Digital Realty

Crawley Campus Data Centre

Air Dispersion Modelling Report

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Table of Contents

List of Tables

List of Figures

Executive Summary

Purpose of Report

Bureau Veritas was commissioned by Digital Realty to undertake an air quality assessment of 17 back-up diesel generators at the Crawley Campus Data Centre ("the site"), located along Manor Royal Road in Crawley, to provide supporting technical information for an Environmental Permit application to operate the site through the Environmental Permitting Regulations (EPR) regime.

The assessment has used detailed dispersion modelling to assess the impacts of emissions to air during back-up generator operation. The site is comprised of two separate Units, each with their own back-up power, therefore the following scenarios have been assessed:

- Unit 1 (LGW15) testing scenarios are as follows:
    1. Monthly testing;
    2. Quarterly testing;
    3. Annual testing; and
    4. 72-hour emergency scenario.
- Unit 2 (LGW16) testing scenarios are as follows:
    1. Monthly testing;
    2. Six-monthly testing;
    3. Quarterly testing;
    4. Load bank test occurring every 2 years; and
    5. 72-hour emergency scenario.
- An additional emergency scenario with both LGW15 and LGW16 generators running for 72 hours was tested.

Each of the generators are operated using diesel as the fuel, hence, the following pollutants were included in the assessment: nitrogen oxides (NO_X), sulphur dioxide (SO_2), carbon monoxide (CO) and particulate matter (PM_{10} and $PM_{2.5}$).

Summary of Conclusions

The assessment has resulted in the following conclusions:

- Considering annual mean results for all scenarios, all results at both human and ecological receptors were below the relevant assessment metric, owing to the minimal annual operating hours of the plant.
- The results for nitrogen deposition show exceedances at all ecological receptors considered in the assessment. However, this is due to the background deposition rate at all receptors exceeding the minimum critical load. When taking the PC, this makes up less

than 1% of the critical loads at all nationally designated ecological receptors considered, and less than 100% at locally designated sites. So, the contribution from the plant can be considered not significant. In the same manner, all results for acid deposition can be described as not significant.

- As such, the plant is not expected to have a significant impact on annual mean pollutant concentrations in the surrounding area.

Regarding LGW15 (Unit 1), the assessment has resulted in the following conclusions:

- Considering short-term results in Scenario 1 (Monthly Testing), all results at human and ecological receptors were below the relevant assessment metrics. The results for Scenario 1 can therefore be considered not significant for human and ecological receptors for Unit 1.

- Considering short-term results in Scenario 2 (Quarterly Testing), all results at human receptors were below the relevant assessment metrics. Exceedances for 24-hour mean NO_X were predicted in this Scenario, however, it is possible that not all the generators will be tested within the same 24-hour period and, as such, these results may be overestimated. Overall, whist this cannot be considered as not significant, there is confidence that the model demonstrates a worst-case assessment and that it is unlikely that exceedances of short-term metrics will occur.

- Short-term results in Scenario 3 (Annual Load Bank Testing), were below the relevant assessment metrics at human and ecological receptors. The results for Scenario 3 can therefore be considered not significant for human and ecological receptors for Unit 1.

- The majority of results for Scenario 4 (Annual Black Building Testing) were below the relevant assessment metrics. However, exceedances were predicted for the 1-hour mean NO_2 metric. Annual testing hours fall below the 18 hours of permissible exceedance for 1-hour mean NO_2 concentrations, so it is not possible that Scenario 4 operation would cause a true exceedance of this metric. In addition, exceedances are also predicted for 24-hour mean NO_X concentrations at ecological receptors for annual testing. For 24-hour mean metrics, it is possible that not all the generators will be tested within the same 24-hour period and as such these results may be overestimated. Exceedances are also predicted for the maximum 1-hour mean NO_2 concentrations at human receptors in regard to the US EPA AEGL 1. AEGL 1 represents the least severe health effects, which are transient and reversible upon cessation of exposure. Overall, whist the results for Scenario 4 testing at ecological receptors cannot be considered as not significant, there is confidence that the model demonstrates a worst-case assessment and that it is unlikely that exceedances of short-term metrics will occur.

- Regarding Scenario 5, (Emergency Operation) exceedances were predicted for 1-hour mean NO_2 concentrations at human receptors. A probability analysis was carried out, taking into account operating hours of Scenario 5, which demonstrated that the probability of a true exceedance was less than 0.01%. Exceedances were also predicted for the maximum 1-hour mean NO_2 concentrations at human receptors in regard to the US EPA AEGL 1, and for the 24-hour mean NO_X concentrations (ecological receptors). However, emergency operation of the plant is extremely unlikely to take place, given that this only applies when there is a loss of main power to the site.

Regarding LGW16 (Unit 2), the assessment has resulted in the following conclusions:

- Considering short-term results in Scenario 1, 2, 3 and 4 for Unit 2, all results at human and ecological receptors were below the relevant assessment metrics. The results for Scenario 1, 2, 3 and 4 can therefore be considered not significant for human and ecological receptors for Unit 2.

- Regarding Scenario 5, (Emergency Operation) exceedances were predicted for 1-hour mean NO_2 concentrations at human receptors. A probability analysis was carried out, taking into account operating hours of Scenario 5, which demonstrated that the probability of a true exceedance was less than 0.01%. Exceedances were also predicted for the 24-hour mean NO_X concentrations (ecological receptors). However, emergency operation of the plant is extremely unlikely to take place, given that this only applies when there is a loss of main power to the site.

Regarding Scenario 6 (Emergency Operation of Units 1 and 2), the assessment has resulted in the following conclusions:

- Exceedances were predicted for 1-hour mean NO_2 concentrations at human receptors. A probability analysis was carried out, taking into account operating hours of Scenario 6, which demonstrated that the probability of a true exceedance was less than 0.01%. Exceedances were also predicted for the maximum 1-hour mean NO_2 concentrations at human receptors in regard to the US EPA AEGL 1, and for the 24-hour mean NO_X concentrations (ecological receptors). However, emergency operation of the plant is extremely unlikely to take place, given that this only applies when there is a loss of main power to the site. In addition, it is extremely unlikely that mains power to both Units will fail concurrently, as they have separate supplies.

1 Introduction

Bureau Veritas have been commissioned by Digital Realty, to undertake an air quality assessment for 17 back-up diesel generators operating at the Crawley Campus data Centre ("the site") located along Manor Royal Road in Crawley. This assessment provides supporting technical information for an Environmental Permit application for the site to operate through the Environmental Permitting Regulations (EPR) regime.

The site is made up of two separate units; Unit 1 (LGW15) and Unit 2 (LGW16), each with their own back-up power supply.

Each of the generators utilise diesel fuel, hence, the following pollutants were included in the assessment: nitrogen oxides (NO_X), sulphur dioxide (SO_2), carbon monoxide (CO) and particulate matter (PM_{10} and $PM_{2.5}$).

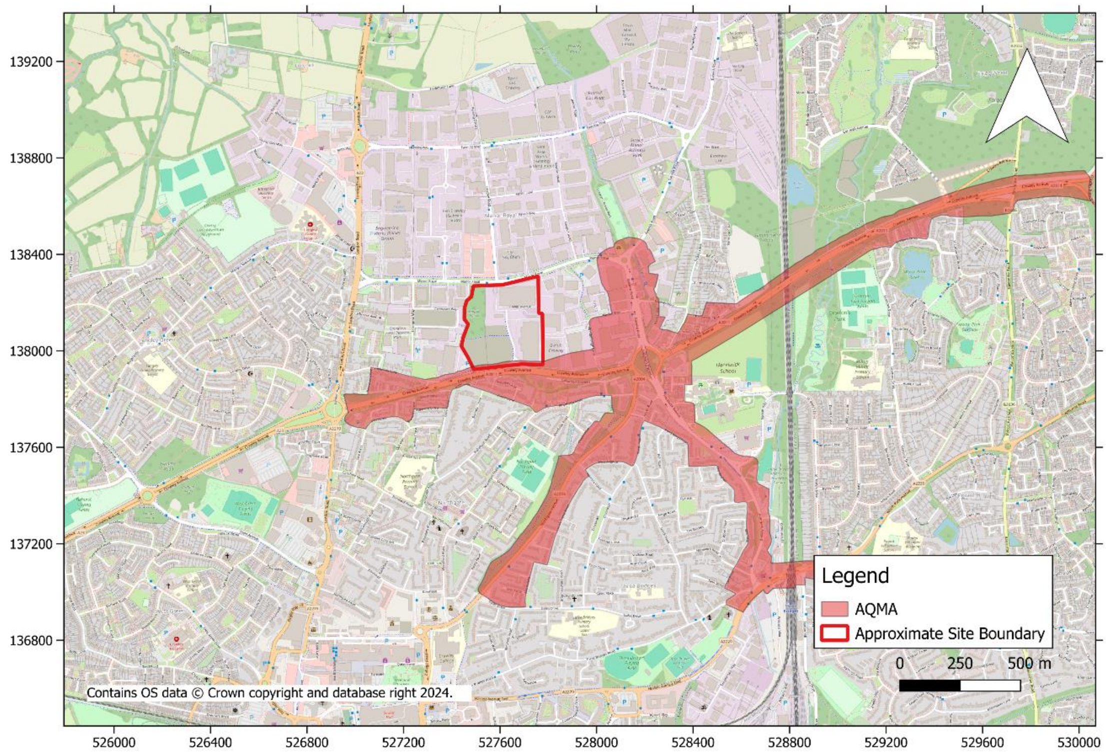
1.1 Site location

The site is located within a business area comprising light industry and commercial units. The site location is shown in Figure 1.1.

The nearest residential properties are located approximately 50 m immediately south of the site on Crawley Avenue. The closest ecological receptor is Punch Copse Ancient Woodland, located approximately 370 m southwest of the site.

In terms of existing air quality conditions in the area, the site is bordered by Crawley Borough Council Air Quality Management Area (AQMA), declared for exceedance of the annual mean Air Quality Objective (AQO) for nitrogen dioxide (NO_2).

Figure 1.1 - Site Location



2 Dispersion Modelling Methodology

ADMS 6 version 6.0.2 modelling software was used for this study. ADMS 6 is an advanced atmospheric dispersion model that has been developed and validated by Cambridge Environmental Research Consultants (CERC). The model was used to predict ground level concentrations of combustion products emitted to atmosphere from the generators at the Redhill site. The model is used extensively throughout the UK for regulatory compliance purposes. It is accepted as an appropriate air quality modelling tool by the Environment Agency (EA) and local authorities.

ADMS 6 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 for the model. This includes, but is not limited to, data describing the local area, meteorological measurements, and emissions data. The data utilised within the modelling assessment is detailed in the following sections of this chapter.

2.1 Process Emissions

Details of the generators at the Crawley Campus site have been provided to Bureau Veritas by the Client. The assessment has assessed the following numbers of generators (gens) across the two buildings (units) at the site:

- LGW15 (Unit 1) – Ten gens total, made up of two gens at 1.2 MW_{th} and five gens at 3.9 MW_{th} (total 33.7 MW_{th}).

- LGW16 (Unit 2) – Seven gens total, each rated at 5.5 MW_{th} (total 38.4 MW_{th}).

The model input parameters for each type of generator are detailed in Table 2.1.

Release rates for PM, NO_X and CO have been derived from information provided by Client, or appropriate library emissions. The release rates for SO_2 have been derived based on the sulphur content of the fuel used for each generator, or by emission rates provided by the Client, where possible.

The calculations which have been undertaken to derive pollutant emission rates from information provided by the generator manufacturers are detailed in Table A1 of Appendix A. Generators' grid locations, provided by the Client, are provided in Table A2 of Appendix A.

2.2 Stack diameter adjustment

Shell and Core Generator A and B are horizontal release stacks and therefore a vertical efflux velocity of 0.1 m/s was assumed to account for reduced vertical momentum. In order to ensure that the volumetric flow of these emissions release points remained constant within the context of the model, it was necessary to adjust the modelled stack diameters to a theoretical stack diameter. The adjusted theoretical stack diameters included in the model are therefore greater than the actual physical stack diameters. In turn, stack downwash was turned off for these sources in line with the ADMS 6.0 user guide recommendations[1]. Point sources with larger diameters are subject to greater stack downwash, and thus stack downwash calculations for an adjusted theoretical stack diameter (required to accommodate an assumed vertical efflux velocity of 0.1 m/s would not be representative of the source in question).

Table 2.1 - Model Input Parameters

Parameter	Cummins QSX15-G8	Cummins QSK60-G3	Cummins QSK60-G22
Number of Generators [a]	2	8	7
Rated Input (MW_{th})	1.2	3.9	5.5
Stack Height (m) [b]	14.5	16	6.8
Stack orientation	Horizontal	Vertical	Vertical
Stack Diameter (mm) [b]	Actual: 600 Calculated: 4807	400	465
Efflux Velocity ($m\ s^{-1}$)	Calculated: 0.1	40.2	50.1
Efflux Temperature (°C)	496 [c]	240 [d]	341 [d]
Emission Concentrations and Rates (per generator) [d]			
NO_x (mg/m^3)	2,158	4,142	3,168
NO_x (g/s)	0.93	5.60	6.03
SO_2 (mg/m^3)	1.2	Data Hall 1 Generator A, B and Data Hall 2 Generator A, B, C, D: 1.5 Data Hall 1 Generator C, D: 0.5 Data Hall 2 Generator C, D: 1.3	37
SO_2 (g/s)	0.0005	Data Hall 1 Generator A, B and Data Hall 2 Generator A, B, C, D: 0.0020 Data Hall 1 Generator C, D: 0.0007 Data Hall 2 Generator C, D: 0.0018	0.07
CO (mg/m^3)	146.6	814	96
CO (g/s)	0.07	0.96	0.18
PM_{10} (mg/m^3)[f]	8.7	2	2
PM_{10} (g/s)	0.004	0.003	0.004

[a] Number of generators provided by Client.
[b] Information provided by Client.
[c] Temperature taken from generator specification sheets.
[d] Temperature assumed from Bureau Veritas' library data.
[e] Emission Rates derived from emission information provided by Client.
[f] Emission Rates derived from library data.

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[1] https://www.cerc.co.uk/environmental-software/assets/data/doc_userguides/CERC_ADMS_6_User_Guide.pdf

9 Ratio of emission between PM_{10} and $PM_{2.5}$ not known, therefore the emission rate for PM_{10} has also been used as a proxy for the emission of $PM_{2.5}$, as a conservative assumption.

The following scenarios have been included in this assessment, based on operating information provided by the Client.

Table 2.2 – Modelled Scenarios

Scenario No.	Unit 1 Testing – Total 10 Gens	Unit 2 Testing – Total 7 Gens
1	**Monthly off load testing** Gens tested individually (10 mins)	**Monthly off load testing** All generators run together (10 mins)
2	**Quarterly testing** Gens tested individually (3 hours)	**Six-monthly testing** Gens tested individually (10 mins)
3	**Load bank testing (annually)** Gens tested individually (1 hour)	**Quarterly testing** All generators run together (10 mins)
4	**Annual black building testing** All generators run together (4 hours)[2]	**Load bank testing (annually)** Gens tested individually (2 hours)
5	All generators run together (72 hours)	All generators run together (72 hours)
6	All gens from both Units run together for 72 hours.	

Since it is not known the exact time during the year when the gensets will operate, the model has assumed that they can operate any hour of the year. However, due to the short-term nature of operation of the plant, results have been post-processed to account for short-term averaging periods, according to the follow:

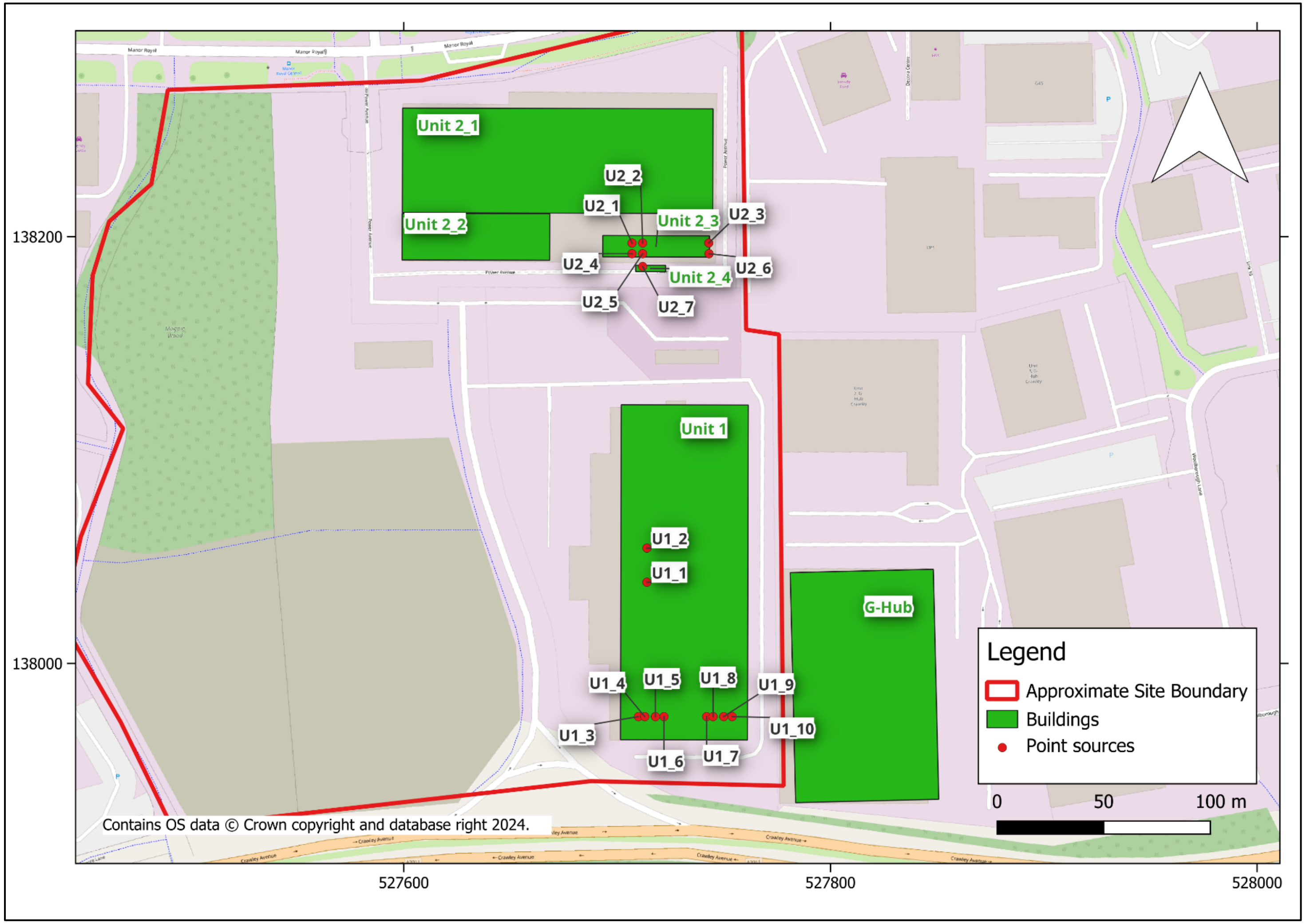
- For annual averaging periods, result have been post-processed using the factor n/8760, where 'n' is the total operating hours within an annual period.
- For averaging periods of 24 hours or 8 hours, results have been post-processed using the factor n/24, or n/8, where 'n' is the total operating hours within the relevant period.
- Where generators are tested for periods less than one hour, results have been post-processed using the factor n/60, where 'n' is the total operating minutes within an hour.

