Environmental Monitoring Solutions Ltd

CSM Bakery – Environmental Permit Application

Air Quality Dispersion Modelling Report

July 2020

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Contact Details		
Company Name	Bureau Veritas UK Limited	Environmental Monitoring Solutions Ltd
Contact Name	Emma Dunabin	Martin Binnie
Position	Senior Consultant	Senior Consultant
Address	2nd Floor Atlantic House Atlas Business Park Simonsway Manchester M22 5PR	Unit 7 President Buildings Savile Street East Sheffield S4 7UQ
Telephone	07970 293688	07853 382908
e-mail	emma.dunabin@bureauveritas.com	Martin.binnie@em-solutions.co.uk
Websites	www.bureauveritas.co.uk	www.em-solutions.co.uk

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	Name	Job Title	Signature
Prepared By	E Dunabin	Senior Consultant	
Approved By	A Wiatr	Technical Director	

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Table of Contents

List of Tables

List of Figures

Executive Summary

Bureau Veritas have been commissioned by Environmental Monitoring Solutions Ltd (EMS), on behalf of CSM Bakery Solutions (CSM), to undertake a detailed air quality assessment to support an Environmental Permit (EP) application for operations at the CSM site in Bromborough.

The requirement for an EP was requested by the Environment Agency (EA) after an investigation into the site's current capacity. As such, the EP will cover current operations at the site and no changes to on-site processes or plant are proposed.

EMS have been assisting CSM with their permit application, which has been duly made on the proviso that an air quality assessment is provided, to demonstrate no significant air quality impacts.

An initial screening of emissions to air was carried out by EMS, which followed the EA's H1 Environmental Risk Assessment methodology, which has since been withdrawn and replaced by the EA's Air Emissions Risk (AER) assessment for your environmental permit. The H1 assessment concluded the need for dispersion modelling of oxides of nitrogen (NO_X) and nitrogen dioxide (NO_2) emissions at the Bromborough site to more precisely assess the air quality at nearby human and ecological receptors. Emissions of carbon monoxide (CO) have also been modelled for completeness.

Detailed dispersion modelling has been undertaken for operational emissions to air from the existing plant, using ADMS dispersion modelling software. Release rates for NO_x and CO for all plant included within the assessment have been derived using information provided by EMS.

The assessment concludes that, under the anticipated operating profile of plant, all concentrations in air at human and ecological receptors are predicted to be below the relevant assessment level and no exceedances are predicted. In terms of nitrogen and acid deposition at ecological receptors, where exceedances are predicted, these are all due to the existing background concentration; the contribution from the plant is very small and can be described as not significant.

It can be considered, therefore, that the air quality impacts of the plant at the Bromborough Site can be considered as not significant.

1 Introduction

Bureau Veritas have been commissioned by Environmental Monitoring Solutions Ltd (EMS), on behalf of CSM Bakery Solutions (CSM), to undertake a detailed air quality assessment to support an Environmental Permit (EP) application for operations at the CSM site in Bromborough. The site location is presented in Figure 1.1.

The requirement for an EP was requested by the Environment Agency (EA) after an investigation into the site's current capacity. As such, the EP will cover current operations at the site and no changes to on-site processes or plant are proposed. EMS have been assisting CSM with their permit application, which has been duly made on the proviso that an air quality assessment is provided. An H1 risk assessment indicated that dispersion modelling would be required in order to evaluate the potential air quality impacts arising from these new sources. This report presents the methodology, input parameters and results of the dispersion modelling undertaken as part of this assessment.

1.1 Process Description

CSM serve retail and food markets, as well as artisan and industrial bakeries, with a broad range of products and solutions, from the ingredients themselves to ready-to-bake and full finished product. The process requires the following key activities, depending on the type of product being produced:

- Mixing;
- Baking and/or frying;
- Packaging; and
- Distribution throughout the UK.

The focus of this assessment is on existing plant currently operating at the Bromborough site, comprising the boiler, fryers and ovens and there are no new emission points to air.

1.2 Scope of Assessment

An initial screening of emissions to air for oxides of nitrogen (NO_x) and carbon monoxide (CO) from existing plant for the assumed operational profile was carried out by EMS using the EA risk assessment H1 software tool as part of the EA guidance; Air Emissions Risk (AER) assessment for your environmental permit[1].

For those operational emissions not screened out by the H1 assessment as being either insignificant or not significant, detailed dispersion modelling requires undertaking in order to more precisely determine their significance. The H1 assessment concluded the need for dispersion modelling of NO_x emissions at the Site to more precisely assess the impacts from activities on sensitive human and ecological receptors located around the site. The dispersion modelling has also included emissions of CO for completion.

1.3 Site Description

The site is located on Stadium Road, approximately 1 km north east from the centre of Bromborough, on the Wirral. The surrounding land use is mainly industrial/commercial, with The

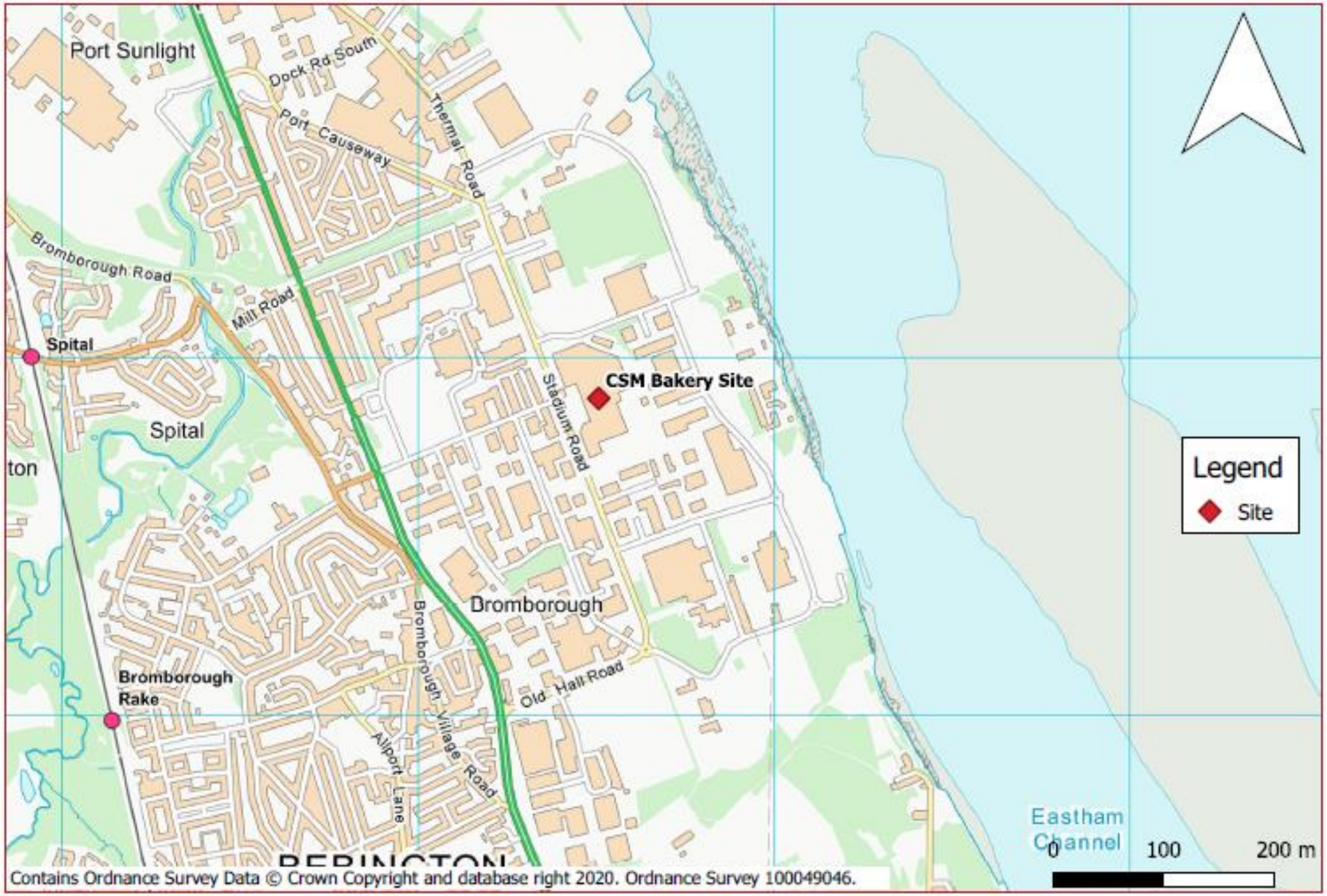
[1] Environment Agency – Air emissions risk assessment for your environmental permit (2016) https://www.gov.uk/guidance/air-emissions-risk-assessment-for-your-environmental-permit

Croft Retail and Leisure Park located to the north west of site. In terms of sensitive receptors, the closest residential receptors to the site are located approximately 390 m from the site at its closest point. In terms of ecological receptors, there are multiple ancient woodland sites within close proximity to the site and the Mersey Estuary is located within 500 m north/east of the site.

When considering existing air quality around the site, the site is not located within or close to an Air Quality Management Area (AQMA) and, at the closest monitoring station to the site, annual average NO_2 concentrations are consistently below the Air Quality Strategy (AQS) objective.

The site location is shown in Figure 1.1.

Figure 1.1 – Site Location



2 Dispersion Modelling Methodology

ADMS 5.2 has been used for the dispersion modelling of process emissions from the Site. ADMS 5 is an advanced atmospheric dispersion model that has been developed and validated by Cambridge Environmental Research Consultants (CERC). The model has been used extensively throughout the UK for regulatory compliance purposes and is accepted as an appropriate air quality modelling tool by the Environment Agency and local authorities.

ADMS 5 parameterises stability and turbulence in the atmospheric boundary layer (ABL) by the Monin-Obukhov length and the boundary layer depth. This approach allows the vertical structure of the ABL to be more accurately defined than by the stability classification methods of earlier dispersion models such as R91 or ISCST3. In ADMS, the concentration distribution follows a symmetrical Gaussian profile in the vertical and crosswind directions in neutral and stable conditions. However, the vertical profile in convective conditions follows a skewed Gaussian distribution to take account of the inhomogeneous nature of the vertical velocity distribution in the Convective Boundary Layer (CBL).

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

A range of input parameters is required including, among others, data describing the local area, meteorological measurements and emissions data. The data used in modelling the emissions are given in the following sections of this chapter.

