awnconsulting

The Tecpro Building,
Clonshaugh Business & Technology Park,
Dublin 17, Ireland.

T: + 353 1 847 4220
F: + 353 1 847 4257
E: info@awnconsulting.com
W: www.awnconsulting.com

EQUINIX DB8 ON-SITE POWER GENERATION CUMULATIVE AIR QUALITY ASSESSMENT

Technical Report Prepared For

Red Engineering Design Ltd
1 Lower Farm Barns
Bainton Road
Bucknell
Bicester
OX27 7 LT
UK

Technical Report Prepared By

Dr. Jovanna Arndt
Senior Air Quality Consultant

Our Reference

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Cork Office
Unit 5, ATS Building,
Carrigaline Industrial Estate,
Carrigaline, Co. Cork.
T: +353 21 438 7400
F: +353 21 483 4606

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Name	Dr. Jovanna Arndt	Ciara Nolan
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EXECUTIVE SUMMARY

This report presents a cumulative air quality assessment for a proposed Equinix DB8 on-site power generation (OSPG) facility adjacent to the DB8 data centre site located off the Nangor Road, Grangecastle, Co. Dublin. There will be a total of 10 gas generators on the OSPG facility and 8 no. diesel generators at the adjacent DB8 data centre, with a maximum of 7 no. diesel generators in operation at any one time, which will provide power to the site when power from the OSPG is not available. The cumulative impact of the DB8 gas generators, standby diesel generators, as well as the existing IED licenced sites, and other neighbouring operational data storage facilities in the vicinity of the site was assessed. Air dispersion modelling of operational stage emissions was carried out using the United States Environmental Protection Agency's regulated model AERMOD. The modelling of air emissions from the site was carried out to assess concentrations of nitrogen dioxide (NO_2) at a variety of locations beyond the site boundary.

The cumulative scenario involved the continuous operation (24 hours per day, 365 days per year) of 8 of the 10 no. gas generators, scheduled testing of 8 no. standby diesel generators, emergency operations of the standby diesel generators for 200 hours as per the USEPA methodology, licenced emissions from the IE licenced sites of Takeda, Pfizer and Grange Backup Power, as well as emissions from neighbouring proposed and operational data storage facilities and energy centres.

A methodology has been published by the UK Environment Agency (UK EA) and is based on considering the statistical likelihood of an exceedance of the NO_2 hourly limit value (18 exceedances are allowable per year before the air standard is deemed to have been exceeded). The assessment assumes a hypergeometric distribution to assess the likelihood of exceedance hours coinciding with the operational hours of the standby generators. The guidance also states that there should be no running time restrictions on generators when providing power on site during an emergency. Both the methodology advised in USEPA guidance as well as the approach described in the UK EA guidance have been applied in this study to ensure a robust assessment of predicted air quality impacts from the standby generators.

Assessment Summary

The results indicate that ambient ground level concentrations are in compliance with the relevant air quality standards for NO_2 for all scenarios modelled.

Under the USEPA methodology NO_2 emissions associated with the cumulative assessment of the DB8 gas generators, standby diesel generators, as well as the existing IED licenced sites, and other neighbouring proposed and operational data storage and energy centre facilities in the vicinity of the site are in compliance with the air quality standards. Emissions under this scenario lead to an ambient NO_2 concentration that is 73% of the ambient 1-hour limit value (measured as a 99.8th percentile) and 89% of the ambient annual mean limit value at the worst case off-site receptor for the worst case year.

The UK Environment Agency assessment methodology determined that in the worst-case year, the DB8 gas generators, standby diesel generators, as well as the existing IED licenced sites, and other neighbouring proposed and operational data storage and energy centre facilities in the vicinity of the site, the facility could operate for a maximum of 3,500 hours before there is a likelihood of an exceedance of the ambient air quality standard (at a 98th percentile confidence level). In addition, the UK guidance recommends that there should be no running time restrictions placed on standby generators which provide power on site only during an emergency power outage.

In summary, cumulative impacts on ambient air quality associated with the proposed development, as well as the existing IED licenced sites, and other neighbouring proposed and operational data storage and energy centre facilities in the vicinity of the site, will be in compliance with the ambient air quality standards which are based on the protection of the environment and human health.

CONTENTS

1.0 INTRODUCTION

This report presents a cumulative air quality assessment for the proposed Equinix DB8 on-site power generation (OSPG) facility adjacent to the DB8 data centre site located off the Nangor Road, Grangecastle, Co. Dublin. There will be a total of 10 gas generators on the OSPG facility and 8 no. diesel generators at the adjacent DB8 data centre, with a maximum of 7 no. diesel generators in operation at any one time, which will provide power to the site when power from the OSPG is not available. In addition, a front-of-house (FOH) generator will also be in operation. The cumulative impact of the DB8 gas generators, standby diesel generators, as well as the existing IED licenced sites, and other neighbouring proposed and operational data storage and energy centre facilities in the vicinity of the site was assessed. Air dispersion modelling of operational stage emissions was carried out using the United States Environmental Protection Agency's regulated model AERMOD. The modelling of air emissions from the site was carried out to assess concentrations of nitrogen dioxide (NO_2) at a variety of locations beyond the site boundary.

The assessment was carried out to determine the cumulative ambient air quality impact of the site and any air quality constraints that may be present. The modelling assessment is based on the continuous operation of 8 of the 10 gas generators at 100% load whilst the diesel generators will be used solely for emergency operation (i.e. less than 500 hours per year) and thus the emission limit values outlined in the Medium Combustion Plant Directive are not applicable to the diesel generators on site. The cumulative scenario also included licenced emissions from IE sites of Takeda, Pfizer and Grange Backup Power, as well as emissions from neighbouring proposed and operational data storage facilities and energy centres.

The site is located in Grange Castle International Business Park, Clondalkin, Dublin 22 which is approximately 13km from Dublin city centre. Most of the land surrounding the site is occupied by industrial campuses including pharmaceutical, data centre, manufacturing and commercial uses (see Figure 1).