It is understood that Unit 1 and Unit 2 testing is not undertaken on the same day, therefore the maximum number of generators that may be running at any one time will be as a result of testing on Unit 1.

In the event of mains power failure, Unit 1 and Unit 2 have independent power supplies to each unit. It is therefore unlikely that the whole site will lose power completely, and it is extremely unlikely that all generators will need to operate simultaneously.

[2] This represents a worst case, as in reality five generators start and run at same time on a first test and then all ten start and run on a second test. The maximum time allowed is eight hours, albeit historically generators run for around four hours.

Figure 2.1 - Emission Points Visualisation



2.3 Meteorology

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

This assessment has utilised meteorological data recorded at Gatwick airport meteorological station during across a five-year period (2019 to 2023). Gatwick airport meteorological station is located approximately 2.5 km to the north of the site and offers data in a suitable format for the model. Figures 2.2 – 2.6 illustrate the frequency of wind directions and wind speeds for the years considered.

ADMS cannot, as standard, model calm weather conditions, since this results in a discontinuity produced by a 'divide by zero' calculation. Most Gaussian plume models simply skip lines of meteorological data where calm conditions occur. Met lines will also be skipped where any of the required meteorological input parameters are missing. The generally accepted best practice requirement is to ensure that no more than 10% of meteorological data is omitted from the model run.

Table 2.3 demonstrates that this requirement was satisfied for the meteorological data years used for the assessment.

Table 2.3 – Meteorological Data Capture – No Calms

Year	Number of met lines used	Number of lines with calm conditions	Number of lines with inadequate data	Number of non-calm met lines with wind speed less than the minimum value of 0.75 m/s	Percentage of lines used
2019	8148	118	94	400	93%
2020	8305	100	0	379	95%
2021	8103	120	121	416	93%
2022	8191	136	1	432	94%
2023	8350	75	17	318	95%

Figure 2.2 - 2019 Gatwick Airport Wind Rose

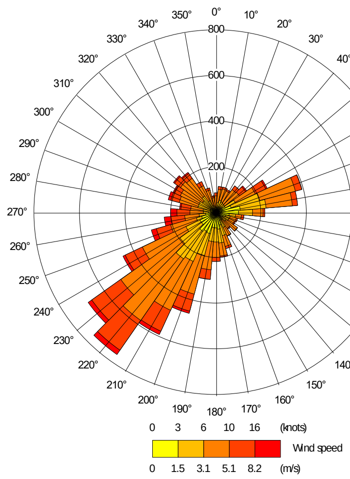


Figure 2.3 - 2020 Gatwick Airport Wind Rose

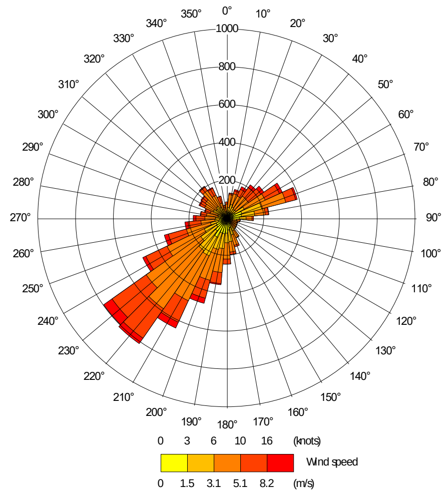


Figure 2.4 - 2021 Gatwick Airport Wind Rose

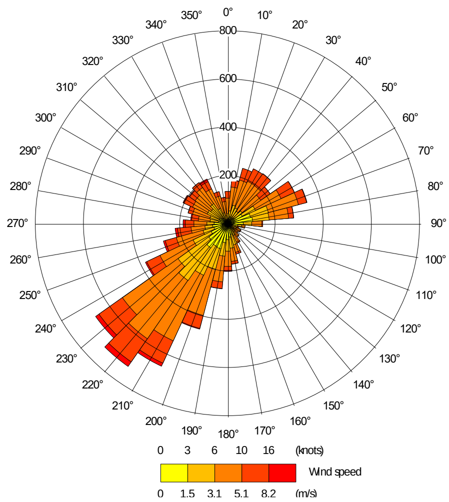


Figure 2.5 – 2022 Gatwick Airport Wind Rose

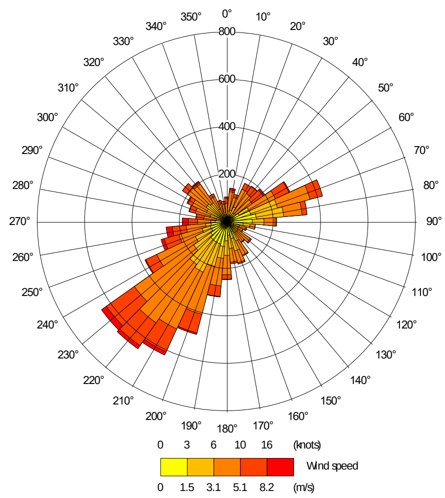
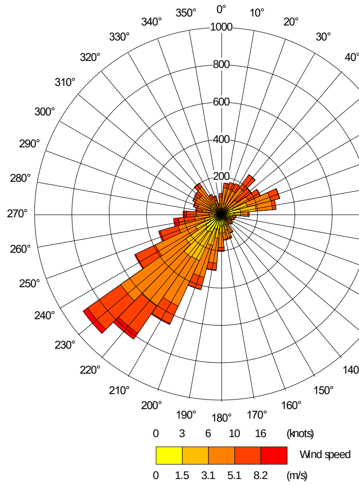


Figure 2.6 - 2023 Gatwick Airport Wind Rose



2.4 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.

Surface Roughness

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

The surface roughness length is related to the height of surface elements; typically, the surface roughness length is approximately 10% of the height of the main surface features. Thus, it follows that surface roughness is higher in urban and congested areas than in rural and open areas. Oke (1987) and CERC (2003) suggest typical roughness lengths for various land use categories (Table 2.4).

Table 2.4 - 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

- 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.

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)

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

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

ℓ_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.

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 them to conclude that, with respect to uncertainty in model predictions:

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

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

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

From examination of 1:10,000 Ordnance Survey maps, it can be seen that within the immediate vicinity of the site, land use is predominately light industrial and residential properties to the south. Consequently, a composite surface roughness length of 1 m has been deemed appropriate to take account of the respective land use categories in the model domain.

2.5 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.

Unit 2 generators are housed within separate containers, which, due to the proximity of the containers to each other, have been included in the model as groups of buildings. In addition, the two units holding the data centres themselves have been modelled.

Details of the buildings included in the model are provided in Table 2.5. Unit 1 was used as the main building in the model for all Unit 1 generators. Unit 2 generator main buildings were adjusted to the relevant Unit 2 buildings.

Table 2.5 - Modelled Buildings

Name	Centre Easting (m)	Centre Northing (m)	Height (m)	Length / Diameter (m)	Width (m)	Angle (º)
Unit 1	527732	138043	14.5	59.5	157.0	90
Unit 2_1	527672	138236	9.0	145.5	49.1	90
Unit 2_2	527634	138200	9.0	69.2	21.8	90
Unit 2_3	527718	138195	6.8	50.0	10.0	90
Unit 2_4	527716	138185	6.8	14.0	3.0	90
G Hub	527816	137989	20.0	67.1	107.9	89

2.6 Terrain

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

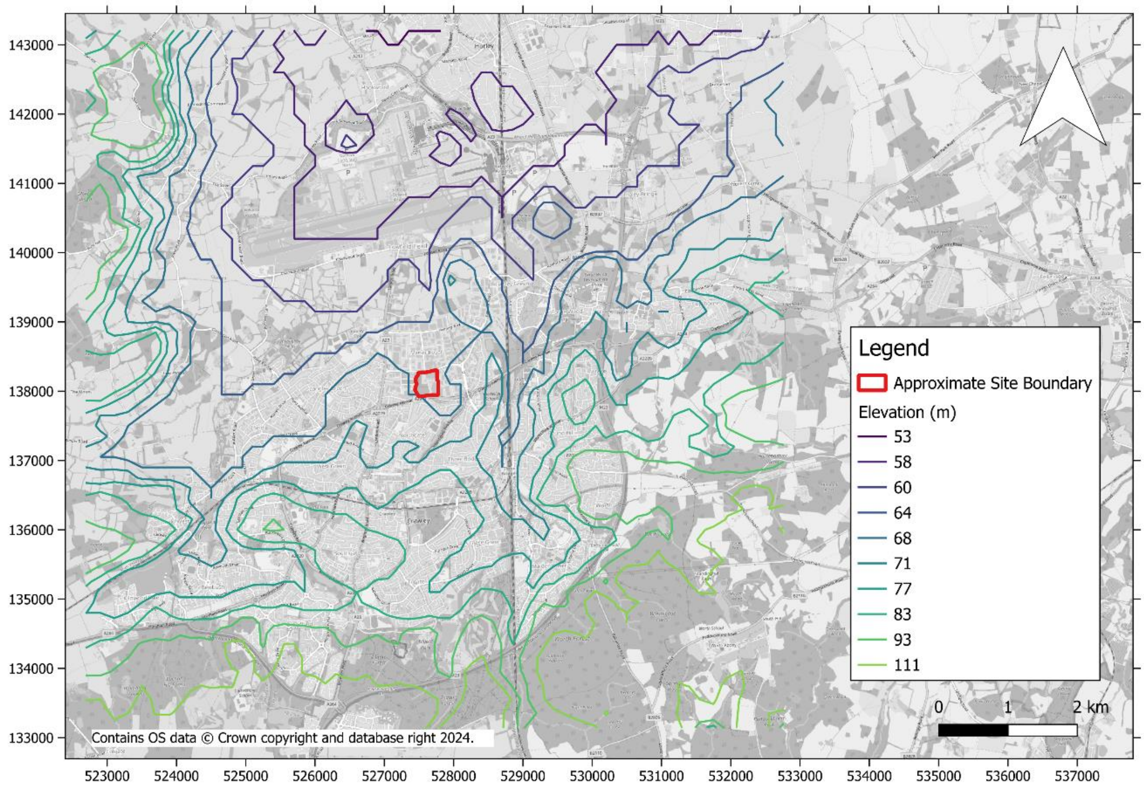
- Plume interactions with windward facing terrain features;
    - Plume interactions with terrain features whereby receptors on hills at a similar elevation to the stack experience elevated concentrations.
    - Direct impaction of the plume on hill slopes in stable conditions.
    - Flow over hills in neutral conditions can experience deceleration forces on the upwind slope, reducing the rate of dispersion and increasing concentrations.
- Plume interactions with lee sides of terrain features; and
    - Regions of recirculation behind steep terrain features can rapidly force pollutants towards the ground culminating in elevated concentrations.
    - Releases into the lee of a hill in stable conditions can also be recirculated, resulting in increased ground level concentrations.
- Plume interactions within valleys.
    - Releases within steep valleys experience restricted lateral dispersion due to the valley sidewalls. During stable overnight conditions, inversion layers develop within the valley essentially trapping all emitted pollutants. Following sunrise and the erosion of the inversion, elevated ground level concentrations can result during fumigation events.
    - Convective circulations in complex terrain due to differential heating of the valley side walls can lead to the impingement of plumes due to crossflow onto the valley sidewalls and the subsidence of plume centrelines, both having the impact of increasing ground level concentrations.

These effects are most pronounced when the terrain gradients exceed 1 in 10, i.e. a 100 m change in elevation per 1 km step in the horizontal plane.

The area of terrain around the site does not exceed this criterion, however a sensitivity analysis has been undertaken to investigate the impact of modelling with and without terrain on the modelled results. As presented in Table 4.2, the use of terrain leads to higher predicted concentrations. Terrain has therefore been included within the model.

A visual representation of the terrain file used is shown in Figure 2.7.

Figure 2.7 – Terrain File used in the Assessment (site indicated in red)



2.7 Modelled Domain

A 2 km x 2 km Cartesian grid centred on the site was modelled, with an approximate receptor resolution of 20 m, to assess the impact of atmospheric emissions from the site on local air quality. 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.

Human Receptors

The 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 5 of this report. Details of the locations of human receptors are given in Table 2.6 and illustrated Figure 2.8 below. Human receptors have been modelled at a height of 1.5 m, representative of the normal ‘breathing zone’ height.

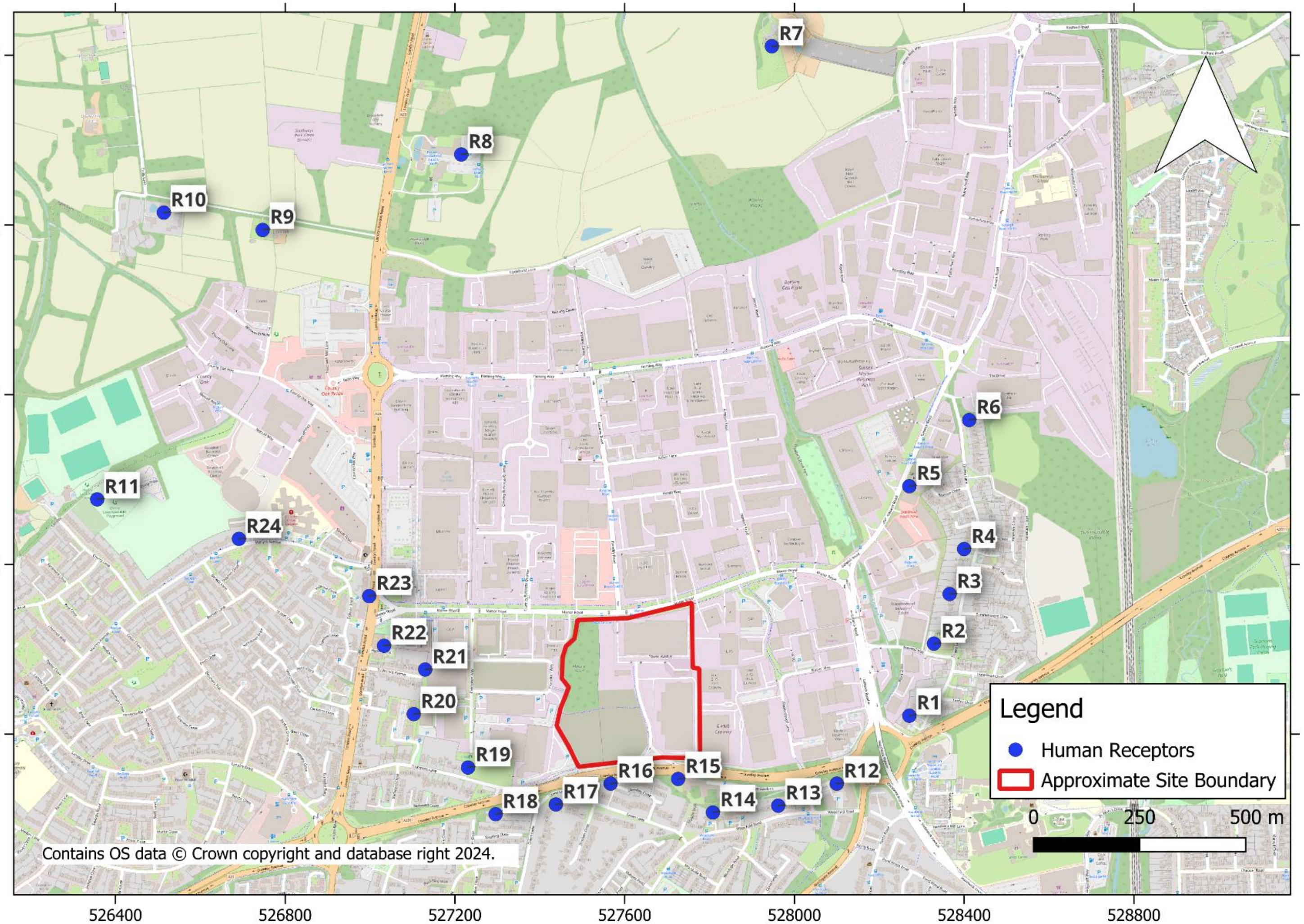
The majority of human receptors are locations where both long-term and short-term pollutant averaging periods will apply (see Table 5.2).

Workplace locations have been excluded in accordance with the guidance from Environmental Protection UK and the Air Quality Standards Regulations 2010. These guidance documents are detailed in Section 5 of this report.

Table 2.6 - Modelled Human Receptors

ID	Receptor Description	Easting (m)	Northing (m)	Height (m)
R1	Residential	528271	138043	1.5
R2	Residential	528329	138213	1.5
R3	Residential	528366	138330	1.5
R4	Residential	528400	138436	1.5
R5	Residential	528271	138584	1.5
R6	Residential	528412	138740	1.5
R7	Residential	527947	139621	1.5
R8	Residential	527215	139366	1.5
R9	Residential	526747	139188	1.5
R10	Residential	526514	139229	1.5
R11	Residential	526357	138553	1.5
R12	Residential	528100	137883	1.5
R13	Residential	527962	137831	1.5
R14	Residential	527808	137815	1.5
R15	Residential	527726	137894	1.5
R16	Residential	527567	137883	1.5
R17	Residential	527438	137834	1.5
R18	Residential	527296	137811	1.5
R19	Residential	527231	137921	1.5
R20	Residential	527103	138047	1.5
R21	Residential	527130	138152	1.5
R22	Residential	527033	138208	1.5
R23	Residential	526998	138325	1.5
R24	Residential	526691	138460	1.5

Figure 2.8 - Location of Modelled Human Receptors



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 Woodlands (AW), Local Wildlife Sites (LWS), Sites of Nature Conservation Importance (SNCIs) and national and Local Nature Reserves (LNR)).

