Public

Air Quality Assessment for Ingevity Boiler Development (Permitting)

Ingevity UK Ltd, Baronet Road Works, Warrington

February 2022

ENG/22/PSP/EC/2701/R

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Executive Summary

Ingevity UK Ltd plans to install a set of up to four steam-raising boilers at the Baronet Road Works site in Warrington. These will replace the current steam raising plant owned and operated by Solvay, which was installed in 1995. The new boilers will initially run on natural gas, but will also be capable of running on hydrogen, enabling the plant to reduce its CO_2 emissions in line with the UK's net zero ambitions once a viable supply is available.

A dispersion modelling study has been undertaken to evaluate the significance of any air quality effects that may arise from the operation of the Proposed Development. Where it was necessary to make assumptions and approximations, a worst-case approach has been adopted to ensure that the modelled concentrations are likely to be over-estimates rather than under-estimates.

This study concludes that no human health based ambient air quality standards or guidelines are predicted to be exceeded due to emissions from the Proposed Development and hence there will be no significant adverse effects on human health.

This study also concludes that there will be no significant adverse effects on the sensitive features at local ecological sites due to emissions from the Proposed Development.

Report Distribution

Mr T Garnett	Project Engineer, Ingevity UK Limited

Abbreviations & Nomenclature

ADMS	Atmospheric Dispersion Modelling System
APIS	Air Pollution Information System
AQAL	Air Quality Assessment Level
AQS	Air Quality Standard
BAT	Best Available Techniques
BAT-AEL	BAT Associated Emission Level
BREF	Bat Reference Document
CO	Carbon Monoxide
CO_2	Carbon Dioxide
EAL	Environmental Assessment Level
ELV	Emission Limit Value
EU	European Union
IRZ	Impact Risk Zone
IED	Industrial Emissions Directive
LCP	Large Combustion Plant
LNR	Local nature Reserve
LWS	Local Wildlife Site
MCPD	Medium Combustion Plant Directive
NNR	National Nature Reserve

NO	Nitric Oxide
NO_2	Nitrogen Dioxide
NOx	Oxides of Nitrogen (NO + NO_2)
PC	Process Contribution
PEC	Predicted Environmental Concentration
SAC	Special Area of Conservation
SPA	Special Protection Area
SSSI	Site of Special Scientific Interest

CONTENTS

1 Introduction

Ingevity UK Ltd plans to install a set of up to four steam-raising boilers at the Baronet Road Works site in Warrington. These will replace the current steam raising plant owned and operated by Solvay, which was installed in 1995. The new boilers will initially run on natural gas, but will also be capable of running on hydrogen, enabling the plant to reduce its CO_2 emissions in line with the UK's net zero ambitions once a viable supply is available.

This study has been designed to assess the effects of emissions to air on local population and ecosystems. This has been carried out by comparing ground level concentrations of released substances with standards and guidelines for ambient air quality, taking background levels of these substances into account. Standards and guidelines which have been specified with regard to potential human health effects have been included together with guidelines for vegetation and ecosystems for assessing the impact of emissions on designated conservation sites.

This study assesses the emissions of nitrogen oxides (NOx) and carbon monoxide (CO). Emissions of other species of relevance to air quality from natural gas or hydrogen fired turbines are negligible.

The assessment assumes operation of four boilers at full load on natural gas for all hours of the year as a worst case scenario.

The detailed assessment within the report relates to the impact of air pollutants associated with the operation of the boilers. There are not anticipated to be any significant additional traffic impacts relative to the current baseline following completion of the proposed development.

2 Site Description

The Proposed Development is located at the western end of the Baronet Works industrial site to the south of Warrington. The River Mersey sits to the north and the Manchester Ship Canal to the south, with the residential area of Lower Walton lying around 500 metres to the east. The Proposed Development will primarily consist of a new boiler house housing up to four gas-fired boilers with the stack located at approximately 359513, 385931. The site location is shown in Figure .

3 Relevant Legislation, Guidance and Significance Criteria

All emission limit values (ELVs) stated in this report are defined at a temperature of 273.15 K, a pressure of 101.3 kPa, dry and at a standardised O_2 content of 3 %. Whilst the UK has now left the European Union (EU), the requirements of EU environmental legislation in place prior to the UK leaving continue to apply. All thermal ratings stated are as net thermal input.

3.1 Emissions Legislation

3.1.1 The Industrial Emissions Directive (2010/75/EU) and LCP BREF (2017/1442)

The Industrial Emissions Directive (IED) sets requirements to apply best available techniques (BAT) for combustion plants on installations with a total rated thermal input of 50 MWth or more under Chapter II. Chapter III of the IED sets ELVs for large combustion plant, defined as combustion plant, the total rated

thermal input of which is equal to or greater than 50 MWth. For new plants, the rated thermal input is aggregated at stack level, but excludes individual units with a thermal rating of less than 15 MWth. The Large Combustion Plant BAT Reference document (LCP BREF) conclusions were published on 17th August 2017 and set BAT Associated Emission Levels (BAT AELs) for large combustion plants, applying the same definition as the IED.

The Proposed Development will consist of a maximum of four boilers emitting via a common stack, with each boiler having an individual thermal rating of 14.65 MWth. As such the individual boiler units fall below the aggregation threshold of 15 MWth set in the IED and LCP BREF and hence the units are not subject to the associated ELVs or BAT AELs.

There is no aggregation threshold in relation to the definition of an installation under the IED. As the combined thermal rating of the boilers is 58.6 MWth, the Proposed Development will therefore constitute an 'installation' under the IED and be subject to BAT as defined in Chapter II.

3.1.2 The Medium Combustion Plant Directive (2015/2193)

The Medium Combustion Plant Directive (MCPD) includes new combustion plant with a rated thermal input equal to or greater than 1 MWth and less than 50 MWth, or a combination of such new plant where discharging up a common stack unless the combination forms a combustion plant covered by Chapter III of the IED.

The MCPD includes emission limit values (ELVs) for NOx for new boilers of 100 mg/Nm^3 for when burning natural gas. The Proposed Development constitutes a 58.6 MWth medium combustion plant, and, as such, will be subject to the MCPD NOx ELV. There are currently no ELVs set within the MCPD for carbon monoxide or for combustion plants burning hydrogen.

3.1.3 The EU Ambient Air Quality Directive (2008/50/EC)

The EU Ambient Air Quality Directive consolidates previous EU air quality legislation and sets legally binding EU-wide limit values or target levels for selected pollutants that are to be achieved by specified dates for the protection of human health or sensitive habitats. The pollutants include nitrogen dioxide (NO_2), and carbon monoxide (CO).

The limit values relate to concentrations in ambient air, defining ambient air as [Article 2(1)]:

> "outdoor air in the troposphere, excluding workplaces as defined in Directive 89/654/EEC where provisions concerning health and safety at work apply and to which members of the public do not have regular access"

Directive 2008/50/EC makes it clear that air quality standards should not be enforced where there is no regular public access [Annex III, Part A (2)]:

(a) any locations situated within areas where members of the public do not have access and there is no fixed habitation;

(b) in accordance with Article 2(1), on factory premises or at industrial installations to which all relevant provisions concerning health and safety at work apply;

(c) on the carriageway of roads; and on the central reservations of roads except where there is normally pedestrian access to the central reservation.

3.2 Air Quality Legislation

3.2.1 The Air Quality Standards Regulations 2010

The EU Ambient Air Quality Directive is implemented in the UK by The Air Quality Standards Regulations 2010.

The standards are legally binding and are based on the assessment of the effects of each pollutant on human health or on ecosystems.

The Regulations define both ambient air quality standards and the locations at which the limit values do not need to be assessed in a similar way to Directive 2008/50/EC.

3.2.2 The Air Quality Strategy for England, Scotland, Wales and Northern Ireland

The Air Quality Strategy (AQS) for England, Scotland, Wales and Northern Ireland sets out air quality objectives for ten of the main air pollutants to protect human health, vegetation and ecosystems, including NO_2 and CO. The AQS is designed to be an evolving process that is monitored and reviewed. The strategy was first published in 1997, with subsequent revisions in 2000, 2003 and the most recently in 2007 (1). Current values of the objectives applicable in the area surrounding the Proposed Development have been adopted in this study.

The AQS sets out a framework for reducing hazards to health from air pollution and ensuring that international commitments are met in the UK. Central to the AQS are health-based criteria for certain air pollutants. These criteria are based on medical and scientific evidence reviewed by the Expert Panel on Air Quality Standards and the World Health Organisation and represent concentration limits, above which sensitive members of the public (e.g. children, the elderly and the ill) might experience adverse health effects. The AQS objectives can be expressed as a maximum ambient concentration that must not be exceeded, or with an allowed number of exceedances within a specified time period.

A selection of the objectives in the AQS are included in the Air Quality Standards Regulations 2010. Compliance with the AQS objectives should focus on areas where members of the public are present over the entire duration of the concentration averaging period specific to the relevant objective.

Health based objectives adopted in this study are shown in Table 3-1.

Table 3-1 Air Quality Standards for the Protection of Human Health

Substance	AQS Concentration ($\mu g/m^3$)	Measured as
Nitrogen Dioxide	40	Annual mean
	200	1 hour mean not to be exceeded more than 18 times a year (99.79th percentile)
Carbon Monoxide	10000	Not to be exceeded when expressed as an 8 hour running mean

The AQS released in 2000 (2) set out objectives for the protection of vegetation and ecosystems. These objectives were retained in the latest version of the AQS and are shown in

Table 3-2.

Table 3-2 Air Quality Standards for the Protection of Vegetation and Ecosystems

Substance	AQS / Critical Level ($\mu g/m^3$)	Measured as
Nitrogen Dioxide	30	Annual mean
	75	Maximum daily mean

These objectives should only apply at locations that are:

- More than 20 km from an agglomeration (population >250,000);
- More than 5 km from a Part A industrial process such as the Proposed Development;
- More than 5 km from motorways;
- More than 5 km from built up areas (population >5,000).

Applying the location criteria excludes the area local to the Proposed Development. However, the Environment Agency recommends assessment at all local nature conservation sites, regardless of location (3), and this approach has been followed in this assessment. Within the latter context, these standards are described as 'critical levels'.

3.2.3 Other Guideline Values

The Environment Agency guidance for assessing air emissions risk (3) contains a table of Environmental Assessment Levels (EALs), in addition to the EU Ambient Air Quality Directive limit values, target values and UK AQS objectives.

Environmental Assessment Levels (EALs) are designed for the protection of human health and should be adopted within environmental permit applications. The guidance provides EALs for a wide range of species not included in the AQS and it also provides EALs for species included in the AQS, but on different averaging time scales.

