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PLUME MODELLING OF PROPOSED DUB14/15 DEVELOPMENT AT GRANGECASTLE SERVER CENTRE.

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Report by AWN Consulting

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Technical Report Prepared For

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EXECUTIVE SUMMARY

This report, prepared by AWN Consulting Ltd, provides an assessment of the potential impact of the plumes associated with the operational phase of the Microsoft DUB14 and DUB15 Data Centre to be constructed at Grangecastle on aircraft, and in particular helicopters, in the region.

The issue of plume characteristics and the effect on the operation of helicopters in the region of the site has been assessed below. An assessment has been undertaken to determine the region surrounding the facility where levels of excess temperature, turbulence (vertical velocity) and reduced oxygen could potentially be encountered. Studies undertaken by the MITRE Corporation (MITRE, 2012) and outlined in the user manual for the "Exhaust-Plume-Analyzer" model detail the likely impact of an exhaust plume on aircraft based on a range of parameters / criteria including the thermal buoyancy and temperature of the plume.

The current study is based on detailed site-specific information. The site-specific study, using USEPA developed model AERMOD for the oxygen assessment and the Cambridge Environmental Research Consultants (CERC) AMDS-5 model for both temperature and vertical velocity, allows the actual emission data for the facility to be used as input into the model. In addition, meteorological data for the region, based on a full year of data from Casement Aerodrome (2019) and building data also forms part of the inputs to the model to allow an accurate representation of the impact of the facility in the surrounding environment. As discussed in detail below, the site-specific risk heights have been found to be limited to a distance of 6.0 metres from the stack top. As the diesel generator have a greater stack height, the maximum height above ordnance datum is 103.55m OD (based on the temperature exclusion zone of 5.5m above stack top) and this defines the relevant exclusion zone due to these emission points.

Conclusion

Thus, in summary the results of the analysis are as follows:

- **Oxygen Content** – within 6.0 metres of the stack top the oxygen concentration will increase above the 12% risk level for oxygen.
- **Temperature** – the temperature of the plume will drop to less than 50°C within 5.5 metres of the stack.
- **Vertical Velocity** – the critical vertical velocity of 4.3 m/s will not be exceeded beyond 0.5 metres from the stack top.

Thus, the maximum extent of the risk zone of the plume for each parameter is shown below based on a full year of meteorological data covering all meteorological conditions including pressure / temperature inversions:

- Risk Zone for Oxygen – **6.0 metres**
- Risk Zone for Temperature – **5.5 metres**
- Risk Zone for Vertical Velocity – **< 0.5 metres**
- **COMBINED RISK ZONE – 6.0 metres above stack top and 103.55m OD**

CONTENTS

1.0 INTRODUCTION

This report, prepared by AWN Consulting Ltd, provides an assessment of the potential impact of the plumes associated with the operational phase of the Microsoft DUB14 and DUB15 Data Centre to be constructed at Grangecastle on aircraft, and in particular helicopters, in the region.

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2.0 METHODOLOGY

The parameters of the plume which are most relevant to helicopters has been investigated by the Mitre Corporation as part of the development of the "*Expanded Model For Determining The Effects Of Vertical Plumes On Aviation Safety*" (MITRE, 2012). These parameters have been reviewed below.

Oxygen

The Mitre Corporation report confirms that oxygen levels below 12% are potentially hazardous to helicopters (MITRE, 2012) and thus the oxygen content of the plume with distance from the stack has been investigated.

In relation to the gas generators, the oxygen content of the plume at stack top will typically be 8.9% but a worst-case level of 6% has been assumed in the assessment as a worst-case.

In relation to the diesel generators, the oxygen content of the plume at stack top will typically be 10.1% but a worst-case level of 8% has been assumed in the assessment as a worst-case.

Temperature

The Mitre Corporation report confirms that temperatures in excess of 50°C are potentially hazardous to helicopters (MITRE, 2012) and thus the temperature of the plume with distance from the stack has been investigated.