2.1 Process Emissions

Details of both the plant to be assessed at the Site have been provided to Bureau Veritas by EMS. Appropriate emission rates have been informed by emissions monitoring results undertaken for EP04a, EP06 and EP10. Where individual stacks do not have test results, there have used proxy data from the flue operating with a similar process, details are provided below and in Table 2.2.

The plant included within the assessment, defined as the Process Contribution (PC) are as follows:

- EP04a – boiler flue;
- EP06 – glazed doughnut fryer flue
- EP07 – glazed doughnut fryer flue
- EP09 – Yum Yum fryer flue;
- EP10 – baked oven flue;
- EP12 – baked oven flue;
- EP13 – baked oven flue; and
- EP14 – baked oven flue.

The parameters and emissions rates used within the assessment for each stack emission source are detailed in Table 2.1 and Table 2.2, with the locations of each of the emission points illustrated in Figure 2.6.

Each stack considered in the assessment is scheduled to operate for 59.5% of the year, equating to annual operating hours of 5,212 hours out of an available 8,760 hours. In order that the worst-case meteorological conditions were captured in the modelling, the emissions have been modelled for 8,760 hours per year, i.e. as a continuous release. However, results for long-term (i.e. annual means) have been post-processed to account for them operating for only 5,212 hours, using a factor of 5,212 ÷ 8,760 ≈ 0.595. Results for short-term means have not been post-processed and are therefore conservative by nature.

Table 2.1 – Model Input Parameters

Parameter	EP04a	EP06	EP07	EP09	EP10	EP12	EP13	EP14
Operating Hours	5,212	5,212	5,212	5,212	5,212	5,212	5,212	5,212
Stack Height (m)	16	15	15	14	12	12	12	12
Flue Diameter (m)	0.40	0.45	0.45	0.45	0.25	0.25	0.25	0.25
Efflux Velocity (m s^{-1})	5.75	6.20	6.20	6.50	2.58	2.58	2.58	2.58
Efflux Temperature (°C)	275	80	80	80	136	136	136	136
Actual Oxygen (%)	5.7	18.3	18.3	18.3	17.1	17.1	17.1	17.1

All input data provided by EMS.

Table 2.2 – Model Pollutant Emission Rates

Parameter	EP04a	EP06	EP07*	EP09*	EP10	EP12**	EP13**	EP14**
NO_x Concentration (mg/m^3)	144	16.7	16.7	16.7	12.1	12.1	12.1	12.1
CO Concentration (mg/m^3)	1.1	63.9	63.9	63.9	14	14	14	14
NO_x Emission Rate (g/s)	0.044	0.002	0.002	0.002	0.002	0.002	0.002	0.002
CO Emission Rate (g/s)	0.0003	0.007	0.007	0.007	0.002	0.002	0.002	0.002

Concentration data derived from emissions monitoring data collected in September 2019 for EP04a, EP06 and EP10.
*Test results for EP06 have been used as proxy data for EP07 and EP09 as they are all fryer flues.
**Test results for EP10 have been used as proxy data for EP12, EP13 and EP14 as they are all baked oven flues.

2.2 Meteorology

For meteorological data to be suitable for dispersion modelling purposes, a number of meteorological parameters need to be measured on an hourly basis including wind speed, wind direction, cloud cover and temperature. In addition to meteorological parameters effecting predicted concentrations, the year of meteorological data that is used for a modelling assessment can also have a significant effect on ground level concentrations. The Liverpool Airport station is located approximately 7.5 km to the east of the site and is considered representative of the meteorological conditions experienced at the site.

Five complete years of meteorological data have been utilised within the modelling of pollutants to take into account year-by-year variations within the dataset. This assessment has utilised meteorological data recorded at Liverpool Airport meteorological station across the period 2015 to 2019. The following figures illustrate the frequency of wind directions and wind speeds for the years considered.

Figure 2.1 – 2015 Liverpool Wind Rose

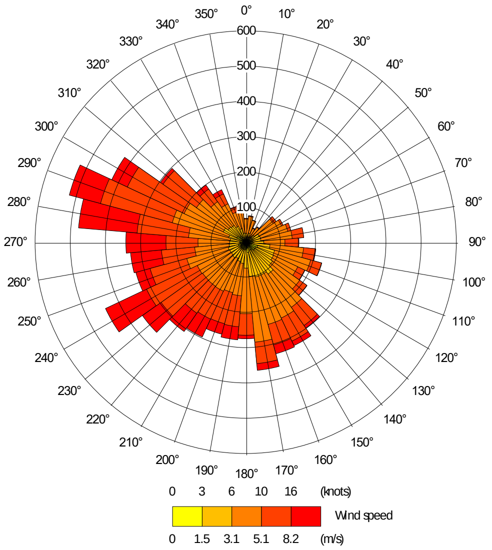


Figure 2.2 – 2016 Liverpool Wind Rose

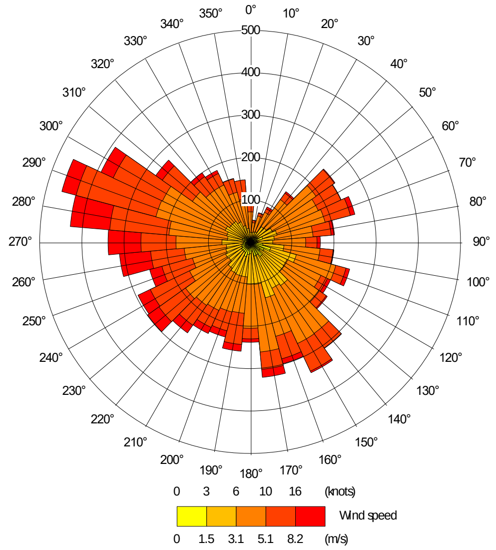


Figure 2.3 – 2017 Liverpool Wind Rose

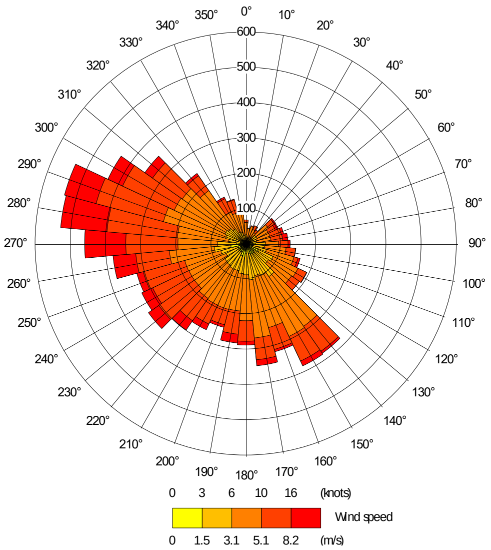


Figure 2.4 – 2018 Liverpool Wind Rose

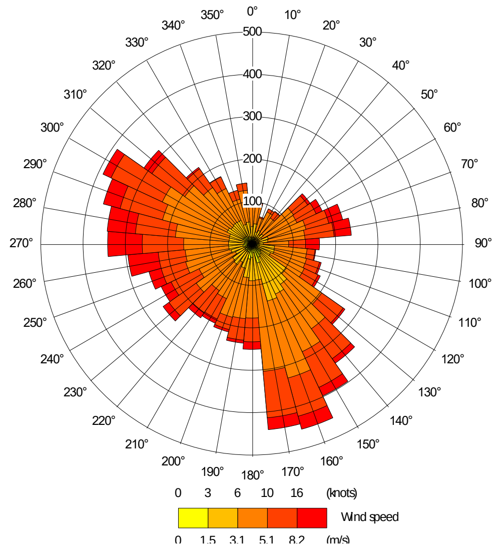


Figure 2.5 – 2019 Liverpool Wind Rose

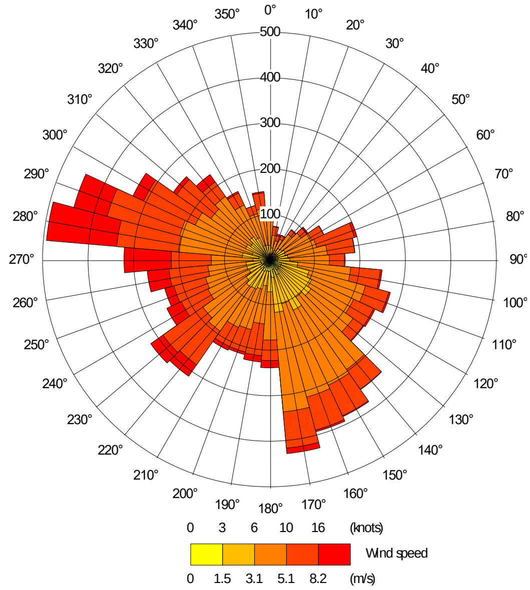


Figure 2.6 – Emission Points Visualisation

2.3 Surface Characteristics

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

2.3.1 Surface Roughness

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

The surface roughness length is related to the height of surface elements; typically, the surface roughness length is approximately 10% of the height of the main surface features. Thus, it follows that surface roughness is higher in urban and congested areas than in rural and open areas. Oke (1987) and CERC (2003) suggest typical roughness lengths for various land use categories as presented within Table 2.3.

Table 2.3 – Typical Surface Roughness Lengths for Various Land Use Categories

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

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

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

The overall impact on ground level concentration is, therefore, strongly correlated to the distance and orientation of a receptor from the emission source.

2.3.2 Surface Energy Budget

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

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

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

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

Where:

α = Priestly-Taylor parameter (dimensionless)

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

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

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

T = Temperature (K)

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

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

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

B= Bowen ratio (dimensionless)

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

2.3.3 Selection of Appropriate Surface Characteristic Parameters for the Site

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

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

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

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

From examination of 1:10,000 Ordnance Survey maps and satellite imagery, it can be seen that within the immediate vicinity of the site, land use is predominately industrial/commercial/residential in addition to the Mersey Estuary nearby. In addition completing an examination of the location of the Liverpool meteorological station the surrounding area is predominantly open fields. Consequently, a composite surface roughness length of 0.5 m was used in the model to account for the different surface roughness lengths within the model domain.

2.4 Buildings

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

The inclusion of buildings within the model can lead to a significant increase in predicted ground concentrations as plume dispersion is hindered by the presence of buildings and plume grounding occurs closer to the site than would otherwise be expected. Details of the buildings included within the model are presented within Table 2.4, with their locations presented within Figure 2.6.