EAL values used in the study in addition to the AQS objectives are shown in Table 3-3

Table 3-3 Environmental assessment levels for the protection of human health

Substance	AQS / Critical Level ($\mu g/m^3$)	Measured as
Carbon Monoxide	30,000	Not to be exceeded when expressed as an hourly mean

3.3 Assessment Criteria for Air Quality and Deposition Impacts on Ecological Sites

Potential impacts on receptors at the local ecologically sensitive sites, resulting from emissions, include direct effects from concentrations of NOx together with effects related to the deposition of acidity and nutrient nitrogen.

Guidance on the assessment of deposition to protected conservation areas is set out on the gov.uk website (3). This requires the assessment of impacts on:

- any special areas of conservation (SACs), special protection areas (SPAs) and Ramsar sites (protected wetlands) within 10 km of the Proposed Installation; and
- any sites of special scientific interest (SSSIs) or local nature sites (ancient woods, local wildlife sites and national and local nature reserves) within 2 km of the of the Proposed Installation.

The critical levels set out in

Table 3-2 are appropriate for the assessment of direct effects of NO_x concentrations at local ecologically sensitive sites,

Deposition associated with emissions of NOx requires assessment against critical loads for nutrient nitrogen and acidity, which are available from the Air Pollution Information System (APIS) database (www.apis.co.uk). APIS is a support tool for staff in the UK conservation and regulatory agencies, industry and local authorities, for assessing the potential effects of substances released to air on habitats and species. For sites where APIS does not include sufficient information for the evaluation of impacts, advice has been provided within the ecological appraisal report (4).

3.4 Air Quality Management Areas

There is one Air Quality Management Area (AQMA) in the immediate locality of the Proposed Development, namely Warrington AQMA 4. This covers the town centre ring road and the main link roads, including the A5060 lying approximately 940 metres to east of the Proposed Development as shown in Figure . The AQMA is declared for annual mean NO_2 concentrations and road transport is cited as the main source (5). Specific receptor points for this AQMA have been included in the assessment.

Warrington AQMA 1 covers stretches of the M6, M62 and M56 motorway corridors, due to potential exceedences of the annual nitrogen dioxide objective related to traffic, but lies 4km away from the Proposed Development at its closest point, and as such will not be significantly impacted by the associated emissions.

3.5 Significance Criteria

3.5.1 Significance Criteria for Air Quality Impacts on Human Health

The guidance on risk assessment on the gov.uk website sets out criteria for determining the significance of emissions from industrial sources (3). These criteria have been adopted in this assessment and are summarised in Table 3-4.

Table 3-4 Significance Criteria for Environment Agency Guidance

Parameter	Significance Criteria	Impact
Stage 1		
Long-term Process Contribution	< 1 % of long-term environmental standard	Insignificant
Short-term Process Contribution	< 10 % of short-term environmental standard	Insignificant
Stage 2		

Parameter	Significance Criteria	Impact
Long-term Predicted Environmental Concentration (Process Contribution plus background)	< 70 % of long-term environmental standard	Not significant
Short-term Process Contribution	< 20 % of the short-term environmental standard minus twice the long-term background concentration	Not significant

Previous H1 guidance has noted that “if an emission is not screened out using this test, it does not necessarily follow that it will have a significant effect or that it will result in an unacceptable environmental risk. Such a judgement can only be made by consideration of the total concentration of a substance (i.e. including existing background contribution from other sources) in relation to an environmental benchmark” (6).

Air Quality Standards are set at levels below which human health impacts or ecological impacts are not expected to occur. Consequently, if the process contribution combined with background levels does not exceed the standard, no adverse impacts should occur.

Where an impact cannot be screened out as “insignificant” based on the outputs of the initial screening and modelling, the significance of the effect has been determined based on professional scientific judgement of the likelihood of emissions causing an exceedance of an Air Quality Assessment Level (AQAL). This is a standard approach which allows the risk and likelihood of exceedance to be investigated and assessed in detail, following the initial assessment.

3.5.2 Significance Criteria for Ecological Impacts

The Environment Agency guidance on “Air emissions risk assessment for your environmental permit” on the gov.uk website (3) states the following significance criteria, applicable to both critical loads and critical levels:

For SACs, SPAs, Ramsar sites and SSSIs, impacts may be considered insignificant where:

- 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.

For local nature sites (ancient woods, local wildlife sites and national and local nature reserves) impacts may be considered insignificant where:

- 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.

Where impacts as not classed as insignificant, the combined PC and estimated background deposition (available from APIS) should be compared to the environmental standard.

4 Assessment Methodology

4.1 Model

The atmospheric dispersion model ADMS (Atmospheric Dispersion Modelling System) version 5.2 has been used. ADMS is used extensively by power station and heat plant operators and the Environment Agency and also by many other industries and consultancies. ADMS was developed by Cambridge Environmental Research Consultants and has been verified extensively against measurements.

4.2 Emission Characteristics

The emission characteristics are presented in Table 4-1. Emission parameters were provided by the boiler supplier. NO_x emission concentrations were modelled at the MCPD ELV of 100 mg/Nm^3 as a worst case, although actual emissions are expected to be below this level. The stack height of 35 metres was derived from a stack height assessment presented in 10.2Appendix A. The data is based on a worst-case of four boilers operating at full load. The four boilers will emit via four individual flues all routed up the same stack and have therefore been modelled as a single combined stack.

The boilers will be capable of firing hydrogen, when sufficient supply becomes available. The supplier has indicated that firing on hydrogen will not result in any significant changes to the emission parameters shown in Table 4-1 and as such, the assessment can be considered applicable to both natural gas and hydrogen firing.

Table 4-1 Emission Characteristics

Parameter	Single Boiler	Combined Four Boilers (modelled case)
Stack location (Easting, Northing)	359513, 385931	359513, 385931
Stack height (m)	35	35
Stack diameter (m)	0.8	1.6
Exit temperature (^{o}C)	136	136
Stack O_2 content (% volume, dry)	8.59	8.59
Stack H_2O content (% volume)	17.16	17.16
Normalised Volume flow rate (Nm^3/s)	3.88	15.51
Actual flow rate (Am^3/s)	10.24	40.96
NO_x concentration (mg/Nm^3)	100	100
CO emission concentration (mg/Nm^3)	40	40
NO_x emission rate (g/s)	0.388	1.551
CO emission rate (g/s)	0.155	0.620

4.3 Meteorological Data

Meteorological data for the dispersion modelling study were obtained from the Meteorological Office. Five years of data from 2016 to 2020 from Rostherne No.2 were used. The meteorological site is located about 15 km to the east of the Proposed Development. This meteorological site was recommended by the

Meteorological Office as the most representative site for the Proposed Development location. The wind roses are shown in 10.2Appendix B.

4.4 Grids

For the human health impact assessment ground level concentrations have been calculated on a regular grid of 101 x 101 points extending 2500m north, east, south and west of the Proposed Development. The spacing between points was 50m.

For the assessment of impacts at sensitive habitat sites, concentrations were predicted on a 20km by 20km grid centred on the Proposed Development with a grid spacing of 100m.

4.5 Surface Roughness

Surface roughness length is a measure of the influence of surface features on dispersion. A value of 0.3 m has been used for the modelling assessment which is appropriate for the agricultural setting around the Proposed Development. A surface roughness length of 0.2 m was assigned for the meteorological site, appropriate for the vegetation in the vicinity of that site location.

4.6 Buildings

The dispersion of substances released from an elevated point source such as the Proposed Development can be influenced by the presence of buildings close to the source. The buildings can interrupt the wind flows and give higher ground level concentrations close to the source than would arise in the absence of the buildings.

Buildings will have a significant effect on dispersion if they are significantly taller than approximately one third of the stack height. The dimensions of the buildings considered in the model are detailed in Table 4-2 and include buildings associated with the Proposed Development itself and buildings already present in the vicinity of the Proposed Development. The building layout is presented in Figure 2.

Following sensitivity runs the Capa Monomer Plant was set as the ‘main’ building in the ADMS building module, as this setting was found to result on the highest overall ground level concentrations.

Table 4-2 Modelled Buildings

Building	Building centre co-ordinates	Height (m)	Length (m)	Width (m)	Angle of length to north (degrees)
New Boiler House	359506 , 385955	13	26	28	73
New Offices	359464 , 385912	16	49	19	73
Cooling Towers	359538 , 385992	15	24	12	73
Tank Farm	359547 , 385970	10	25	20	73
Capa Monomer Plant	359582 , 386020	30	55	16	73

4.7 NOx Chemistry

The Air Quality Strategy objectives for the protection of human health relate to the concentrations of the nitrogen dioxide component of nitrogen oxides. For natural gas combustion approximately 10% of the NOx at the stack exit point will be in the form of nitrogen dioxide with the remainder in the form of nitric oxide (NO). Once released, NO can be converted to NO_2 by reaction with low level ozone in the atmosphere. The process is also reversible in sunlight and the net rate of conversion of NO to NO_2 in the plume is, therefore, a function of the rate of dilution of the plume by ambient air, trace gas concentrations in the air and meteorology.

Conversion rates for NO to NO_2 of 0.7 and 0.35 for long-term and short-term impacts respectively have been used in line with advice from the Environment Agency (7).

4.8 Human Receptor Points

The closest residential receptors to the Proposed Development are around 450 metres away. Impacts representative of nine residential locations within approximately 1 km of the Proposed Development have been modelled together with three locations representing impacts on Warrington AQMA 4. The receptor locations are summarised in Table 4-3 and shown in Figure 1.

Table 4-3 Modelled human receptors

Reference	Description	OS grid reference (eastings, northings)	Distance from stack (m)
R1	Mill Lane 1	359215 , 385466	552
R2	Mill Lane 2	359369 , 385505	450
R3	Turf Farm	359650 , 385492	460
R4	Forrest Way	359032 , 386853	1040
R5	Baronet Mews	360071 , 386290	664
R6	Baronet Road	360049 , 386229	613
R7	Morley Road	360260 , 386178	787
R8	Pool Lane	360281 , 386009	772
R9	Walton Lea Cottages	360210 , 385632	758
R10	AQMA 1	360455 , 386030	947
R11	AQMA 2	360404 , 386224	938
R12	AQMA 3	360318 , 386478	973

5 Baseline Conditions

Consideration has been given to existing background concentrations arising from sources other than the Proposed Development to take account of the potential adverse effects arising from total exposure to pollutant concentrations. Measurements of existing air quality in the vicinity of the Proposed Development are summarised in 10.2Appendix C. Based on measurements presented, values to represent background annual mean concentrations for the study area have been estimated and are presented in Table 5-1.