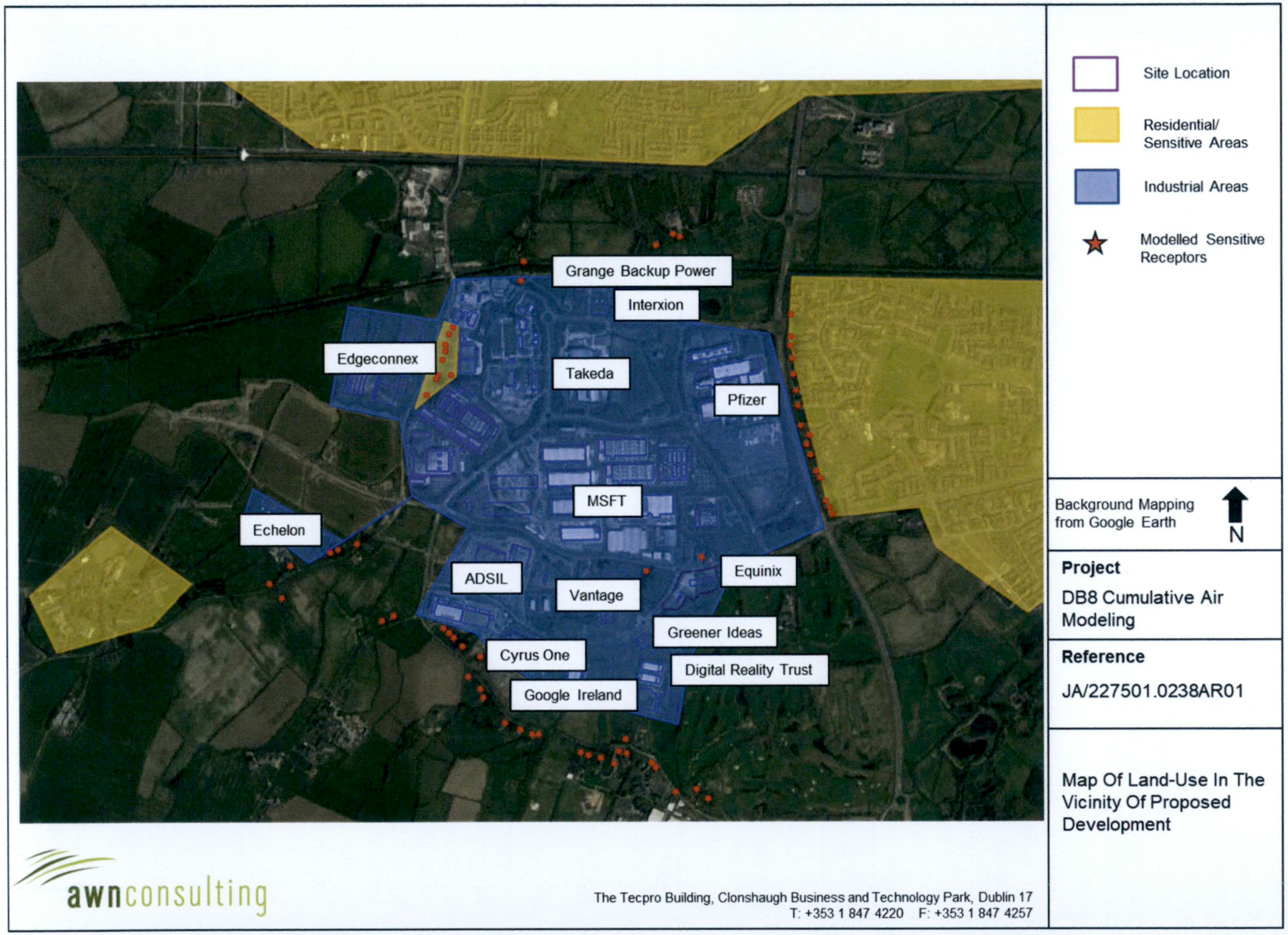


Figure 1 Map Of Land-Use In The Vicinity Of Proposed Development

2.0 ASSESSMENT CRITERIA

2.1 Ambient Air Quality Standards

In order to reduce the risk to health from poor air quality, national and European statutory bodies have set limit values in ambient air for a range of air pollutants. These limit values or "Air Quality Standards" are health or environmental-based levels for which additional factors may be considered. The applicable standards in Ireland include the Air Quality Standards Regulations 2011, which incorporate EU Directive 2008/50/EC (see Table 1). The ambient air quality standards applicable for NO_2 are outlined in this Directive.

Air quality significance criteria are assessed on the basis of compliance with the appropriate standards or limit values. These standards have been used in the current assessment to determine the potential impact of NO_2 emissions from the facility on ambient air quality.

Table 1 Air Quality Standards 2011 (Based on Directive 2008/50/EC)

Pollutant	Regulation Note 1	Limit Type	Value
Nitrogen Dioxide (NO_2)	2008/50/EC	Hourly limit for protection of human health - not to be exceeded more than 18 times/year	200 µg/m^3
		Annual limit for protection of human health	40 µg/m^3

Note 1 EU 2008/50/EC – Clean Air For Europe (CAFÉ) Directive replaces the previous Air Framework Directive (1996/30/EC) and daughter directives 1999/30/EC and 2000/69/EC

3.0 ASSESSMENT METHODOLOGY

Emissions from the facility have been modelled using the AERMOD dispersion model (Version 21112) which has been developed by the U.S. Environmental Protection Agency (USEPA)[(1)] and following guidance issued by the EPA[(2)]. The model is a steady-state Gaussian plume model used to assess pollutant concentrations associated with industrial sources and has replaced ISCST3[(3)] as the regulatory model by the USEPA for modelling emissions from industrial sources in both flat and rolling terrain[(4-6)]. The model has more advanced algorithms and gives better agreement with monitoring data in extensive validation studies[(6-10)]. An overview of the AERMOD dispersion model is outlined in Appendix I.

The air dispersion modelling input data consisted of information on the physical environment (including building dimensions and terrain features), design details from all emission points on-site and five years of appropriate hourly meteorological data. Using this input data the model predicted ambient ground level concentrations beyond the site boundary for each hour of the modelled meteorological years. The model post-processed the data to identify the location and maximum of the worst-case ground level concentration. This worst-case concentration was then added to the background concentration to give the worst-case predicted environmental concentration (PEC). The PEC was then compared with the relevant ambient air quality standard to assess the significance of the releases from the site.

The modelling aims to achieve compliance with the guidance outlined within Appendix K of the EPA document *AG4 Guidance for Air Dispersion Modelling*[(2)] .

Throughout this study a conservative approach was taken. This will most likely lead to an over-estimation of the levels that will arise in practice. The conservative assumptions are outlined below:

- Maximum predicted concentrations were reported in this study, even if no residential receptors were near the location of this maximum;
- Conservative background concentrations were used in the assessment;
- The effects of building downwash, due to on-site buildings, has been included in the model;
- The gas generators were assumed to be in continuous operation 24 hours per day, 365 days per year;
- A conservative assumption has been made for the purpose of the air dispersion modelling assessment that the standby generators will be tested weekly with one generator tested within any one hour;
- Emergency operations were assumed to occur for a maximum of 200 hours per year calculated according to USEPA methodology; and
- Licensed emission points were assumed to be in operation 24 hours per day, 365 days per year.

3.1 Air Dispersion Modelling Methodology

The United States Environmental Protection Agency (USEPA) approved AERMOD dispersion model has been used to predict the ground level concentrations (GLC) of compounds emitted from the principal emission sources on-site.

The modelling incorporated the following features:

- Two receptor grids were created at which concentrations would be modelled. Receptors were mapped with sufficient resolution to ensure all localised "hot-spots" were identified without adding unduly to processing time. The receptor grids were based on Cartesian grids with the site at the centre. Modelling was carried out covering an area of 8 km x 8 km with the site at the centre. An outer grid was mapped with 200 m resolution. The inner (fine) grid consisted of receptors every 100 m extended to 2.5 km from the site. The total calculation points for the gridded modelling including discrete receptors are 2,522.

- Discrete receptors were also added to the model to represent nearby residential receptors.

- All on-site buildings and significant process structures were mapped into the computer to create a three dimensional visualisation of the site and its emission points. Buildings and process structures can influence the passage of airflow over the emission stacks and draw plumes down towards the ground (termed building downwash). The stacks themselves can influence airflow in the same way as buildings by causing low pressure regions behind them (termed stack tip downwash). Both building and stack tip downwash were incorporated into the modelling.

- Detailed terrain has been mapped into the model using SRTM data with 30m resolution. The site is located in an area of complex terrain. All terrain features have been mapped in detail into the model using the terrain pre-processor AERMAP(11).

- Hourly-sequenced meteorological information has been used in the model. Meteorological data over a five year period (Casement Aerodrome 2017 – 2021) was used in the model (see Figure 2 and Appendix II).
- The source and emissions data, including stack dimensions, gas volumes and emission temperatures have been incorporated into the model.