Additionally, the Client provided a site-specific Nature and Heritage Conservation Screening Report undertaken by the Environment Agency (EA)[3]. The report identified ecological sites to be considered in the air quality assessment.

Following the above guidance and the EA's Screening Report, Table 2.7 and Figure 2.9 provide details of the ecological receptor points which have been considered within this assessment.

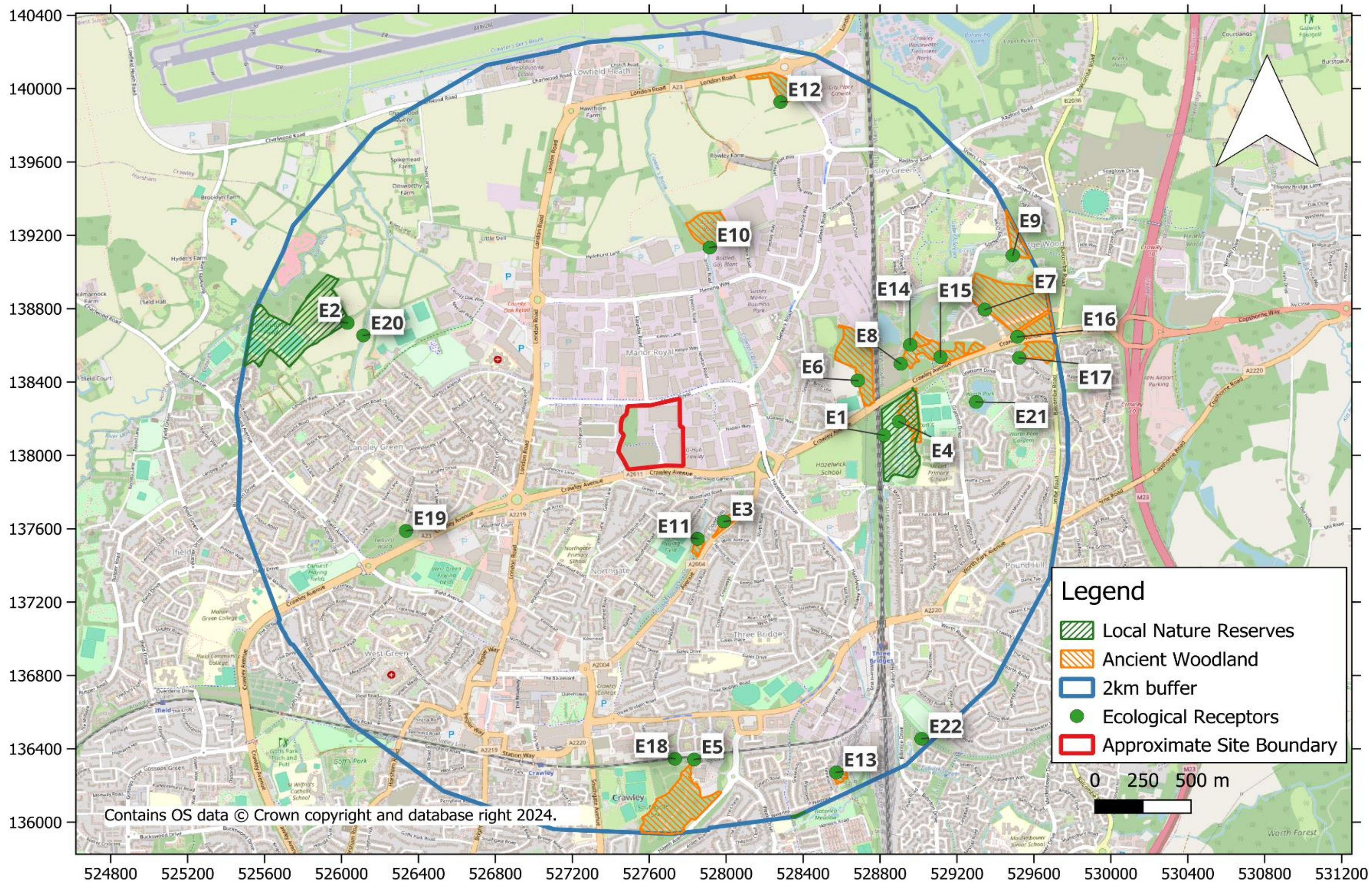
Table 2.7 - Modelled Ecological Receptors

ID	Receptor Description	Easting (m)	Northing (m)	Height (m)
E1	Gratton Park LNR	528820	138109	0
E2	Willoughby Fields LNR	526031	138722	0
E3	Punch Copse AW	527989	137639	0
E4	The Lag Furze Field AW	528899	138184	0
E5	The Hawth AW	527834	136341	0
E6	Summerveres AW	528684	138408	0
E7	Forge Wood Three Acre AW	529345	138795	0
E8	Tinslow AW	528908	138499	0
E9	Titchmeres AW	529491	139091	0
E10	Rowley Wood LWS and AW	527915	139133	0
E11	Unnamed AW	527852	137545	0
E12	Unnamed AW2	528283	139927	0
E13	Unnamed AW3	528573	136271	0
E14	Unnamed AW4	528957	138602	0
E15	Unnamed AW5	529115	138536	0
E16	Unnamed AW6	529515	138646	0

[3] Environment Agency (2021) Nature and Heritage Conservation. Screening Report: Bespoke Installation. Reference EPR/UP3604MT/A001.

E17	Unnamed AW7	529524	138532	0
E18	The Hawth LWS	527734	136345	0
E19	Ewhurst wood LWS	526336	137588	0
E20	Willoughby Fields LWS	526114	138654	0
E21	Gratton Ponds LWS	529300	138291	0
E22	Worthway LWS	529017	136454	0

Figure 2.9 - Location of Assessed Ecological Receptors



2.8 Deposition

The predominant route by which emissions to air will affect land in the vicinity of a process is by deposition of atmospheric emissions. Potential ecological receptors can be sensitive to the deposition of pollutants, particularly nitrogen and sulphur 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 (Environment Agency, 2014) recommends deposition velocities for various pollutants, according to land use classification, as presented in the below table.

Table 2.8 - Recommended Deposition Velocities

Pollutant	Deposition Velocity (m s^{-1})	
	Short Vegetation	Long Vegetation/Forest
NO_X	0.0015	0.003
SO_2	0.012	0.024
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})

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):

- 1 keq ha^{-1} y^{-1} = 14 kg N ha^{-1} y^{-1}
- 1 keq ha^{-1} y^{-1} = 32 kg S ha^{-1} y^{-1}

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 2.8) to the modelled annual mean concentrations of NO_X and SO_2. 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).

2.9 Other Treatments

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

2.10 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 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[4]. 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

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

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

Similarly, the assessment has used a NO_X to NO ratio of 30% for long term average concentrations and, 65% for short term concentrations, as detailed in the following section.

3 Existing Ambient Data

3.1 Local Air Quality Management

Crawley Borough Council ("the Council") under its Local Air Quality Management (LAQM) obligations, continually reviews and assesses concentrations of key air pollutants in the borough to ascertain the requirement, or otherwise, to declare an AQMA.

The Council declared an AQMA in 2015 following exceedance of the NO_2 annual mean Air Quality Objectives (AQO). The site borders the AQMA boundary as showed in Figure 1.1.

The most recent publicly available monitoring data has been collated from the Council's Air Quality 2024 Annual Status Report[5], which contains monitoring data for 2019 to 2023.

Continuous Monitoring Data

The Council operated one continuous monitor, located to the east of Gatwick Airport, 3.5 km to the north east of the site. This location is not considered representative of air quality conditions within the model area, and has not been considered further within this assessment.

Passive Monitoring Data

The Council operated 51 non-automatic (passive) monitoring locations in 2023, of which 11 are within 1 km of the site. Table 3.1 contains the annual mean NO_2 concentration results for the diffusion tubes sites within 1 km of the site, for the years 2019 to 2023.

Table 3.1 - NO_2 Diffusion Tube Monitoring Results

Site Name	X	Y	Site Type	Annual Mean Concentration (µg/m^3)				
				2019	2020	2021	2022	2023
CR3	528438	138392	Urban Background	21	16	17	17	13
CR55	528446	138085	Roadside	42	36	35	37	30
CR62	528438	138088	Urban Background	40	34	34	36	29
CR63	528153	137912	Roadside	49	42	42	45	35
CR64	528150	137825	Roadside	38	30	31	31	26
CR69	528443	138082	Urban Background	44	36	36	3	32
CR76	528292	137810	Roadside	35	28	31	29	24
CR77	528362	137812	Roadside	35	28	31	31	25
CR89	527715	137893	Urban Background	22	17	19	18	14
CR105	526940	137831	Roadside	44	36	36	38	32
CR106	527000	138357	Roadside	46	33	37	37	30

Current monitoring results show that recent and current concentrations of NO_2 in the area local to the site are compliant with the annual mean NO_2 annual mean AQOs.

3.2 Defra Mapped Background Concentrations

Defra maintains a nationwide model of existing and future background air quality concentrations at a 1 km grid square resolution. The datasets include annual average concentration estimates for

[5] https://crawley.gov.uk/sites/default/files/2024-08/Annual%20Air%20Quality%20report%202024.pdf

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 at the assessed human and ecological receptor locations have been derived from the Defra background maps for the 1 km grid square in which they are located.

The annual average process contribution is 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 (AQS/O) and the likelihood of an exceedance determined.

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/O. 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 Environment Agency guidance. Those background annual mean concentrations used in the assessment are detailed in Table 3.2.

As NO_X is the sum of NO_2 and NO, background NO concentrations were calculated by subtracting NO_2 background concentrations from NO_X background concentrations.

Table 3.2 - Background Annual Mean Concentrations used in the Assessment

Grid square (E, N)	2023 Annual Mean Pollutant Concentrations (µg/m^3)						
	NO_X [a]	NO_2 [a]	NO [a]	PM_{10} [a]	$PM_{2.5}$ [a]	CO [b]	SO_2 [b]
528500, 138500	22.3	15.9	6.4	14.2	9.5	0.4	5.4
527500, 139500	22.1	15.7	6.4	13.7	9.0	0.4	4.1
526500, 139500	19.1	13.9	5.3	13.3	8.8	0.4	3.9
526500, 138500	17.7	13.0	4.7	13.9	9.6	0.4	4.4
528500, 137500	31.3	20.9	10.3	15.3	10.6	0.4	3.1
527500, 137500	20.0	14.5	5.5	14.6	10.1	0.4	3.0
527500, 138500	28.6	19.5	9.1	14.3	9.7	0.4	6.8
527500, 136500	17.8	13.2	4.7	14.4	9.8	0.4	2.7
529500, 138500	20.2	14.6	5.5	14.4	9.8	0.4	3.5
529500, 139500	18.2	13.3	4.9	13.0	8.8	0.4	3.8
528500, 139500	22.2	15.8	6.4	13.2	8.9	0.5	5.9
528500, 136500	19.5	14.2	5.3	14.3	9.8	0.4	2.8
526500, 137500	18.3	13.4	4.8	14.4	10.0	0.4	2.9
529500, 136500	16.0	11.9	4.1	14.4	10.1	0.4	2.7

[a] 2023 annual mean background concentration of NO_2, NO_X, PM_{10} and $PM_{2.5}$ taken from Defra's UK Air Quality Archive (1 km x 1 km grid squares). 2023 annual mean background concentrations of NO were calculated by subtracting background concentrations of NO_2 from background concentrations of NO_X.

[b] Background concentration of SO_2 taken from Defra's UK Air Quality Archive (1 km x 1 km grid squares) 2001 background maps.

3.3 Background Deposition Rates

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 3.4 provides 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 5 km grid square resolution.

Table 3.3 - Estimated Background Deposition Rate

ID	Background Nitrogen Deposition (kg N ha^{-1} y^{-1})	Background Nitric Acid Deposition (keq ha^{-1} y^{-1})	Background Sulphuric Acid Deposition (keq ha^{-1} y^{-1})
E1	24.07	1.72	0.22
E2	24.09	1.72	0.22
E3	24.16	1.73	0.23
E4	24.07	1.72	0.22
E5	24.16	1.73	0.22
E6	24.07	1.72	0.22
E7	23.97	1.70	0.21
E8	24.07	1.72	0.22
E9	23.91	1.71	0.20
E10	24.19	1.73	0.22
E11	24.16	1.73	0.23
E12	24.05	1.72	0.21
E13	24.13	1.72	0.21
E14	24.07	1.72	0.22
E15	23.97	1.71	0.21
E16	23.97	1.71	0.21
E17	23.97	1.70	0.21
E18	24.16	1.73	0.22
E19	24.06	1.72	0.23
E21	24.09	1.72	0.22
E22	13.34	0.95	0.16

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

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.

4.1 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 parameter resulting in the highest ground level process contribution at any modelled receptor location and are presented in Table 4.1.

Table 4.1 - 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	0.89	0.55

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

4.2 Terrain

A sensitivity analysis has been undertaken to investigate the impact of modelling with and without terrain on the modelled results. Results have been normalised by the value obtained from the parameter resulting in the highest ground level process contribution at any modelled receptor location and are presented in Table 3.5.

Table 4.2 - Terrain Inclusion Sensitivity Analysis

Terrain	Normalised Maximum Ground Level Concentration	
	NO_x Annual Mean	NO_x 99.79 Percentile of 1-Hour Mean
With Terrain	1.00	0.98
Without Terrain	0.87	1.00

From the above predicted ground level concentrations, it can be seen that the inclusion of terrain in the model results in higher concentrations for annual mean and in lower concentrations for 1-hour mean. As exceedances of hourly means are more likely, the model has not used terrain data.

4.3 Surface Roughness

A sensitivity analysis has been undertaken to investigate the impact of modelling with different surface roughness lengths. Results have been normalised by the value obtained from the parameter resulting in the highest ground level process contribution at any modelled receptor location and are presented below.

Table 4.3 – Surface Roughness Sensitivity Analysis

Parameter	Normalised Maximum Ground Level Concentration	
	NO_x Annual Mean	NO_x 99.79 Percentile of 1-Hour Mean
0.3 m	0.89	1.00
0.5 m	0.93	0.99

1 m	0.98	0.97
1.5 m	1.00	0.97

From the above predicted ground level concentrations, it can be seen that for the annual mean averaging period, a surface roughness of 1 m provides the highest results. However, for the 1-hour mean, a surface roughness length of 0.3 m predicts the highest result.

A surface roughness of 1.5 m has been used in the assessment as this is most representative of the land use in the vicinity of the site.

4.4 Meteorological Year Sensitivity Testing

Results in this assessment 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 Section 5.

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 2021 and 2023 provide the worst-case conditions for long-term and short-term means, respectively. However, this can vary by receptor, hence the consideration of the worst-case meteorological year by receptor, as described above.

Table 4.4 - Inter-year Variability in Concentration (Normalised)

Receptor	Annual Mean					1-hour Mean				
	2019	2020	2021	2022	2023	2019	2020	2021	2022	2023
R15	0.63	0.69	1.00	0.70	0.77	0.98	0.95	0.99	0.98	1.00

4.5 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.

In addition to all available input data. this assessment has incorporated a number of worst-case assumptions, as described above, which may 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 Relevant Legislation and Guidance

5.1 UK Legislation

The Air Quality Standards Regulations 2010

The Air Quality Standards Regulations 2010 (the 'Regulations') came into force on the 11th June 2010 and transpose EU 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."*

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. Paragraph 22 of the 2007 Air Quality Strategy, states 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.

Environment Act 2021

The Environment Act 2021 came into force on 9th November 2021, with Part 4 of the Act (and associated Schedules 11 and 12) reserved for matters pertaining to air quality.

The Environment Act 2021 includes amendments to Environment Act 1995 (further detail in Section 5.2) the Clean Air Act 1993 to give Local Authorities more power. It also requires the Secretary of State to set at least one long-term target in relation to air quality and, in addition, a short-term legally binding target to reduce $PM_{2.5}$.

5.2 Local Air Quality Management

Part IV of the Environment Act 1995 requires that Local Authorities periodically review air quality within their individual areas. As previously discussed, this Act has now been amended and supplemented by the Environment Act 2021 Schedule 11. Defra have said: "Responsibility for tackling local air pollution will now be shared with designated relevant public authorities, all tiers of local government and neighbouring authorities."

This process of Local Air Quality Management (LAQM) is an integral part of delivering the Government's AQOs.

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 objectives in the Regulations.

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 Government's AQOs 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 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 AQOs are met.

5.3 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.

Air Quality Guidelines for Europe, the World Health Organisation (WHO)

The updated WHO Global Air Quality Guidelines (WHO, 2021) provides a basis for protecting public health from adverse effects of air pollutants and to eliminate or reduce exposure to those pollutants that are known or likely to be hazardous to human health or well-being. These guidelines are intended to provide guidance and information to international, national and local authorities making risk management decisions, particularly in setting air quality standards.

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, with the exception of NO, these EALs and EQS are equivalent to the AQS and AQOs set in force by the Air Quality Strategy for England, Scotland Wales and Northern Ireland. The EALs for NO have been derived from the old HSE EH40 WELs.

US Environmental Protection Agency (US EPA) Acute Exposure Guideline Levels (AEGLs)

The US EPA provides exposure guidelines designed to help responders deal with emergencies involving chemical spills or other catastrophic events where members of the general public are exposed to a hazardous airborne chemical. AEGL "levels" are dictated by the severity of the toxic effects caused by the exposure, with Level 1 being the least and Level 3 being the most severe. Effects are described as follow[6]:

- Level 1: Notable discomfort, irritation, or certain asymptomatic non-sensory effects. However, the effects are not disabling and are transient and reversible upon cessation of exposure;

- Level 2: Irreversible or other serious, long-lasting adverse health effects or an impaired ability to escape; and

- Level 3: Life-threatening health effects or death.

Annual mean NO_2 concentrations were assessed against the US EPA hourly mean AEGLs 1 to 3[7], as requested by the EA, to evaluate the acute exposure risk assessment (acute exposures are single, non-repetitive exposures that don't exceed 8 hours).