In relation to the gas generators, the temperature of the plume at stack top is 688.15K (415°C). In relation to the diesel generators, the temperature of the plume at stack top is 733.85K (460.7°C).

Vertical Velocity

High vertical velocities are also a concern when considering helicopter / plume interactions as they can lead to increased turbulence in the atmosphere. The literature (CASA, 2012) suggests that the critical level for vertical velocities is 4.3 m/s. Thus, modelling has been undertaken to understand the worst-case vertical velocities of both the gas generator plume and diesel generator plume with distance from the stack.

The change in each of these parameters with distance from the stack has been reviewed below. For each of these parameters, a full year of meteorological conditions has been used in the analysis including periods of atmospheric pressure / temperature inversions. Meteorological data for the year 2019 for Casement Aerodrome has been used in the analysis for all scenarios outlined. The ADMS-5 model has the capability to process calm conditions by setting the wind speed to 0.3 m/s and allowing an equal probability for all wind directions. This option has been used in this assessment for both the temperature assessment and the vertical velocity assessment.

The model was also run with a high density receptor grid based on 5m horizontal spacing and 0.5m vertical spacing in the region of the stack top to determine the changes in the parameters above over very short distances. The receptor spacing of 0.5m was selected as the change with vertical distance in oxygen, temperature and vertical velocity from the stack top is rapid and would be difficult to determine with a coarser grid resolution.

3.0 PROCESS EMISSIONS

The proposed DUB14 building will have 18 operational emergency generator stacks (with 2 catchers) which will have a height of 30.75m. The proposed DUB15 gas generator compound will have 20 gas generators at a height of 25.0m (92.25m OD). The source information for the modelled emission points has been summarised in Table 1.

Stack Reference	Height Above Ground Level (m)	Exit Diameter (m)	Cross-Sectional Area (m^2)	Temp (K)	Max Volume Flow (Nm^3/hr)	Exit Velocity (m/sec actual)	NO_2	
							Concentration (mg/Nm^3)	Mass Emission (g/s)
DUB14 Diesel Generators	30.75 (98.0m OD)	0.8	0.50	733.85	9,801	23.4	2,816	7.67
DUB15 Gas Generators	25.0 (92.25m OD)	0.6	0.28	688.15	8,930	34.4	95	0.63

Table 1 Summary of Source Information For The Gas Generator & Diesel Generator Plumes

4.0 RESULTS & DISCUSSION

4.1 Oxygen / Plume Interaction

The Mitre Corporation report (MITRE, 2012) confirms that depleted oxygen is generally of greatest concern when considering helicopter / plume interactions. The Mitre Corporation report confirms that at an oxygen content below 12% oxygen there is a risk of engine cut-out whilst above this level there is no risk to helicopter engines. Thus, modelling has been undertaken to determine the oxygen percentage of both the gas generators and diesel generators plume with distance from the stacks.

The following equation is used to model the % of oxygen in the plume with distance from the stack top. For a given emission concentration of any pollutant *e* (in $\mu g/m^3$), the oxygen content *O* (%), is related to the plume concentration *c* (in $\mu g/m^3$) by the following relationship (6.0 is the worst-case plume oxygen percentage at release for gas generators):

$$c / e = (20.95-O) / (20.95-6.0)$$

Thus, the calculation can be re-arranged to determine the oxygen content (%) of the plume as a function of distance from the stack top. The re-arranged equation is:

$$O\ (\%) = 20.95- [(c/e) * (14.95)]$$

AERMOD was thus run to calculate the pollutant concentration and identify the distance from the plume centreline where the 12% oxygen level was exceeded for both the gas generators and diesel generators. Modelling was undertaken using Casement Aerodrome data for 2019. Shown in Figure 1 is the result for the full year for the gas generators and in Figure 2 is the result for the full year for the diesel generators.