3.2 Terrain

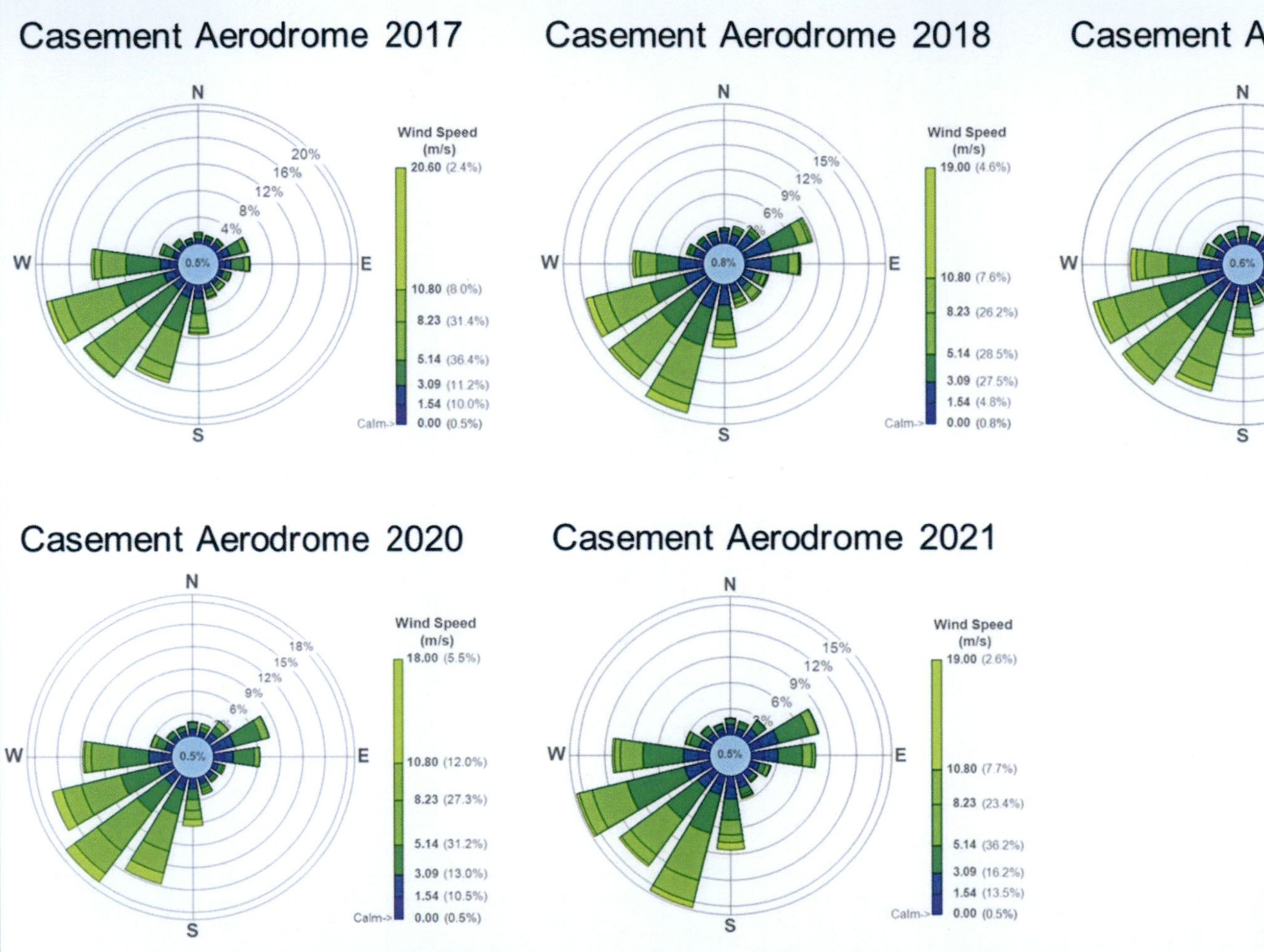
The AERMOD air dispersion model has a terrain pre-processor AERMAP[11] which was used to map the physical environment in detail over the receptor grid. The digital terrain input data used in the AERMAP pre-processor was obtained from SRTM. This data was run to obtain for each receptor point the terrain height and the terrain height scale. The terrain height scale is used in AERMOD to calculate the critical dividing streamline height, H_{crit}, for each receptor. The terrain height scale is derived from the Digital Elevation Model (DEM) files in AERMAP by computing the relief height of the DEM point relative to the height of the receptor and determining the slope. If the slope is less than 10%, the program goes to the next DEM point. If the slope is 10% or greater, the controlling hill height is updated if it is higher than the stored hill height.

In areas of complex terrain, AERMOD models the impact of terrain using the concept of the dividing streamline (H_c). As outlined in the AERMOD model formulation[1] a plume embedded in the flow below H_c tends to remain horizontal; it might go around the hill or impact on it. A plume above H_c will ride over the hill. Associated with this is a tendency for the plume to be depressed toward the terrain surface, for the flow to speed up, and for vertical turbulent intensities to increase.

AERMOD model formulation states that the model "captures the effect of flow above and below the dividing streamline by weighting the plume concentration associated with two possible extreme states of the boundary layer (horizontal plume and terrain-following). The relative weighting of the two states depends on: 1) the degree of atmospheric stability; 2) the wind speed; and 3) the plume height relative to terrain. In stable conditions, the horizontal plume "dominates" and is given greater weight while in neutral and unstable conditions, the plume traveling over the terrain is more heavily weighted"[4].

3.3 Meteorological Data

The selection of the appropriate meteorological data has followed the guidance issued by the USEPA[1]. A primary requirement is that the data used should have a data capture of greater than 90% for all parameters. Casement Aerodrome meteorological station, which is located approximately 1.5 km south of the site, collects data in the correct format and has a data collection of greater than 90%. Long-term hourly observations at Casement Aerodrome meteorological station provide an indication of the prevailing wind conditions for the region (see Figure 2 and Appendix II)[12]. Results indicate that the prevailing wind direction is westerly to south-westerly in direction over the period 2017 – 2021. The mean wind speed is approximately 5.5 m/s over the period 2017 – 2021.



awnconsulting

The Tecpro Building, Clonshaugh Business and Technology Park, Dublin 17
T: +353 1 847 4220 F: +353 1 847 4257

Project
DB8 Cumulative Air Modeling

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Casement Aerodrome Windrose 2017 - 2021

Figure 2 Casement Aerodrome Windrose 2017-2021

3.4 Geophysical Considerations

AERMOD simulates the dispersion process using planetary boundary layer (PBL) scaling theory[1]. PBL depth and the dispersion of pollutants within this layer are influenced by specific surface characteristics such as surface roughness, albedo and the availability of surface moisture. Surface roughness is a measure of the aerodynamic roughness of the surface and is related to the height of the roughness element. Albedo is a measure of the reflectivity of the surface whilst the Bowen ratio is a measure of the availability of surface moisture.

AERMOD incorporates a meteorological pre-processor AERMET[13] to enable the calculation of the appropriate parameters. The AERMET meteorological preprocessor requires the input of surface characteristics, including surface roughness (z_0), Bowen Ratio and albedo by sector and season, as well as hourly observations of wind speed, wind direction, cloud cover, and temperature. The values of albedo, Bowen Ratio and surface roughness depend on land-use type (e.g., urban, cultivated land etc) and vary with seasons and wind direction. The assessment of appropriate land-use type was carried out to a distance of 10km from the meteorological station for Bowen Ratio and albedo and to a distance of 1km for surface roughness in line with USEPA recommendations[13,14] as outlined in Appendix II.

In relation to AERMOD, detailed guidance for calculating the relevant surface parameters has been published[15]. The most pertinent features are:

- The surface characteristics should be those of the meteorological site (Casement Aerodrome) rather than the installation;
- Surface roughness should use a default 1km radius upwind of the meteorological tower and should be based on an inverse-distance weighted geometric mean. If land use varies around the site, the land use should be sub-divided by sectors with a minimum sector size of 30°;
- Bowen ratio and albedo should be based on a 10km grid. The Bowen ratio should be based on an un-weighted geometric mean. The albedo should be based on a simple un-weighted arithmetic mean.

AERMOD has an associated pre-processor, AERSURFACE[14] which has representative values for these parameters depending on land use type. The AERSURFACE pre-processor currently only accepts NLCD92 land use data which covers the USA. Thus, manual input of surface parameters is necessary when modelling in Ireland. Ordnance survey discovery maps (1:50,000) and digital maps such as those provided by the EPA, National Parks and Wildlife Service (NPWS) and Google Earth® are useful in determining the relevant land use in the region of the meteorological station. The Alaska Department of Environmental Conservation has issued a guidance note for the manual calculation of geometric mean for surface roughness and Bowen ratio for use in AERMET[15]. This approach has been applied to the current site with full details provided in Appendix II.