Table 5-1 Estimated annual mean background concentrations

Receptors	Substance	Estimated annual mean background concentration (μgm^{-3})
Nitrogen Dioxide	R1-R9	21.4
	R10-R12	37.1
Carbon Dioxide	R1-R12	416

6 Air Quality Model inputs

A separate Annex of all air quality model inputs is included in Appendix D in line with Environment Agency Guidance (7).

7 Results

The following section presents the results of the human health impact assessment.

For each substance and concentration statistic, the Tables show:

- The AQS objective or Environmental Assessment Level (EAL) that concentrations are compared against
- Typical background annual mean concentrations in the study area
- The contribution of the Proposed Development to ground level concentrations, the Process Contribution (PC)
- The PC expressed as a percentage of the AQS objective or EAL
- The Predicted Environmental Concentration (PEC), the combination of the process contribution and background concentrations
- The PEC expressed as a percentage of the AQS objective or EAL
- The significance descriptor based on the approaches set out in Section 3.5

7.1 Human Health Impact Assessment

7.1.1 Annual mean NO_2 concentrations

Table 7-1 shows the maximum predicted annual mean ground level concentrations of nitrogen dioxide over the five years modelled at the maximum impact location and at the modelled receptors assuming continuous operation of four boilers at full load all year. The concentrations have been scaled by the Environment Agency long-term NOx to NO_2 conversion factor of 0.7. It can be seen that the predicted process contribution is less than 1% of the AQS at all locations and taking background concentrations into account, the impacts can be classified as insignificant at the grid maximum and at all receptors based on the criteria in **Error! Reference source not found.**.

Figure 3 shows the modelled annual mean NO_2 process contributions for 2020, the year with the highest grid maximum PC.

Table 7-1 Predicted annual mean NO_2 process contribution (PC) and predicted environmental concentration (PEC) for the Proposed Development

Receptor	AQS objective (µg/m$_3$)	Back-ground (µg/m^3)	PC (µg/m^3)	PC/AQS (%)	PEC (µg/m3)	PEC/ AQS (%)	Descriptor
Grid Maximum	40	21.4	0.38	0.9%	21.8	54%	Insignificant
R1: Mill Lane 1	40	21.4	0.08	0.2%	21.5	54%	Insignificant
R2: Mill Lane 2	40	21.4	0.07	0.2%	21.5	54%	Insignificant
R3: Turf Farm	40	21.4	0.08	0.2%	21.5	54%	Insignificant
R4: Forrest Way	40	21.4	0.10	0.2%	21.5	54%	Insignificant
R5: Baronet Mews	40	21.4	0.17	0.4%	21.6	54%	Insignificant
R6: Baronet Road	40	21.4	0.19	0.5%	21.6	54%	Insignificant
R7: Morley Road	40	21.4	0.16	0.4%	21.6	54%	Insignificant
R8: Pool Lane	40	21.4	0.15	0.4%	21.6	54%	Insignificant
R9: Walton Lea Cottages	40	21.4	0.23	0.6%	21.6	54%	Insignificant
R10: AQMA 1	40	37.1	0.12	0.3%	37.2	93%	Insignificant
R11: AQMA 2	40	37.1	0.13	0.3%	37.2	93%	Insignificant
R12: AQMA 3	40	37.1	0.12	0.3%	37.2	93%	Insignificant

7.1.2 99.79th percentile hourly mean NO_2 concentrations

Table 7-2 shows the maximum predicted 99.79th percentile hourly mean ground level concentrations of nitrogen dioxide over the five years modelled at the maximum impact location and at the modelled receptors assuming continuous operation of four boilers at full load all year. The concentrations have been scaled by the Environment Agency short-term NOx to NO_2 conversion factor of 0.35. The background concentration for short-term PECs was based on twice the annual mean concentrations in Table 5-1 in line with Environment Agency guidance (3).

It can be seen that the predicted process contribution is less than the short-term significance threshold of 10% of the AQS at all locations and can therefore be classified as insignificant at the grid maximum and at all receptors based on the criteria in Section 3.5.1.

Figure 4 shows the 99.79th NO_2 hourly mean process contributions for 2020, the year with the highest grid maximum PC.

Table 7-2 Predicted 99.79th NO_2 hourly mean process contribution (PC) and predicted environmental concentration (PEC) for the Proposed Development

Receptor	AQS objective (µg/m^3)	Back-ground (µg/m^3)	PC (µg/m^3)	PC/AQS (%)	PEC (µg/m3)	PEC/AQS (%)	Descriptor
Grid Maximum	200	42.8	14.9	7.4%	57.7	29%	Insignificant
R1: Mill Lane 1	200	42.8	3.1	1.6%	45.9	23%	Insignificant
R2: Mill Lane 2	200	42.8	3.2	1.6%	46.0	23%	Insignificant
R3: Turf Farm	200	42.8	2.3	1.2%	45.1	23%	Insignificant
R4: Forrest Way	200	42.8	1.1	0.6%	43.9	22%	Insignificant
R5: Baronet Mews	200	42.8	1.8	0.9%	44.6	22%	Insignificant

Receptor	AQS objective (µg/m³)	Back-ground (µg/m³)	PC (µg/m³)	PC/AQS (%)	PEC (µg/m3)	PEC/AQS (%)	Descriptor
R6: Baronet Road	200	42.8	2.0	1.0%	44.8	22%	Insignificant
R7: Morley Road	200	42.8	1.6	0.8%	44.4	22%	Insignificant
R8: Pool Lane	200	42.8	1.6	0.8%	44.4	22%	Insignificant
R9: Walton Lea Cottages	200	42.8	1.6	0.8%	44.4	22%	Insignificant
R10: AQMA 1	200	74.2	1.3	0.6%	75.5	38%	Insignificant
R11: AQMA 2	200	74.2	1.3	0.7%	75.5	38%	Insignificant
R12: AQMA 3	200	74.2	1.2	0.6%	75.4	38%	Insignificant

7.1.3 Conclusions for NO_2 concentrations

The assessment of long-term and short-term NO_2 concentrations includes a range of worst-case modelling assumptions as follows:

- The maximum impact at any point in the local area over the five modelled meteorological years was included in the assessment
- Impacts have been assessed assuming full load operation of four boilers for the entire year
- Impacts have been assessed assuming NO_x is emitted at the MCPD boiler ELV of 100 mg/Nm^3

Based on the low impacts and the worst-case assumptions, it can confidently be concluded that emissions of NOx from the Proposed development would pose no significant risks to human health.

7.1.4 Maximum 8 hour mean CO concentrations

Table 7-3 shows the maximum predicted 8 hourly running mean ground level concentrations of carbon monoxide over the five years modelled at the maximum impact location and at the modelled receptors assuming continuous operation of four boilers at full load all year.

Table 7-3 Predicted maximum 8 hour running mean CO process contribution (PC) and predicted environmental concentration (PEC) for the Proposed Development

Receptor	AQS objective (µg/m³)	Back-ground (µg/m³)	PC (µg/m³)	PC/AQS (%)	PEC (µg/m3)	PEC/AQS (%)	Descriptor
Grid Maximum	10000	832	13.8	0.14%	845.8	8.5%	Insignificant
R1: Mill Lane 1	10000	832	2.88	0.03%	834.9	8.3%	Insignificant
R2: Mill Lane 2	10000	832	3.12	0.03%	835.1	8.4%	Insignificant
R3: Turf Farm	10000	832	2.50	0.03%	834.5	8.3%	Insignificant
R4: Forrest Way	10000	832	1.14	0.01%	833.1	8.3%	Insignificant
R5: Baronet Mews	10000	832	1.83	0.02%	833.8	8.3%	Insignificant
R6: Baronet Road	10000	832	1.99	0.02%	834.0	8.3%	Insignificant
R7: Morley Road	10000	832	1.70	0.02%	833.7	8.3%	Insignificant
R8: Pool Lane	10000	832	1.57	0.02%	833.6	8.3%	Insignificant

Receptor	AQS objective (µg/m³)	Back-ground (µg/m³)	PC (µg/m³)	PC/AQS (%)	PEC (µg/m3)	PEC/AQS (%)	Descriptor
R9: Walton Lea Cottages	10000	832	1.56	0.02%	833.6	8.3%	Insignificant
R10: AQMA 1	10000	832	1.24	0.01%	833.2	8.3%	Insignificant
R11: AQMA 2	10000	832	1.38	0.01%	833.4	8.3%	Insignificant
R12: AQMA 3	10000	832	1.18	0.01%	833.2	8.3%	Insignificant

It can be seen that the predicted process contribution is less than the short-term significance threshold of 10% of the AQS at all locations and can therefore be classified as insignificant at the grid maximum and at all receptors based on the criteria in Section 3.5.1.

7.1.5 Maximum hourly mean CO concentrations

Table 7-4 shows the maximum predicted hourly mean ground level concentrations of carbon monoxide over the five years modelled at the maximum impact location and at the modelled receptors assuming continuous operation of four boilers at full load all year.

It can be seen that the predicted process contribution is less than the short-term significance threshold of 10% of the AQS at all locations and can therefore be classified as insignificant at the grid maximum and at all receptors based on the criteria in Section 3.5.1.

Table 7-4 Predicted maximum hourly mean CO process contribution (PC) and predicted environmental concentration (PEC) for the Proposed Development

Receptor	AQS objective (µg/m³)	Back-ground (µg/m³)	PC (µg/m³)	PC/AQS (%)	PEC (µg/m3)	PEC/AQS (%)	Descriptor
Grid Maximum	30000	832	23.3	0.08%	855	2.9%	Insignificant
R1: Mill Lane 1	30000	832	4.73	0.02%	837	2.8%	Insignificant
R2: Mill Lane 2	30000	832	5.06	0.02%	837	2.8%	Insignificant
R3: Turf Farm	30000	832	2.98	0.01%	835	2.8%	Insignificant
R4: Forrest Way	30000	832	1.60	0.01%	834	2.8%	Insignificant
R5: Baronet Mews	30000	832	2.23	0.01%	834	2.8%	Insignificant
R6: Baronet Road	30000	832	2.47	0.01%	834	2.8%	Insignificant
R7: Morley Road	30000	832	2.07	0.01%	834	2.8%	Insignificant
R8: Pool Lane	30000	832	1.96	0.01%	834	2.8%	Insignificant
R9: Walton Lea Cottages	30000	832	1.95	0.01%	834	2.8%	Insignificant
R10: AQMA 1	30000	832	1.58	0.01%	834	2.8%	Insignificant
R11: AQMA 2	30000	832	1.78	0.01%	834	2.8%	Insignificant
R12: AQMA 3	30000	832	1.53	0.01%	834	2.8%	Insignificant

7.1.6 Conclusions for CO concentrations

The assessment of short-term CO concentrations includes a range of worst-case modelling assumptions as follows:

- The maximum impact at any point in the local area over the five modelled meteorological years was included in the assessment
- Impacts have been assessed assuming full load operation of four boilers for the entire year

Based on the low impacts and the worst-case assumptions, it can confidently be concluded that emissions of CO from the Proposed development would pose no significant risks to human health.