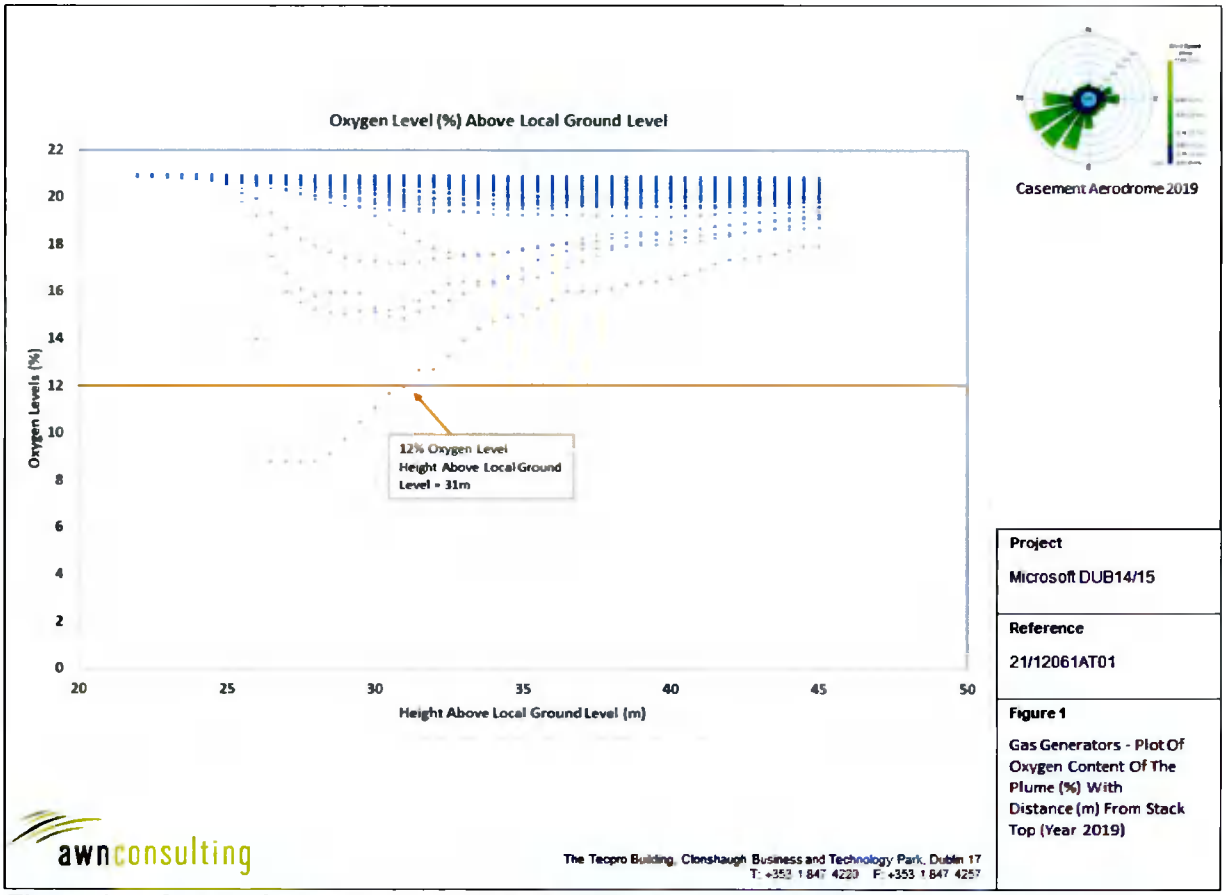

Figure 1 Oxygen Content Of The Plume (%) With Distance From Stack Top – Gas Generators

