO_2, NH_3 and SO_2 concentrations ($\mu g.m^{-3}$) by the deposition velocities ($m.s^{-1}$) set out in the table below.

Table 3 Deposition Velocities

Pollutant	Deposition Velocity ($m.s^{-1}$)	
	Grassland	Woodland
NOx	0.0015	0.003
SO_2	0.012	0.024
NH_3	0.02	0.03

- Units of $\mu g.m^{-2}.s^{-1}$ have been converted to units of $kg.ha^{-1}.year^{-1}$ by multiplying the dry deposition flux by the standard conversion factor of 96 for NO_2, 259.9 for NH_3 and 157.7 for SO_2. The total N deposition flux has then been calculated as the sum of the contribution from NO_2 and NH_3.
- Predicted contributions to nitrogen and sulphur deposition have been calculated and compared with the relevant critical load range for the habitat types associated with the designated site. These have been derived from the APIS database.

Critical Loads – Acidification

D.6 The acid deposition rate, in equivalents $keq.ha^{-1}.year^{-1}$, has been calculated by multiplying the dry deposition flux ($kg.ha^{-1}.year^{-1}$) by a conversion factor of 0.071428 for N and 0.0625 for S. This takes into account the degree to which a chemical species is acidifying, calculated as the proportion of N within the molecule.

D.7 Wet deposition in the near field is not significant compared with dry deposition for N and S [17] and therefore for the purposes of this assessment, wet deposition has not been considered.

D.8 Predicted contributions to acid deposition have been calculated and compared with the critical load function for the habitat types associated with the designated site as derived from the APIS database.

Significance Criteria

D.9 The PCs and PECs have been compared against the relevant critical level/load, for the relevant habitat type/interest feature.

D.10 For SACS, SPAs and Ramsars, the Environment Agency guidelines (EA, 2020b) state that:

"To screen out a PC for any substance so that you don't need to do any further assessment of it, the PC must meet both of the following criteria:

- *the short-term PC is less than 10% of the short-term environmental standard*
- *the long-term PC is less than 1% of the long-term environmental standard*

If you meet both of these criteria you don't need to do any further assessment of the substance.

If you don't meet them you need to carry out a second stage of screening to determine the impact of the PEC."

D.11 It continues by stating that:

"If your long-term PC is greater than 1% and your PEC is less than 70% of the long-term environmental standard, the emissions are insignificant – you don't need to assess them any further. If your PEC is greater than 70% of the long-term environmental standard, you need to do detailed modelling."

D.12 For LWSs, it states:

"If your emissions meet both of the following criteria they're insignificant – you don't need to assess them any further:

- *the short-term PC is less than 100% of the short-term environmental standard*
- *the long-term PC is less than 100% of the long-term environmental standard*

You don't need to calculate PEC for local nature sites. If your PC exceeds the screening criteria you need to do detailed modelling."

Results

D.13 The predicted annual-mean NO_X, SO_2 and NH_3 concentrations are compared with the critical levels in Table D.1.

D.14 The predicted daily-mean NOx and HF concentrations and weekly-mean HF concentrations are compared with the critical levels in Table D.2.

D.15 The predicted nutrient N deposition rates are compared with the critical load in Table D.3. The lowest critical loads for nitrogen deposition have been obtained from APIS.

D.16 The maximum predicted acid deposition rates are compared with the critical load function in Table D.4. The critical loads for the nitrogen and sulphur component for acid deposition have been also obtained from APIS.

Table D.1 Predicted Annual-Mean NOx, SO_2 and NH_3 Concentrations at Designated Habitat Sites ($\mu g.m^{-3}$)

Habitat Site	Annual-mean NOx PC	PC as % of CL	Annual-mean SO_2 PC	PC as % of CL	Annual-mean NH_3 PC	PC as % of CL
Critical Level	**30**		**20**		**3**	
Lower Derwent SAC, SPA, Ramsar and NNR	0.345	1	0.086	0	0.017	1
River Derwent SAC	0.022	0	0.005	0	0.001	0
Skipwith Common SAC	0.003	0	0.001	0	<0.0005	0
Melbourne and Thornton Ing SSSI	0.345	1	0.086	1	0.017	1

Table D.2 Predicted Daily-Mean NOx and HF and Weekly-mean HF Concentrations at Designated Habitat Sites ($\mu g.m^{-3}$)