5.4 Air Quality Impacts of the Process

The atmospheric emissions of a number of pollutants have been identified as requiring detailed dispersion modelling. The emitted pollutants of primary concern to the local environment are:

- Oxides of nitrogen (NO_X as NO_2);

- Nitrogen monoxide (NO);

- Carbon monoxide (CO);

[6] US EPA. About Acute Exposure Guideline Levels (AEGLs). Available at: https://www.epa.gov/aegl/about-acute-exposure-guideline-levels-aegls

[7] US EPA. Nitrogen Dioxide - AEGL Program. Available at: https://www.epa.gov/aegl/nitrogen-dioxide-aegl-program

- Particulate matter (PM_{10} and $PM_{2.5}$); and
- Sulphur dioxide (SO_2).

A brief description of each pollutant is given in Table 5.1.

Table 5.1 - Summary of the Pollutants Assessed

Pollutant	Description and effect on human health and the environment	Principal Sources
Oxides of Nitrogen (NO_X) [A, B, C]	Nitrogen dioxide (NO_2) and Nitric oxide (NO) are both collectively referred to as oxides of Nitrogen (NO_X). It is NO_2 that is associated with adverse effects on human health. Most atmospheric emissions are in the form of NO which is converted to NO_2 in the atmosphere through reactions with Ozone. The oxidising properties of NO_2 theoretically could damage lung tissue, and exposure to very high concentrations of NO_2 can lead to inflammation of lung tissue, affect the ability to fight infection. The greatest impact of NO_2 is on individuals with asthma or other respiratory conditions, but consistent impacts on these individuals is at levels of greater than 564 µg/m^3, much higher than typical UK ambient concentrations.	All combustion processes produce NO_X emissions, and the principal source of NO_X is road transport, which accounted for 32% of total UK emissions in 2008. Emissions from power stations contributed a further 20%.
Carbon Monoxide (CO) [B, C]	The toxicity of CO results in it binding avidly to haemoglobin and thus reducing the oxygencarrying capacity of the blood. In very high doses, the restriction of oxygen to the brain and heart can be fatal. At lower concentrations, CO can affect higher cerebral function, heart function and exercise capacity.	The principal source of CO is emissions from petrol vehicles, accounting for 54% of total UK emissions in 2008.
Particulate Matter (PM_{10} and $PM_{2.5}$) [D,F]	Particulate matter is the term used to describe all suspended solid matter. Particulate matter with an aerodynamic diameter of less than 10 µm (PM_{10}) is the subject of health concerns because of its ability to penetrate and remain deep within the lungs. The health effects of particles are difficult to assess, and evidence is mainly based on epidemiological studies. Evidence suggests that there may be associations between increased PM_{10} concentrations and increased mortality and morbidity rates, changes in symptoms or lung function, episodes of hospitalisation or doctors consultations. Recent reviews by the World Health Organisation (WHO) and Committee on the Medical Effects of Air Pollutants (COMEAP) have suggested exposure to a finer fraction of particles ($PM_{2.5}$) give a stronger association with the observed health effects. $PM_{2.5}$ typically makes up around two-thirds of PM_{10} emissions and concentrations.	Road transport, industrial processes and electricity generation. Other pollutants, including NO_2 and SO_2, have the potential to form secondary particulates which are often smaller than PM_{10}.
Sulphur Dioxide (SO_2) [B]	At high concentrations SO_2 is a potent bronchoconstrictor, and asthmatic individuals are more susceptible. It is likely that SO_2 contributes to respiratory symptoms, reduced lung function and rises in hospital admissions. Exposure to high levels of SO_2 over a long period can result in structural changes in the lungs and may enhance sensitisation to allergens.	The principal source of SO_2 is the combustion of fossil fuels containing sulphur and, in the UK, this is primarily through the combustion of coal in power stations, oil refining and solid fuel manufacturing, accounting for 57% of total UK SO_2 emissions in 2008.

A **Defra, 2021, Part IV of the Environment Act 1995 Local Air Quality Management: Technical Guidance LAQM.TG(16).**

B **Harrison, R.M., *Air Pollution: Sources, Concentrations and Measurements*. In: Harrison, R.M., 2000, *Pollution: Causes, Effects and Controls*, 4th Edition Royal Society of Chemistry.**

C **Walters, S. and Ayers, J., *The Health Effects of Air Pollution*. In: Harrison, R.M., 2000, *Pollution: Causes, Effects and Controls*, 4th Edition Royal Society of Chemistry.**

D **Defra, 2007, The Air Quality Strategy for England, Scotland, Wales and Northern Ireland**

5.5 Criteria Appropriate to the Assessment

Table 5.2 sets out those AQS, AQOs and EALs that are relevant to the assessment with regard to human receptors.

Table 5.2 - Air Quality Standards, Objectives and Environmental Assessment Levels

Pollutant	AQS/AQO/ EAL/AEGL	Averaging Period	Value ($\mu g/m^3$)
Nitrogen dioxide (NO_2)	AQS	Annual mean	40
	AQS	1-hour mean, not more than 18 Exceedances a year (equivalent of 99.79 Percentile)	200
	AEGL 1 [a]	1-hour mean (100 Percentile)	956
	AEGL 2 [a]	1-hour mean (100 Percentile)	22,950
	AEGL 3 [a]	1-hour mean (100 Percentile)	38,250
Carbon monoxide (CO)	AQS	8-hour mean	10,000
	EAL	1-hour mean	30,000
PM_{10}	AQS	Annual mean	40
	AQS	24-hour mean, not more than 35 Exceedances per year (90.41 percentile)	50
$PM_{2.5}$	AQS	Annual mean	20
Sulphur dioxide (SO_2)	AQS	1-hour mean not to be exceeded more than 24 times a year (equivalent to 99.73 percentile)	350
	AQS	24-hour mean, not to be exceeded more than 3 times a year (equivalent to 99.18 percentile)	125
	AQO	15-min mean, not to be exceeded more than 35 times a year (equivalent to 99.9 percentile)	266
Nitrogen monoxide (NO)[b]	EAL	1-hour mean (100 percentile)	4,400
	EAL	Annual mean	310

[a] US Environmental Protection Agency (EPA) Acute Exposure Guideline Levels (AEGL) are provided as ppm. They were converted to $\mu g/m^3$ using the European Commission (EC) conversion factor for NO_2 of 1 ppb = 1.9125 $\mu g/m^3$ as recommended by Defra[8].
[b] NO concentrations were assessed against the relevant EALs for NO, which have been derived from the old HSE EH40 Workplace Exposure Levels (WELs).

5.6 Critical Levels and Critical Loads Relevant to the Assessment of Ecological Receptors

A summary of the relevant AQS and EAL that apply to the emissions from the plant and their impact on ecological receptors are given in Table 5.3..

[8] Defra. Frequently Asked Questions. How do you convert ppb into $\mu g/m^3$? Available Online: https://uk-air.defra.gov.uk/air-pollution/faq?question=16

Table 5.3 - Relevant Air Quality Standards and Environmental Assessment Levels for Ecological Receptors

Pollutant	AQS/EAL	Averaging Period	Value ($\mu g/m^3$)
Oxides of nitrogen (NO_X)	AQS	Annual mean	30
Oxides of nitrogen (NO_X)	Target	Daily mean	75
	WHO Assessment Level	Daily mean	200*
Sulphur dioxide (SO_2)	AQS	Annual mean	20
*Where O_3 and SO_2 are not present above their respective critical levels.			

The Air Pollution Information System (APIS) website[9] provides specific information on the potential effects of nitrogen deposition on various habitats and species. This information, relevant to habitats of some of the ecological receptors considered in this assessment, is presented in **Table 5.4**.

Table 5.4 - Typical Habitat and Species Information Concerning Nitrogen Deposition from APIS

AQS/EAL	Averaging Period	Value ($\mu g/m^3$)
Saltmarsh	30-40	Many saltmarshes receive large nutrient loadings from river and tidal inputs. It is unknown whether other types of species-rich saltmarsh would be sensitive to nitrogen deposition. Increase in late-successional species, increased productivity but only limited information available for this type of habitat.
Littoral Sediments Coastal Stable Dune Grasslands	20 - 30	Increase late successional species, increase productivity increase in dominance of graminoids.
	10-20	Foredunes receive naturally high nitrogen inputs. Key concerns of the deposition of nitrogen in these habitats relate to changes in species composition.
Alkaline Fens and Reed beds	10-35	Nitrogen deposition provides fertilization. Increase in tall graminoids (grasses or Carex species) resulting in loss of rare species and decrease in diversity of subordinate plant species.
Temperate and boreal forests	10-20	Increased nitrogen deposition in mixed forests increases susceptibility to secondary stresses such as drought and frost, can cause reduced crown growth. Also can reduce the diversity of species due to increased growth rates of more robust plants.
Hay Meadow	20-30	The key concerns are related to changes in species composition following enhanced nitrogen deposition. Indigenous species will have evolved under conditions of low nitrogen availability. Enhanced Nitrogen deposition will favour those species that can increase their growth rates and competitive status e.g. rough grasses such as false brome grass (Brachypodium pinnatum) at the expense of overall species diversity. The overall threat from competition will also depend on the availability of propagules
Acid Grasslands	10-25	Nitrogen deposition provides fertilization to acid grasslands, this increase robust grass growth that may limit other species reducing diversity.
Raised bog and blanket bog	5-10	Nitrogen deposition provides fertilization, this increase robust vegetation growth that may limit other species reducing diversity
Oak Woodland	10-15	Increased nitrogen deposition in Oak forests increases susceptibility to secondary stresses such as drought and frost, can cause reduced crown growth

9 http://www.apis.ac.uk/

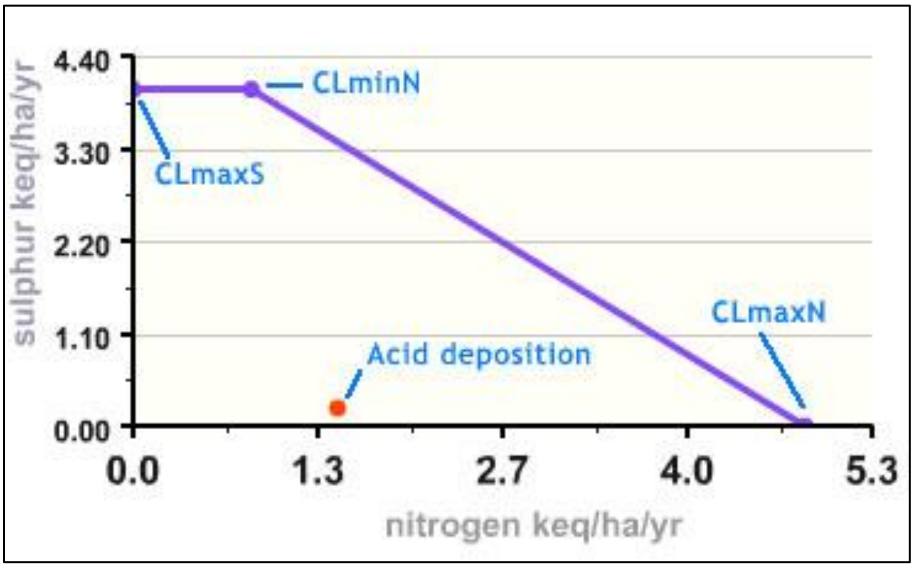
Habitat and Species Specific Information	Critical Load (kg N ha^{-1} yr^{-1})	Specific Information Concerning Nitrogen Deposition

Information relating specifically to acid deposition is provided using three critical load parameters:

- $CL_{max}S$: the maximum critical load of sulphur, above which sulphur alone would be considered to cause an exceedance;
- $CL_{min}N$: a measure of the ability of the habitat/ecosystem to ‘consume’ deposited nitrogen; and
- $CL_{max}N$: the maximum critical load of nitrogen, above which nitrogen alone would be considered to cause an exceedance.

These three parameters define the critical load function, as illustrated in Figure 4.1. The region under the three-node line represents results where critical loads are not exceeded, whereas combinations of deposition above this line would be considered an exceedance.

Figure 5.1 - Critical Load Function (sourced from APIS)



Source: http://www.apis.ac.uk/clf-guidance

6 Assessment Results

This section sets out the results of the dispersion modelling and compares predicted ground level concentrations to ambient air quality standards. 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 Assessment Level (AQAL), i.e. the relevant Air Quality Standard or Objective (AQS/AQO) or Environmental Assessment Level (EAL).

For reference, the scenarios assessed are detailed in Table 6.1.

Table 6.1 – Scenarios Assessed

Scenario No.	Unit 1 Testing – Total 10 Gens	Unit 2 Testing – Total 7 Gens
1	**Monthly off load testing** Gens tested individually (10 mins)	**Monthly off load testing** All generators run together (10 mins)
2	**Quarterly testing** Gens tested individually (3 hours)	**Six-monthly testing** Gens tested individually (10 mins)
3	**Load bank testing (annually)** Gens tested individually (1 hour)	**Quarterly testing** All generators run together (10 mins)
4	**Annual black building testing** All generators run together (4 hours)[10]	**Load bank testing (annually)** Gens tested individually (2 hours)
5	All generators run together (72 hours)	All generators run together (72 hours)
6	All gens from both Units run together for 72 hours.	

Results are presented for the meteorological year resulting in the highest concentrations at any receptor location, as a worst-case assumption. Results that exceed the relevant AQAL are presented in bold within the results tables.

6.1 Model Results for Annual Mean Metrics

Results assessed against annual mean metrics for NO_X, NO_2, PM_{10}, $PM_{2.5}$, SO_2 and NO need to take account total annual running hours for each Scenario, as they can all take place over the corresponding proportion of the year.

As such, results for annual mean metrics have been presented separately to short-term metrics, taking account of the cumulative annual operating hours across the four testing scenarios. Summary results are presented in Table 6.2 for the worst-case receptor for each parameter and are inclusive of Scenarios 1, 2, 3 and 4. Full results tables are contained in Appendix C.

The annual operating hours for Unit 1 and Unit 2 through have been calculated to be as follows:

- Unit 1: total generator hours = 19 hours. Therefore, annual factor: 19/8760 ≈ 0.0022.
- Unit 2: total generator hours = 9 hours. Therefore, annual factor: 9/8760 ≈ 0.0010.

[10] This represents a worst case, as in reality five generators start and run at same time on a first test and then all ten start and run on a second test. The maximum time allowed is eight hours, albeit historically generators run for around four hours.

Annual results have therefore factored Unit 1 generator concentrations and Unit 2 generator concentrations separately, as per the factors above. These have then been summed to provide total annual mean results for the site.

Maximum Annual Mean Concentrations – All Testing Scenarios

The summary results show that annual mean results for NO_2, NO, PM_{10} and $PM_{2.5}$ at human receptors and annual mean results for NO_X and SO_2 at ecological receptors are all comfortably below the relevant AQAL.

In terms of human receptors, the maximum long-term results were at receptor R15, located approximately 50 m to the south of the site. The maximum NO_X results at any ecological receptor (in terms of PEC) is predicted to occur at E6, Summerveres AW, located approximately 940 east of the site. The maximum SO_2 results at any ecological receptor (in terms of PEC) is predicted to occur at E12, representing an unnamed AW, located approximately 1,700 m to the north east of the site.

Table 6.2 - Maximum Annual Mean Concentrations in Air at Human and Ecological Receptors: Unit 1 and 2

Parameter	Annual Mean				
	AQAL µg/m³	PC µg/m³	PEC µg/m³	% PC OF AQAL	% PEC OF AQAL
Human Receptors					
Annual mean NO_2	40	0.32	21.01	0.8	52.5
Annual mean PM_{10}	40	<0.01	15.30	<0.1	38.2
Annual mean $PM_{2.5}$	20	<0.01	10.58	<0.1	52.9
Annual Mean NO	310	0.14	10.37	<0.1	3.3
Ecological Receptors					
Annual mean NO_X	30	0.08	22.33	0.3	74.4
Annual mean SO_2	20	<0.01	5.88	<0.1	19.6
AQAL = Air Quality Assessment Level PC = Process Contribution PEC = Predicted Environmental Concentration (PC + background)					

Deposition Rates at Ecological Receptors – All Testing Scenarios

The impact assessment for ecological receptors also includes an assessment of pollutants deposited to land in the form of nitrogen deposition and acid deposition. These are also based on annual mean metrics, as such, these results are presented in full in Table 6.3 for nitrogen deposition and Table 6.4 for acid deposition.

The results for acid deposition are presented in line with the Critical Load Function Tool as contained on the Air Pollution Information System (APIS) website[11]. As described on APIS: "the Critical Load Function is a three-node line on a graph representing the acidity critical load. Combinations of deposition above this line would exceed the critical load, while all areas below or on the line represent an "envelope of protection" where critical loads are not exceeded". Therefore, where 'no exceedance' is stated with regards to acid deposition, it denotes no exceedance of the critical load function.

[11] http://www.apis.ac.uk/critical-load-function-tool

The results for nitrogen deposition show exceedances at all ecological receptors considered in the assessment. However, this is due to the background deposition rate at all receptors exceeding the minimum critical load (CL). When taking the PC, this makes up less than 1% of the critical loads at all nationally designated ecological receptors considered, and less than 100% at locally designated sites. The contribution from the plant can therefore be considered not significant.

In the same manner, all results for acid deposition can be described as not significant. Habitats within Gratton ponds LWS have been considered to be classified as “fen, marsh and swamps” which are not classified as sensitive to acidity (https://www.apis.ac.uk/).