7.2 Habitats Impact Assessment

The impacts of emissions to air on local ecological sites have been assessed in line with Environment Agency guidance (3). Potential impacts on sensitive receptors at the local sites include direct effects resulting from concentrations of NOx together with effects related to the deposition of acidity and nutrient nitrogen.

7.2.1 Local Ecologically Sensitive Sites

There are two Special Areas of Conservation (SACs) and one Special Protection Area (SPA) within 10km of the Proposed Development. The SPA is also designated as a RAMSAR site (wetland of international importance) designated under the RAMSAR convention:

- Manchester Mosses SAC
- Rixton Clay Pits SAC
- Mersey Estuary SPA and Ramsar

The Environment Agency Guidance (3) also requires assessment of impacts on any national nature reserves (NNRs), local nature reserves (LNRs), ancient woodlands and local wildlife sites (LWS) within 2km of the Proposed Development. There are no ancient woodlands, NNRs or LNRs located within 2km.

There are six LWS located within 2km of the Proposed Development:

- Walton Locks LWS
- Appleton Reservoir LWS
- Upper Mersey Estuary LWS
- Sankey Canal LWS
- Moore Nature Reserve LWS
- Rows Wood LWS

Natural England has developed Impact Risk Zones (IRZs) as an initial tool to help assess the risk of developments adversely affecting SSSIs, taking into account the type and scale of developments. Whilst the Woolston Eyes SSSI does not lie within 2km of the Proposed Development, being around 4.6 km to the east, the Proposed Development does sit within the IRZ for this SSSI in relation to being a combustion process with an energy input of greater than 50 MWth. Impacts have therefore been considered for the Woolston Eyes SSSI as a precautionary approach.

The locations of the local ecological sites are shown in Figure 5.

7.2.2 Modelling methodology

Potential impacts on sensitive receptors include direct effects resulting from air concentrations of NOx together with effects related to the deposition of acidity and nutrient nitrogen (arising from NOx emissions).

Annual mean concentrations and annual deposition have been predicted on a 20 km by 20 km grid centred on the Proposed Development with a grid spacing of 100 m using the emission rates for NOx specified in Table 4-1. Five years of meteorology were used as described in 4.3, to ensure that worst case meteorological conditions were captured.

Results presented are the maximum predicted for any year of meteorological data at any modelled point over each sensitive site. As a precautionary approach, these runs assumed no plume depletion due to deposition.

Dry deposition to both non-woodland and woodland features has been assessed by multiplying the modelled concentrations by the deposition velocities shown in Table 7-5 followed by appropriate unit conversion for comparison to acid and nutrient nitrogen critical loads. Wet deposition of NOx is negligible in comparison with dry deposition and has therefore been omitted. These runs did not incorporate NOx chemistry and effectively assign the same deposition velocity to NO and NO_2. This represents a precautionary approach for nitrogen deposition as this is primarily associated with NO_2 with the NO deposition velocity being negligible in comparison.

Table 7-5 Deposition parameter values for nitrogen oxides used in ADMS

Habitat type	Dry deposition velocity (m/s)
Non-woodland	0.0015
Woodland	0.003

7.2.3 Critical Levels and Critical Loads

Air impacts at ecological sites have been assessed using the critical levels for NOx set out in the Environment Agency Guidance (3) and shown in

Table 3-2. Air impacts have been assessed at all ecological sites as a precautionary approach.

Acid and nutrient nitrogen deposition at local ecological sites has been assessed against appropriate critical loads extracted from the Air Pollution Information System (APIS) database (www.apis.co.uk). APIS is a support tool for staff in the UK conservation and regulatory agencies, industry and local authorities, for assessing the potential effects of substances released to air on habitats and species.

Site relevant acid and nutrient nitrogen critical loads were available from APIS for the local Natura 2000 sites and SSSIs for the sensitive habitat features present. As a precautionary measure, the lowest critical load across all features present at each SSSI has been used and the lower (i.e. most stringent) end of the critical load range for the most sensitive species applied. It was assumed that these applied at the point of maximum impact, although critical loads may vary geographically across each site in practice. Where both

woodland and non-woodland features were present, the lowest critical loads for each category were used for assessment.

APIS does not include critical loads for LWS or for freshwater features. Where critical loads were not available, advice was sought from the project ecologist and the ecology report supporting the planning application (4) for this Proposed Development, with respect to the potential sensitivity to acid and nitrogen deposition of the features present.

The following points in relation to the applied critical loads should be noted:

- Rixton Clay Pits SAC is assigned as having potential sensitivity for acid and nitrogen deposition in relation to the Great Crested Newt and its use of freshwater habitats, but has no critical loads assigned in APIS. Critical loads have been set based on the 'Fen, Marsh and Swamp' habitat for nitrogen deposition and the 'Bogs' habitat for acid deposition as a precautionary approach. These were assigned using the search by location feature in APIS.
- The only potential sensitivity to acid deposition in APIS in relation to the Mersey Estuary SPA is for the Great Crested Grebe for the 'standing open water and canals habitat', for which no critical loads are assigned. The ecology report advised that the Mersey Estuary is likely to constitute eutrophic standing water and the habitat is therefore not considered to be sensitive to acid deposition.
- No bird species are listed as sensitive to acid deposition for the Woolston Eyes SSSI
- The Pochard and Gadwall are listed as having potential site specific sensitivity for nitrogen deposition for the Woolston Eyes SSSI in relation to the 'standing open water and canals' habitat, for which no critical loads are assigned in APIS. The ecology report advised that the standing water within the SSSI is likely to be eutrophic and as such, unlikely to be sensitive to nitrogen or acid deposition.
- The Walton Locks LWS, Appleton Reservoir LWS, Upper Mersey Estuary LWS and Sankey Canal LWS constitute standing open water which is likely to be eutrophic in nature, such that these habitats are unlikely to be sensitive to air pollution, including acid and nitrogen deposition.

The Environment Agency approach for assessing deposition against acid critical loads (See http://www.apis.ac.uk/clf-guidance) requires that:

- If PEC nitrogen deposition < CLminN, sulphur deposition is compared against CLmaxS.
- If PEC nitrogen deposition > CLminN, the sum of the nitrogen and sulphur deposition is compared against CLmaxN.

As CLminN was exceeded by background deposition at all local sensitive sites for both woodland and non-woodland critical loads, the latter approach comparing total acid deposition against CLmaxN has been applied in all cases. As sulphur emissions from gas plant are insignificant only nitrogen deposition has been considered in relation to the impact from the Proposed Development.

7.2.4 Results: Air Concentrations at Designated Sites

7.2.4.1 Assessment against NOx Annual Mean Critical Level

Table 7-6 compares the modelled annual mean NOx concentrations due to the Proposed Development to the annual mean NOx critical level over the five years modelled at the maximum impact location on each ecological site assuming continuous operation of four boilers at full load all year.

Table 7-6 also states whether the PC is below the long-term significance threshold of 1% for SAC, SPA and SSSI sites and 100% for LWS (See Section 3.5.2). It can be seen that the PC is below the significance threshold at all sites.

Table 7-6 Predicted process contributions (PC) assessed against the annual mean NOx critical level

Site	Critical Level µg/m³	PC µg/m³	PC/Critical Level (%)	Descriptor
Manchester Mosses SAC	30	0.017	0.06%	Insignificant
Rixton Clay Pits SAC	30	0.013	0.04%	Insignificant
Mersey Estuary Ramsar and SPA	30	0.010	0.03%	Insignificant
Woolston Eyes SSSI	30	0.033	0.11%	Insignificant
Walton Locks LWS	30	0.205	0.68%	Insignificant
Appleton Reservoir LWS	30	0.047	0.16%	Insignificant
Upper Mersey Estuary LWS	30	0.048	0.16%	Insignificant
Sankey Canal LWS	30	0.090	0.30%	Insignificant
Moore Nature Reserve LWS	30	0.428	1.43%	Insignificant
Rows Wood LWS	30	0.019	0.06%	Insignificant

The assessment includes a range of worst-case modelling assumptions as follows:

- The maximum impact at any point on each ecological site over the five modelled meteorological years was used for the assessment
- Impacts have been assessed assuming full load operation of four boilers for the entire year
- Impacts have been assessed assuming NOx is emitted at the MCPD boiler ELV of 100 mg/Nm3
- It has been assumed that all local ecological sites contain features sensitive to NOx concentrations
- No plume depletion due to deposition has been modelled

Given the precautionary nature of the assessment and the very low levels of impact, it can confidently be concluded that emissions from the Proposed Development would not be at levels likely to lead to adverse effects on the sensitive ecological features at the local Natura 2000 sites, Ramsar, SSSI or LWS due to long-term NOx concentrations.

7.2.4.2 Assessment against NOx Maximum Daily Mean Critical Level

Table 7-7 compares the modelled maximum daily mean NOx concentrations due to the Proposed Development to the daily mean NOx critical level over the five years modelled at the maximum impact location on each ecological site assuming continuous operation of four boilers at full load all year.

Table 7-7 also states whether the PC is below the short-term significance threshold of 10% for SAC, SPA and SSSI sites and 100% for LWS (See Section 3.5.2). It can be seen that the PC is below the significance threshold at all sites.

Table 7-7 Predicted process contributions (PC) assessed against the Maximum Daily Mean NOx critical level

Site	Critical Level µg/m³	PC µg/m³	PC/Critical Level (%)	Descriptor
Manchester Mosses SAC	200	0.18	0.09%	Insignificant
Rixton Clay Pits SAC	200	0.15	0.08%	Insignificant

Site	Critical Level µg/m³	PC µg/m³	PC/Critical Level (%)	Descriptor
Mersey Estuary Ramsar and SPA	200	0.24	0.12%	Insignificant
Woolston Eyes SSSI	200	0.35	0.17%	Insignificant
Walton Locks LWS	200	2.92	1.46%	Insignificant
Appleton Reservoir LWS	200	0.82	0.41%	Insignificant
Upper Mersey Estuary LWS	200	1.01	0.50%	Insignificant
Sankey Canal LWS	200	1.02	0.51%	Insignificant
Moore Nature Reserve LWS	200	4.76	2.38%	Insignificant
Rows Wood LWS	200	0.75	0.37%	Insignificant

The assessment includes a range of worst-case modelling assumptions as follows:

- The maximum impact at any point on each ecological site over the five modelled meteorological years was used for the assessment
- Impacts have been assessed assuming full load operation of four boilers for the entire year
- Impacts have been assessed assuming NOx is emitted at the MCPD boiler ELV of 100 mg/Nm3
- It has been assumed that all local ecological sites contain features sensitive to NOx concentrations
- No plume depletion due to deposition has been modelled

Given the precautionary nature of the assessment and the very low levels of impact, it can confidently be concluded that emissions from the Proposed Development would not be at levels likely to lead to adverse effects on the sensitive ecological features at the local Natura 2000 sites, Ramsar, SSSI or LWS due to short-term NOx concentrations.