3.5 Building Downwash

When modelling emissions from an industrial installation, stacks which are relatively short can be subjected to additional turbulence due to the presence of nearby buildings. Buildings are considered nearby if they are within five times the lesser of the building height or maximum projected building width (but not greater than 800m).

The USEPA has defined the "Good Engineering Practice" (GEP) stack height as the building height plus 1.5 times the lesser of the building height or maximum projected building width. It is generally considered unlikely that building downwash will occur when stacks are at or greater than GEP(16).

When stacks are less than this height, building downwash will tend to occur. As the wind approaches a building it is forced upwards and around the building leading to the formation of turbulent eddies. In the lee of the building these eddies will lead to downward mixing (reduced plume centreline and reduced plume rise) and the creation of a cavity zone (near wake) where re-circulation of the air can occur. Plumes released from short stacks may be entrained in this airflow leading to higher ground level concentrations than in the absence of the building.

The Plume Rise Model Enhancements (PRIME)(9)(10) plume rise and building downwash algorithms, which calculates the impact of buildings on plume rise and dispersion, have been incorporated into AERMOD. The building input processor BPIP-PRIME produces the parameters which are required in order to run PRIME. The model takes into account the position of each stack relative to each relevant building and the projected shape of each building for 36 wind directions (at 10° intervals). The model determines the change in plume centreline location with downwind distance based on the slope of the mean streamlines and coupled to a numerical plume rise model(9).

Given that the proposed stacks are less than 2.5 times the lesser of the building height or maximum projected building width, building downwash will need to be taken into account and the PRIME algorithm run prior to modelling with AERMOD. The dominant building for each relevant stack will vary as a function of wind direction and relative building heights.

4.0 BACKGROUND CONCENTRATIONS OF POLLUTANTS

Air quality monitoring programmes have been undertaken in recent years by the EPA and Local Authorities(17). The most recent annual report on air quality "*Air Quality in Ireland 2020*" (17), details the range and scope of monitoring undertaken throughout Ireland. As part of the implementation of the Framework Directive on Air Quality (1996/62/EC), four air quality zones have been defined in Ireland for air quality management and assessment purposes(17). Dublin is defined as Zone A and Cork as Zone B. Zone C is composed of 23 towns with a population of greater than 15,000. The remainder of the country, which represents rural Ireland but also includes all towns with a population of less than 15,000 is defined as Zone D. In terms of air monitoring, Grangecastle is categorised as Zone A(18).

In 2020 the EPA reported(17) that Ireland was compliant with EU legal limits at all locations, however this was largely due to the reduction in traffic due to Covid-19 restrictions. The EPA report details the effect that the Covid-19 restrictions had on stations, which included reductions of up to 50% at some monitoring stations which have traffic as a dominant source. The report also notes that CSO figures show that while traffic volumes are still slightly below 2019 levels, they have significantly increased since 2020 levels. 2020 concentrations are therefore predicted to be an exceptional year and not consistent with long-term trends. For this reason, they have not been included in the baseline section.

With regard to NO_2, continuous monitoring data from the EPA(17), at suburban Zone A background locations in Rathmines, Swords and Ballyfermot show that current levels of NO_2 are below both the annual and 1-hour limit values, with annual average levels ranging from 15 - 22 µg/m^3 in 2019 (see Table 2). Sufficient data is available for the station in Ballyfermot to observe long-term trends over the period 2015 – 2019(17), with annual average results ranging from 16 – 20 µg/m^3. Based on these results, an estimate of the current background NO_2 concentration in the region of the facility is 17 µg/m³.

Table 2 Annual Mean and 99.8th Percentile 1-Hour NO_2 Concentrations In Zone A Locations (µg/m³)

Station	Averaging Period	Year				
		2015	2016	2017	2018	2019
Rathmines	Annual Mean NO_2 (µg/m³)	18	20	17	20	22
	99.8th%ile 1-hr NO_2 (µg/m³)	105	88	86	87	102
Ballyfermot	Annual Mean NO_2 (µg/m³)	16	17	17	17	20
	99.8th%ile 1-hr NO_2 (µg/m³)	127	90	112	101	101
Swords	Annual Mean NO_2 (µg/m³)	13	16	14	16	15
	99.8th%ile 1-hr NO_2 (µg/m³)	93	96	79	85	80

Note 1 Annual average limit value of 40 µg/m³ and hourly limit value of 200 µg/m³ (EU Council Directive 2008/50/EC & S.I. No. 180 of 2011)

The Plume Volume Molar Ratio Method (PVMRM) was used to model NO_2 concentrations. The PVMRM is a regulatory option in AERMOD which assumes that the amount of NO converted to NO_2 is proportional to the ambient ozone concentration[19,20]. The PVMRM uses both plume size and O_3 concentration to derive the amount of O_3 available for the reaction between NO and O_3. NO_X moles are determined by emission rate and travel time through the plume segment. The concentration is usually limited by the amount of ambient O_3 that is entrained in the plume. Thus, the ratio of the moles of O_3 to the moles of NO_X gives the ratio of NO_2/NO_X that is formed after the NO_X leaves the stack. In addition, it has been assumed that 10% of the NO_X in the stack gas is already in the form of NO_2 before the gas leaves the stack (in reality the levels are usually closer to 5%)[19,20]. The model has also assumed a final equilibrium ratio for NO_2/NO_X of 0.90 which again is pessimistic and more likely to be in the range 0.7 – 0.8 [19,20]. The equation used in the algorithm to derive the ratio of NO_2/NO_X is:

$$NO_2/NO_X = (\text{moles } O_3/ \text{ moles } NO_X) + 0.10$$

A background ozone concentration of 54 µg/m³ was used in the modelling assessment, based on a review of worst case background ozone data for Zone A sites[17].

In relation to the annual average background, the ambient background concentration was added directly to the process concentration with the short-term peaks assumed to have an ambient background concentration of twice the annual mean background concentration.

5.0 PROCESS EMISSIONS

The OSPG will have 10 no. gas generators, eight of which will operate continually for a full year based on eight in operation at 100% load. The adjacent DB8 data centre has 8 no. diesel generators, with a maximum of 7 no. diesel generators in operation at any one time, which will provide power to the site when power from the OSPG is not available. In addition, a front-of-house (FOH) generator will also be in operation.

USEPA Guidance suggests that for emergency operations, an average hourly emission rate should be used rather than the maximum hourly rate[21]. As a result, the maximum hourly emission rates from the emergency generators were reduced by $\frac{200}{8760}$ and the generators were modelled over a period of one full year. However, in reality, and based on recent experience over the past number of years, generators are rarely used other than during testing and maintenance described above.

A second methodology has been published by the UK Environment Agency. The consultation document is entitled "*Diesel Generator Short-Term NO_2 Impact Assessment*"[(22)]. The methodology is based on considering the statistical likelihood of an exceedance of the NO_2 hourly limit value (18 exceedances are allowable per year before the air standard is deemed to have been exceeded). The assessment assumes a hypergeometric distribution to assess the likelihood of exceedance hours coinciding with the emergency operational hours of the generators. The cumulative hypergeometric distribution of 19 and more hours per year is computed and the probability of an exceedance determined. The guidance suggests that the 98th percentile confidence level should be used to indicate if an exceedance is likely. The guidance suggests that the assessment should be conducted at the nearest residential receptor or at locations where people are likely to be exposed and that there should be no running time restrictions on these generators when providing power on site during an emergency.

Both the methodology advised in the USEPA guidance as well as the approach described in the UK EA guidance have been applied for the scenarios modelled in this study to ensure a robust assessment of predicted air quality impacts from the standby generators. This also follows the guidance outlined in Appendix K of the EPA AG4 guidance[(2)].