Table 6.3 - Nitrogen Deposition Rates at Ecological Receptors – All Scenarios: Unit 1 and Unit 2

Receptor ID	CL (kg N ha^{-1} yr^{-1})	PC (kg N ha^{-1} yr^{-1})	%PC of CL_{min}	Background Deposition rate (kg N ha^{-1} yr^{-1})	PEDR (kg N ha^{-1} yr^{-1})	%PEDR of CL_{min}
E1	10	0.01	0.1	24.07	24.08	240.8
E2	10	<0.01	<0.1	24.09	24.09	240.9
E3	10	0.02	0.2	24.16	24.18	241.8
E4	10	0.01	0.1	24.07	24.08	240.8
E5	10	<0.01	<0.1	24.16	24.16	241.6
E6	10	0.01	0.1	24.07	24.08	240.8
E7	10	0.01	0.1	23.97	23.98	239.8
E8	10	0.01	0.1	24.07	24.08	240.8
E9	10	0.01	0.1	23.91	23.92	239.2
E10	10	0.01	0.1	24.19	24.20	242.0
E11	10	0.02	0.2	24.16	24.18	241.8
E12	10	0.01	0.1	24.05	24.06	240.6
E13	10	<0.01	<0.1	24.13	24.13	241.3
E14	10	0.01	0.1	24.07	24.08	240.8
E15	10	0.01	0.1	23.97	23.98	239.8
E16	10	<0.01	<0.1	23.97	23.97	239.7
E17	10	<0.01	<0.1	23.97	23.97	239.7
E18	10	<0.01	<0.1	24.16	24.16	241.6
E19	10	0.01	0.1	24.06	24.07	240.7
E20	10	<0.01	<0.1	24.09	24.09	240.9
E21	10	<0.01	<0.1	13.34	13.34	133.4
E22	10	<0.01	<0.1	24.10	24.10	241.0

CL = Critical load – the CL selected for each designated site relates to its most N-sensitive habitat (or a similar surrogate) listed on the site citation for which data on Critical Loads are available and is also based on a precautionary approach using professional judgement.

PC = Process contribution

PEDR = Predicted environmental deposition rate (PC + background)

Table 6.4 - Acid Deposition Rates at Ecological Receptors - All Scenarios: Unit 1 and Unit 2

Receptor ID	PC	Background	PEC	PC (% of CL function)	PEC (% of CL function)	Impact
E1	<0.01	1.94	1.94	<0.1	64.1	Not significant
E2	<0.01	1.94	1.94	<0.1	64.0	Not significant
E3	<0.01	1.96	1.96	0.1	64.7	Not significant
E4	<0.01	1.94	1.94	<0.1	64.1	Not significant
E5	<0.01	1.95	1.95	<0.1	64.3	Not significant
E6	<0.01	1.94	1.94	<0.1	64.1	Not significant
E7	<0.01	1.91	1.91	<0.1	63.2	Not significant
E8	<0.01	1.94	1.94	<0.1	64.1	Not significant
E9	<0.01	1.91	1.91	<0.1	63.3	Not significant
E10	<0.01	1.95	1.95	<0.1	64.4	Not significant
E11	<0.01	1.96	1.96	<0.1	64.7	Not significant
E12	<0.01	1.93	1.93	<0.1	63.8	Not significant
E13	<0.01	1.93	1.93	<0.1	63.6	Not significant
E14	<0.01	1.94	1.94	<0.1	64.1	Not significant
E15	<0.01	1.92	1.92	<0.1	63.5	Not significant
E16	<0.01	1.92	1.92	<0.1	63.5	Not significant
E17	<0.01	1.91	1.91	<0.1	63.1	Not significant
E18	<0.01	1.95	1.95	<0.1	64.3	Not significant
E19	<0.01	1.95	1.95	<0.1	64.3	Not significant
E20	<0.01	1.94	1.94	<0.1	64.0	Not significant
E21	N/A	N/A	N/A	N/A	N/A	N/A
E22	<0.01	1.92	1.92	<0.1	63.3	Not significant

CL = Critical load – *the CL selected for each designated site relates to its most N-sensitive habitat (or a similar surrogate) listed on the site citation for which data on Critical Loads are available and is also based on a precautionary approach using professional judgement.*

PC = Process contribution

PEC = Predicted Environmental Concentration (PC + background)

6.2 Short-term Model Results for Unit 1 (LGW15)

6.2.1 Unit 1 - Scenario 1 (Monthly Testing)

Table 6.5 details the results of the short-term impact assessment results for the Scenario 1 operation for Unit 1. This is a summary table, providing the maximum result at any receptor for each pollutant and averaging period. The full results are contained within Appendix C.

Table 6.5 indicates that the results for all of short-term assessment metrics are below the relevant AQAL for all human and ecological receptors.

Table 6.5 - Short-term Results at Human and Ecological Receptors for Unit 1 - Scenario 1

Parameter	AQAL µg/m³	PC µg/m³	PEC µg/m³	% PC of AQAL	% PEC of AQAL
Human Receptors					
99.79 percentile 1-hour mean NO_2	200	137.12	166.06	68.6	83.0
90.41 percentile 24-hour mean PM_{10}	50	<0.01	30.59	<0.1	61.2
1-hour mean CO	30,000	87.58	901.47	0.3	3.0
8-hour mean CO	10,000	8.65	889.10	0.1	8.9
99.18 percentile 24-hour mean SO_2	125	<0.01	13.64	<0.1	10.9
99.73 percentile 1 hour mean SO_2	350	0.13	13.66	<0.1	3.9
99.9 percentile 15-minute mean SO_2	266	0.21	13.67	0.1	5.1
100 percentile 1-hour mean NO	4,400	289.67	300.63	6.6	6.8
US EPA AEGL 1 100 percentile 1-hour mean NO_2	956	155.97	184.91	16.3	19.3
US EPA AEGL 2 100 percentile 1-hour mean NO_2	22,950	155.97	184.91	0.7	0.8
US EPA AEGL 3 100 percentile 1-hour mean NO_2	38,250	155.97	184.91	0.4	0.5
Ecological Receptors					
24-hour mean NO_X	75	2.38	45.17	3.2	60.2

6.2.2 Unit 1 - Scenario 2 (Quarterly Testing)

Table 6.6 details the results of the short-term impact assessment results for the Scenario 2 operation for Unit 1. This is a summary table, providing the maximum result at any receptor for each pollutant and averaging period. The full results are contained within Appendix C.

Table 6.6 indicates that the results for most of short-term assessment metrics are below the relevant AQAL for all human and ecological receptors. Exceedances are predicted for the 24-hour mean NO_X concentrations (ecological receptors). However the PC does not exceed the AQAL.

Table 6.6 - Short-term Results at Human and Ecological Receptors for Unit 1 - Scenario 2

Parameter	AQAL μg/m³	PC μg/m³	PEC μg/m³	% PC of AQAL	% PEC of AQAL
Human Receptors					
99.79 percentile 1-hour mean NO_2	200	170.39	199.33	85.2	99.7
90.41 percentile 24-hour mean PM_{10}	50	0.01	30.59	<0.1	61.2
1-hour mean CO	30,000	102.56	901.66	0.3	3.0
8-hour mean CO	10,000	91.66	895.56	0.9	9.0
99.18 percentile 24-hour mean SO_2	125	0.08	13.64	0.1	10.9
99.73 percentile 1 hour mean SO_2	350	0.16	13.66	<0.1	3.9
99.9 percentile 15-minute mean SO_2	266	0.16	13.66	0.1	5.1
100 percentile 1-hour mean NO	4,400	339.23	350.19	7.7	8.0
US EPA AEGL 1 100 percentile 1-hour mean NO_2	956	182.66	211.60	19.1	22.1
US EPA AEGL 2 100 percentile 1-hour mean NO_2	22,950	182.66	211.60	0.8	0.9
US EPA AEGL 3 100 percentile 1-hour mean NO_2	38,250	182.66	211.60	0.5	0.6
Ecological Receptors					
24-hour mean NO_X	75	41.20	**81.10**	54.9	**108.1**

6.2.3 Unit 1 - Scenario 3 (Load Bank Testing)

Table 6.7 details the results of the short-term impact assessment results for the Scenario 3 operation for Unit 1. This is a summary table, providing the maximum result at any receptor for each pollutant and averaging period. The full results are contained within Appendix C.

Table 6.7 indicates that the results for all of short-term assessment metrics are below the relevant AQAL for all human and ecological receptors.

Table 6.7 - Short-term Results at Human and Ecological Receptors for Unit 1 – Scenario 3

Parameter	AQAL μg/m³	PC μg/m³	PEC μg/m³	% PC of AQAL	% PEC of AQAL
Human Receptors					
99.79 percentile 1-hour mean NO_2	200	170.39	199.33	85.2	99.7
90.41 percentile 24-hour mean PM_{10}	50	0.02	30.59	<0.1	61.2

Parameter	AQAL µg/m³	PC µg/m³	PEC µg/m³	% PC of AQAL	% PEC of AQAL
1-hour mean CO	30,000	102.56	901.66	0.3	3.0
8-hour mean CO	10,000	66.41	894.51	0.7	8.9
99.18 percentile 24-hour mean SO_2	125	0.03	13.64	<0.1	10.9
99.73 percentile 1 hour mean SO_2	350	0.16	13.66	<0.1	3.9
99.9 percentile 15-minute mean SO_2	266	0.16	13.66	0.1	5.1
100 percentile 1-hour mean NO	4,400	339.23	350.19	7.7	8.0
US EPA AEGL 1 100 percentile 1-hour mean NO_2	956	182.66	211.60	19.1	22.1
US EPA AEGL 2 100 percentile 1-hour mean NO_2	22,950	182.66	211.60	0.8	0.9
US EPA AEGL 3 100 percentile 1-hour mean NO_2	38,250	182.66	211.60	0.5	0.6
Ecological Receptors					
24-hour mean NO_X	75	14.29	54.20	19.1	72.3

6.2.4 Unit 1 - Scenario 4 (Annual Black Building Testing)

Table 6.8 details the results of the short-term impact assessment results for the Scenario 4 operation for Unit 1. This is a summary table, providing the maximum result at any receptor for each pollutant and averaging period. The full results are contained within Appendix C.

The results indicate that the concentrations for the majority of short-term assessment metrics are below the relevant AQAL. However, exceedances of the 1-hour mean NO_2 AQAL are predicted for the 1-hour mean NO_2 concentrations at human receptors (presented in bold in table).

Since the total annual operating hours for Scenario 4 is 4 hours of operation per year, it is not possible that generator operation in this scenario could cause an exceedance of the 99.79th percentile 1-hour mean, as the operational events are below the 18 permissible hours of exceedance.

Exceedances are also predicted for the maximum 1-hour mean NO_2 concentrations at human receptors in regard to the US EPA AEGL 1 (presented in bold in table). AEGL 1 represents the least severe health effects, which are transient and reversible upon cessation of exposure. Maximum 1-hour mean NO_2 concentrations are well below the AEGL 2 and 3.

Exceedances are also predicted for the 24-hour mean NO_X concentrations (ecological receptors). However the PC does not exceed the AQAL.

Isopleths for the 100 percentile 1-hour mean NO_2, for the annual testing of Unit 1 are presented in Appendix B.

Table 6.8 - Short-term Results at Human and Ecological Receptors for Unit 1 - Scenario 4

Parameter	AQAL µg/m³	PC µg/m³	PEC µg/m³	% PC of AQAL	% PEC of AQAL
Human Receptors					
99.79 percentile 1-hour mean NO_2	200	**810.07**	**839.01**	**405.0**	**419.5**
90.41 percentile 24-hour mean PM_{10}	50	0.08	30.60	0.2	61.2
1-hour mean CO	30,000	513.28	1,281.28	1.7	4.3
8-hour mean CO	10,000	207.70	975.70	2.1	9.8
99.18 percentile 24-hour mean SO_2	125	0.10	13.65	0.1	10.9
99.73 percentile 1 hour mean SO_2	350	0.81	13.77	0.2	3.9
99.9 percentile 15-minute mean SO_2	266	0.86	13.83	0.3	5.2
100 percentile 1-hour mean NO	4,400	1.723.74	1,734.70	39.2	39.4
US EPA AEGL 1 100 percentile 1-hour mean NO_2	956	928.17	**957.10**	97.1	**100.1**
US EPA AEGL 2 100 percentile 1-hour mean NO_2	22,950	928.17	957.10	4.0	4.2
US EPA AEGL 3 100 percentile 1-hour mean NO_2	38,250	928.17	957.10	2.4	2.5
Ecological Receptors					
24-hour mean NO_X	75	57.17	**97.07**	76.2	**129.4**

6.2.5 Unit 1 - Scenario 5 (Emergency Operation)

Table 6.9 details the results of the short-term impact assessment results for the Scenario 4 operation for Unit 1. This is a summary table, providing the maximum result at any receptor for each pollutant and averaging period. The full results are contained within Appendix C.

The results indicate that the concentrations for the majority of short-term assessment metrics are below the relevant AQAL. However, exceedances of the 1-hour mean NO_2 AQAL are predicted for the 1-hour mean NO_2 concentrations at human receptors (presented in bold in table). Therefore, further probability analysis has been undertaken to investigate whether these are 'true' exceedances, given that the metric for short-term NO_2 allows for up to 18 exceedances in a year.

Exceedances are also predicted for the maximum 1-hour mean NO_2 concentrations at human receptors in regard to the US EPA AEGL 1 (presented in bold in table). AEGL 1 represents the least severe health effects, which are transient and reversible upon cessation of exposure. Maximum 1-hour mean NO_2 concentrations are well below the AEGL 2 and 3.

Exceedances are also predicted for the 24-hour mean NO_X concentrations (ecological receptors) However, emergency operation of the plant is extremely unlikely to take place.

Emergency operation is extremely unlikely to occur, as it represents a complete loss of mains power to the site.

Isopleths of PC of 99.79 percentile 1-hour mean NO_2, 100 percentile 1-hour mean NO_2 and 24-hour mean NO_X for the emergency scenario of Unit 1 are presented in Appendix B.

Table 6.9 - Short-term Results at Human and Ecological Receptors for Unit 1 - Scenario 5

Parameter	AQAL µg/m³	PC µg/m³	PEC µg/m³	% PC of AQAL	% PEC of AQAL
Human Receptors					
99.79 percentile 1-hour mean NO_2	200	**810.07**	**839.01**	**405.0**	**419.5**
90.41 percentile 24-hour mean PM_{10}	50	0.45	30.67	0.9	61.3
1-hour mean CO	30,000	513.28	1,281.28	1.7	4.3
8-hour mean CO	10,000	415.39	1,183.39	4.2	11.8
99.18 percentile 24-hour mean SO_2	125	0.62	13.68	0.5	10.9
99.73 percentile 1 hour mean SO_2	350	0.81	13.77	0.2	3.9
99.9 percentile 15-minute mean SO_2	266	0.86	13.83	0.3	5.2
100 percentile 1-hour mean NO	4,400	1,723.74	1,734.70	39.2	39.4
US EPA AEGL 1 100 percentile 1-hour mean NO_2	956	928.17	**957.10**	97.1	**100.1**
US EPA AEGL 2 100 percentile 1-hour mean NO_2	22,950	928.17	957.10	4.0	4.2
US EPA AEGL 3 100 percentile 1-hour mean NO_2	38,250	928.17	957.10	2.4	2.5
Ecological Receptors					
24-hour mean NO_X	75	**343.03**	**382.93**	**457.4**	**510.6**

Probability Analysis – Unit 1 – Scenario 5 (Emergency Operation)

The PEC is predicted to exceed the 99.79 percentile 1-hour mean for NO_2 with predicted values at receptors up to 419.5% of the AQS for Scenario 5 (Emergency Operation) for Unit 1. Under this Scenario, the worst-case operations would occur where all ten U1 generators operate concurrently for up to 72 hours.

The worst-case receptor for the Commissioning Scenario was R15, located to the south of the site. This probability analysis has used the exceedance data output from the worst-case gens for the full hour, in order to demonstrate a worst-case assessment. The meteorological data year resulting in the highest concentrations was 2021, which had 8,760 hours.

The AQMAU 'Diesel generator short term NO_2 Impact assessment[12] details that the hypergeometric distribution, given below, can be used to calculate the probability of the worst-case meteorological conditions and the generator hours of operation occurring at the same time, where:

$$P(X = k) = f(k; N, K, n) = \frac{\binom{K}{k}\binom{N-K}{n-k}}{\binom{N}{n}}$$

N is the population size (the number of hours in a year (8760).

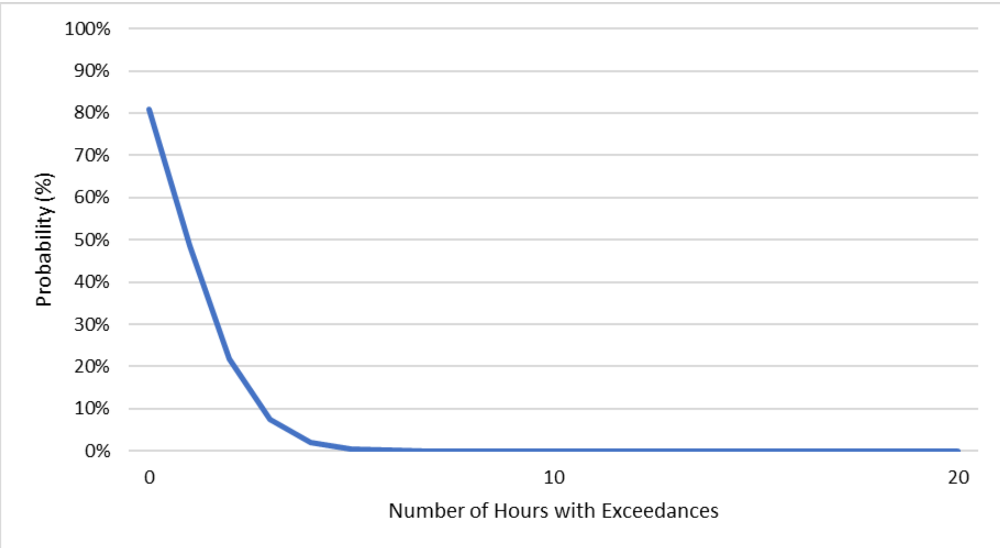
K is the number of success states of the population (the number of meteorological lines in the year that will cause an exceedance).

n is the number of draws (the number of hours of generator operation).

k is the number of observed success (the number of predicted exceedances).

The model has predicted the greatest number of exceedances at the assessed receptors to be 972 of the 8,760 meteorological lines assessed for the year. The hypergeometric distribution has then been used to calculate the probability of those lines coinciding with the hours of operation to cause an exceedance. Figure 6.1 shows the probability of Scenario 5 for Unit 1 resulting in a specific number of exceedances using the hypergeometric distribution. If the Scenario 5 ran for 72 hours, the probability of exceeding the objective more than the 18 allowed exceedances is less than 0.01%. Therefore it is considered that there is no risk of adverse effects from Unit 1 Scenario 5.