Table 2.4 – Modelled Buildings

Name	Centre Easting (m)	Centre Northing (m)	Height (m)	Length / Diameter (m)	Width (m)	Angle (°)
Building001	335510	382884	10	87	223	70
Building002	335436	383005	8	108	55	70
Building003	335550	382956	10	37	116	70
Building004	335587	382927	10	13	25	70
Building005	335485	382771	13	37	95	70
Building006	335519	382766	15	18	4	70

2.5 Model Domain and Receptors

2.5.1 Model Domain

To assess the impact of atmospheric emissions from the site on local air quality, pollutant concentrations were output to a 2 km x 2 km Cartesian grid centred on the site, with an approximate receptor resolution of 10 m. This grid resolution has been selected to ensure that all local receptors are within the gridded area and the resolution is such that the maximum impact will be identified and is finer than the recommended minimum gridded resolution of 1.5 times the stack height.

2.5.2 Human Receptors

The discrete receptors considered were chosen based on locations where people may be located and judged in terms of the likely duration of their exposure to pollutants and proximity to the site, following the guidance given in Section 3 of this report. Details of the locations of human receptors are presented in Table 2.5, and illustrated in Figure 2.7 below.

Table 2.5 – Assessed Human Receptors

ID	Receptor Description	Easting (m)	Northing (m)	Height (m)
H1	Residential	335169	383374	1.5
H2	Residential	335139	383316	1.5
H3	Residential	335082	383294	1.5
H4	Residential	334914	383224	1.5
H5	Residential	334797	383166	1.5
H6	Residential	334786	383132	1.5
H7	Residential	334846	382964	1.5
H8	Residential	334837	382713	1.5
H9	Residential	334883	382611	1.5
H10	Residential	334930	382495	1.5
H11	Pub	335090	382219	1.5
H12	Residential	335183	382067	1.5
H13	Police Station	335196	381984	1.5
H14	Residential	335217	381838	1.5
H15	Residential	335266	381624	1.5
H16	Residential	335376	381378	1.5
H17	Rugby Club	335701	381677	1.5
H18	Eastham Country Park	336355	381820	1.5
H19	Residential	336088	381273	1.5
H20	Golf Course	335944	381530	1.5
H21	Eastham Country Park	336084	381914	1.5
H22	The Croft Retail & Leisure Park	335271	383072	1.5

2.5.3 Ecological Receptors

The Environment Agency's AER Guidance provides the following detail regarding consideration of ecological receptors:

- Check if there are any of the following within 10 km of your site (within 15 km if you operate a large electric power station or refinery):
  - Special Protection Areas (SPAs)
  - Special Areas of Conservation (SACs)
  - Ramsar Sites (protected wetlands)
- Check if there are any of the following within 2 km of your site:
  - Sites of Special Scientific Interest (SSSIs)
  - Local Nature Sites (ancient woods, local wildlife sites, Sites of Nature Conservation Importance (SNCIs) and national and local nature reserves).

Following the above guidance, upon reviewing the Natural England MAGIC mapping website[2] and Wirral Council's information on Sites of Biological Importance (SBI)[3], the ecological receptors considered in the assessment are provided in Table 2.6. Those ecological receptors within 2 km of the site are illustrated in Figure 2.7. There are only two receptors that are more than 2 km away from the site (E13 and E14).

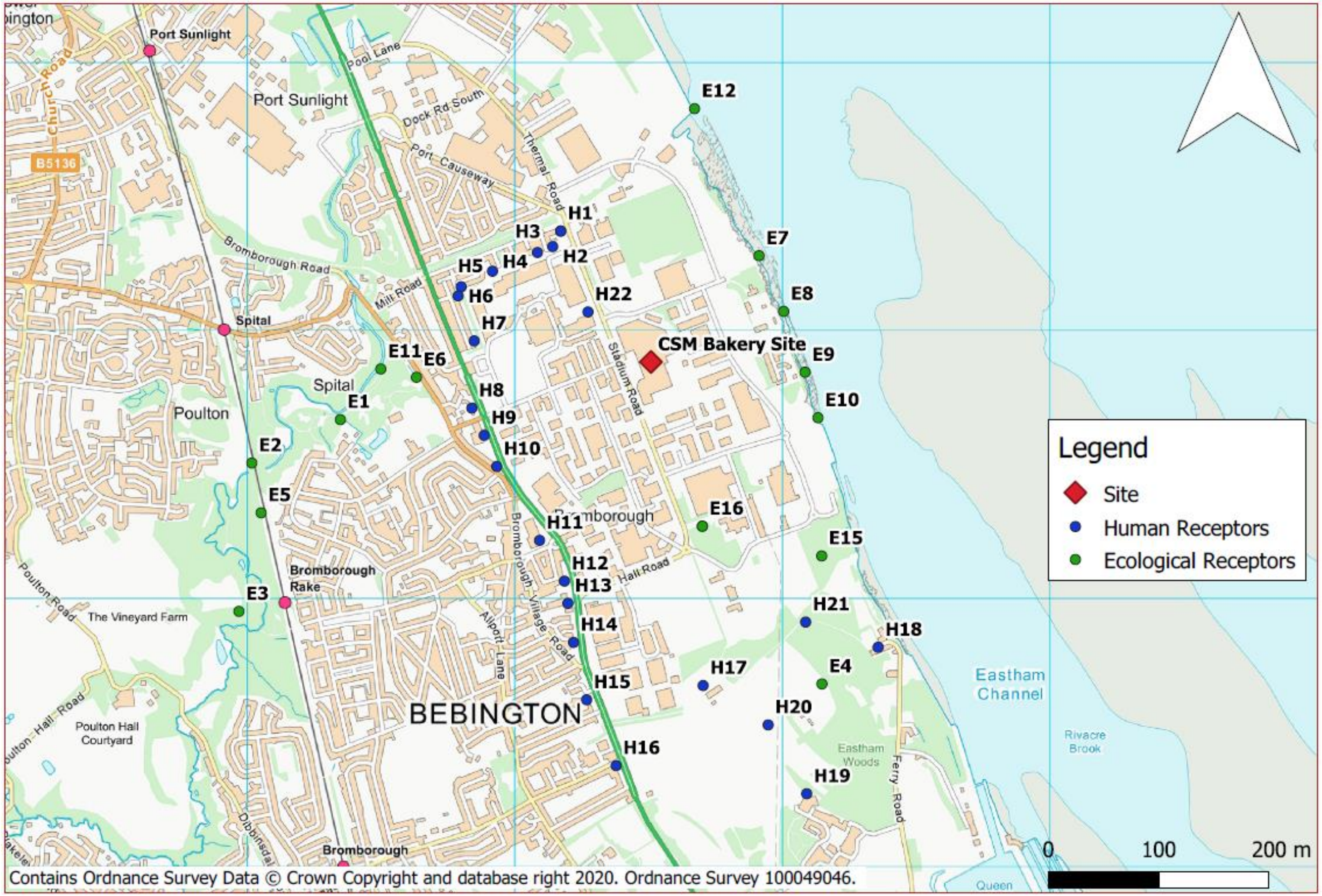
Table 2.6 – Assessed Ecological Receptors

ID	Receptor Description	Easting (m)	Northing (m)	Height (m)
E1	Patricks Wood AW	334346	382670	0
E2	Railway Wood AW	334015	382508	0
E3	Footpath Wood AW	333967	381954	0
E4	Eastham Wood AW	336145	381683	0
E5	Marsfords Wood AW	334050	382322	0
E6	Brotherton Park and Dibbinsdale LNR	334630	382828	0
E7	Mersey Estuary Ramsar/SSSI	335910	383282	0
E8	Mersey Estuary Ramsar/SSSI	336002	383074	0
E9	Mersey Estuary Ramsar/SSSI	336082	382847	0
E10	Mersey Estuary Ramsar/SSSI	336130	382677	0
E11	Dibbinsdale SSSI	334497	382859	0
E12	New Ferry SSSI	335669	383831	0
E13	Dee Estuary Ramsar/SAC/SPA	326132	380560	0
E14	Mersey Narrows and North Wirral Foreshore Ramsar	332648	390426	0
E15	Eastham Woods SBI	336144	382161	0
E16	Old Hall Road Woods Bromborough SBI	335698	382272	0

[2] MAGIC website - https://magic.defra.gov.uk/home.htm

[3] https://www.wirral.gov.uk/planning-and-building/local-plans-and-planning-policy/local-plans/unitary-development-plan/sites

Figure 2.7 – Location of Modelled Receptors within 2 km of the Site



2.6 Deposition

2.6.1 Nitrogen and Acid Deposition

The predominant route by which emissions will affect land in the vicinity of a process is by deposition of atmospheric emissions. Ecological receptors can potentially be sensitive to the deposition of pollutants, particularly nitrogen compounds, which can affect the character of the habitat through eutrophication and acidification.

Deposition processes in the form of dry and wet deposition remove material from a plume and alter the plume concentration. Dry deposition occurs when particles are brought to the surface by gravitational settling and turbulence. They are then removed from the atmosphere by deposition on the land surface. Wet deposition occurs due to rainout (within cloud) scavenging and washout (below cloud) scavenging of the material in the plume. These processes lead to a variation with downwind distance of the plume strength and may alter the shape of the vertical concentration profile as dry deposition only occurs at the surface.

Near to sources of pollutants (<2 km), dry deposition is the predominant removal mechanism (Fangmeier et al. 1994). Dry deposition may be quantified from the near-surface plume concentration and the deposition velocity (Chamberlin and Chadwick, 1953);

$$F_d = v_d C(x, y, 0)$$

where:

F_d = dry deposition flux (µg m^{-2} s^{-1})

v_d = deposition velocity (m s^{-1})

$C(x, y, 0)$ = ground level concentration (µg m^{-3})

Assuming irreversible uptake, the total wet deposition rate is found by integrating through a vertical column of air;

$$F_w = \int_0^z \Lambda C \; dz$$

where;

F_w = wet deposition flux (µg m^{-2} s^{-1})

Λ = washout co-efficient (s^{-1})

C = local airborne concentration (µg m^{-3})

z = height (m)

The washout co-efficient is an intrinsic function of the rate of rainfall.

Environment Agency guidance AQTAG06[4] recommends deposition velocities for various pollutants, according to land use classification (Table 2.7).