The cumulative impact scenario assessed the combined impact of the facility as outlined above as well as scheduled testing emissions associated with standby diesel generators in the neighbouring proposed and operational data storage facilities obtained from relevant planning permission applications (ADSIL, Cyrus One, Google Ireland, Interxion, Edgeconnex, Echelon, Microsoft, Digital Reality Trust and Vantage Data Centres Dub 11 Ltd) as well as proposed energy centres (Greener Ideas Limited and Vantage Data Centres Dub 11 Ltd). Emissions from nearby IED licensed sites including Pfizer, Takeda and Grange Backup Power were also included in the cumulative modelling. These emission points emit air pollutants on an essentially continuous basis over the course of a year. Nearby data storage facilities have emission points (standby diesel generators) which are classified as potential emission points as these will only operate under exceptional circumstances and thus will not be in operation on a day-to-day basis. For this reason, the emergency operations emission points associated with other nearby data storage facilities were not considered for the purpose of this assessment. This approach is in line with the methodology of AG4[(2)]. Testing of the standby diesel generators from these facilities has been included in the cumulative impact scenario.

The process emissions used for the cumulative scenario are outlined in

Table 3 Process Emission Details for Cumulative Assessment

Stack Reference	Height Above Ground Level (m)	Exit Diameter (m)	Temp (K)	Exit Velocity (m/sec actual)	NO_2 Mass Emission (g/s)
OSPG (Gas Generators)	14	0.4	707.15	50.4	0.38
Front of House generator	20	0.5	778.25	11.4	1.42
DB8 Diesel generators – Testing	20	0.6	736.15	20.8	7.30
DB8 Diesel generators – Emergency Operations	20	0.6	736.15	20.8	7.30 Note 1 / 0.167 Note 2
Microsoft (DUB03) Generators	31.5	0.6	784.15	26.5	3.77 Note 3
Microsoft (DUB04) Generators	18.1	0.6	833.15	34.8	8.38 Note 3
Microsoft (DUB05) Generators	25	0.6	833.15	34.8	2.52 Note 3
Microsoft (DUB06) Generators	25	0.6	833.15	34.8	2.52 Note 3
Microsoft (DUB07) Generators	25	0.6	833.15	34.8	2.52 Note 3
Microsoft (DUB08) Generators	25	0.6	833.15	34.8	2.52 Note 3
Microsoft (DUB09) Generators	25	0.8	733.85	23.4	1.40 Note 3
Microsoft (DUB10) Generators	25	0.8	733.85	23.4	1.40 Note 3
Microsoft (DUB11) Generators	30	0.6	833.15	34.8	2.52 Note 3
Microsoft (DUB12) Generators	24	0.8	733.85	23.4	1.40 Note 3
Microsoft (DUB13) Generators	23.25	0.8	733.85	23.4	1.40 Note 3
Microsoft (DUB14) Gas Generators	25	0.7	633.15	36.9	0.97
Microsoft (DUB15) Generators	30.75	0.8	733.85	23.4	1.40 Note 3
ADSIL IE Reg. No. P1170-01 Building A Generators	25	0.508	720.1 754.15 Note 4	18.4 46.01 Note 4	0.927 4.393 Note 4
ADSIL IE Reg. No. P1170-01 Building B Generators	25	0.508	720.1 754.15 Note 4	18.4 46.01 Note 4	0.927 4.393 Note 4
ADSIL IE Reg. No. P1170-01 Building C Generators	25	0.508	720.1 754.15 Note 4	18.4 46.01 Note 4	0.927 4.393 Note 4
ADSIL IE Reg. No. P1184-01 Generators	20	0.555	655.15 Note 5 754.15 Note 6	14.54 Note 5 37.34 Note 6	0.692 Note 5 4.39 Note 6
Cyrus One Generators	20	0.555	655.15 Note 5 754.15 Note 6	14.54 Note 5 37.34 Note 6	0.692 Note 5 4.39 Note 6

Stack Reference	Height Above Ground Level (m)	Exit Diameter (m)	Temp (K)	Exit Velocity (m/sec actual)	NO_2 Mass Emission (g/s)
IE Reg. No. P1165-01DUB40 Gas Engines	25	1.6	656.15	27.2	1.89 56.7 Note 7
IE Reg. No. P1165-01DUB40 Generators	25	0.6	833.15	33.6	7.29
Edgeconnex Gas Engines	25	0.7	673.15	14.7	0.22
Edgeconnex Phase 1 Generators	15	0.5	805.15	37.5	1.14
Edgeconnex Phase 2 Generators	15	0.5	805.15	37.5	1.14
Edgeconnex Phase 3 Generators	15	0.5	805.15	37.5	1.14
Edgeconnex DUB03 Generators	15	0.41	743	39.34	1.14
Edgeconnex DUB04 Generators	15	0.4	762.15	63	0.48
Edgeconnex DUB05 Generators	25	0.65	773	21.4	0.81
Google Ireland Generators	16.95	0.6	758	22.33	7.12
Google Ireland Generators	24.64	0.7	761	22.97	8.4
Interxion (DUB03) Generators	17	0.6	500	3.27	0.62
Interxion (DUB04) Generators	17	0.5	833.15	44.56	1.49
Digital Reality Trust (DUB13) Generators Note 8	20	0.51	881.15	35	0.645 Note 5
Digital Reality Trust (DUB14) Generators Note 8	20	0.51	881.15	35	0.645 Note 5
Digital Reality Trust (DUB15) Generators	20	0.51	881.15	35	0.645 Note 5
Digital Reality Trust (DUB16) Generators	20	0.51	881.15	35	0.645 Note 5
Vantage (DUB11) Gas Generators	30	1.2	633.15	28.4	0.20
Vantage (DUB11) Generators	22.3	0.6	695	10	1.05 Note 5
Pfizer A1-1	45	0.85	441	10.9	0.29
Pfizer A1-2	45	0.85	441	10.9	0.29
Pfizer A1-3	45	0.85	441	10.9	0.29
Pfizer A2-1	45	2	441	9.15	1.33

Stack Reference	Height Above Ground Level (m)	Exit Diameter (m)	Temp (K)	Exit Velocity (m/sec actual)	NO_2 Mass Emission (g/s)
Pfizer A2-1	45	0.85	441	10.9	1.33
Takeda EP-UT-01	15	0.55	453.15	12.12	0.19
Takeda EP-P1-04	12	0.25	523.15	6.56	0.017
Grange A2-1	25	2.77	663.15	27.6	4.5
Grange A2-2	25	3.2	663.15	27.6	6.0

Note 1 Maximum emission rate used to model the hypergeometric distribution at the 98th%ile confidence level.

Note 2 Reduced emission rates based on USEPA protocol (assuming 200 hours / annum) used to predict 1-hour mean NO_2 concentrations during emergency operation of generators.

Note 3 30% load emission rates for weekly batch testing of generators – triplicate of generators tested sequentially for 15 minutes each hour until all generators onsite.

Note 4 Load banking

Note 5 Monthly scheduled testing

Note 6 Yearly scheduled testing

Note 7 Testing of dual fuel gas engine in liquid fuel mode

Note 8 No air dispersion model available online as part of planning application – process emissions assumed to be same as for Digital Reality Trust DUB15/16.

6.0 RESULTS

6.1 Cumulative Assessment (USEPA Methodology)

The cumulative assessment involved modelling the DB8 gas generators, standby diesel generators, as well as the existing IED licenced sites, and other neighbouring proposed and operational data storage and energy centre facilities in the vicinity of the site, listed in

Table **3**. The NO_2 modelling results at the worst-case off-site receptor are detailed in Table 4. The results indicate that the ambient ground level concentrations are below the relevant air quality standards for NO_2. For the worst-case year, emissions from the site lead to an ambient NO_2 concentration (including background) which is 73% of the maximum ambient 1-hour limit value (measured as a 99.8th percentile) and 89% of the annual limit value at the most impacted off-site sensitive receptor.