Figure 6.1 - Hypergeometric Distribution, Scenario 5 (Emergency Operation – Unit 1)



12 Diesel generator short term NO_2 impact - Air Quality Modelling & Assessment Unit (AQMAU) 2016

6.3 Short-term Model Results for Unit 2 (LGW16)

6.3.1 Unit 2 - Scenario 1 (Monthly Testing)

Table 6.10 details the results of the short-term impact assessment results for the Scenario 1 operation for Unit 2. This is a summary table, providing the maximum result at any receptor for each pollutant and averaging period. The full results are contained within Appendix C.

Table 6.10 indicates that the results for all of short-term assessment metrics are below the relevant AQAL for all human and ecological receptors.

Table 6.10 - Short-term Results at Human and Ecological Receptors for Unit 2 - Scenario 1

Parameter	AQAL µg/m³	PC µg/m³	PEC µg/m³	% PC of AQAL	% PEC of AQAL
Human Receptors					
99.79 percentile 1-hour mean NO_2	200	113.69	142.62	56.8	71.3
90.41 percentile 24-hour mean PM_{10}	50	<0.01	30.59	<0.1	61.2
1-hour mean CO	30,000	13.23	894.42	<0.1	3.0
8-hour mean CO	10,000	0.33	888.15	<0.1	8.9
99.18 percentile 24-hour mean SO_2	125	0.08	13.68	0.1	10.9
99.73 percentile 1 hour mean SO_2	350	3.69	15.72	1.1	4.5
99.9 percentile 15-minute mean SO_2	266	8.52	19.36	3.2	7.3
100 percentile 1-hour mean NO	4,400	283.76	294.72	6.4	6.7
US EPA AEGL 1 100 percentile 1-hour mean NO_2	956	152.79	181.73	16.0	19.0
US EPA AEGL 2 100 percentile 1-hour mean NO_2	22,950	152.79	181.73	0.7	0.8
US EPA AEGL 3 100 percentile 1-hour mean NO_2	38,250	152.79	181.73	0.4	0.5
Ecological Receptors					
24-hour mean NO_x	75	3.3	45.94	4.3	61.3

6.3.2 Unit 2 - Scenario 2 (6-monthly Testing)

Table 6.11 details the results of the short-term impact assessment results for the Scenario 2 operation for Unit 2. This is a summary table, providing the maximum result at any receptor for each pollutant and averaging period. The full results are contained within Appendix C.

Table **6.11** indicates that the results for all of short-term assessment metrics are below the relevant AQAL for all human and ecological receptors.

Table 6.11 - Short-term Results at Human and Ecological Receptors for Unit 2 - Scenario 2

Parameter	AQAL µg/m³	PC µg/m³	PEC µg/m³	% PC of AQAL	% PEC of AQAL
Human Receptors					
99.79 percentile 1-hour mean NO_2	200	32.57	63.12	16.3	31.6
90.41 percentile 24-hour mean PM_{10}	50	<0.01	30.59	<0.1	61.2
1-hour mean CO	30,000	3.80	889.84	<0.1	3.0
8-hour mean CO	10,000	0.33	888.15	<0.1	8.9
99.18 percentile 24-hour mean SO_2	125	0.03	13.65	<0.1	10.9
99.73 percentile 1 hour mean SO_2	350	1.07	14.24	0.3	4.1
99.9 percentile 15-minute mean SO_2	266	1.75	14.74	0.7	5.5
100 percentile 1-hour mean NO	4,400	81.54	92.50	1.9	2.1
US EPA AEGL 1 100 percentile 1-hour mean NO_2	956	43.90	72.84	4.6	7.6
US EPA AEGL 2 100 percentile 1-hour mean NO_2	22,950	43.90	72.84	0.2	0.3
US EPA AEGL 3 100 percentile 1-hour mean NO_2	38,250	43.90	72.84	0.1	0.2
Ecological Receptors					
24-hour mean NO_x	75	1.08	45.04	1.4	60.0

6.3.3 Unit 2 - Scenario 3 (Quarterly Testing)

Table 6.12 details the results of the short-term impact assessment results for the Scenario 3 operation for Unit 2. This is a summary table, providing the maximum result at any receptor for each pollutant and averaging period. The full results are contained within Appendix C.

The Table indicates that the results for all of short-term assessment metrics are below the relevant AQAL for all human and ecological receptors

Table 6.12 - Short-term Results at Human and Ecological Receptors for Unit 2 – Scenario 3

Parameter	AQAL µg/m^3	PC µg/m^3	PEC µg/m^3	% PC of AQAL	% PEC of AQAL
Human Receptors					
99.79 percentile 1-hour mean NO_2	200	37.90	66.83	18.9	33.4
90.41 percentile 24-hour mean PM_{10}	50	<0.01	30.59	<0.1	61.2
1-hour mean CO	30,000	4.41	890.14	<0.1	3.0
8-hour mean CO	10,000	0.11	888.05	<0.1	8.9
99.18 percentile 24-hour mean SO_2	125	0.03	13.65	<0.1	10.9
99.73 percentile 1 hour mean SO_2	350	1.23	14.33	0.4	4.1
99.9 percentile 15-minute mean SO_2	266	5.68	17.45	2.1	6.6
100 percentile 1-hour mean NO	4,400	94.59	105.55	2.1	2.4
US EPA AEGL 1 100 percentile 1-hour mean NO_2	956	50.93	79.87	5.3	8.4
US EPA AEGL 2 100 percentile 1-hour mean NO_2	22,950	50.93	79.87	0.2	0.3
US EPA AEGL 3 100 percentile 1-hour mean NO_2	38,250	50.93	79.87	0.1	0.2
Ecological Receptors					
24-hour mean NO_x	75	1.08	45.04	1.4	60.0

6.3.4 Unit 2 - Scenario 4 (Annual Load Bank Testing)

Table 6.13 details the results of the short-term impact assessment results for the Scenario 4 operation for Unit 2. This is a summary table, providing the maximum result at any receptor for each pollutant and averaging period. The full results are contained within Appendix C.

Table 6.13 indicates that the results for all of short-term assessment metrics are below the relevant AQAL for all human and ecological receptors

Table 6.13 - Short-term Results at Human and Ecological Receptors for Unit 2 - Scenario 4

Parameter	AQAL µg/m^3	PC µg/m^3	PEC µg/m^3	% PC of AQAL	% PEC of AQAL
Human Receptors					
99.79 percentile 1-hour mean NO_2	200	33.94	63.66	17.0	31.8

Parameter	AQAL μg/m³	PC μg/m³	PEC μg/m³	% PC of AQAL	% PEC of AQAL
90.41 percentile 24-hour mean PM_{10}	50	0.01	30.60	<0.1	61.2
1-hour mean CO	30,000	4.09	889.90	<0.1	3.0
8-hour mean CO	10,000	4.07	889.79	<0.1	8.9
99.18 percentile 24-hour mean SO_2	125	0.34	13.79	0.3	11.0
99.73 percentile 1 hour mean SO_2	350	1.11	14.25	0.3	4.1
99.9 percentile 15-minute mean SO_2	266	1.33	14.47	0.5	5.4
100 percentile 1-hour mean NO	4,400	87.82	98.79	2.0	2.2
US EPA AEGL 1 100 percentile 1-hour mean NO_2	956	47.29	76.23	4.9	8.0
US EPA AEGL 2 100 percentile 1-hour mean NO_2	22,950	47.29	76.23	0.2	0.3
US EPA AEGL 3 100 percentile 1-hour mean NO_2	38,250	47.29	76.23	0.1	0.2
Ecological Receptors					
24-hour mean NO_X	75	12.94	52.84	17.2	70.5

6.3.5 Unit 2 - Scenario 5 (Emergency Operation)

Table 6.14 details the results of the short-term impact assessment results for the Scenario 5 operation for Unit 2. This is a summary table, providing the maximum result at any receptor for each pollutant and averaging period. The full results are contained within Appendix C.

The results indicate that the concentrations for the majority of short-term assessment metrics are below the relevant AQAL. However, exceedances of the 1-hour mean NO_2 AQAL are predicted for the 1-hour mean NO_2 concentrations at human receptors (presented in bold in table). Therefore, further probability analysis has been undertaken to investigate whether these are 'true' exceedances, given that the metric for short-term NO_2 allows for up to 18 exceedances in a year.

Exceedances are also predicted for the maximum 1-hour mean NO_2 concentrations at human receptors in regard to the US EPA AEGL 1 (presented in bold in table). AEGL 1 represents the least severe health effects, which are transient and reversible upon cessation of exposure. Maximum 1-hour mean NO_2 concentrations are well below the AEGL 2 and 3.

Exceedances are also predicted for the 24-hour mean NO_X concentrations (ecological receptors) However, emergency operation of the plant is extremely unlikely to take place.

Emergency operation is extremely unlikely to occur, as it represents a complete loss of mains power to the site.

Isopleths of PC of 99.79 percentile 1-hour mean NO_2 and 24-hour mean NO_X for the emergency operation of Unit 2 are presented in Appendix B.

Table 6.14 - Short-term Results at Human and Ecological Receptors for Unit 2 - Scenario 5

Parameter	AQAL µg/m³	PC µg/m³	PEC µg/m³	% PC of AQAL	% PEC of AQAL
Human Receptors					
99.79 percentile 1-hour mean NO_2	200	**227.38**	**256.31**	**113.7**	**128.2**
90.41 percentile 24-hour mean PM_{10}	50	0.12	30.64	0.2	61.3
1-hour mean CO	30,000	24.46	900.84	0.1	3.0
8-hour mean CO	10,000	15.96	895.10	0.2	9.0
99.18 percentile 24-hour mean SO_2	125	4.08	15.42	3.3	12.3
99.73 percentile 1 hour mean SO_2	350	7.37	17.80	2.1	5.1
99.9 percentile 15-minute mean SO_2	266	8.52	19.36	3.2	7.3
100 percentile 1-hour mean NO	4,400	567.51	578.48	12.9	13.1
US EPA AEGL 1 100 percentile 1-hour mean NO_2	956	305.58	334.52	32.0	35.0
US EPA AEGL 2 100 percentile 1-hour mean NO_2	22,950	305.58	334.52	1.3	1.5
US EPA AEGL 3 100 percentile 1-hour mean NO_2	38,250	305.58	334.52	0.8	0.9
Ecological Receptors					
24-hour mean NO_x	75	**155.22**	**195.12**	**207.0**	**260.2**

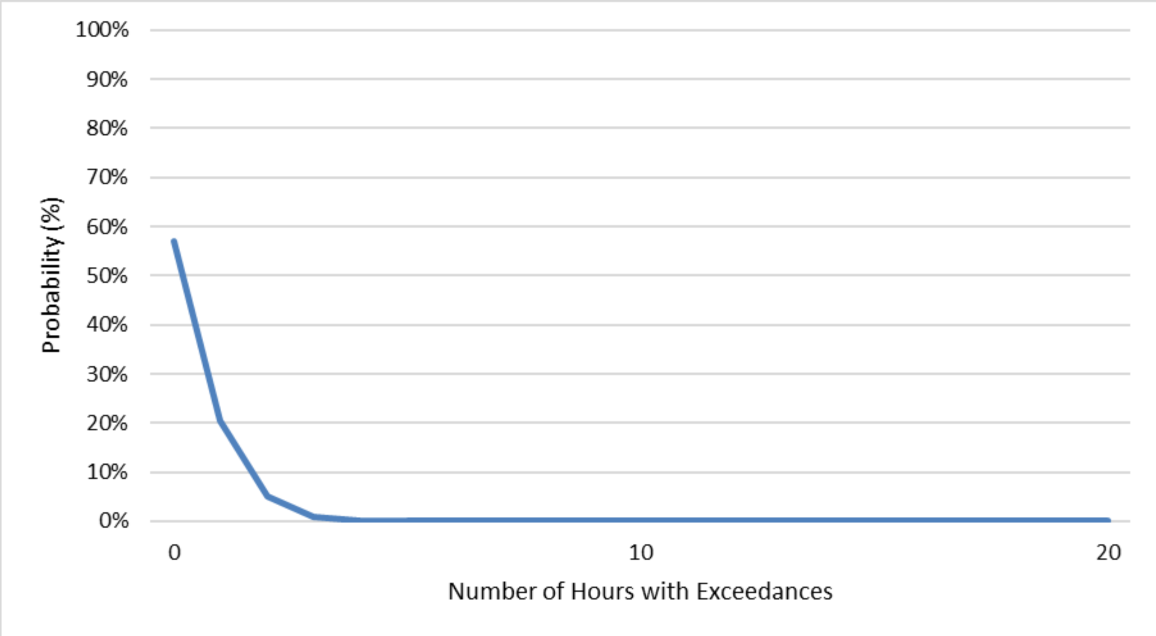
Probability Analysis – Unit 2 - Scenario 5 (Emergency Operation)

The PEC is predicted to exceed the 99.79 percentile 1-hour mean for NO_2 with predicted values at receptors up to 128.2% of the AQS for Scenario 5 (Emergency Operation) for Unit 1. Under this Scenario, the worst-case operations would occur where all seven U2 generators operate concurrently for up to 72 hours.

The worst-case receptor for the Commissioning Scenario was R15, located to the south of the site. This probability analysis has used the exceedance data output from the worst-case gens for the full hour, in order to demonstrate a worst-case assessment. The meteorological data year resulting in the highest concentrations was 2020, which had 8,784 hours.

The model has predicted the greatest number of exceedances at the assessed receptors to be 102 of the 8,784 meteorological lines assessed for the year. The hypergeometric distribution has then been used to calculate the probability of those lines coinciding with the hours of operation to cause an exceedance. Figure 6.2 shows the probability of Scenario 5 for Unit 2 resulting in a specific number of exceedances using the hypergeometric distribution. If the Scenario 5 ran for 72 hours, the probability of exceeding the objective more than the 18 allowed exceedances is less than 0.01%. Therefore it is considered that there is no risk of adverse effects from Scenario 5.

Figure 6.2 - Hypergeometric Distribution, Scenario 5 (Emergency Operation – Unit 2)



6.4 Short-term Model Results for Emergency Scenario 6 (Both Units)

Table 6.15 details the results of the short-term impact assessment results for the Scenario 6 operation for both Units. This is a summary table, providing the maximum result at any receptor for each pollutant and averaging period. The full results are contained within Appendix C.

The results indicate that the concentrations for the majority of short-term assessment metrics are below the relevant AQAL. However, exceedances of the 1-hour mean NO_2 AQAL are predicted for the 1-hour mean NO_2 concentrations at human receptors (presented in bold in table). Therefore, further probability analysis has been undertaken to investigate whether these are 'true' exceedances, given that the metric for short-term NO_2 allows for up to 18 exceedances in a year.

Exceedances are also predicted for the maximum 1-hour mean NO_2 concentrations at human receptors in regard to the US EPA AEGL 1 (presented in bold in table). AEGL 1 represents the least severe health effects, which are transient and reversible upon cessation of exposure. Maximum 1-hour mean NO_2 concentrations are well below the AEGL 2 and 3.

Exceedances are also predicted for the 24-hour mean NO_X concentrations (ecological receptors) However, emergency operation of the plant is extremely unlikely to take place.

Emergency operation is extremely unlikely to occur, as it represents a complete loss of mains power to the site. In addition, it is extremely unlikely that mains power to both Units will fail concurrently, as they have separate supplies.

Isopleths of PC of 99.79 percentile 1-hour mean NO_2, 100 percentile 1-hour mean NO_2 and 24-hour mean NO_X for the emergency operation of both units are presented in Appendix B.

Table 6.15 - Short-term Results at Human and Ecological Receptors for Both Units - Scenario 6

Parameter	AQAL µg/m^3	PC µg/m^3	PEC µg/m^3	% PC of AQAL	% PEC of AQAL
Human Receptors					
99.79 percentile 1-hour mean NO_2	200	**968.54**	**997.48**	**484.3**	**498.7**
90.41 percentile 24-hour mean PM_{10}	50	0.53	30.73	1.1	61.5
1-hour mean CO	30,000	522.25	1,290.25	1.7	4.3
8-hour mean CO	10,000	426.56	1,194.56	4.3	11.9
99.18 percentile 24-hour mean SO_2	125	4.58	15.47	3.7	12.4
99.73 percentile 1 hour mean SO_2	350	7.95	17.83	2.3	5.1
99.9 percentile 15-minute mean SO_2	266	9.11	19.36	3.4	7.3
100 percentile 1-hour mean NO	4,400	1,916.07	1,927.04	43.5	43.8
US EPA AEGL 1 100 percentile 1-hour mean NO_2	956	1,031.73	**1,060.67**	**107.9**	**110.9**
US EPA AEGL 2 100 percentile 1-hour mean NO_2	22,950	1,031.73	1,060.67	4.5	4.6
US EPA AEGL 3 100 percentile 1-hour mean NO_2	38,250	1,031.73	1,060.67	2.7	2.8
Ecological Receptors					
24-hour mean NO_X	75	**493.74**	**533.64**	**658.3**	**711.5**

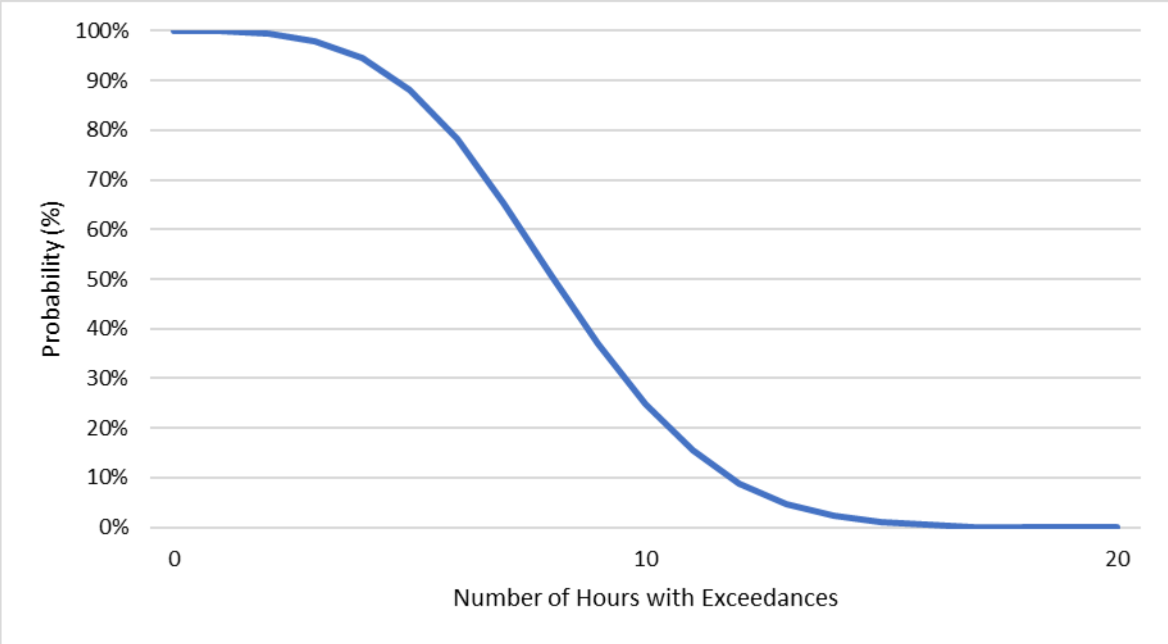
Probability Analysis – Both Units – Scenario 6 (Emergency Operation)

The PEC is predicted to exceed the 99.79 percentile 1-hour mean for NO_2 with predicted values at receptors up to 128.2% of the AQS for Scenario 6 (Emergency Operation) for both Units 1 and 2 Under this Scenario, the worst-case operations would occur where all 17 generators operate concurrently for up to 72 hours.