7.2.5 Results: Nitrogen and Acid Deposition from Air to Land at Designated Sites

Table 7-8 compares the modelled nitrogen deposition due to the Proposed Development to the nutrient nitrogen critical loads (CLnutN) over the five years modelled at the maximum impact location on each ecological site assuming continuous operation of four boilers at full load all year.

Table 7-9 compares the modelled acid deposition due to the Proposed Development to the acid critical loads (CLmaxN) over the five years modelled at the maximum impact location on each ecological site assuming continuous operation of four boilers at full load all year.

The tables also state whether the PC is below the long-term significance threshold of 1% for SAC, SPA, SSSI and Ramsar sites and 100% for LWS (See Section 3.5.2). It can be seen that the PC is below the significance threshold at all sites for both nitrogen and acid deposition.

The assessment includes a range of worst-case modelling assumptions as follows:

- The maximum impact under the worst case meteorological year of the five modelled has been used. Critical loads are set at levels to protect against long-term deposition effects spanning multiple years, so in practice the average impact would be more representative;
- Impacts have been assessed assuming full load operation of four boilers for the entire year;
- The lowest (most stringent) end of the critical load range has been applied;
- The highest deposition over the entire site has been used for the assessment;

- It has been assumed that all nitrogen emissions are in the form of NO_2. Emissions of NOx from gas-fired boilers are primarily in the form of NO (~90%) which has a negligible dry deposition rate. Environment Agency conversion factors suggest a maximum of 70% of NO_x as NO_2 for local impacts.
- No plume depletion due to deposition has been modelled

Given the precautionary nature of the assessment, using the worst-case assumptions above and the insignificant levels of impact relative to the nutrient nitrogen and acid critical loads, it can confidently be concluded that nitrogen and acid deposition resulting from emissions from the Proposed Development, would not be at levels likely to lead to adverse effects on the sensitive ecological features at the local Natura 2000 sites, Ramsar, SSSIs or to result in significant pollution at the local LWS.

Table 7-8 Predicted process contributions (PC) assessed against the nutrient nitrogen critical load (CLNutN)

Site	Woodland (W) or Non-woodland (NW)	Critical Load kgN/ha/yr	PC kgN/ha/yr	PC/Critical Load (%)	Descriptor
Manchester Mosses SAC	NW	5	0.0024	0.05%	Insignificant
Rixton Clay Pits SAC	NW	10	0.0018	0.02%	Insignificant
Mersey Estuary Ramsar and SPA	NW	20	0.0014	0.01%	Insignificant
Woolston Eyes SSSI	Features not sensitive				
Walton Locks LWS	Features not sensitive				
Appleton Reservoir LWS	Features not sensitive				
Upper Mersey Estuary LWS	Features not sensitive				
Sankey Canal LWS	Features not sensitive				
Moore Nature Reserve LWS	NW	20	0.0616	0.31%	Insignificant
Moore Nature Reserve LWS	W	10	0.1231	1.23%	Insignificant
Rows Wood LWS	W	10	0.0053	0.05%	Insignificant

Table 7-9 Predicted process contributions (PC) assessed against the acid critical load (CLmaxN)

Site	Woodland (W) or Non-woodland (NW)	Critical Load keq/ha/yr	PC keq/ha/yr	PC/Critical Load (%)	Descriptor
Manchester Mosses SAC	NW	0.564	0.0002	0.03%	Insignificant
Rixton Clay Pits SAC	NW	0.568	0.0001	0.02%	Insignificant
Mersey Estuary Ramsar and SPA	Features not sensitive				
Woolston Eyes SSSI	Features not sensitive				
Walton Locks LWS	Features not sensitive				
Appleton Reservoir LWS	Features not sensitive				
Upper Mersey Estuary LWS	Features not sensitive				
Sankey Canal LWS	Features not sensitive				
Moore Nature Reserve LWS	NW	5.07	0.0044	0.09%	Insignificant
Moore Nature Reserve LWS	W	2.928	0.0088	0.30%	Insignificant
Rows Wood LWS	W	1.806	0.0004	0.02%	Insignificant

8 Cumulative Effects

As air quality impacts from the Proposed Development are below significance at the grid maximum impact point and at all local receptors, including ecological sites there is no need to consider cumulative effects.

9 Model Uncertainty

The ADMS model has been extensively validated against available measured data obtained from real world situations, field campaigns and wind tunnel experiments; a range of validation papers can be found on the CERC website model validation page (https://cerc.co.uk/environmental-software/model-validation.html).

The most significant source of uncertainty in any dispersion modelling process is associated with the dispersion modelling process itself. This uncertainty has been addressed through the use of a series of worst-case assumptions to ensure that estimates of impacts on air quality are likely to be over-estimates rather than under-estimates. This conservative approach also removes the need for detailed sensitivity analysis across the multiple model inputs. The worst-case assumptions include:

- Assuming that all four boilers are operating at full load for the entire year (Section 4.2);
- The use of the highest impacts over five years of meteorological data (Section 7);
- The use of upper estimates of background concentrations (Section 5, Appendix C); and
- Assuming NOx is emitted at the MCPD boiler ELV of 100 mg/Nm^3 (Section 4.2)
- Consideration of impacts at the offsite grid maximum point on the modelling grid (Section 7.1).

For the assessment of impacts on local ecological sites, the following worst-case assumptions were also included:

- The assessment of impacts at the maximum impact point over each sensitive site (Section 7.2.2);
- The assumption that there is no plume depletion due to deposition (Section 7.2.2);
- The assumption that all NOx is present as NO_2 which has a much higher deposition velocity than NO (Section 7.2.2);
- The use of the lowest (i.e. most stringent) critical loads for nitrogen and acid deposition (Section 7.2.3).

10 Conclusions

10.1 Impacts on human health

Annual mean concentrations of nitrogen dioxide resulting from emissions from the Proposed Development are insignificant in relation to the annual mean air quality objective.

Short-term concentrations of nitrogen dioxide resulting from emissions from the Proposed Development are insignificant relative to the 99.79th percentile hourly mean air quality objective.

Short-term concentrations of carbon monoxide resulting from emissions from the Proposed Development are insignificant relative to the maximum 8 hour running mean air quality objective and the maximum one hour mean environmental assessment level.

Based on the above, it can be concluded with confidence that the Proposed Development will not result in any significant impacts on human health due to emissions to air.

10.2 Impacts on habitats

Annual mean concentrations and maximum daily mean concentrations of oxides of nitrogen resulting from emissions from the Proposed Development are below significance at all local ecological sites.

Annual acid and nitrogen deposition resulting from emissions from the Proposed Development are below significance at all local ecological sites.

Based on the above, it can be concluded with confidence that the Proposed Development will not result in any significant adverse impacts on the sensitive features at the local ecological sites due to emissions to air.

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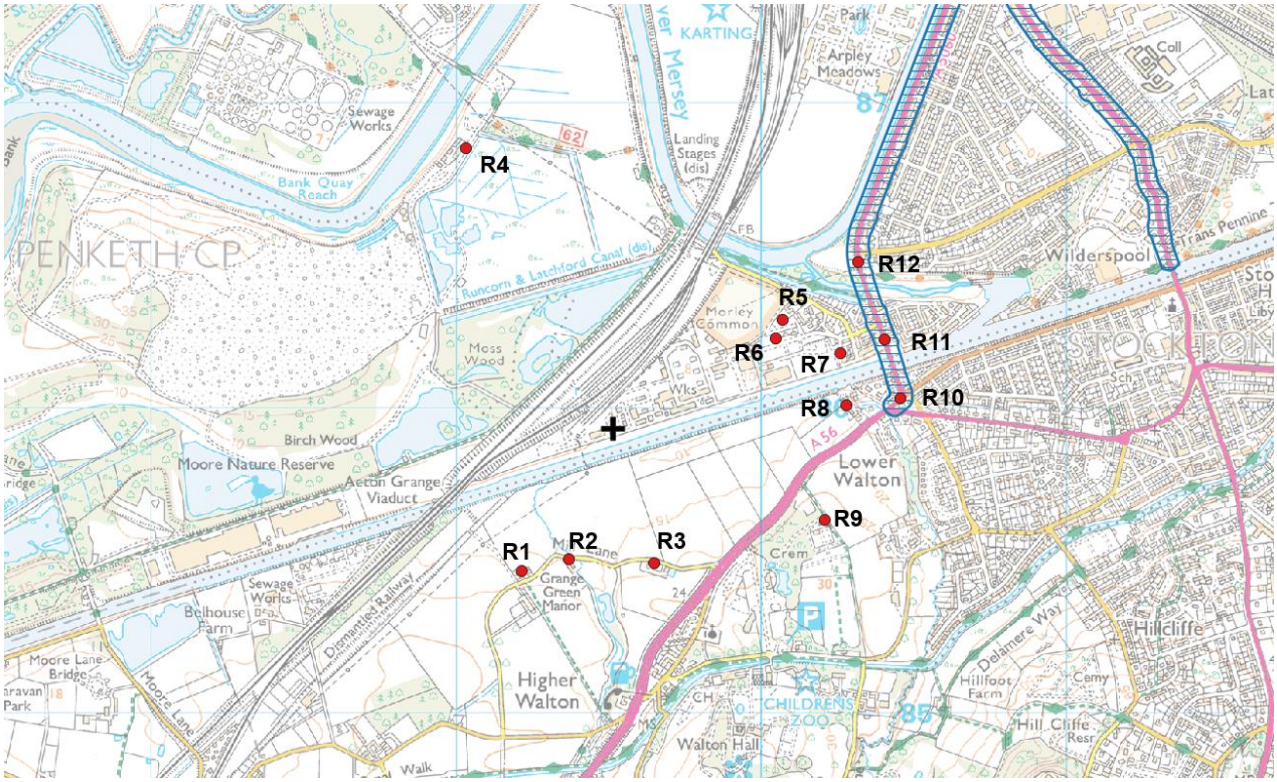