The geographical variations in ground level NO_2 concentrations beyond the facility boundary for the worst-case years modelled are illustrated as concentration contours in Figure 3 and Figure 4.

Table 4 Dispersion Model Results for Nitrogen Dioxide (NO_2) – Cumulative Assessment

Pollutant / Meteorological Year	Averaging Period	Background (µg/m^3)	Process Contribution NO_2 (µg/m^3)	Predicted Emission Concentration NO_2 (µg/m^3)	Standard (µg/m^3) Note 1	PEC as a % of Limit Value
NO_2 / 2017	Annual mean	16	19.7	35.7	40	89%
	99.8th%ile of 1-hr means	32	111.3	143.3	200	72%
NO_2 / 2018	Annual mean	17	15.7	31.7	40	79%
	99.8th%ile of 1-hr means	16	109.4	141.4	200	71%
NO_2 / 2019	Annual mean	32	17.8	33.8	40	84%
	99.8th%ile of 1-hr means	16	113.3	145.3	200	73%
NO_2 / 2020	Annual mean	32	16.9	32.9	40	82%
	99.8th%ile of 1-hr means	16	109.1	141.1	200	71%
NO_2 / 2021	Annual mean	32	16.3	32.3	40	81%
	99.8th%ile of 1-hr means	16	108.9	140.9	200	70%

Note 1 Air Quality Standards 2011 (from EU Directive 2008/50/EC and S.I. 180 of 2011)

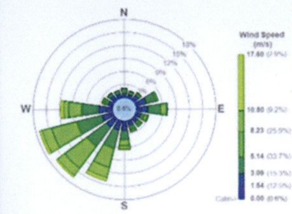
6.2 Cumulative Assessment (UK Environment Agency Methodology)

Emissions from the DB8 gas generators, standby diesel generators, as well as the existing IED licenced sites, and other neighbouring proposed and operational data storage and energy centre facilities in the vicinity of the site were assessed using the UK Environment Agency methodology[22]. The methodology, based on considering the statistical likelihood of an exceedance of the NO_2 hourly limit value assuming a hypergeometric distribution, has been undertaken at the worst-case residential receptor. The cumulative hypergeometric distribution of 19 and more hours per year was computed and the probability of an exceedance determined as outlined in Table 5. The results have been compared to the 98th percentile confidence level to indicate if an exceedance is likely at various operational hours for the facility. The results indicate that the facility can operate for a maximum of 3,500 hours in any given year without the likelihood of an exceedance of the ambient air quality standard (at a 98th percentile confidence level).

Table 5 Hypergeometric Statistical Results at Worst-Case Residential Receptor – NO_2

Pollutant / Meteorological Year	Hours of operation (Hours) (98th%ile) Allowed Prior To Exceedance Of Limit Value	UK Guidance – Probability Value = 0.02 (98th%ile)Note 1
NO_2 / 2017	8,760	0.02
NO_2 / 2018	8,760	
NO_2 / 2019	8,760	
NO_2 / 2020	3,,500	
NO_2 / 2021	6020	

Note 1 Guidance Outlined In UK EA publication "Diesel Generator Short-Term NO_2 Impact Assessment"[22]



Background Mapping from Google Earth

99.8th%ile of 1-Hour Mean NO_2 Concentrations (excluding background) Maximum Concentration At Nearby Residential Receptor = 113.3 μg/m³

Boundary Of Facility

Scale

1:20,000

N

Project

DB8 Cumulative Air Modeling

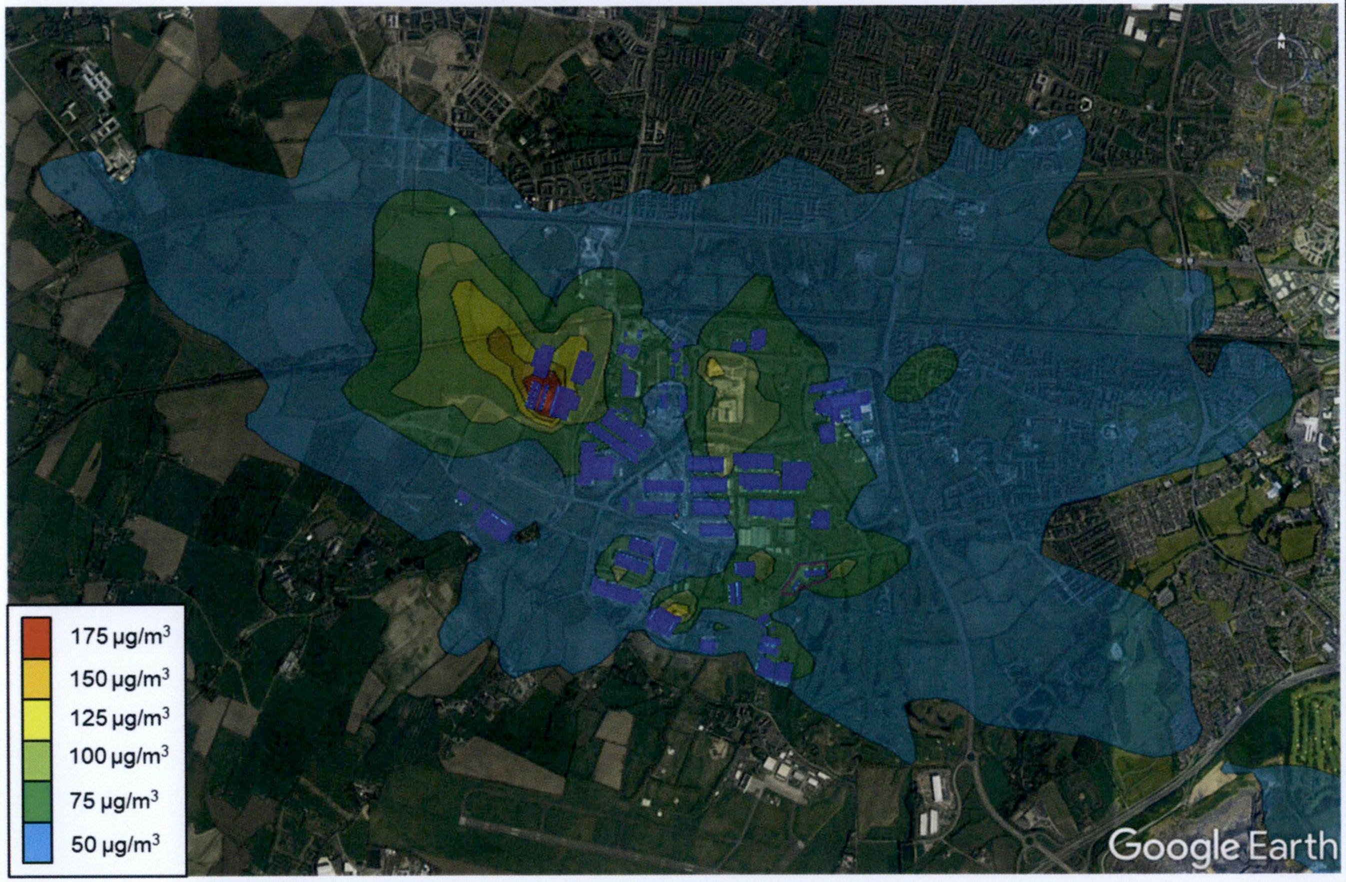
Reference

JA/227501.0238AR01

99.8th%ile of 1-Hour NO_2 Concentrations (μg/m³)

Cumulative Assessment

Year 2019



awnconsulting

The Tecpro Building, Clonshaugh Business and Technology Park, Dublin 17
T: +353 1 847 4220 F: +353 1 847 4257