Habitat Site	Daily-mean NOx PC	PC as % of CL	Daily-mean HF PC	PC as % of CL	Weekly-mean HF PC	PC as % of CL
Critical Level	**75**		**5**		**0.5**	
Lower Derwent SAC, SPA, Ramsar and NNR	2.42	3	0.012	0	0.005	1
River Derwent SAC	0.57	1	0.003	0	<0.0005	0
Skipwith Common SAC	0.06	0	<0.0005	0	<0.0005	0
Melbourne and Thornton Ing SSSI	2.42	3	0.012	0	0.005	1

Table D.3 Predicted Nutrient N Deposition at Designated Habitat Sites ($kg.ha^{-1}.yr^{-1}$)

Habitat Site	CL	N Deposition PC	PC as % of CL	AC	N Deposition PEC
Lower Derwent SAC, SPA, Ramsar and NNR	20	0.204	1	-	
River Derwent SAC	No data	0.013	-	-	
Skipwith Common SAC	10	0.002	0	-	
Melbourne and Thornton Ing SSSI	10	0.204	2	52.1	52.3

Table D.4 Predicted Acid Deposition at Designated Habitat Sites ($keq.ha^{-1}.yr^{-1}$)

Habitat Site	Min N CL	Max N CL	Max S CL	N PC	S PC	AC - N	AC - S	PEC - N	PEC - S	PC as % of CLF
Lower Derwent SAC, SPA, Ramsar and NNR	0.856	4.856	4	0.015	0.020	2.8	0.3	2.815	0.320	1
River Derwent SAC	no data	no data	no data	0.001	0.001	0.8	0.2	0.801	0.201	-
Skipwith Common SAC	0.642	0.802	0.16	<0.0005	<0.0005	1.3	0.2	1.300	0.200	0
Melbourne and Thornton Ing SSSI	0.856	4.856	4	0.015	0.020	3.7	0.3	3.715	0.320	1

Interpretation of Results

Annual-mean NOx, SO_2 and NH_3

D.17 The maximum annual-mean NOx, SO_2 and NH_3 PCs do not exceed 1% of the critical level and the impacts can be screened out as insignificant.

Daily-mean NOx and HF

D.18 The maximum daily-mean NOx and HF PCs do not exceed 10% of the critical level and the impacts can be screened out as insignificant.

Weekly-mean HF

D.19 The maximum weekly-mean HF PC does not exceed 10% of the critical level and the impacts can be screened out as insignificant.

Nutrient N Deposition

D.20 The maximum nitrogen deposition PCs do not exceed 1% of the critical load and the impacts can be screened out as insignificant at all sites except Melbourne and Thornton Ing SSSI.

D.21 At the Melbourne and Thornton Ing SSSI, the PC is 2% of the critical load and the impacts are potentially significant. The AC of 52.1 kgN/ha/yr is well above the CL of 10 kgN/ha/yr. Advice has been sought from the projects ecologist who have advised that this increase will have no effect on the habitat given the very high AC (the PC is only 0.4% of the AC) and the fact that ecological systems are already moderate/high nutrient status habitats as they are on the floodplain.

Acid Deposition

D.22 The maximum acid deposition PCs do not exceed 1% of the critical load and the impacts can be screened out as insignificant.

References

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3 OPSI (2016) The Environmental Permitting (England and Wales) Regulations 2016

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5 Defra, 2010, The Air Quality Standards Regulations.

6 Defra, 2007, The Air Quality Strategy for England, Scotland, Wales and Northern Ireland. Volume 2.

7 World Health Organisation Guidelines (http://www.who.int/en/)

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9 Defra (2016) Local Air Quality Management Technical Guidance, 2016 (LAQM.TG16)

10 Environment Agency (2007) Review of methods for NO to NO_2 conversion in plumes at short ranges

11 Environment Agency (undated) Conversion Ratios for NOx and NO_2

12 https://www.gov.uk/guidance/environmental-permitting-air-dispersion-modelling-reports

13 Drawn from Defra Maps at http://uk-air.defra.gov.uk/data/laqm-background-maps?year=2018

14 Environment Agency (2010) Environmental Permitting Regulations (EPR) – H1 Environmental Risk Assessment, Annex K

15 https://www.gov.uk/guidance/environmental-permitting-air-dispersion-modelling-reports

16 Air Pollution Information System (APIS) http://www.apis.ac.uk/

17 Approaches to modelling local nitrogen deposition and concentrations in the context of Natura 2000 - Topic 4

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