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Figure 1 Proposed Development Location

Black cross shows stack location
Red Dots show location of modelled receptors
Blue shaded area shows Warrington AQMA 4

Reference	Receptor Description
R1	Mill Lane 1
R2	Mill Lane 2
R3	Turf Farm
R4	Forrest Way
R5	Baronet Mews
R6	Baronet Road
R7	Morley Road
R8	Pool Lane
R9	Walton Lea Cottages
R10	AQMA 1
R11	AQMA 2
R12	AQMA 3

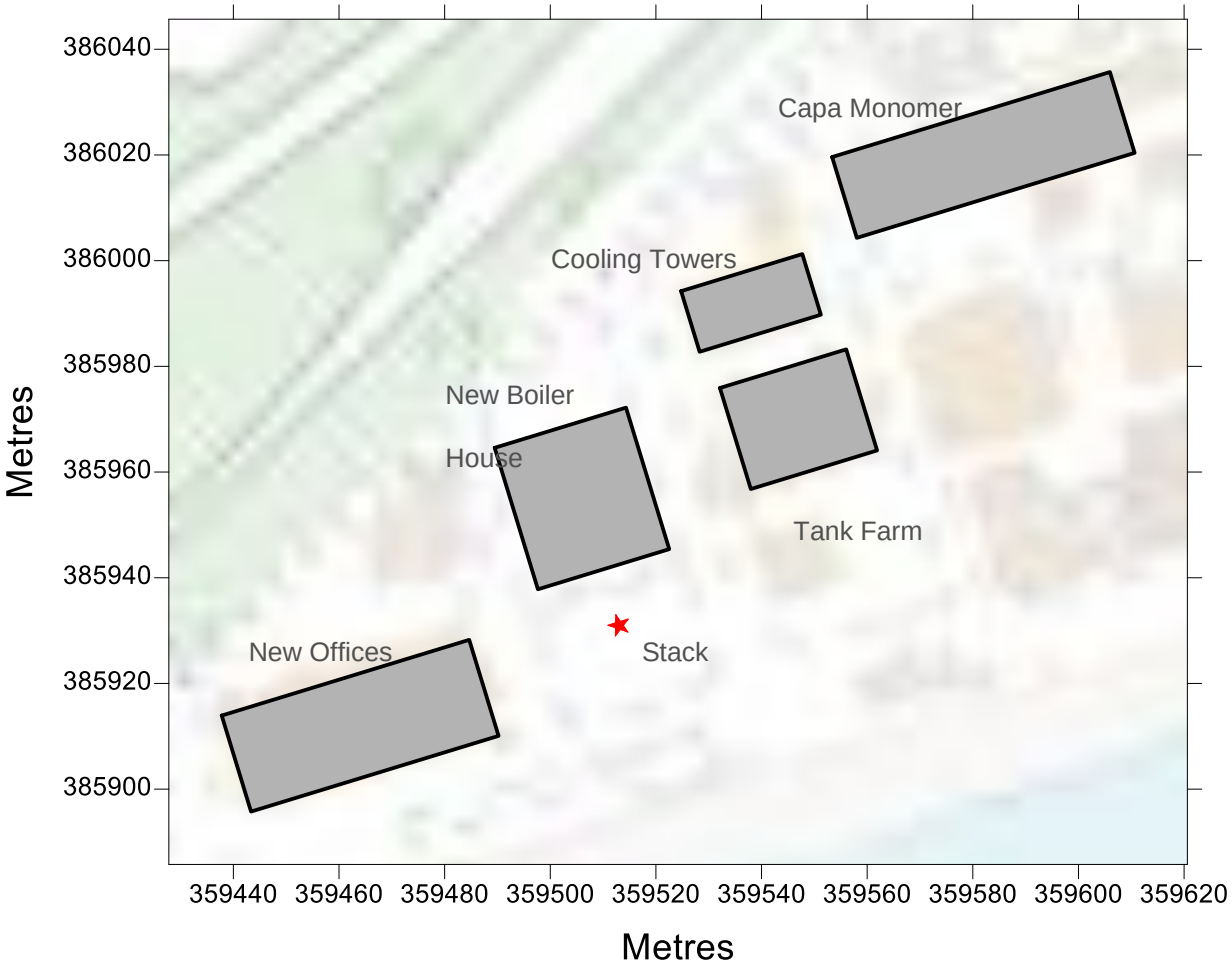


Figure 2 Modelled Stack and Building Layout

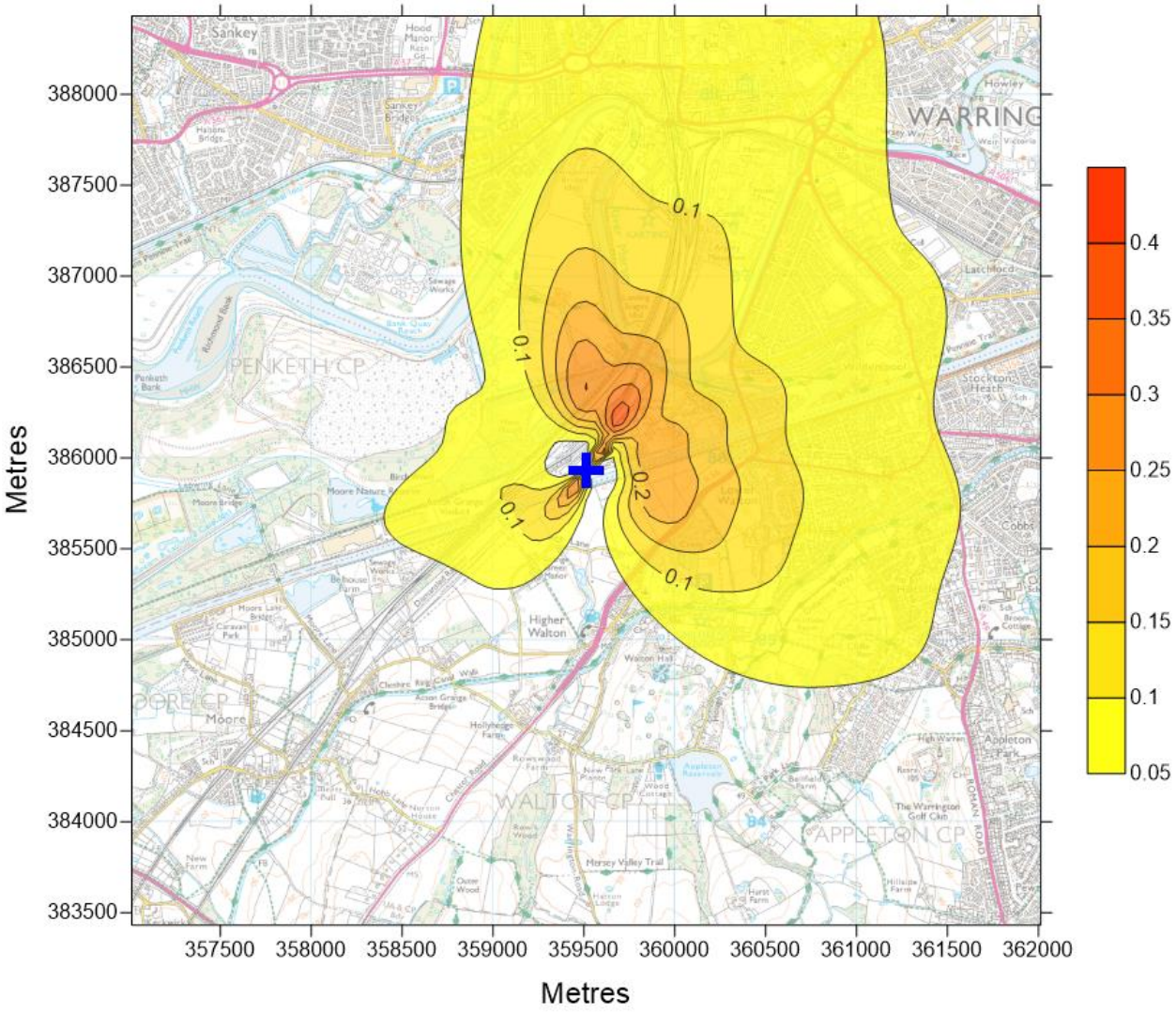


Figure 3 Predicted annual average hourly mean NO_2 concentrations (µg/m^3) resulting from Proposed Development for 2020 meteorology