Figure 3 Cumulative Assessment - Maximum 1-Hour NO_2 Concentrations (as 99.8th%ile) (µg/m³) 2019 (excluding background concentrations)

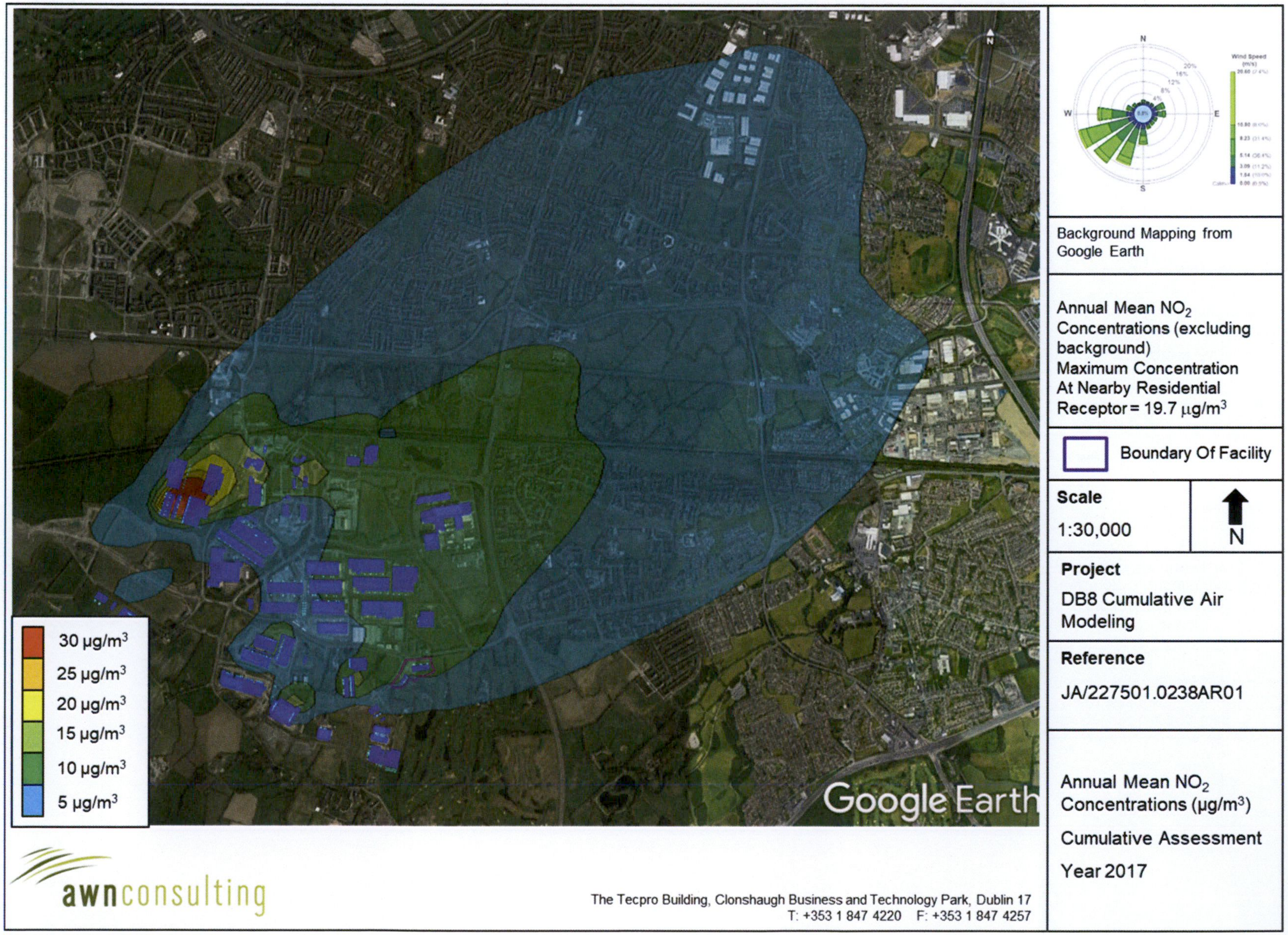


Figure 4 Cumulative Assessment - Annual Mean NO_2 Concentrations (μg/m³) 2017 (excluding background concentrations)

7.0 ASSESSMENT SUMMARY

The results indicate that ambient ground level concentrations are in compliance with the relevant air quality standards for NO_2 for all scenarios modelled.

Under the USEPA methodology NO_2 emissions associated with the cumulative assessment of the DB8 gas generators, standby diesel generators, as well as the existing IED licenced sites, and other neighbouring proposed and operational data storage and energy centre facilities in the vicinity of the site are in compliance with the air quality standards. Emissions under this scenario lead to an ambient NO_2 concentration that is 73% of the ambient 1-hour limit value (measured as a 99.8th percentile) and 89% of the ambient annual mean limit value at the worst case off-site receptor for the worst case year.

The UK Environment Agency assessment methodology determined that in the worst-case year, the DB8 gas generators, standby diesel generators, as well as the existing IED licenced sites, and other neighbouring proposed and operational data storage and energy centre facilities in the vicinity of the site, could operate for a maximum of 3,500 hours before there is a likelihood of an exceedance of the ambient air quality standard (at a 98th percentile confidence level). In addition, the UK guidance recommends that there should be no running time restrictions placed on standby generators which provide power on site only during an emergency power outage.

In summary, impacts on ambient air quality associated with both the gas generators and the standby diesel generators at the site will be in compliance with the ambient air quality standards which are based on the protection of the environment and human health.

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APPENDIX I

Description of the AERMOD Model

The AERMOD dispersion model has been developed in part by the U.S. Environmental Protection Agency (USEPA)[1,4]. The model is a steady-state Gaussian model used to assess pollutant concentrations associated with industrial sources. The model is an enhancement on the Industrial Source Complex-Short Term 3 (ISCST3) model which has been widely used for emissions from industrial sources.

Improvements over the ISCST3 model include the treatment of the vertical distribution of concentration within the plume. ISCST3 assumes a Gaussian distribution in both the horizontal and vertical direction under all weather conditions. AERMOD with PRIME, however, treats the vertical distribution as non-Gaussian under convective (unstable) conditions while maintaining a Gaussian distribution in both the horizontal and vertical direction during stable conditions. This treatment reflects the fact that the plume is skewed upwards under convective conditions due to the greater intensity of turbulence above the plume than below. The result is a more accurate portrayal of actual conditions using the AERMOD model. AERMOD also enhances the turbulence of night-time urban boundary layers thus simulating the influence of the urban heat island.

In contrast to ISCST3, AERMOD is widely applicable in all types of terrain. Differentiation of the simple versus complex terrain is unnecessary with AERMOD. In complex terrain, AERMOD employs the dividing-streamline concept in a simplified simulation of the effects of plume-terrain interactions. In the dividing-streamline concept, flow below this height remains horizontal, and flow above this height tends to rise up and over terrain. Extensive validation studies have found that AERMOD (precursor to AERMOD with PRIME) performs better than ISCST3 for many applications and as well or better than CTDMPLUS for several complex terrain data sets[8].

Due to the proximity to surrounding buildings, the PRIME (Plume Rise Model Enhancements) building downwash algorithm has been incorporated into the model to determine the influence (wake effects) of these buildings on dispersion in each direction considered. The PRIME algorithm takes into account the position of the stack relative to the building in calculating building downwash. In the absence of the building, the plume from the stack will rise due to momentum and/or buoyancy forces. Wind streamlines act on the plume leads to the bending over of the plume as it disperses. However, due to the presence of the building, wind streamlines are disrupted leading to a lowering of the plume centreline.

When there are multiple buildings, the building tier leading to the largest cavity height is used to determine building downwash. The cavity height calculation is an empirical formula based on building height, the length scale (which is a factor of building height & width) and the cavity length (which is based on building width, length and height). As the direction of the wind will lead to the identification of differing dominant tiers, calculations are carried out in intervals of 10 degrees.