The worst-case receptor for the Commissioning Scenario was R15, located to the south of the site. This probability analysis has used the exceedance data output from the worst-case gens for the full hour, in order to demonstrate a worst-case assessment. The meteorological data year resulting in the highest concentrations was 2021, which had 8,760 hours.

The model has predicted the greatest number of exceedances at the assessed receptors to be 1,058 of the 8,760 meteorological lines assessed for the year. The hypergeometric distribution has then been used to calculate the probability of those lines coinciding with the hours of operation to cause an exceedance. Figure 6.3 shows the probability of Scenario 6 for both Units resulting in a specific number of exceedances using the hypergeometric distribution. If the Scenario 6 ran for 72 hours, the probability of exceeding the objective more than the 18 allowed exceedances is less than 0.01%. Therefore it is considered that there is no risk of adverse effects from Scenario 6.

Figure 6.3 - Hypergeometric Distribution, Scenario 6 (Emergency Operation – Unit 1 and 2)



7 Conclusions

Bureau Veritas was commissioned by Digital Realty to undertake an air quality assessment of 17 back-up diesel generators at the Crawley Campus Data Centre ("the site"), located along Manor Royal Road in Crawley, to provide supporting technical information for an Environmental Permit application to operate the site through the Environmental Permitting Regulations (EPR) regime.

The assessment has used detailed dispersion modelling to assess the impacts of emissions to air during back-up generator operation, comprising the following scenarios.

Unit 1 (LGW15) testing scenarios are as follows:

- Monthly testing;
- Quarterly testing;
- Annual testing; and
- 72-hour emergency scenario.

Unit 2 (LGW16) testing scenarios are as follows:

- Monthly testing;
- Six-monthly testing;
- Quarterly testing;
- Load bank test occurring every 2 years; and
- 72-hour emergency scenario.

An additional emergency scenario with both LGW15 and LGW16 generators running for 72 hours was tested.

Each of the generators are operated using diesel as the fuel, hence, the following pollutants were included in the assessment: nitrogen oxides (NO_X), sulphur dioxide (SO_2), carbon monoxide (CO) and particulate matter (PM_{10} and $PM_{2.5}$).

The assessment has resulted in the following conclusions:

- Considering annual mean results for all scenarios, all results at both human and ecological receptors were below the relevant assessment metric, owing to the minimal annual operating hours of the plant.

- The results for nitrogen deposition show exceedances at all ecological receptors considered in the assessment. However, this is due to the background deposition rate at all receptors exceeding the minimum critical load. When taking the PC, this makes up less than 1% of the critical loads at all nationally designated ecological receptors considered, and less than 100% at locally designated sites. So, the contribution from the plant can be considered not significant. In the same manner, all results for acid deposition can be described as not significant.

- As such, the plant is not expected to have a significant impact on annual mean pollutant concentrations in the surrounding area.

Regarding LGW15 (Unit 1), the assessment has resulted in the following conclusions:

- Considering short-term results in Scenario 1 (Monthly Testing), all results at human and ecological receptors were below the relevant assessment metrics. The results for Scenario 1 can therefore be considered not significant for human and ecological receptors for Unit 1.

- Considering short-term results in Scenario 2 (Quarterly Testing), all results at human receptors were below the relevant assessment metrics. Exceedances for 24-hour mean NO_X were predicted in this Scenario, however, it is possible that not all the generators will be tested within the same 24-hour period and, as such, these results may be overestimated. Overall, whist this cannot be considered as not significant, there is confidence that the model demonstrates a worst-case assessment and that it is unlikely that exceedances of short-term metrics will occur.

- Short-term results in Scenario 3 (Annual Load Bank Testing), were below the relevant assessment metrics at human and ecological receptors. The results for Scenario 3 can therefore be considered not significant for human and ecological receptors for Unit 1.

- The majority of results for Scenario 4 (Annual Black Building Testing) were below the relevant assessment metrics. However, exceedances were predicted for the 1-hour mean NO_2 metric. Annual testing hours fall below the 18 hours of permissible exceedance for 1-hour mean NO_2 concentrations, so it is not possible that Scenario 4 operation would cause a true exceedance of this metric. In addition, exceedances are also predicted for 24-hour mean NO_X concentrations at ecological receptors for annual testing. For 24-hour mean metrics, it is possible that not all the generators will be tested within the same 24-hour period and as such these results may be overestimated. Exceedances are also predicted for the maximum 1-hour mean NO_2 concentrations at human receptors in regard to the US EPA AEGL 1. AEGL 1 represents the least severe health effects, which are transient and reversible upon cessation of exposure. Overall, whist the results for Scenario 4 testing at ecological receptors cannot be considered as not significant, there is confidence that the model demonstrates a worst-case assessment and that it is unlikely that exceedances of short-term metrics will occur.

- Regarding Scenario 5, (Emergency Operation) exceedances were predicted for 1-hour mean NO_2 concentrations at human receptors. A probability analysis was carried out, taking into account operating hours of Scenario 5, which demonstrated that the probability of a true exceedance was less than 0.01%. Exceedances were also predicted for the maximum 1-hour mean NO_2 concentrations at human receptors in regard to the US EPA AEGL 1, and for the 24-hour mean NO_X concentrations (ecological receptors). However, emergency operation of the plant is extremely unlikely to take place, given that this only applies when there is a loss of main power to the site.

Regarding LGW16 (Unit 2), the assessment has resulted in the following conclusions:

- Considering short-term results in Scenario 1, 2, 3 and 4 for Unit 2, all results at human and ecological receptors were below the relevant assessment metrics. The results for Scenario 1, 2, 3 and 4 can therefore be considered not significant for human and ecological receptors for Unit 2.

- Regarding Scenario 5, (Emergency Operation) exceedances were predicted for 1-hour mean NO_2 concentrations at human receptors. A probability analysis was carried out, taking into account operating hours of Scenario 5, which demonstrated that the probability of a true exceedance was less than 0.01%. Exceedances were also predicted for the 24-hour mean NO_X concentrations (ecological receptors). However, emergency operation of the plant is extremely unlikely to take place, given that this only applies when there is a loss of main power to the site.

Regarding Scenario 6 (Emergency Operation of Units 1 and 2), the assessment has resulted in the following conclusions:

- Regarding Scenario 6, (Emergency Operation of Units 1 and 2) exceedances were predicted for 1-hour mean NO_2 concentrations at human receptors. A probability analysis was carried out, taking into account operating hours of Scenario 6, which demonstrated that the probability of a true exceedance was less than 0.01%. Exceedances were also predicted for the maximum 1-hour mean NO_2 concentrations at human receptors in regard to the US EPA AEGL 1, and for the 24-hour mean NO_X concentrations (ecological receptors). However, emergency operation of the plant is extremely unlikely to take place, given that this only applies when there is a loss of main power to the site. In addition, it is extremely unlikely that mains power to both Units will fail concurrently, as they have separate supplies.

Appendices

Appendix A: Emission Calculations and Model Input Parameters

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Table A1 - Generator Emission Rate Calculations

ID	Source Name	Calculation / Information Source[1]	QSX15-G8	QSK60-G3	
a	**Electrical Output of Generators (kW)**	Provided by Client	440	1650	2200
b	**Efficiency (%)**	Calculated by a/c	36	42	40
c	**Thermal Input (kW)**	Provided by Client	1200	3.9	5500
d	**Discharge Diameter (mm)**	Provided by Client	Actual diameter: 600 Calculated: 4,807	400	465
e	**Discharge Height (m)**	Provided by Client	14.5	16	6.8
f	**Discharge Temperature (ºC)**	Detailed on generator emissions sheet [2], or Data not available, proxy data used based on previous modelling.	496	240	341
g	**Actual O_2 (%)**	Data not available, proxy data used based on previous modelling.	10.3	13.9	12.9
h	**Reference O_2 (%)**	Provided by Client	5	5	5
i	**Net Calorific Value of Diesel (MJ/kg)**	Heat Values of various fuels (http://www.world-nuclear.org/information-library/facts-and-figures/heat-values-of-various-fuels.aspx)	42.8	42.8	42.8
j	**Fuel Required to provide energy input (kg/s)**	Calculated by **c/i/1000**	0.03	0.09	0.13
k	**Waste gas from combustion (m^3/kg)**	Oil Fuel Properties http://www.globalcombustion.com/oil-fuel-properties/	11.9	11.9	11.9
l	**Total waste gas at 0% O_2 (m^3/s)**	Calculated by **j*k**	0.345	1.084	1.526
m	**Total waste gas at ambient temperature and 15% O_2 (Reference Conditions (m^3/s))**	Calculated by **l**/((273+15)/273)*(20.9/(20.9-**h**))	0.430	1.35	1.902
n	**Sulphur Content of Diesel Fuel (ppm)**	Provided by Client	9	11 (U1_1, 2, 3, 4, 7, 8) 4 (U1_5, 6) 10 (U1_9, 10)	11

[1] Where equations appear in **bold** in the Calculation / Information Source column these represent values in the table with the relevant labelled IDs in the first column.

Table A2 - Location of Modelled Sources

Source Name	Model ID	Unit	Generator Make	Generator Model	X (m)	Y (m)
Shell and Core Generator A	U1_1	LGW15	Cummins	QSX15-G8	527714	138038
Shell and Core Generator B	U1_2	LGW15	Cummins	QSX15-G8	527714	138054
Data Hall 1 Generator A	U1_3	LGW15	Cummins	QSK60-G3	527710	137975
Data Hall 1 Generator B	U1_4	LGW15	Cummins	QSK60-G3	527713	137975
Data Hall 1 Generator C	U1_5	LGW15	Cummins	QSK60-G3	527718	137975
Data Hall 1 Generator D	U1_6	LGW15	Cummins	QSK60-G3	527722	137975
Data Hall 2 Generator A	U1_7	LGW15	Cummins	QSK60-G3	527742	137975
Data Hall 2 Generator B	U1_8	LGW15	Cummins	QSK60-G3	527745	137975
Data Hall 2 Generator C	U1_9	LGW15	Cummins	QSK60-G3	527750	137975
Data Hall 2 Generator D	U1_10	LGW15	Cummins	QSK60-G3	527754	137975
S1	U2_1	LGW16	Cummins	QSK60-G22	527707	138197
S2	U2_2	LGW16	Cummins	QSK60-G22	527712	138197
S3	U2_3	LGW16	Cummins	QSK60-G22	527743	138197
S4	U2_4	LGW16	Cummins	QSK60-G22	527707	138192
S5	U2_5	LGW16	Cummins	QSK60-G22	527712	138192
S6	U2_6	LGW16	Cummins	QSK60-G22	527743	138192
S7	U2_7	LGW16	Cummins	QSK60-G22	527712	138186

Appendix B:
Pollutant Concentration Isopleths

Figure B1 - 99.79th Percentile of 1 Hourly Mean NO_2 PC isopleth for Unit 1 Scenario 5 (met 2021)

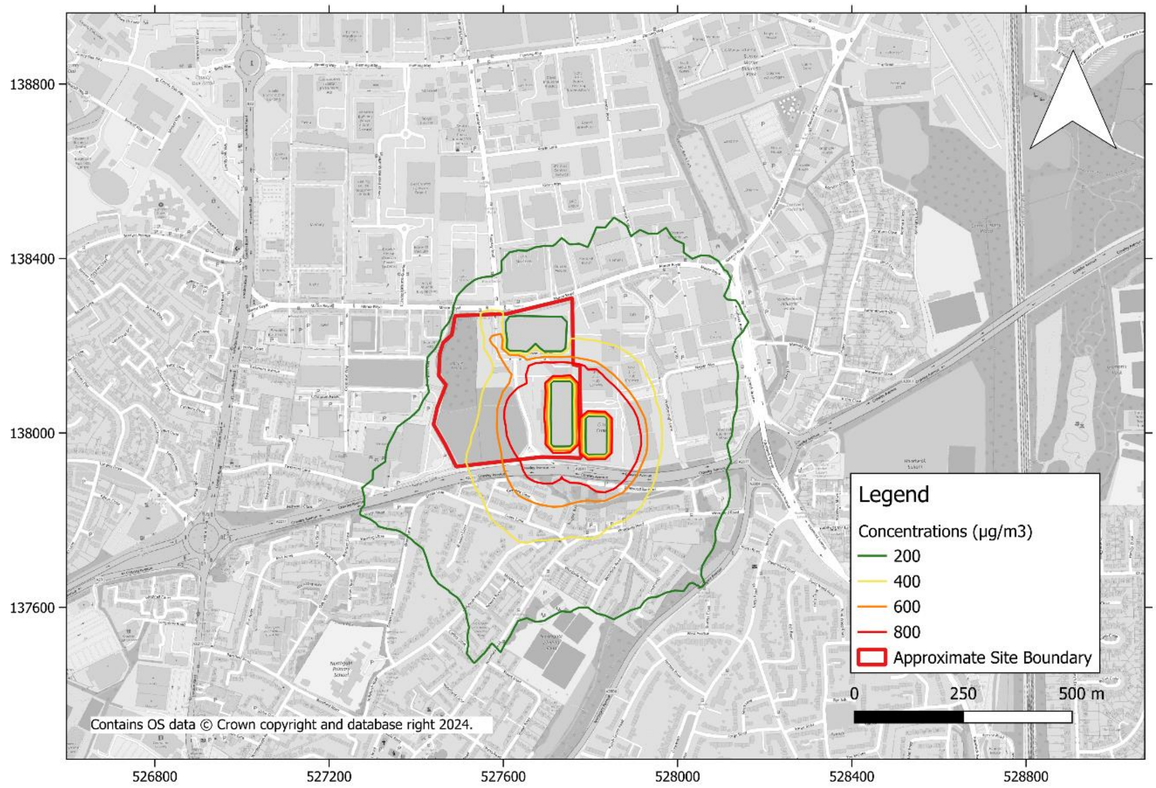


Figure B2 - 24-hour Mean NO_X PC isopleth for Unit 1 Scenario 5 (met 2020)

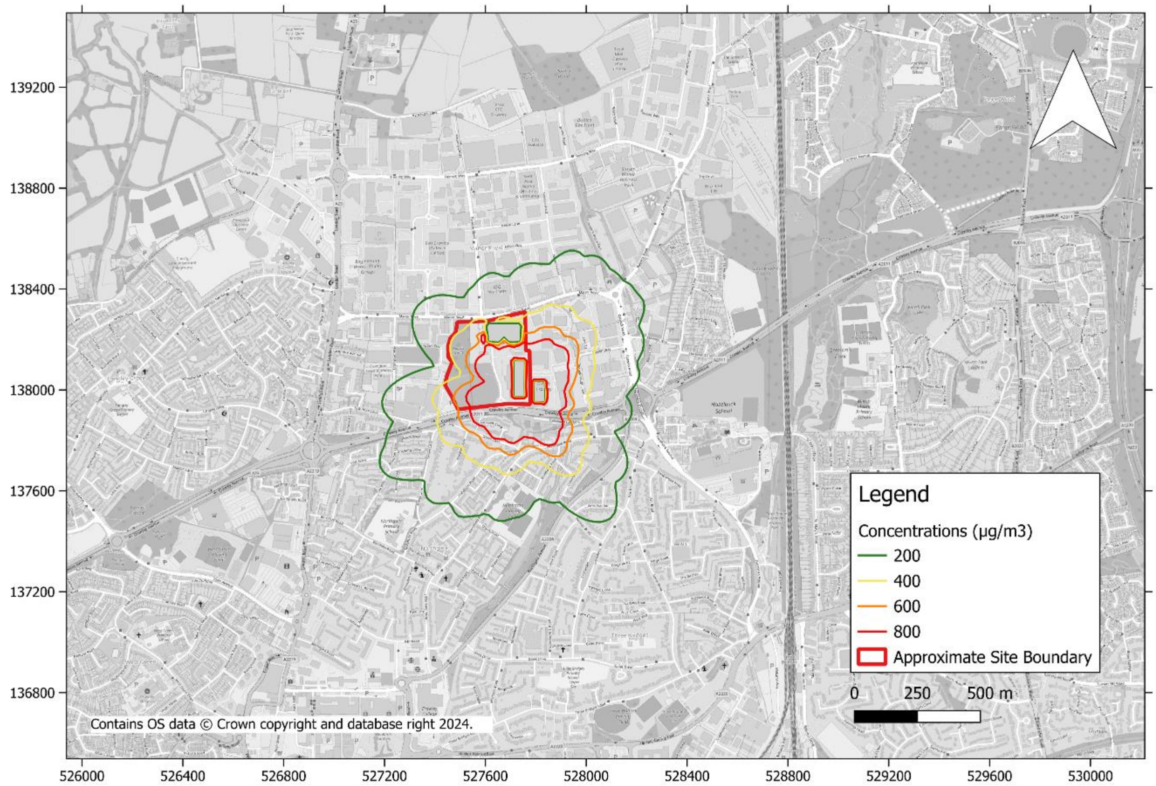


Figure B3 - 100th Percentile of 1 Hourly Mean NO_2 PC isopleth for Unit 1 Scenario 5 (met 2023)