Table 2.7 – Recommended Deposition Velocities

Pollutant	Deposition Velocity (m s^{-1})	
	Short Vegetation	Long Vegetation/Forest
NO_x	0.0015	0.003

Source: Environment Agency (2014) 'Technical Guidance on Detailed Modelling Approach for an Appropriate Assessment for Emissions to Air', AQTAG06 Updated Version (March 2014)'

In order to assess the impacts of deposition, habitat-specific critical loads and critical levels have been created. These are generally defined as (e.g., Nilsson and Grennfelt, 1988):

> *"a quantitative estimate of exposure to one or more pollutants below which significant harmful effects on specified sensitive elements of the environment do not occur according to present knowledge"*

It is important to distinguish between a critical load and a critical level. The critical load relates to the quantity of a material deposited from air to the ground, whilst critical levels refer to the concentration of a material in air. The UK Air Pollution Information System (APIS) provides critical load data for ecological sites in the UK.

The critical loads used to assess the impact of compounds deposited to land which result in eutrophication and acidification are expressed in terms of kilograms of nitrogen deposited per hectare per year (kg N ha^{-1} y^{-1}) and kilo equivalents deposited per hectare per year (keq ha^{-1} y^{-1}). To enable a direct comparison against the critical loads, the modelled total wet and dry deposition flux (µg m^{-2} s^{-1}) must be converted into an equivalent value.

For a continuous release, the annual deposition flux of nitrogen can be expressed as:

$$F_{NTot} = \left(\frac{K_2}{K_3}\right) \cdot t \cdot \sum_{i=1}^{T} F_i \left(\frac{M_N}{M_i}\right)$$

where:

F_{NYot} = Annual deposition flux of nitrogen (kg N ha^{-1} y^{-1})

K_2 = Conversion factor for m^2 to ha (= 1x104 m^2 ha^{-1})

K_3 = Conversion factor for µg to kg (= 1x109 µg kg^{-1})

t = Number of seconds in a year (= 3.1536x107 s y^{-1})

i = 1,2,3…….T

T = Total number of nitrogen containing compounds

F = Modelled deposition flux of nitrogen containing compound (µg m^{-2} s^{-1})

[4] Technical Guidance on Detailed Modelling Approach for an Appropriate Assessment for Emissions to Air', AQTAG06, Environment Agency (2014), Updated Version (March 2014)'

M_N = Molecular mass of nitrogen (kg)

M = Molecular mass of nitrogen containing compound (kg)

The unit eq (1 keq ≡ 1,000 eq) refers to molar equivalent of potential acidity resulting from e.g. sulphur, oxidised and reduced nitrogen, as well as base cations. Conversion units are provided in AQTAG(06).

Table 2.8 – Deposition Conversion Factors

Pollutant	Chemical Element	Conversion Factor µg/m2/s [of Pollutant] → kg/ha/yr [of Chemical Element]
NO_x (as NO_2)	Nitrogen (N)	95.9

Table 2.9 – Acidification Conversion Factors

Chemical Element	Conversion Factor µg/m2/s [of Pollutant] → keq/ha/yr [of Chemical Element]
Nitrogen (N)	6.84

For the purposes of this assessment, dry deposition rates of nitrogen and acidic equivalents at the identified ecological receptors have been calculated by applying the 'long vegetation' deposition velocities (as detailed in Table 2.7) to the modelled annual mean concentrations of NO_x. Wet deposition has not been assessed since this is not a significant contributor to total deposition over shorter ranges (Fangmeier et al. 1994; Environment Agency, 2006).

Estimated background deposition rates of nutrient nitrogen and total acid deposition for the UK are available via the Air Pollution Information Service (APIS) website (http://www.apis.ac.uk). Table 2.10 provides the estimated deposition rates for the ecological receptors considered in this study, as obtained from the APIS website. It should be noted that the level of uncertainty associated with these modelled estimates is relatively high and the results are presented from the model across the UK on a coarse 5 km grid square resolution.

Table 2.10 – Estimated Background Deposition Rates

ID	Background Nitrogen Deposition (kg N ha^{-1} y^{-1})	Background Acid N Deposition (keq ha^{-1} y^{-1})	Background Acid S Deposition (keq ha^{-1} y^{-1})
E1	29.54	2.11	0.22
E2	29.54	2.11	0.22
E3	29.54	2.11	0.22
E4	21.00	1.50	0.31
E5	29.54	2.11	0.22
E6	29.54	2.11	0.22
E7	18.70	1.33	0.90
E8	18.70	1.33	0.90
E9	18.70	1.33	0.90
E10	18.70	1.33	0.90
E11	29.60	2.11	0.22
E12	17.60	0.79	0.29
E13	21.40	1.58	0.26
E14	14.20	1.02	0.28
E15	21.00	1.50	0.31
E16	21.00	1.50	0.31

Source: Air Pollution Information Service (APIS) website (http://www.apis.ac.uk)

2.7 Other Treatments

Specialised model treatments, for short-term (puff) releases, coastal models, fluctuations or photochemistry were not used in this assessment.

2.8 Conversion of NO to NO_2

Emissions of NO_x from combustion processes are predominantly in the form of nitric oxide (NO). Excess oxygen in the combustion gases and further atmospheric reactions cause the oxidation of NO to nitrogen dioxide (NO_2). NO_x chemistry in the lower troposphere is strongly interlinked in a complex chain of reactions involving Volatile Organic Compounds (VOCs) and Ozone (O_3). Two of the key reactions interlinking NO and NO_2 are detailed below:

$$NO_2 + hv \xrightarrow{O_2} NO + O_3 \qquad (R_1)$$

$$NO + O_3 \longrightarrow NO_2 + O_2 \qquad (R_2)$$

Where *hv* is used to represent a photon of light energy (i.e., sunlight).

Taken together, reactions R_1 and R_2 produce no net change in O_3 concentrations, and NO and NO_2 adjust to establish a near steady state reaction (photo-equilibrium). However, the presence of VOCs and CO in the atmosphere offer an alternative production route of NO_2 for photolysis, allowing O_3 concentrations to increase during the day with a subsequent decrease in the NO_2:NO_x ratio.

However, at night, the photolysis of NO_2 ceases, allowing reaction R_2 to promote the production of NO_2, at the expense of O_3, with a corresponding increase in the NO_2:NO_x ratio. Similarly, near to an emission source of NO, the result is a net increase in the rate of reaction R_2, suppressing O_3 concentrations immediately downwind of the source, and increasing further downwind as the concentrations of NO begin to stabilise to typical background levels (Gillani and Pliem 1996).

Given the complex nature of NO_x chemistry, the Environment Agency's Air Quality Modelling and Assessment Unit (AQMAU) have adopted a pragmatic, risk based approach in determining the conversion rate of NO to NO_2 which dispersion model practitioners can use in their detailed assessments[5]. The AQMAU guidance advises that the source term should be modelled as NO_x (as NO_2) and then suggests a tiered approach when considering ambient NO_2:NO_x ratios:

- **Screening Scenario:** 50 % and 100 % of the modelled NO_x process contributions should be used for short-term and long-term average concentration, respectively. That is, 50 % of the predicted NO_x concentrations should be assumed to be NO_2 for short-term assessments and 100 % of the predicted NO_x concentrations should be assumed to be NO_2 for long-term assessments;

- **Worst Case Scenario:** 35 % and 70 % of the modelled NO_x process contributions should be used for short-term and long-term average concentration, respectively. That is, 35 % of the predicted NO_x concentrations should be assumed to be NO_2 for short-term assessments and 70 % of the predicted NO_x concentrations should be assumed to be NO_2 for long-term assessments; and

- **Case Specific Scenario:** Operators are asked to justify their use of percentages lower than 35 % for short-term and 70 % for long-term assessments in their application reports.

In addition, AER guidance for air dispersion modelling reports states that worst case scenario conversion ratios of 35% for short-term average concentrations and 70% for long-term average concentrations should be applied for combustion processes.

In line with the AQMAU and AER guidance, this assessment has therefore used a NO_x to NO_2 ratio of 70% for long term average concentrations and 35% for short term concentrations.

[5] http://www.environment-agency.gov.uk/static/documents/Conversion_ratios_for__NOx_and_NO2_.pdf

3 Relevant Legislation and Guidance

3.1 EU Legislation

3.1.1 Directive 2008/50/EC on Ambient Air Quality and Cleaner Air for Europe

Directive 2008/50/EC (the 'Directive'), which came into force in June 2008, consolidates existing EU-wide air quality legislation (with the exception of Directive 2004/107/EC) and provides a new regulatory framework for $PM_{2.5}$.

The Directive sets limits, or target levels, for selected pollutants that are to be achieved by specific dates and details procedures EU Member States should take in assessing ambient air quality. The limit and target levels relate to concentrations in ambient air. At Article 2(1), the Directive defines ambient air as:

> *"…outdoor air in the troposphere, excluding workplaces as defined by 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."*

In accordance with Article 2(1), Annex III, Part A, paragraph 2 details locations where compliance with the limit values does not need to be assessed:

> *"Compliance with the limit values directed at the protection of human health shall not be assessed at the following locations:*
>
> *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 reservation of roads except where there is normally pedestrian access to the central reservation.*

3.2 UK Legislation

3.2.1 The Air Quality Standards Regulations 2010

The Air Quality Standards Regulations 2010 (the 'Regulations') came into force on the 11th June 2010 and transpose Directive 2008/50/EC into UK legislation. The Directive's limit values are transposed into the Regulations as 'Air Quality Standards' (AQS) with attainment dates in line with the Directive.

These standards are legally binding concentrations of pollutants in the atmosphere which can broadly be taken to achieve a certain level of environmental quality. The standards are based on the assessment of the effects of each pollutant on human health including the effects of sensitive groups or on ecosystems.

Similar to Directive 2008/50/EC, the Regulations define ambient air as;

> *"…outdoor air in the troposphere, excluding workplaces where members of the public do not have regular access."*

With direction provided in Schedule 1, Part 1, Paragraph 2 as to where compliance with the AQS' does not need to be assessed:

> *"Compliance with the limit values directed at the protection of human health does not need to be assessed at the following locations:*

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

b) on factory premises or at industrial locations to which all relevant provisions concerning health and safety at work apply;

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

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

The 2007 Air Quality Strategy for England, Scotland Wales and Northern Ireland provides a framework for improving air quality at a national and local level and supersedes the previous strategy published in 2000.