Contours plotted: 0.05 µg/m^3 to 0.4 µg/m^3

Stack location shown with blue cross

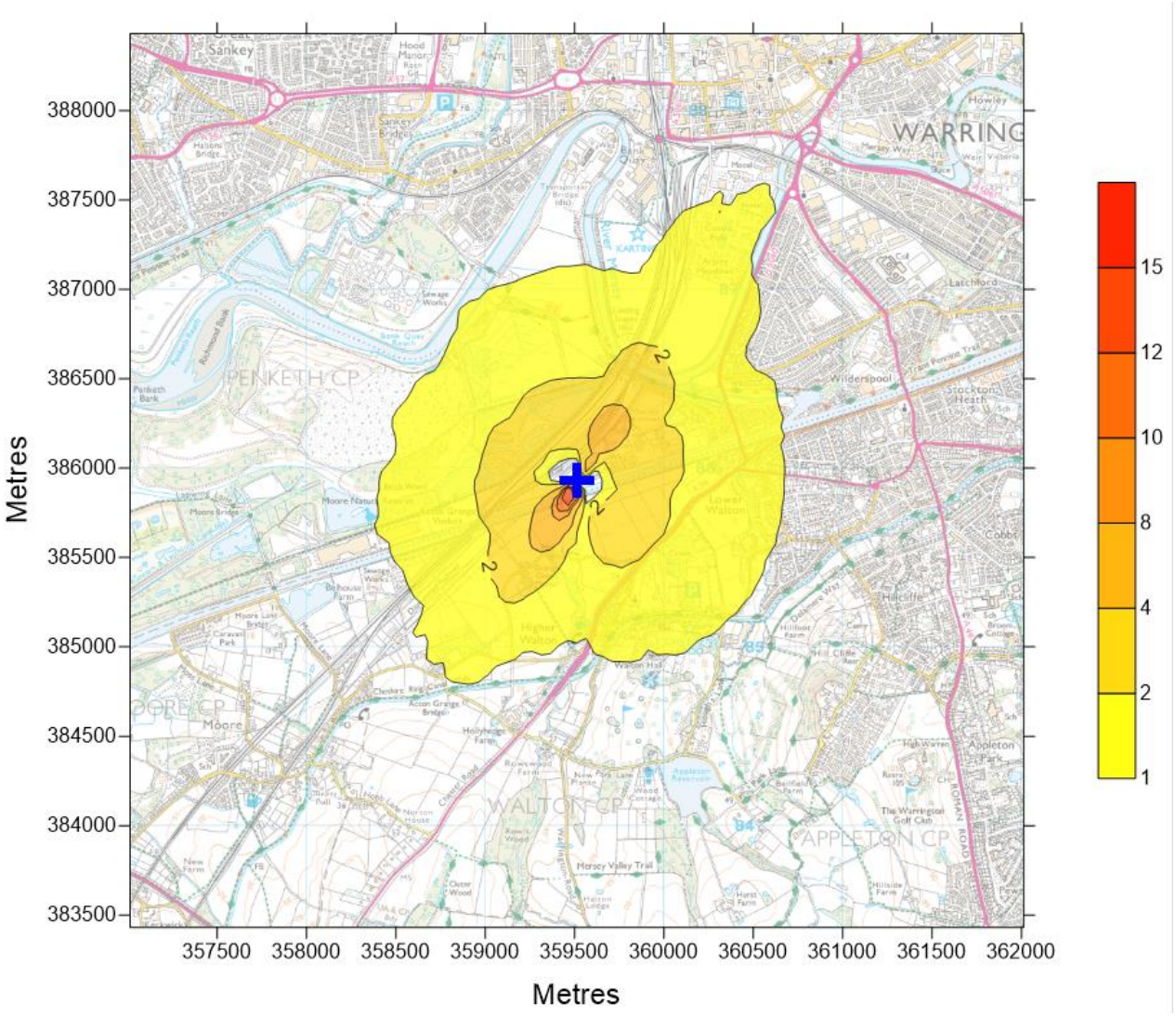


Figure 4 Predicted 99.79th percentile hourly mean NO_2 concentrations (µg/m^3) resulting from Proposed Development for 2020 meteorology

Contours plotted: 1 µg/m^3 to 15 µg/m^3

Stack location shown with blue cross

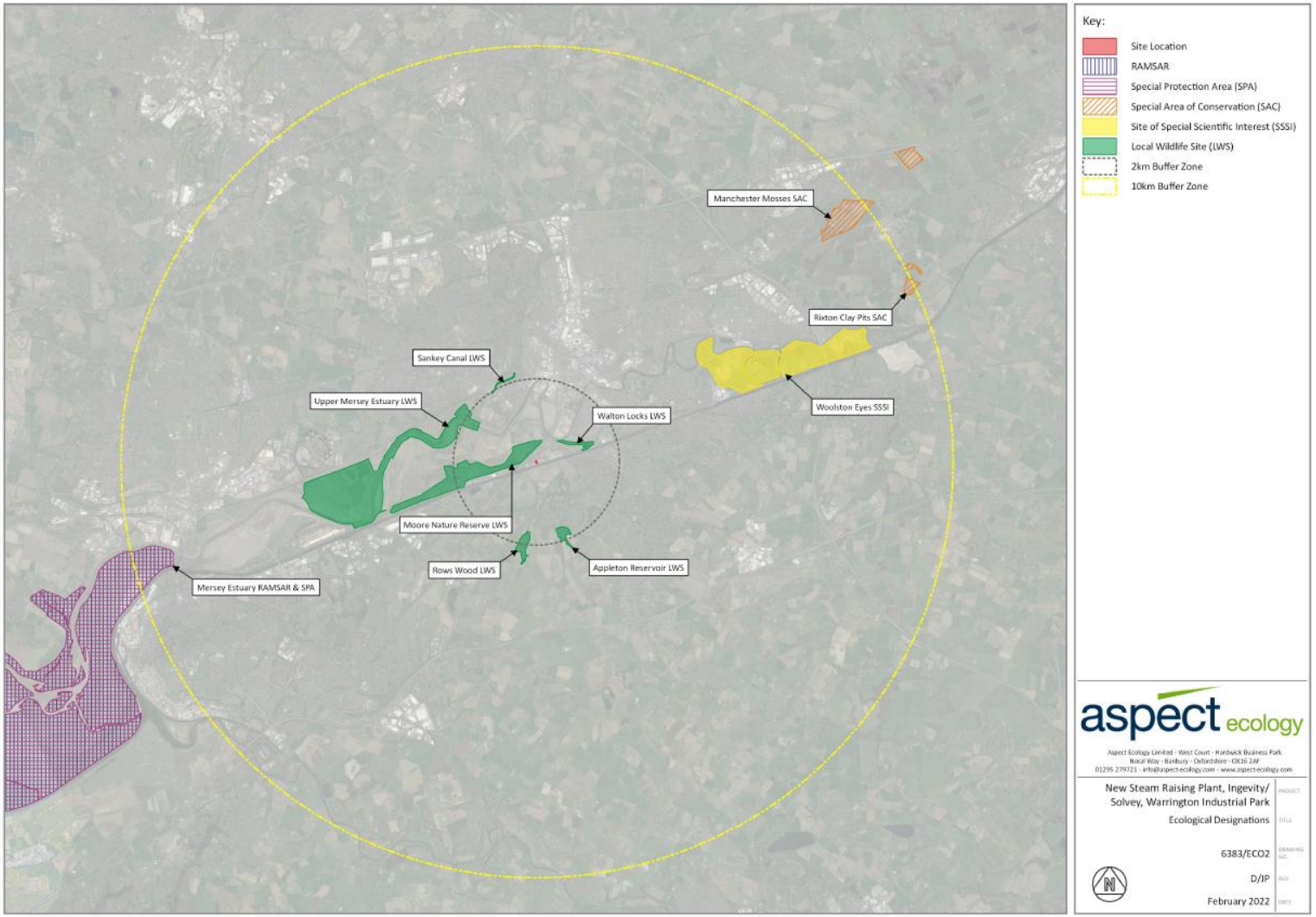


Figure 5 Local Ecological Sites showing 2 km (black line) and 10 km (yellow line) screening distances

APPENDIX A
Stack Height Assessment

A1 Stack Height Assessment

An evaluation of the stack height for the Proposed Development has been undertaken using ADMS v5.2. The selection of an appropriate stack release height requires a number of factors to be taken into account, the most important of which is the need to balance a release height sufficient to achieve adequate dispersion of pollutants against other constraints such as visual impact. Stack heights between 20 m and 40 m in increments of 5 m have been investigated. Emission Parameters other than the stack height are as set out in Table 4-1 and all other inputs are as set out in Section Assessment Methodology4.

Figure A1-1 (a) and Figure A1-1 (b) show the highest process contribution (PC) to annual mean and 99.79th percentile hourly mean NO_2 concentrations, respectively, at any point on the modelled grid over five years of meteorology, expressed as a percentage of the corresponding air quality standard (AQS). The significance thresholds of 1% for annual mean impacts and 10% for short-term impacts (See Section 3.5) are also shown in the respective Figures.

The purpose of the graph is to evaluate the optimum release height in terms of the dispersion of pollutants which would occur, against the visual constraints of further increases in release height. Analysis of the two curves shows that the benefit of incremental increases in release height up to 35 m is relatively pronounced with evidence of an inflection point at this height. At heights above 35 m, the air quality benefit of increasing the stack height further is reduced.

It is also evident that air quality impacts fall below significance at around 35 metres. Given that the graphs show the highest impact on the modelled grid, impacts at other receptors on the grid will be less than this value and hence further below significance.

The stack height of the current steam raising plant owned and operated by Solvay at the Baronet Road Works site, which the Proposed Development will replace, is 40 metres, hence a 35 metre stack would be consistent with current visual impacts.

The assessment shows that the use of a stack of height 35 m above ground level would be capable of mitigating both the short-term and long-term impacts of the modelled emissions of emitted pollutants. Therefore, a stack height of 35 m is considered to be appropriate when balancing the visual impacts versus air quality benefits.

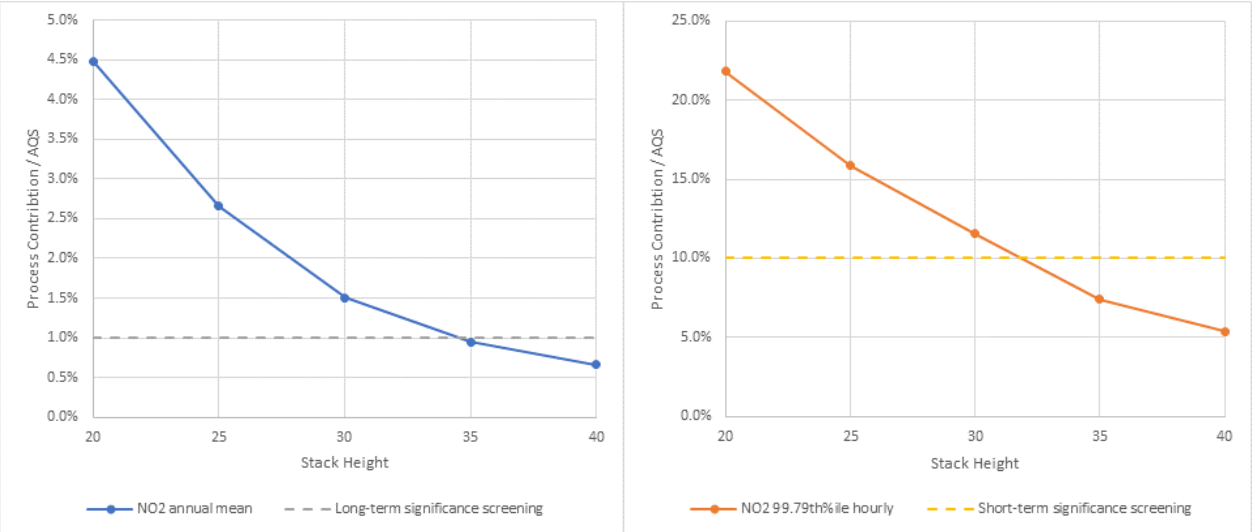
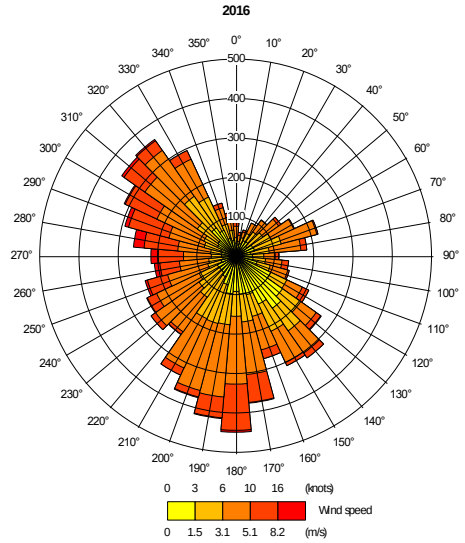
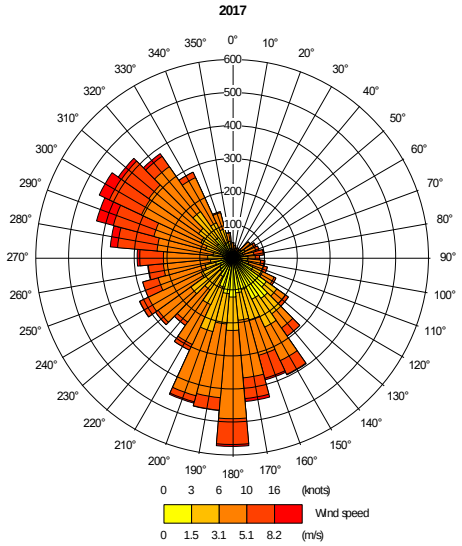