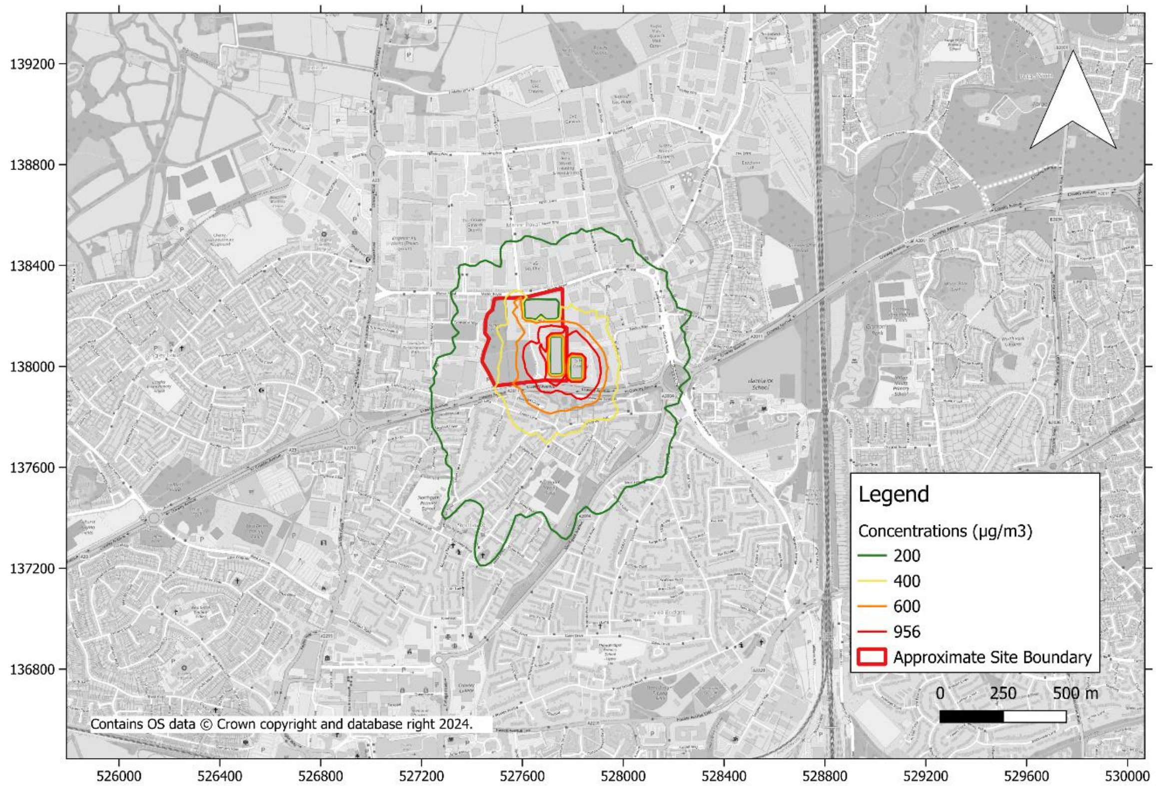


Figure B4 - 99.79th Percentile of 1 Hourly Mean NO_2 PC isopleth for Unit 2 Scenario 5 (met 2021)

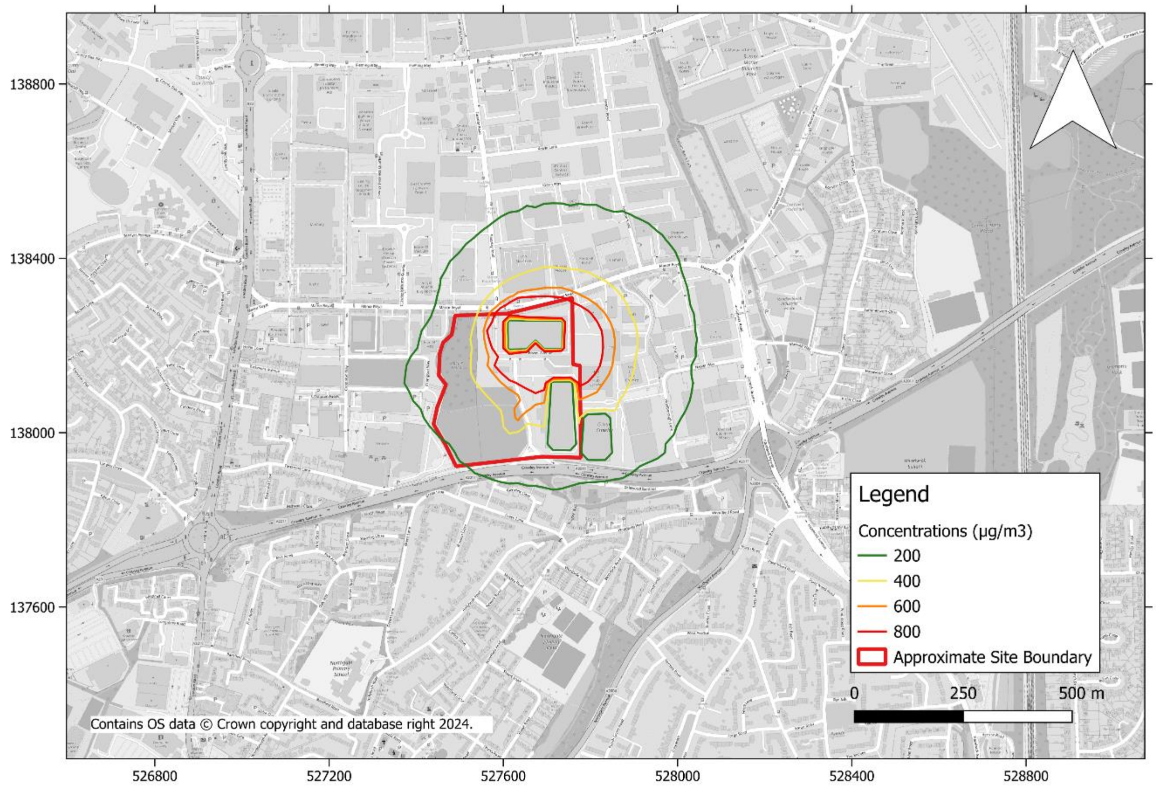


Figure B5 - 24-hour Mean NO_X PC isopleth for Unit 2 Scenario 5 (met 2020)

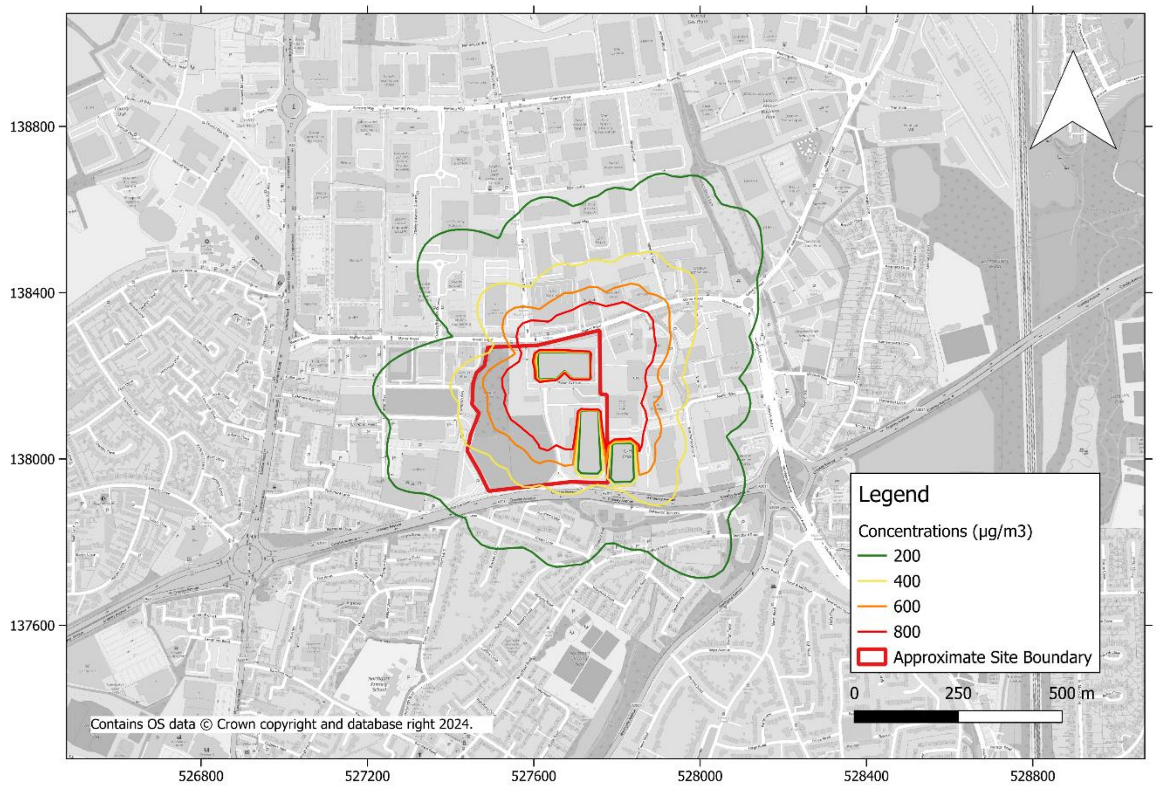


Figure B6 - 99.79th Percentile of 1 Hourly Mean NO_2 PC isopleth for Scenario 6 (met 2021)

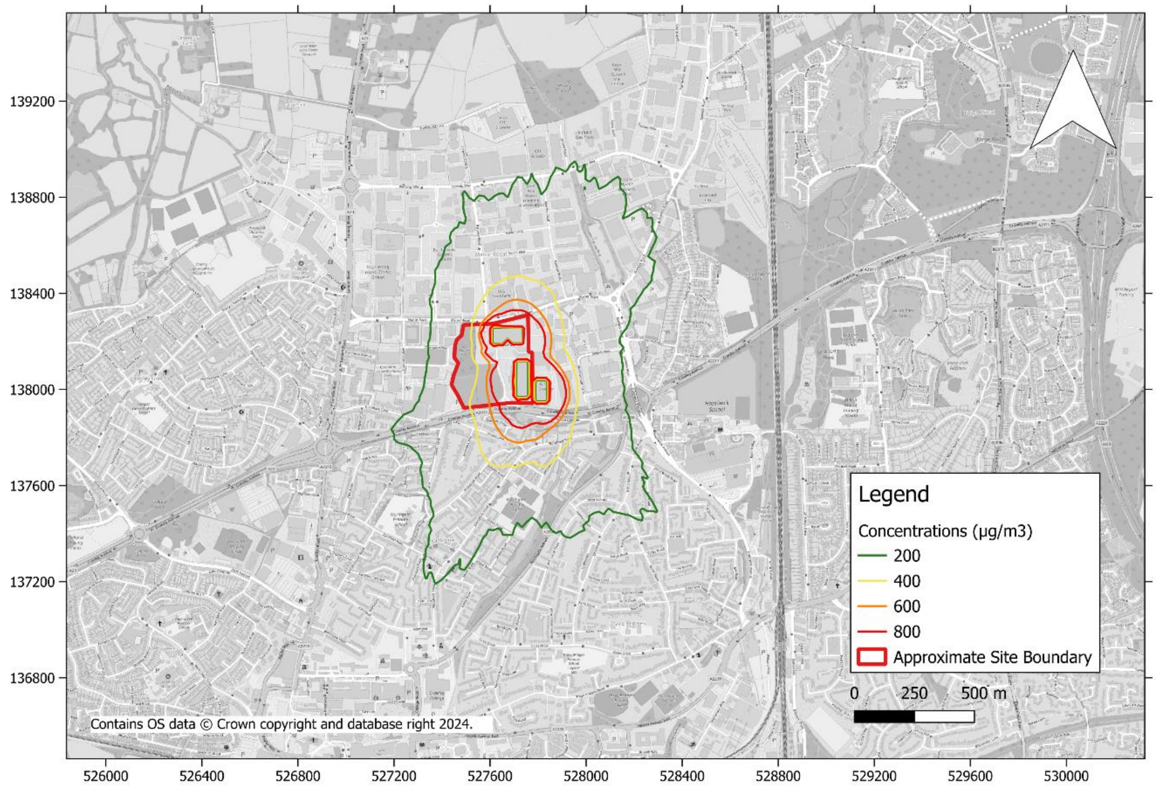


Figure B7 - 24-hour Mean NO_X PC isopleth for Scenario 6 (met 2020)

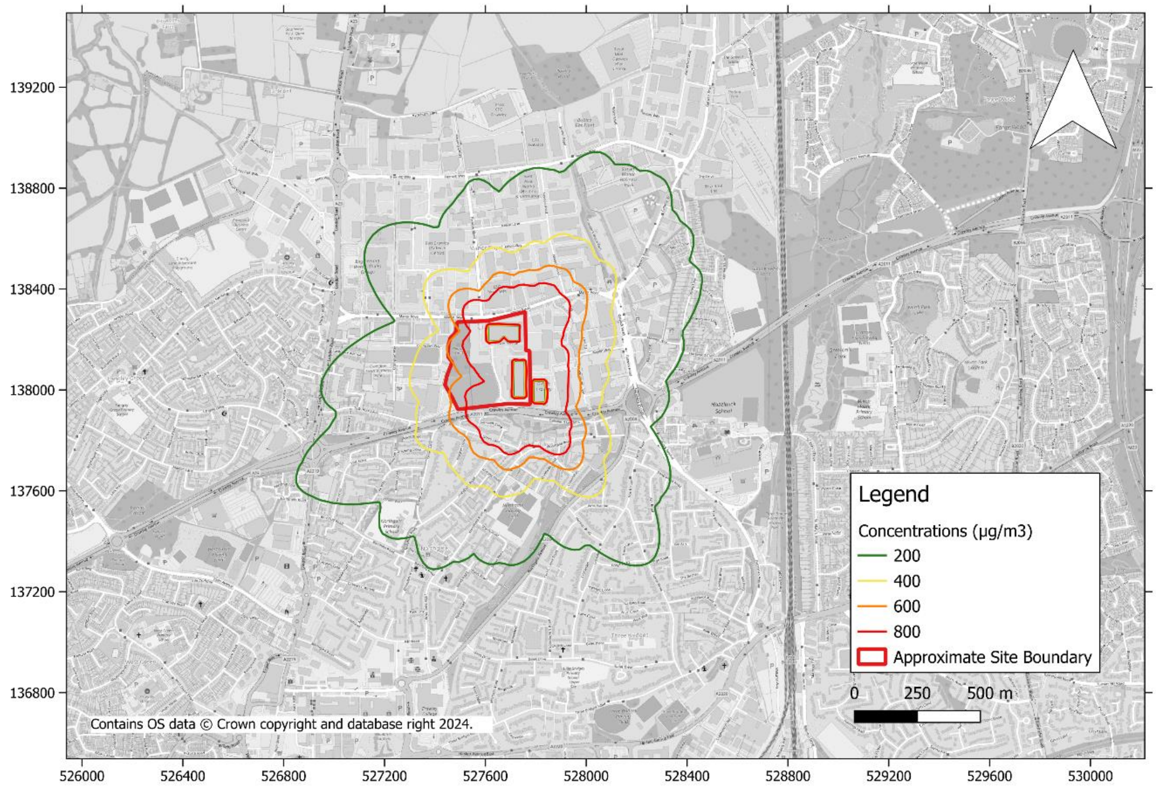
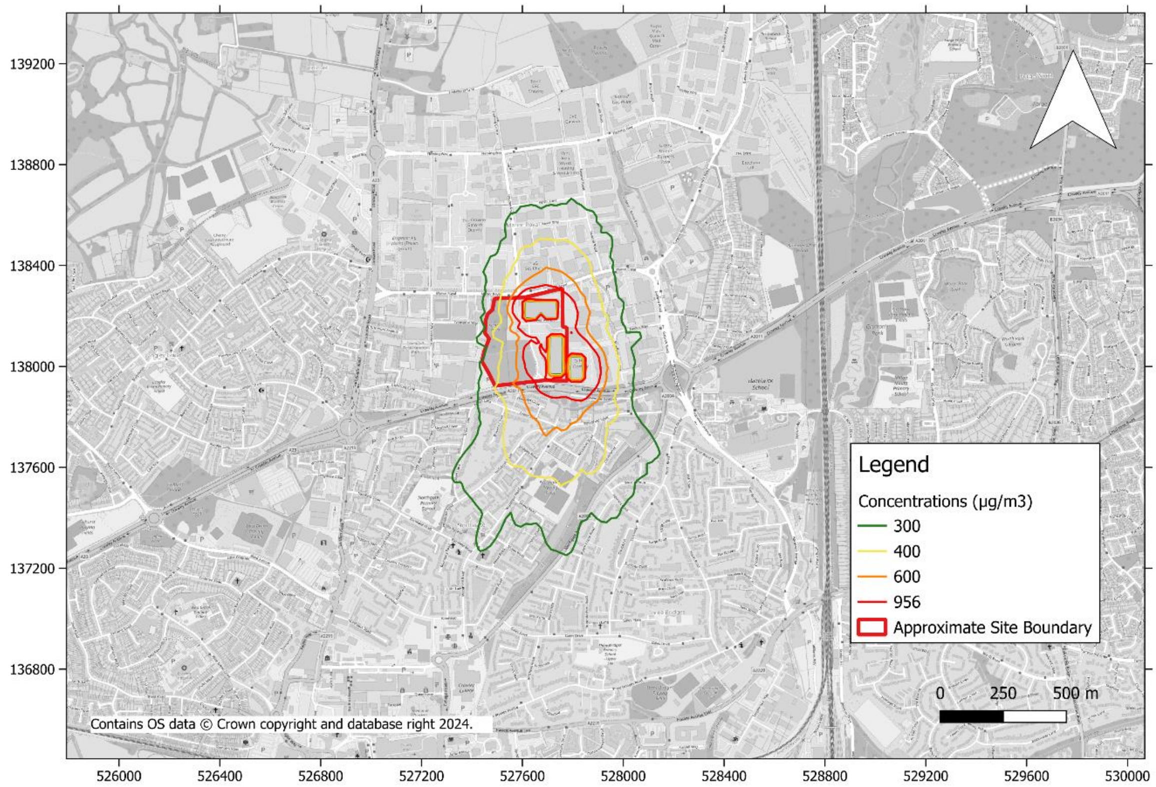


Figure B8 - 100th Percentile of 1 Hourly Mean NO_2 PC isopleth for Scenario 6 (met 2023)



Appendix C: Full Results Tables

Appendix D: Model Files