Central to the Air Quality Strategy are health-based criteria for certain air pollutants; these criteria are based on medical and scientific reports on how and at what concentration each pollutant affects human health. The objectives derived from these criteria are policy targets often expressed as a maximum ambient concentration not to be exceeded, without exception or with a permitted number of exceedances, within a specified timescale. At paragraph 22 of the 2007 Air Quality Strategy, the point is made that the objectives are:

> *"…a statement of policy intentions or policy targets. As such, there is no legal requirement to meet these objectives except where they mirror any equivalent legally binding limit values…"*

The AQOs, based on a selection of the objectives in the Air Quality Strategy, were incorporated into UK legislation through the Air Quality Regulations 2000, as amended.

Paragraph 4(2) of The Air Quality (England) Regulations 2000 states:

> *"The achievement or likely achievement of an air quality objective prescribed by paragraph (1) shall be determined by reference to the quality of air at locations –*
>
> *a) which are situated outside of buildings or other natural or man-made structures above or below ground; and*
>
> *b) where members of the public are regularly present*

Consequently, compliance with the AQOs should focus on areas where members of the general public are present over the entire duration of the concentration averaging period specific to the relevant objective.

3.3 Local Air Quality Management

Part IV of the Environment Act 1995 requires that Local Authorities periodically review air quality within their individual areas. This process of Local Air Quality Management (LAQM) is an integral part of delivering the Government's AQS objectives.

To carry out an air quality Review and Assessment under the LAQM process, the Government recommends a three-stage approach. This phased review process uses initial simple screening methods and progresses through to more detailed assessment methods of modelling and monitoring in areas identified to be at potential risk of exceeding the AQS objectives.

Review and assessments of local air quality aim to identify areas where national policies to reduce vehicle and industrial emissions are unlikely to result in air quality meeting the AQS objectives by the required dates.

For the purposes of determining the focus of Review and Assessment, local authorities should have regard to those locations where members of the public are likely to be regularly present and are likely to be exposed over the averaging period of the AQS objective.

Where the assessment indicates that some or all of the objectives may be potentially exceeded, the local authority has a duty to declare an AQMA. The declaration of an AQMA requires the local authority to implement an Air Quality Action Plan (AQAP), to reduce air pollution concentrations so that the required AQS objectives are met.

3.4 Environmental Permitting Regulations (EPR)

The Environmental Permitting Regulations (England and Wales)[6], which came into force on 6 April 2010 (replacing the 2007 Regulations), was amended in 2017 to include the Medium Combustion Plant Directive (MCPD). The MCPD forms part of the European Union's Clean Air Policy Package (2013) for medium sized combustion plants with emissions of between 1 and 50 MW_{th} input. Through regulating emissions of SO_2, NO_x and dust into the air, the MCPD aims to reduce air pollution and lessen the risks to human health and the environment that they may cause.

The EPR provides a single regulatory framework transposing EU Directives (Industrial Emissions Directive and Medium Combustion Plant Directive) into UK legislation, by defining the permitting and compliance system for industry and regulators.

3.5 Other Guideline Values

In the absence of statutory standards for the other prescribed substances that may be found in the emissions, there are several sources of applicable air quality guidelines.

3.5.1 Environmental Assessment Levels (EALs)

The Environment Agency's AER Guidance provides methods for quantifying the environmental impacts of emissions to all media. The AER guidance contains long and short-term Environmental Assessment Levels (EALs) and Environmental Quality Standards (EQS) for releases to air derived from a number of published UK and international sources. For the pollutants considered in this study, these EALs and EQS are equivalent to the objectives set in force by the AQS for England, Scotland Wales and Northern Ireland.

3.6 Criteria Appropriate to the Assessment

Table 3.1 sets out those air quality standards and objectives that are relevant to the assessment with regard to human and ecological receptors.

Table 3.1 – Air Quality Standards and Objectives appropriate to the Assessment

Pollutant	Averaging Period	Value (µg m^{-3})
Nitrogen dioxide (NO_2) – human receptors	Annual mean	40
	1-hour mean, not more than 18 exceedances a year (equivalent of 99.79 Percentile)	200
Carbon monoxide (CO) – human receptors	Maximum rolling 8-hour mean	10,000
	Maximum 1-hour mean	30,000
Nitrogen oxides (NO_x) – ecological receptors	Annual mean	30
	24-hour mean	75

[6] The Environmental Permitting Regulations (England and Wales) 2010, Statutory Instrument No 675, The Stationary Office Limited

4 Existing Ambient Data

4.1 Local Air Quality Management

The Site is located within the jurisdiction of Wirral Council (the Council), which, under their Local Air Quality Management (LAQM) obligations, continually review and assess concentrations of key air pollutants in the borough to ascertain the requirement, or otherwise, to declare an Air Quality Management Area (AQMA). However, air quality in the borough is generally good and the Council does not currently have any AQMAs.

4.2 Monitoring Data

The Council operated two automatic monitoring sites during 2019, as well as non-automatic (passive) monitoring of NO_2 at 31 sites.

Considering the closest monitoring sites to the CSM site, neither of the automatic monitoring sites are within close proximity, however there are passive diffusion tube monitoring sites within 2 km of the site. Details of the diffusion tubes close to the Site are provided in Table 4.1, and the location of the diffusion tubes, in addition to the current AQMA boundaries are presented with Figure 4.1.

Table 4.1 – NO_2 Diffusion Tube Monitoring Close to the Site

Site ID	Site Location	Site Type	OS Grid Ref (E, N)	Distance to Site (km)	Height (m)	2019 Annual Mean NO_2 Concentration (µg/m³)
W26/19	Allport Lane, Bromborough	Roadside	335053, 381295	1.48	2	19
W27	New Chester Road, New Ferry	Roadside	334194, 384348	1.79	2.1	26
2019 monitoring results as contained within the 2020 ASR[7].						

4.3 Background Concentrations used in the Assessment

Defra maintains a nationwide model of existing and future background air quality concentrations on a 1 km grid square resolution. The datasets include annual average concentration estimates for NO_x, NO_2, PM_{10}, $PM_{2.5}$, CO and SO_2 and benzene. The model used is empirical in nature: it uses the national atmospheric emissions inventory (NAEI) emissions to model the concentrations of pollutants at the centroid of each 1 km grid square but then calibrates these concentrations in relation to actual monitoring data.

Annual mean background concentrations have been obtained from the Defra 2017-based background maps[8], for the assessment year of 2020, based on the 1 km grid squares which cover the modelled area. Concentrations of CO have been collated from the 2001 background maps, as the most recent dataset available for this pollutant.

The modelled concentrations are added to the annual average background concentration to give a total concentration at each receptor location. This total concentration can then be compared against the relevant air quality standard/objective and the likelihood of an exceedance determined.

[7] Wirral Council 2020 Air Quality Annual Status Report
https://www.wirral.gov.uk/sites/default/files/all/environmental%20problems/Pollution/ASR%202020.pdf

[8] Defra Background Maps (2020). http://laqm.defra.gov.uk/review-and-assessment/tools/background-maps.html

It is not technically rigorous to add predicted short-term or percentile concentrations to ambient background concentrations not measured over the same averaging period, since peak contributions from different sources would not necessarily coincide in time or location. Without hourly ambient background monitoring data available it is difficult to make an assessment against the achievement or otherwise of the short-term AQS objective. For the current assessment, conservative short-term ambient levels have been derived by applying a factor of two to the annual mean background data as per the recommendation in within the AER Guidance for NO_x.

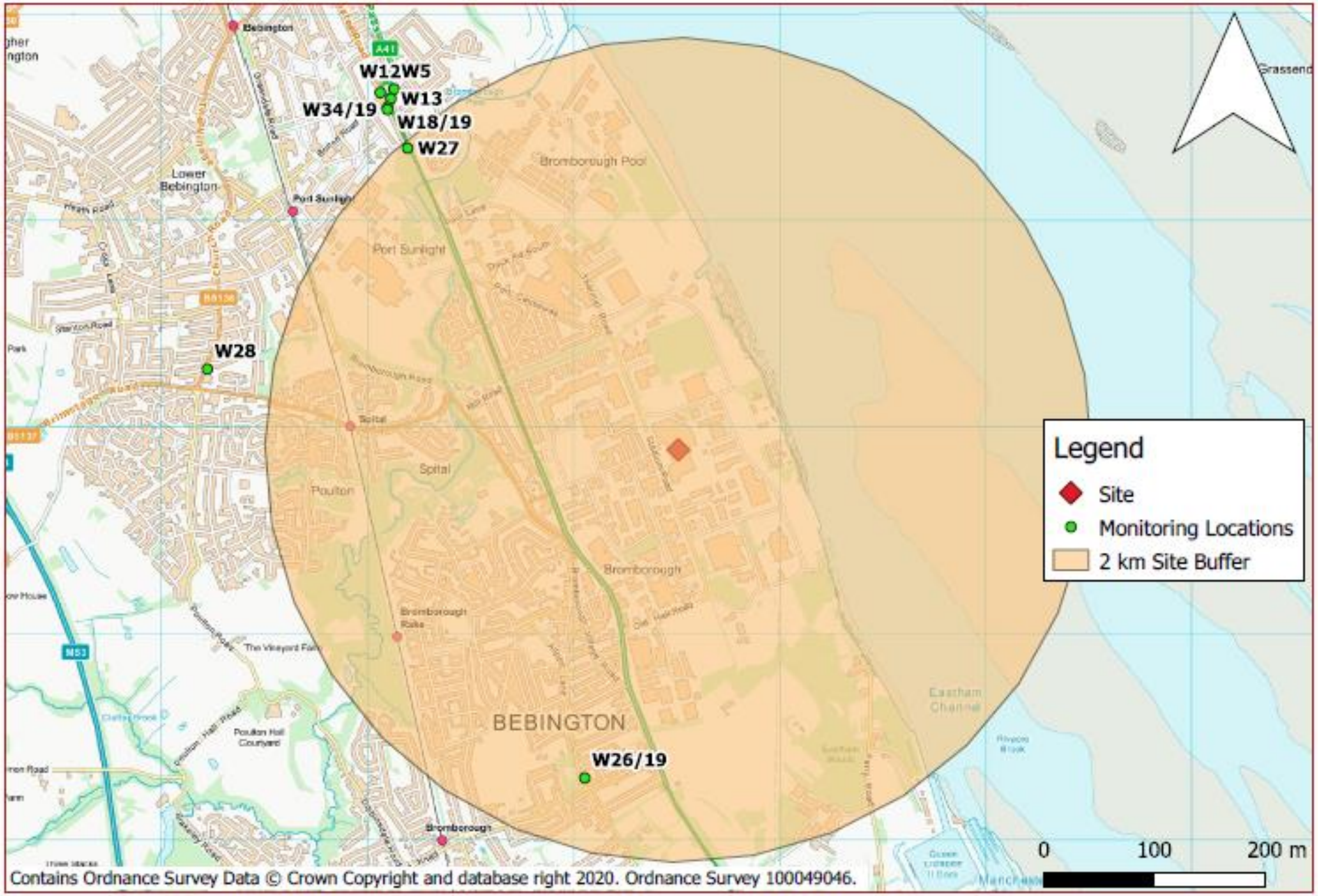
The annual mean background concentrations used in the assessment are detailed in Table 4.2.