In PRIME, the nature of the wind streamline disruption as it passes over the dominant building tier is a function of the exact dimensions of the building and the angle at which the wind approaches the building. Once the streamline encounters the zone of influence of the building, two forces act on the plume. Firstly, the disruption caused by the building leads to increased turbulence and enhances horizontal and vertical dispersion. Secondly, the streamline descends in the lee of the building due to the reduced pressure and drags the plume (or part of) nearer to the ground, leading to higher ground level concentrations. The model calculates the descent of the plume as a function of the building shape and, using a numerical plume rise model, calculates the change in the plume centreline location with distance downwind.

The immediate zone in the lee of the building is termed the cavity or near wake and is characterised by high intensity turbulence and an area of uniform low pressure. Plume mass captured by the cavity region is re-emitted to the far wake as a ground-level volume source. The volume source is located at the base of the lee wall of the building, but is only evaluated near the end of the near wake and beyond. In this region, the disruption caused by the building downwash gradually fades with distance to ambient values downwind of the building.

AERMOD has made substantial improvements in the area of plume growth rates in comparison to ISCST3[3,5]. ISCST3 approximates turbulence using six Pasquill-Gifford-Turner Stability Classes and bases the resulting dispersion curves upon surface release experiments. This treatment, however, cannot explicitly account for turbulence in the formulation. AERMOD is based on the more realistic modern planetary boundary layer (PBL) theory which allows turbulence to vary with height. This use of turbulence-based plume growth with height leads to a substantial advancement over the ISCST3 treatment.

Improvements have also been made in relation to mixing height[1,3]. The treatment of mixing height by ISCST3 is based on a single morning upper air sounding each day. AERMOD, however, calculates mixing height on an hourly basis based on the morning upper air sounding and the surface energy balance, accounting for the solar radiation, cloud cover, reflectivity of the ground and the latent heat due to evaporation from the ground cover. This more advanced formulation provides a more realistic sequence of the diurnal mixing height changes.

AERMOD also has the capability of modelling both unstable (convective) conditions and stable (inversion) conditions. The stability of the atmosphere is defined by the sign of the sensible heat flux. Where the sensible heat flux is positive, the atmosphere is unstable whereas when the sensible heat flux is negative the atmosphere is defined as stable. The sensible heat flux is dependent on the net radiation and the available surface moisture (Bowen Ratio). Under stable (inversion) conditions, AERMOD has specific algorithms to account for plume rise under stable conditions, mechanical mixing heights under stable conditions and vertical and lateral dispersion in the stable boundary layer.

AERMOD also contains improved algorithms for dealing with low wind speed (near calm) conditions. As a result, AERMOD can produce model estimates for conditions when the wind speed may be less than 1 m/s, but still greater than the instrument threshold.

APPENDIX II

Meteorological Data - AERMET

AERMOD incorporates a meteorological pre-processor AERMET (version 16216)[12]. AERMET allows AERMOD to account for changes in the plume behaviour with height. AERMET calculates hourly boundary layer parameters for use by AERMOD, including friction velocity, Monin-Obukhov length, convective velocity scale, convective (CBL) and stable boundary layer (SBL) height and surface heat flux. AERMOD uses this information to calculate concentrations in a manner that accounts for changes in dispersion rate with height, allows for a non-Gaussian plume in convective conditions, and accounts for a dispersion rate that is a continuous function of meteorology.

The AERMET meteorological preprocessor requires the input of surface characteristics, including surface roughness (z_0), Bowen Ratio and albedo by sector and season, as well as hourly observations of wind speed, wind direction, cloud cover, and temperature. A morning sounding from a representative upper air station, latitude, longitude, time zone, and wind speed threshold are also required.

Two files are produced by AERMET for input to the AERMOD dispersion model. The surface file contains observed and calculated surface variables, one record per hour. The profile file contains the observations made at each level of a meteorological tower, if available, or the one-level observations taken from other representative data, one record level per hour.

From the surface characteristics (i.e. surface roughness, albedo and amount of moisture available (Bowen Ratio)) AERMET calculates several boundary layer parameters that are important in the evolution of the boundary layer, which, in turn, influences the dispersion of pollutants. These parameters include the surface friction velocity, which is a measure of the vertical transport of horizontal momentum; the sensible heat flux, which is the vertical transport of heat to/from the surface; the Monin-Obukhov length which is a stability parameter relating the surface friction velocity to the sensible heat flux; the daytime mixed layer height; the nocturnal surface layer height and the convective velocity scale which combines the daytime mixed layer height and the sensible heat flux. These parameters all depend on the underlying surface.

The values of albedo, Bowen Ratio and surface roughness depend on land-use type (e.g., urban, cultivated land etc) and vary with seasons and wind direction. The assessment of appropriate land-use types was carried out in line with USEPA recommendations[4] and using the detailed methodology outlined by the Alaska Department of Environmental Conservation[14]. AERMET has also been updated to allow for an adjustment of the surface friction velocity (u*) for low wind speed stable conditions based on the work of Qian and Venkatram (BLM, 2011). Previously, the model had a tendency to over-predict concentrations produced by near-ground sources in stable conditions.

Surface roughness

Surface roughness length is the height above the ground at which the wind speed goes to zero. Surface roughness length is defined by the individual elements on the landscape such as trees and buildings. In order to determine surface roughness length, the USEPA recommends that a representative length be defined for each sector, based on geometric mean of the inverse distance area-weighted land use within the sector, by using the eight land use categories outlined by the USEPA. The area-weighted surface roughness length derived from the land use classification within a radius of 1km from Casement Aerodrome is shown in Table A1.

Table A1 Surface Roughness based on an inverse distance area-weighted average of the land use within a 1km radius of Casement Aerodrome.

Sector	Area Weighted Land Use Classification	Spring	Summer	Autumn	Winter[Note 1]
0-360	100% Grassland	0.050	0.100	0.010	0.010

Note 1 Winter defined as periods when surfaces covered permanently by snow whereas autumn is defined as periods when freezing conditions are common, deciduous trees are leafless and no snow is present (Iqbal (1983)). Thus for the current location autumn more accurately defines "winter" conditions at the proposed facility.

Albedo

Noon-time Albedo is the fraction of the incoming solar radiation that is reflected from the ground when the sun is directly overhead. Albedo is used in calculating the hourly net heat balance at the surface for calculating hourly values of Monin-Obuklov length. The area-weighted arithmetic mean albedo derived from the land use classification over a 10km x 10km area centred on Casement Aerodrome is shown in Table A2.

Table A2 Albedo based on an area-weighted arithmetic mean of the land use over a 10km x 10km area centred on Casement Aerodrome.

Area Weighted Land Use Classification	Spring	Summer	Autumn	WinterNote 1
0.5% Water, 30% Urban, 0.5% Coniferous Forest 38% Grassland, 19% Cultivated Land	0.155	0.180	0.187	0.187

Note 1 For the current location autumn more accurately defines "winter" conditions at the proposed facility.

Bowen Ratio

The Bowen ratio is a measure of the amount of moisture at the surface of the earth. The presence of moisture affects the heat balance resulting from evaporative cooling which, in turn, affects the Monin-Obukhov length which is used in the formulation of the boundary layer. The area-weighted geometric mean Bowen ratio derived from the land use classification over a 10km x 10km area centred on Casement Aerodrome is shown in Table A3.

Table A3 Bowen Ratio based on an area-weighted geometric mean of the land use over a 10km x 10km area centred on Casement Aerodrome.

Area Weighted Land Use Classification	Spring	Summer	Autumn	Winter[Note 1]
0.5% Water, 30% Urban, 0.5% Coniferous Forest 38% Grassland, 19% Cultivated Land	0.549	1.06	1.202	1.202

Note 1 For the current location autumn more accurately defines "winter" conditions at the proposed facility.