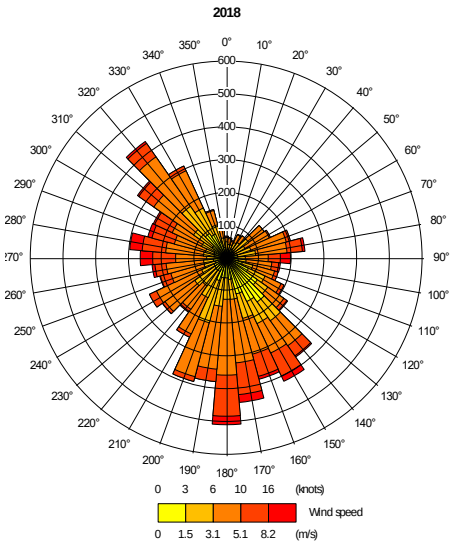
Figure A1-1 Predicted process contributions to (a) annual mean ground level NO_2 concentrations and (b) 99.79th percentile hourly mean NO_2 concentrations with varying stack height

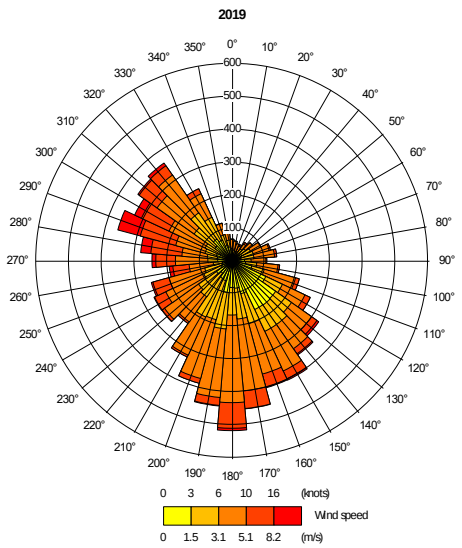
APPENDIX B
Wind Roses

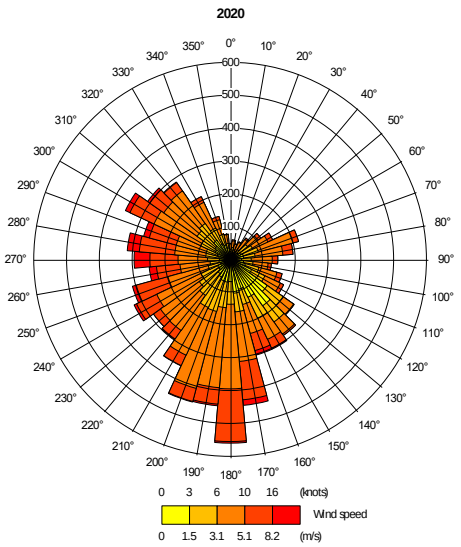
B1 Wind Roses for Rostherne No.2 (2016-2020)











APPENDIX C
Existing (Baseline) Air Quality

C1 Existing (Baseline) Air Quality

Measurements of air quality in the vicinity of the Proposed Development have been collated. Based on the measurements, estimates of annual mean concentrations of nitrogen dioxide and carbon monoxide have been derived. The background concentrations are added to modelled plant contributions to determine that overall concentrations are compliant with air quality standards.

C1.1 Nitrogen Dioxide

C1.1.1 Monitored Concentrations

There is an extensive NO_2 monitoring network operated on behalf of Warrington Borough Council comprising primarily of roadside diffusion tube measurements, together with three continuous monitoring sites. Annual mean NO_2 concentrations from 2015-2019 are available from the Local Air Quality Management Annual Status Report for 2020 (8). There are three monitoring locations around 1 km to the east of the Proposed Development, all of which are next to the A5060 within Warrington AQMA 4. The details and monitored concentrations are presented in Table C1-1.

Table C1-1 Local Authority Monitoring

Identifier	Method	Distance to Road (m)	Distance to Proposed Development (m)	2015 µg/m³	2016 µg/m³	2017 µg/m³	2018 µg/m³	2019 µg/m³
CM3 Chester Road	Continuous	2	980	37	34	32	30	30
DT14 Chester Road	Diffusion Tube	2	950	**40.1**	38.4	34.5	34.1	30.7
DT15 Walton Terrace	Diffusion Tube	2	940	**45.1**	**40.9**	37.1	34.5	31.4

Defra also operates a continuous NO_2 monitoring site approximately 2.3 km to the north of the Proposed Development. The details and monitored concentrations for the last five years are presented in Table C1-2. It should be noted that the concentrations for 2020 and 2021 will reflect reduced emissions due to pandemic travel restrictions and hence these may not be representative of typical values.

Table C1-2 Defra Automatic Monitoring

Identifier	Method	Distance to Road (m)	Distance to Proposed Development (m)	2017 µg/m³	2018 µg/m³	2019 µg/m³	2020 µg/m³	2021 µg/m³
Warrington (UKA00538)	Continuous	100	2300	21.0	21.4	20.5	14.9	15.1

C1.1.2 Background Mapped Concentrations

The Department for Environment, Food and Rural Affairs (Defra) provide air pollution background concentration maps at 1km resolution to assist local authorities in carrying out Review and Assessment of local air quality. The current 2018 reference year maps for NO_2 show concentrations ranging from 10.9 μgm^{-3} to 19.5 μgm^{-3} within 2.5 km of the Proposed Development.

C1.1.3 Selection of background NO_2 concentration

It can be seen that the roadside monitoring concentrations are considerably higher than the mapped concentrations and the concentrations recorded at the Defra monitoring site. Measurements within two metres of a major road are not likely to be representative of typical background exposure levels, even for properties in the immediate vicinity of the road. The roadside concentrations do show a continuous reduction from 2015 to 2019, with no exceedances of the 40 μgm^{-3} annual mean air quality standard since 2016 and this is attributed to measures to tackle air pollution within AQMA within the 2020 Annual Status Report.

To provide a reasonably precautionary estimate of background NO_2 concentrations, the highest concentration measured at the Defra site of 21.4 μgm^{-3} will be applied for the receptors which are not located within the AQMA (R1 to R9) with the highest 2017-2019 roadside diffusion tube concentration of 37.1 μgm^{-3} applied for the three receptors within the AQMA (R10-R12).

C1.2 Carbon Monoxide

There is no carbon monoxide monitoring carried out in the vicinity of the Proposed Development. Defra provide air pollution background concentration maps for carbon monoxide at 1km resolution based on 2001, which should provide a worst-case in terms of traffic emissions. The maps show concentrations ranging from 341 μgm^{-3} to 416 μgm^{-3} within 2.5 km of the Proposed Development. The highest concentration of 416 μgm^{-3} has been selected as a precautionary estimate of background CO concentrations.

APPENDIX D
Summary of Model Input Parameters

D1 Model Input Parameters

This Appendix summarises the model input parameters. Copies of the modelling input files have also been submitted with the permit application.

Table D1-1 Stack Location and Emission Characteristics

Parameter	Single Boiler	Combined Four Boilers (modelled case)
Stack location (Easting, Northing)	359513, 385931	359513, 385931
Stack height (m)	35	35
Stack diameter (m)	0.8	1.6
Exit temperature (^oC)	136	136
Stack O_2 content (% volume, dry)	8.59	8.59
Stack H_2O content (% volume)	17.16	17.16
Normalised Volume flow rate (Nm^3/s)	3.88	15.51
Actual flow rate (Am^3/s)	10.24	40.96
NO_x concentration (mg/Nm^3)	100	100
CO emission concentration (mg/Nm^3)	40	40
NO_x emission rate (g/s)	0.388	1.551
CO emission rate (g/s)	0.155	0.620

Table D1-2 Building Dimensions

Building	Building centre co-ordinates (eastings, northings)	Height (m)	Length (m)	Width (m)	Angle of length to north (degrees)
New Boiler House	359506 , 385955	13	26	28	73
New Offices	359464 , 385912	16	49	19	73
Cooling Towers	359538 , 385992	15	24	12	73
Tank Farm	359547 , 385970	10	25	20	73
Capa Monomer Plant (main building)	359582 , 386020	30	55	16	73

Table D1-3 Modelling Grids

Reference	Units	Value
Human Health Assessment		
Grid Start	Eastings, Northings	357013, 383431
Grid Finish	Eastings, Northings	362013, 388431
Number of Grid Points x	Grid Points	101
Number of Grid Points y	Grid Points	101
Habitats Assessment		
Grid Start	Eastings, Northings	349513, 375931
Grid Finish	Eastings, Northings	369513, 395931
Number of Grid Points x	Grid Points	201
Number of Grid Points y	Grid Points	201

Table D1-4 Modelled Receptors

Reference	Description	OS grid reference (eastings, northings)
R1	Mill Lane 1	359215 , 385466
R2	Mill Lane 2	359369 , 385505
R3	Turf Farm	359650 , 385492
R4	Forrest Way	359032 , 386853
R5	Baronet Mews	360071 , 386290
R6	Baronet Road	360049 , 386229
R7	Morley Road	360260 , 386178
R8	Pool Lane	360281 , 386009
R9	Walton Lea Cottages	360210 , 385632
R10	AQMA 1	360455 , 386030
R11	AQMA 2	360404 , 386224
R12	AQMA 3	360318 , 386478

Table D1-5 Other Inputs

Parameter	Value
Meteorological Input Files	rosthadms16.met to rosthadms20.met
Surface Roughness at Proposed Development	0.3 m
Surface Roughness at Meteorological Site	0.2 m

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