Table 4.2 – 2020 Background Annual Mean Concentrations used in the Assessment

Receptor ID	Grid square (E, N)	Annual Mean Pollutant Concentrations (µg m^{-3})		
		NO_x	NO_2	CO
H1	335500,383500	17.0	12.3	371
H2	335500,383500	17.0	12.3	371
H3	335500,383500	17.0	12.3	371
H4	334500,383500	18.6	13.4	381
H5	334500,383500	18.6	13.4	381
H6	334500,383500	18.6	13.4	381
H7	334500,382500	14.9	11.0	374
H8	334500,382500	14.9	11.0	374
H9	334500,382500	14.9	11.0	374
H10	334500,382500	14.9	11.0	374
H11	335500,382500	19.0	13.6	367
H12	335500,382500	19.0	13.6	367
H13	335500,381500	15.6	11.4	370
H14	335500,381500	15.6	11.4	370
H15	335500,381500	15.6	11.4	370
H16	335500,381500	15.6	11.4	370
H17	335500,381500	15.6	11.4	370
H18	336500,381500	20.1	14.2	365
H19	336500,381500	20.1	14.2	365
H20	335500,381500	15.6	11.4	370
H21	336500,381500	20.1	14.2	365
H22	335500,383500	17.0	12.3	371
E1	334500,382500	14.9	11.0	374
E2	334500,382500	14.9	11.0	374
E3	333500,381500	12.0	9.0	370
E4	336500,381500	20.1	14.2	365
E5	334500,382500	14.9	11.0	374
E6	334500,382500	14.9	11.0	374
E7	335500,383500	17.0	12.3	371
E8	336500,383500	15.6	11.4	371
E9	336500,382500	16.8	12.2	367
E10	336500,382500	16.8	12.2	367
E11	334500,382500	14.9	11.0	374
E12	335500,383500	17.0	12.3	371

E13	326500,380500	7.8	6.0	276
E14	332500,390500	27.4	18.6	483
E15	336500,382500	16.8	12.2	367
E16	335500,382500	19.0	13.6	367

Figure 4.1 – Location of NO_2 Diffusion Tube Monitoring in Relation to the Site



4.4 Sensitivity Analysis and Uncertainty

Wherever possible, this assessment has used worst-case scenarios, which will exaggerate the impact of the emissions on the surrounding area, including emissions, operational profile, ambient concentrations, meteorology and surface roughness. This assessment has considered the years predicting the highest ground-level concentrations at the nearest sensitive receptor for comparison with the AQS objectives.

Sensitivity analysis has been undertaken for a number of model input parameters to investigate the results of the model with respect to changes in buildings, surface roughness and model code.

4.4.1 Buildings

A sensitivity analysis has been undertaken to investigate the impact of modelling with and without buildings on the modelled results. Results have been normalised by the value obtained from the surface roughness length resulting in the highest ground level process contribution at any modelled receptor location and are presented in Table 4.3.

Table 4.3 – Building Inclusion Sensitivity Analysis

Buildings	Normalised Maximum Ground Level Concentration	
	NO_x Annual Mean	NO_x 99.79 Percentile of 1-Hour Mean
With buildings	1.00	1.00
Without buildings	0.85	0.79

From the above predicted ground level concentrations, it can be seen that the inclusion of buildings in the model results in slightly higher concentrations for the both averaging periods. The model therefore used in this assessment included buildings in order to demonstrate a robust assessment.

4.4.2 Model Code

A sensitivity analysis has been undertaken to investigate the impact of changes in the model code on the modelled results. The model was run with the following:

- ADMS version 5.2.4; and
- AERMOD version 18081 (using the ADMS met pre-processor).

Table 4.4 contains the results of the analysis. Results have been normalised by the value obtained from the model version resulting in the highest ground level process contribution at any modelled receptor location. The analysis shows that AERMOD results in slightly higher concentrations for the annual mean and more significantly higher concentrations for the 1-hour mean. However, ADMS is widely used for this kind of assessment and, although it is noted that AERMOD may predict higher concentrations, ADMS has been used for the purposes of this assessment.

Table 4.4 – Model Code Sensitivity Analysis

Model Code	Normalised Maximum Ground Level Concentration	
	NO_x Annual Mean	NO_x 99.79 Percentile of 1-Hour Mean
ADMS	1.00	1.00
AERMOD	1.45	2.11

4.4.3 Surface Roughness

A sensitivity analysis has been undertaken to investigate the impact of modelling different surface roughness lengths; once using a composite surface roughness length of 0.5 m, averaged over the entire model domain and once using a variable surface roughness length file. The variable surface roughness file can be visualised in Figure 4.2.

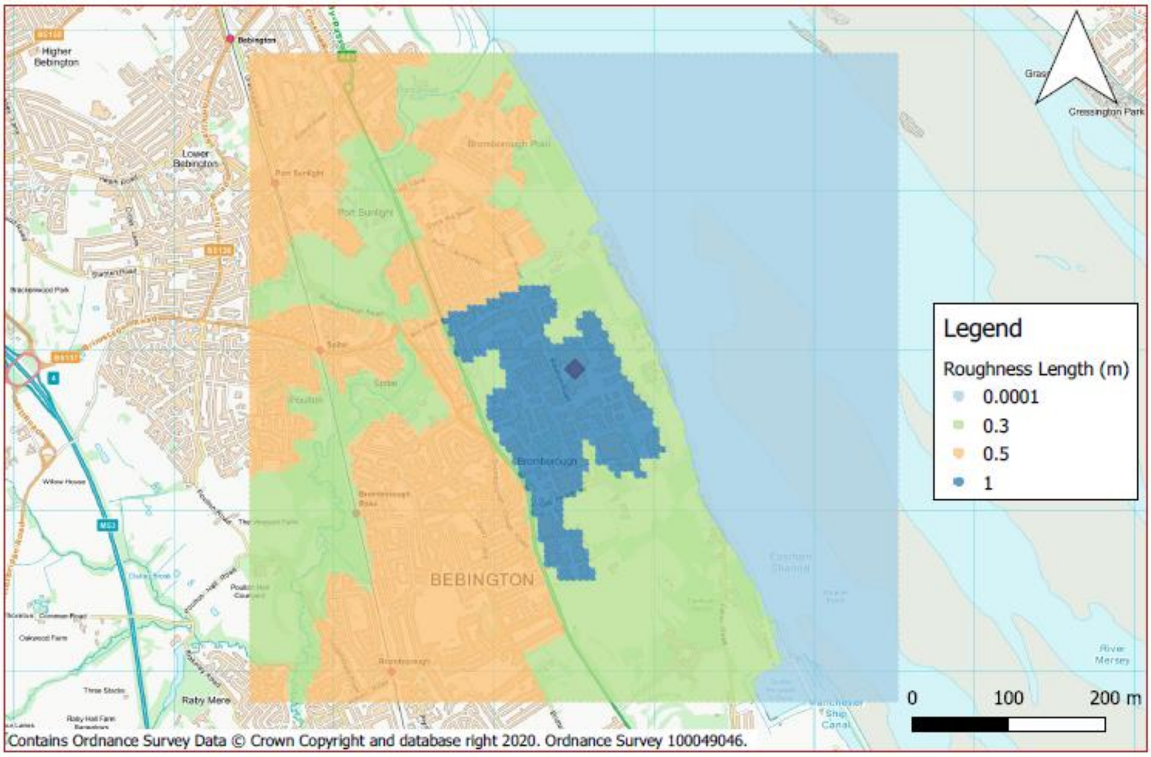
Results have been normalised by the value obtained from the surface roughness length resulting in the highest ground level process contribution at any modelled receptor location and are presented below.

Table 4.5 – Surface Roughness Sensitivity Analysis

Surface Roughness (m)	Normalised Maximum Ground Level Concentration	
	NO_x Annual Mean	NO_x 99.79 Percentile of 1-Hour Mean
Composite roughness length of 0.5 m	1.00	1.00
Variable surface roughness length	0.61	0.85

From the above predicted ground level concentrations, it can be seen that results with a composite roughness length are higher than those using a variable surface roughness file. As such, the model used in this assessment has used a composite roughness length, in order to provide a conservative assessment.

Figure 4.2 – Variable Surface Roughness File



4.4.4 Model Uncertainty

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

This assessment has incorporated a number of worst-case assumptions, as described above, which will result in an overestimation of the predicted ground level concentrations from the process. Therefore, the actual predicted ground level concentrations would be expected to be lower than this and, in some cases, significantly lower.

5 Assessment of Impact

This section sets out the results of the dispersion modelling and compares predicted pollutant concentrations to ambient air quality standards or objectives. The predicted concentrations resulting from the process are presented with background concentrations and the percentage contribution that the predicted environmental concentrations would make towards the relevant air quality standards or objectives.

Results are presented for the meteorological year resulting in the highest concentrations at any receptor location, as a worst case assumption. The worst-case meteorological year was determined separately for long and short-term concentrations at the worst-case receptor location for each pollutant, thus the worst case data has been reported within the section below.

For information, a table showing the inter-year variability of met conditions at the worst-case human receptor is provided below. The results have been normalised against the maximum value. At the worst-case human receptor, it demonstrates that 2019 provides the worst-case conditions. However, this can vary by receptor, hence the consideration of the worst-case meteorological year by receptor, as described above.

Table 5.1 – Inter-year Variability in Concentration (Normalised)

Receptor	Annual Mean					1-hour Mean				
	2015	2016	2017	2018	2019	2015	2016	2017	2018	2019
H22	0.75	0.81	0.74	0.86	1.00	0.87	0.94	0.89	0.94	1.00

5.1 NO_2 Impacts at Human Receptors

Table 5.2 details the results of the impact assessment for NO_2 and an assessment against both the long term annual mean (40 µg/m^3), and the short term 99.79th Percentile 1-hour mean (200 µg/m^3) AQS objectives.

Table 5.2 – NO_2 Impacts at Human Receptors

Receptor	Annual Mean				99.79th Percentile of 1-Hour Mean			
	PC µg/m^3	PEC µg/m^3	% PC of AQS	% PEC of AQS	PC µg/m^3	PEC µg/m^3	% PC of AQS	% PEC of AQS
H1	0.03	12.36	0.1%	30.9%	0.45	25.12	0.2%	12.6%
H2	0.03	12.36	0.1%	30.9%	0.44	25.11	0.2%	12.6%
H3	0.02	12.36	0.1%	30.9%	0.44	25.12	0.2%	12.6%
H4	0.02	13.42	<0.1%	33.5%	0.41	27.21	0.2%	13.6%
H5	0.01	13.42	<0.1%	33.5%	0.36	27.16	0.2%	13.6%
H6	0.01	13.42	<0.1%	33.5%	0.36	27.16	0.2%	13.6%
H7	0.02	11.05	<0.1%	27.6%	0.39	22.45	0.2%	11.2%
H8	0.01	11.05	<0.1%	27.6%	0.37	22.44	0.2%	11.2%
H9	0.01	11.05	<0.1%	27.6%	0.38	22.45	0.2%	11.2%
H10	0.01	11.05	<0.1%	27.6%	0.40	22.47	0.2%	11.2%
H11	0.01	13.59	<0.1%	34.0%	0.32	27.48	0.2%	13.7%
H12	0.00	13.59	<0.1%	34.0%	0.31	27.47	0.2%	13.7%
H13	0.00	11.44	<0.1%	28.6%	0.30	23.18	0.2%	11.6%
H14	0.00	11.44	<0.1%	28.6%	0.22	23.09	0.1%	11.5%
H15	0.00	11.44	<0.1%	28.6%	0.19	23.06	0.1%	11.5%
H16	0.00	11.44	<0.1%	28.6%	0.15	23.03	0.1%	11.5%
H17	0.00	11.44	<0.1%	28.6%	0.20	23.08	0.1%	11.5%
H18	0.01	14.17	<0.1%	35.4%	0.21	28.55	0.1%	14.3%

Receptor	Annual Mean				99.79th Percentile of 1-Hour Mean			
	PC µg/m³	PEC µg/m³	% PC of AQS	% PEC of AQS	PC µg/m³	PEC µg/m³	% PC of AQS	% PEC of AQS
H19	0.00	14.17	<0.1%	35.4%	0.14	28.48	0.1%	14.2%
H20	0.00	11.44	<0.1%	28.6%	0.18	23.06	0.1%	11.5%
H21	0.01	14.17	<0.1%	35.4%	0.23	28.56	0.1%	14.3%
H22	0.06	12.39	0.1%	31.0%	0.62	25.30	0.3%	12.6%
AQS = Air Quality Strategy Objective; PC = Process Contribution; PEC = Predicted Environmental Concentration (PC + Background)								

Table 5.2 indicates that long and short term Predicted Environmental Concentrations (PECs) of NO_2 are comfortably below the respective assessment metric at all applicable human receptors.

A concentration isopleth for the 99.79th percentile of the one hour mean process contribution for 2019 is presented Appendix B.

5.2 CO Impacts at Human Receptors

Table 5.3 details the results of the impact assessment for CO and an assessment against both the maximum rolling 8-hour mean AQS (10,000 µg/m³), and the maximum 1-hour mean (30,000 µg/m³) Environmental Assessment Level (EAL). All results are significantly below the relevant assessment metrics.

Table 5.3 – CO Impacts at Human Receptors

Receptor	Maximum rolling 8-hour mean				Maximum 1-hour mean			
	PC µg/m³	PEC µg/m³	% PC of AQS	% PEC of AQS	PC µg/m³	PEC µg/m³	% PC of EAL	% PEC of EAL
H1	0.8	742.8	<0.1%	7.4%	1.2	743.2	<0.1%	2.5%
H2	0.7	742.7	<0.1%	7.4%	1.3	743.3	<0.1%	2.5%
H3	0.6	742.6	<0.1%	7.4%	1.2	743.2	<0.1%	2.5%
H4	0.5	762.5	<0.1%	7.6%	1.1	763.1	<0.1%	2.5%
H5	0.6	762.6	<0.1%	7.6%	1.0	763.0	<0.1%	2.5%
H6	0.6	762.6	<0.1%	7.6%	1.0	763.0	<0.1%	2.5%
H7	0.6	748.6	<0.1%	7.5%	1.2	749.2	<0.1%	2.5%
H8	0.6	748.6	<0.1%	7.5%	1.0	749.0	<0.1%	2.5%
H9	0.5	748.5	<0.1%	7.5%	1.2	749.2	<0.1%	2.5%
H10	0.7	748.7	<0.1%	7.5%	1.0	749.0	<0.1%	2.5%
H11	0.5	734.5	<0.1%	7.3%	1.2	735.2	<0.1%	2.5%
H12	0.4	734.4	<0.1%	7.3%	1.1	735.1	<0.1%	2.5%
H13	0.4	740.4	<0.1%	7.4%	1.1	741.1	<0.1%	2.5%
H14	0.4	740.4	<0.1%	7.4%	1.0	741.0	<0.1%	2.5%
H15	0.4	740.4	<0.1%	7.4%	0.9	740.9	<0.1%	2.5%
H16	0.4	740.4	<0.1%	7.4%	0.7	740.7	<0.1%	2.5%
H17	0.4	740.4	<0.1%	7.4%	0.8	740.8	<0.1%	2.5%
H18	0.4	730.4	<0.1%	7.3%	0.7	730.7	<0.1%	2.4%
H19	0.2	730.2	<0.1%	7.3%	0.6	730.6	<0.1%	2.4%
H20	0.2	740.2	<0.1%	7.4%	0.7	740.7	<0.1%	2.5%
H21	0.4	730.4	<0.1%	7.3%	0.8	730.8	<0.1%	2.4%
H22	1.4	743.4	<0.1%	7.4%	1.8	743.8	<0.1%	2.5%
AQS = Air Quality Strategy Objective; PC = Process Contribution; PEC = Predicted Environmental Concentration (PC + Background)								

5.3 NO_x Impacts at Ecological Receptors – Concentrations in Air

Table 5.4 details the results of the impact assessment for NO_x at the ecological receptors considered in the assessment, against the relevant assessment levels of 30 µg/m³ for the annual mean and 75 µg/m³ for the 24-hour mean results. A concentration isopleth is provided in Appendix B showing predictions of 24-hour mean NO_x in 2019.

All results are comfortably below the relevant assessment metrics and no further assessment is required.

Table 5.4 – NO_x Impacts at Ecological Receptors

Receptor – Height	Annual Mean				24-hour mean			
	PC µg/m³	PEC µg/m³	% PC of AQS	% PEC of AQS	PC µg/m³	PEC µg/m³	% PC of EAL	% PEC of EAL
E1	0.01	14.95	<0.1%	49.8%	0.40	30.28	0.5%	40.4%
E2	0.01	14.95	<0.1%	49.8%	0.20	30.08	0.3%	40.1%
E3	0.01	11.97	<0.1%	39.9%	0.14	24.06	0.2%	32.1%
E4	0.01	20.08	<0.1%	66.9%	0.14	40.29	0.2%	53.7%
E5	0.01	14.95	<0.1%	49.8%	0.12	30.00	0.2%	40.0%
E6	0.01	14.95	<0.1%	49.8%	0.65	30.53	0.9%	40.7%
E7	0.04	17.09	0.1%	57.0%	0.51	34.60	0.7%	46.1%
E8	0.05	15.66	0.2%	52.2%	0.53	31.76	0.7%	42.3%
E9	0.05	16.85	0.2%	56.2%	0.48	34.07	0.6%	45.4%
E10	0.04	16.84	0.1%	56.1%	1.17	34.76	1.6%	46.3%
E11	0.01	14.95	<0.1%	49.8%	0.50	30.38	0.7%	40.5%
E12	0.02	17.06	0.1%	56.9%	0.22	34.31	0.3%	45.8%
E13	<0.01	7.78	<0.1%	25.9%	0.03	15.58	<0.1%	20.8%
E14	<0.01	27.44	<0.1%	91.5%	0.03	54.91	<0.1%	73.2%
E15	0.01	16.81	<0.1%	56.0%	0.23	33.82	0.3%	45.1%
E16	0.02	19.01	0.1%	63.4%	0.38	38.38	0.5%	51.2%

5.4 NO_x Impacts at Ecological Receptors – Deposition to Land

Table 5.5 presents the results for nutrient nitrogen deposition at ecological receptors. The PC at all receptors is very low, but with a high background deposition, the PEC exceeds the minimum critical load (CL) at all receptors. However, the impact at all the ecological receptors can be described as not significant due to the PC being less than 1% of the CL.

Table 5.5 – Nitrogen Deposition Results (kg N ha^{-1} y^{-1})

Receptor	Nitrogen Deposition					
	Minimum CL	PC	PEC	%PC of CL	%PEC of CL	Impact
E1	10	0.003	29.54	0.03%	295%	Not significant
E2	10	0.002	29.54	0.02%	295%	Not significant
E3	10	0.002	29.54	0.02%	295%	Not significant
E4	10	0.002	21.00	0.02%	210%	Not significant
E5	10	0.002	29.54	0.02%	295%	Not significant
E6	10	0.004	29.54	0.04%	295%	Not significant
E7	5	0.006	18.71	0.12%	374%	Not significant
E8	5	0.007	18.71	0.15%	374%	Not significant
E9	5	0.008	18.71	0.16%	374%	Not significant

Receptor	Nitrogen Deposition					
	Minimum CL	PC	PEC	%PC of CL	%PEC of CL	Impact
E10	5	0.006	18.71	0.12%	374%	Not significant
E11	10	0.003	29.60	0.03%	296%	Not significant
E12	20	0.002	17.60	0.01%	88%	Not significant
E13	8	0.000	21.40	<0.01%	268%	Not significant
E14	20	0.000	14.20	<0.01%	71%	Not significant
E15	10	0.002	21.00	0.02%	210%	Not significant
E16	10	0.002	21.00	0.02%	210%	Not significant
Critical Loads for E1 – E6 and E15 – E16 (Ancient Woodland and LWS) have been estimated from APIS based on the habitat being Broadleaved/Coniferous unmanaged woodland.						

Table 5.6 and Table 5.7 provide the inputs and results for acid deposition at ecological receptors.

Table 5.6 – Acid Critical Loads and Deposition Rates (keq ha^{-1} y^{-1})

Receptor	Acid Deposition								
	$CL_{max}S$	$CL_{min}N$	$CL_{max}N$	S PC*	N PC	S back-ground	N back-ground	S PEC	N PEC
E1	1.37	0.36	1.73	0	<0.001	0.2	2.1	0.2	2.1
E2	1.37	0.36	1.73	0	<0.001	0.2	2.1	0.2	2.1
E3	1.37	0.36	1.73	0	<0.001	0.2	2.1	0.2	2.1
E4	1.49	0.14	1.63	0	<0.001	0.3	1.5	0.3	1.5
E5	1.37	0.36	1.73	0	<0.001	0.2	2.1	0.2	2.1
E6	1.37	0.36	1.73	0	<0.001	0.2	2.1	0.2	2.1
E7	0.18	0.32	0.50	0	<0.001	0.9	1.3	0.9	1.3
E8	0.18	0.32	0.50	0	0.001	0.9	1.3	0.9	1.3
E9	0.18	0.32	0.50	0	0.001	0.9	1.3	0.9	1.3
E10	0.18	0.32	0.50	0	<0.001	0.9	1.3	0.9	1.3
E11	1.36	0.36	1.72	0	<0.001	0.2	2.1	0.2	2.1
E12	N/A	N/A	N/A	0	<0.001	0.3	0.8	0.3	0.8
E13	4.12	0.44	4.56	0	<0.001	0.3	1.6	0.3	1.6
E14	4.08	0.44	4.30	0	<0.001	0.3	1.0	0.3	1.0
E15	0.00	0.00	0.00	0	<0.001	0.3	1.5	0.3	1.5
E16	1.50	0.14	1.64	0	<0.001	0.3	1.5	0.3	1.5
An acid deposition critical load for has been estimated based upon a habitat of Acid Grassland for each receptor location using the APIS database due to specific results not held for the receptor. * Since all the plant at the CSM site are gas fired SO_2 has not been explicitly modelled and would be negligible.									

Table 5.7 – Acid deposition: Comparison with Critical Loads

Receptor	Acid Deposition (keq ha^{-1} y^{-1})						
	PC	Background	PEC	%PC of CL_{min}	% Background of CL_{min}	%PEC of CL_{min}	Impact
E1	No exceedance	0.6	0.6	<0.1	134.9	134.9	Not significant

Receptor	Acid Deposition (keq ha^{-1} y^{-1})						
	PC	Background	PEC	%PC of CL_{min}	% Background of CL_{min}	%PEC of CL_{min}	Impact
E2	No exceedance	0.6	0.6	<0.1	134.9	134.9	Not significant
E3	No exceedance	0.6	0.6	<0.1	134.9	134.9	Not significant
E4	No exceedance	0.2	0.2	<0.1	110.8	110.8	Not significant
E5	No exceedance	0.6	0.6	<0.1	134.9	134.9	Not significant
E6	No exceedance	0.6	0.6	<0.1	134.9	134.9	Not significant
E7	No exceedance	1.7	1.7	0.1	447.8	447.9	Not significant
E8	No exceedance	1.7	1.7	0.1	447.8	447.9	Not significant
E9	No exceedance	1.7	1.7	0.1	447.8	447.9	Not significant
E10	No exceedance	1.7	1.7	0.1	447.8	447.9	Not significant
E11	No exceedance	0.6	0.6	<0.1	135.4	135.4	Not significant
E12*	N/A	N/A	N/A	N/A	N/A	N/A	N/A
E13	No exceedance	No exceedance	No exceedance	<0.1	40.4	40.4	Not significant
E14	No exceedance	No exceedance	No exceedance	<0.1	30.2	30.2	Not significant
E15*	N/A	N/A	N/A	N/A	N/A	N/A	N/A
E16	No exceedance	0.2	0.2	<0.1	110.5	110.5	Not significant

*Critical Loads not available for this receptor. ‘No exceedance’ demonstrates no exceedance of the critical load function tool as available on APIS.

Although the PEC exceeds the minimum CL at the majority of receptors, all results can be considered as not significant, since the PC from the CSM site is no more than 0.1% of the minimum CL at all receptors considered.

6 Conclusions

Bureau Veritas have been commissioned by Environmental Monitoring Solutions Ltd (EMS), on behalf of CSM Bakery Solutions (CSM), to undertake a detailed air quality assessment to support an Environmental Permit (EP) application for operations at the CSM site in Bromborough.

The requirement for an EP was requested by the EA after an investigation into the site's current capacity. EMS have been assisting CSM with their permit application, which has been duly made on the proviso that an air quality assessment is provided, to demonstrate no significant air quality impacts.

An initial screening of emissions to air was carried out by EMS, which followed the EA's H1 Environmental Risk Assessment methodology, which has since been withdrawn and replaced by the EA's Air Emissions Risk (AER) assessment for your environmental permit. The H1 assessment concluded the need for dispersion modelling of oxides of nitrogen (NO_x) and nitrogen dioxide (NO_2) emissions at the Bromborough site to more precisely assess the air quality at nearby human and ecological receptors. Emissions of carbon monoxide (CO) have also been modelled for completeness.

Detailed dispersion modelling has been undertaken for operational emissions to air from the existing plant, using ADMS dispersion modelling software. Release rates for NO_x and CO for all plant included within the assessment have been derived using information provided by EMS.

The assessment concludes that, under the anticipated operating profile of plant, all concentrations in air at human and ecological receptors are predicted to be below the relevant assessment level and no exceedances are predicted. In terms of nitrogen and acid deposition at ecological receptors, where exceedances are predicted, these are all due to the existing background concentration; the contribution from the plant is very small and can be described as not significant.

It can be considered, therefore, that the air quality impacts of the plant at the Bromborough Site can be considered as not significant.

Appendices

Appendix A:
ADMS Model Files

Appendix B:
Contour Plots – 2019 met year

Figure B.1 – 99.79th Percentile of 1-hour mean NO_2 Process Contribution Isopleth (µg/m³)

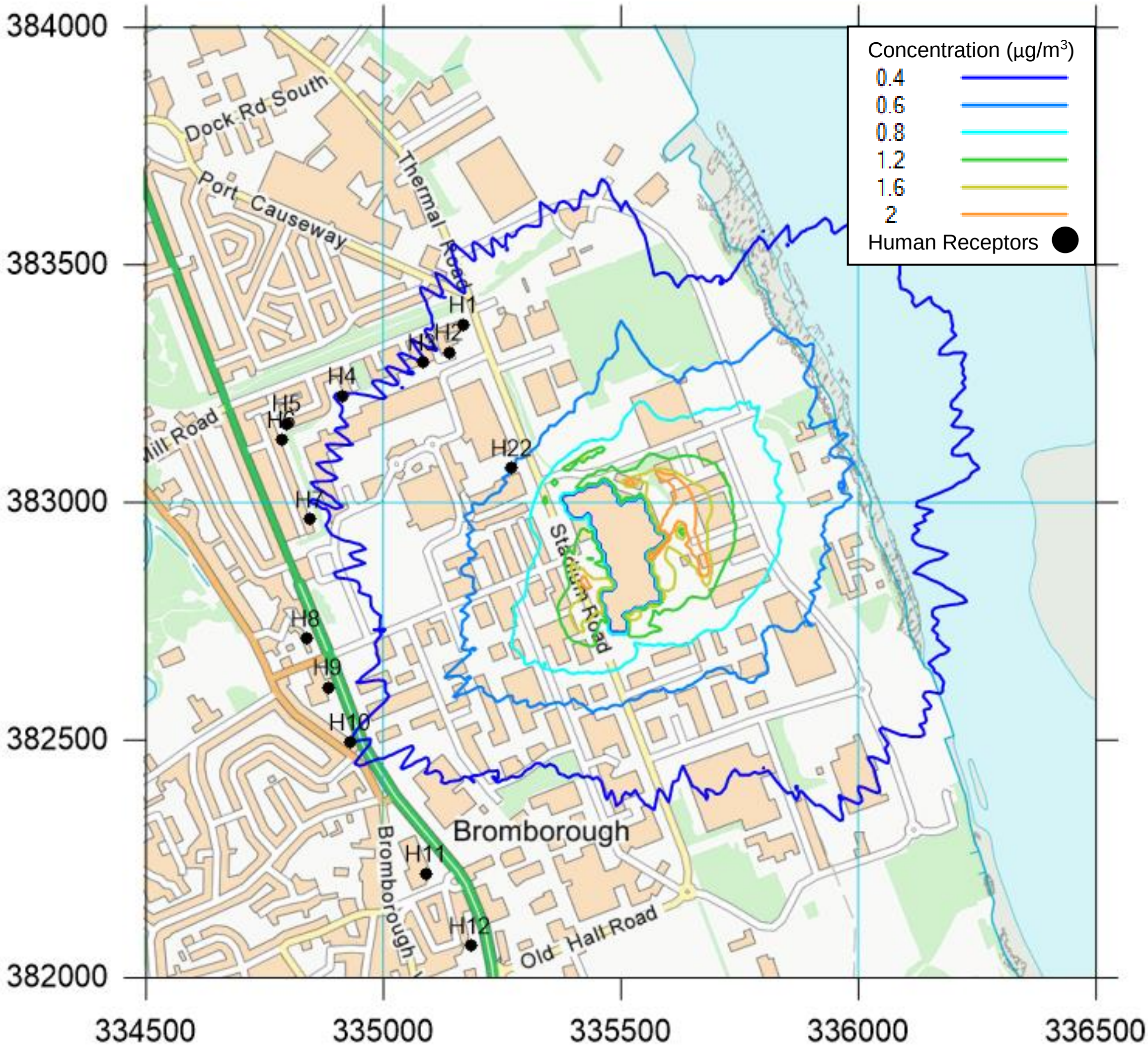


Figure B.2 – 24-hour mean NO_x Process Contribution Isopleth (µg/m³)