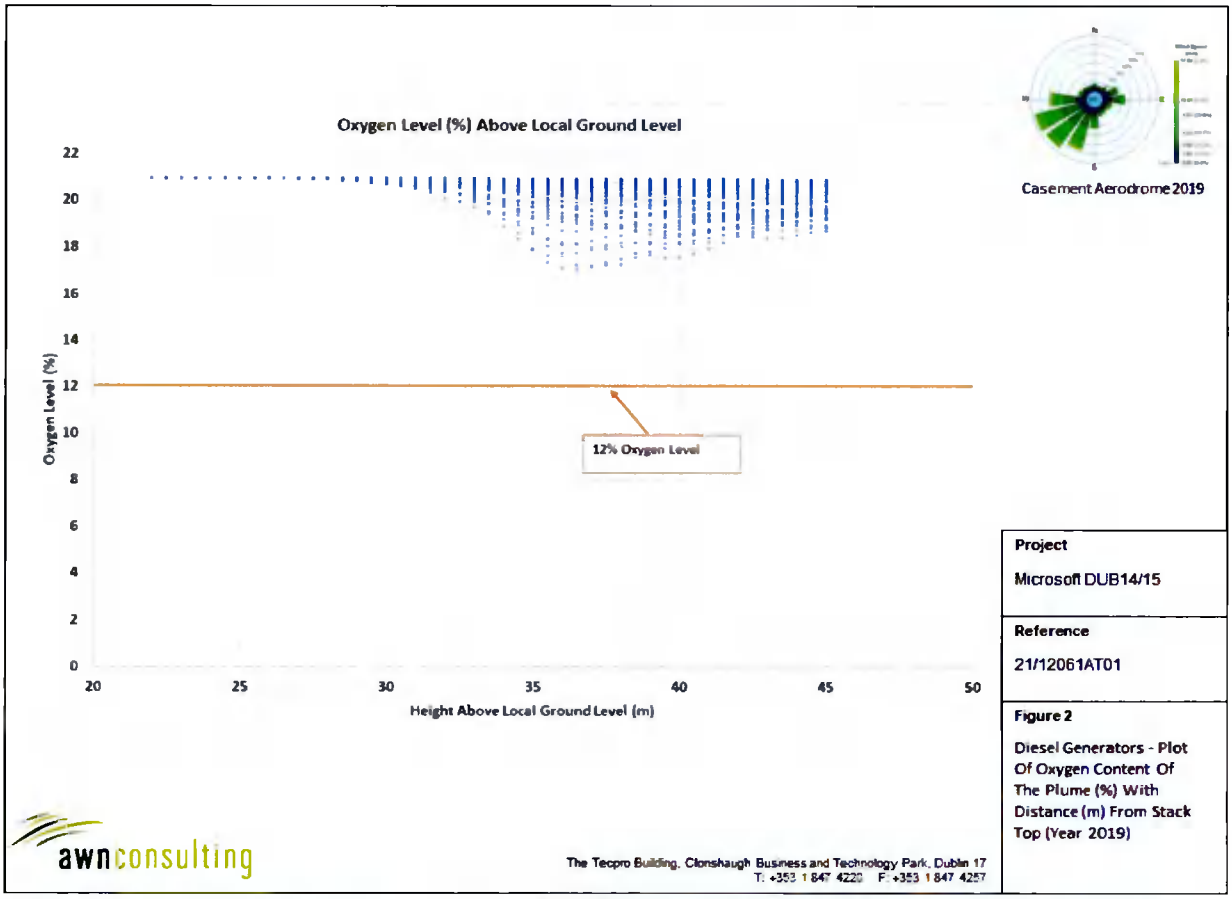

Figure 2 Oxygen Content Of The Plume (%) With Distance From Stack Top – Diesel Generators

The modelling results confirm that within a distance of 6.0 metres from the stack top the oxygen content of the gas generators plume will be 12% or greater. This analysis is based on every hour of the year for 2019 and includes all meteorological conditions including pressure / temperature inversions. For the diesel generator, within 0.5m the oxygen content is greater than 12% oxygen.

4.2 Temperature / Plume Interaction

Temperatures in excess of 50°C are potentially hazardous to helicopters and thus the decrease in the initial temperature of both the gas generators plume (415°C) and the diesel generators plume (460.7°C) with distance from the stack has been investigated. Modelling of the temperature of the plume with distance from the stack has been undertaken using the CERC ADMS-5 model for every hour of the year based on Casement Aerodrome 2019 meteorological data. The model has a specific temperature module which can, as part of the model output, give the temperature of the plume centreline with distance from the stack top.

The results are outlined below in Figure 3 for 2019 for the gas generators and in Figure 4 for the diesel generators.

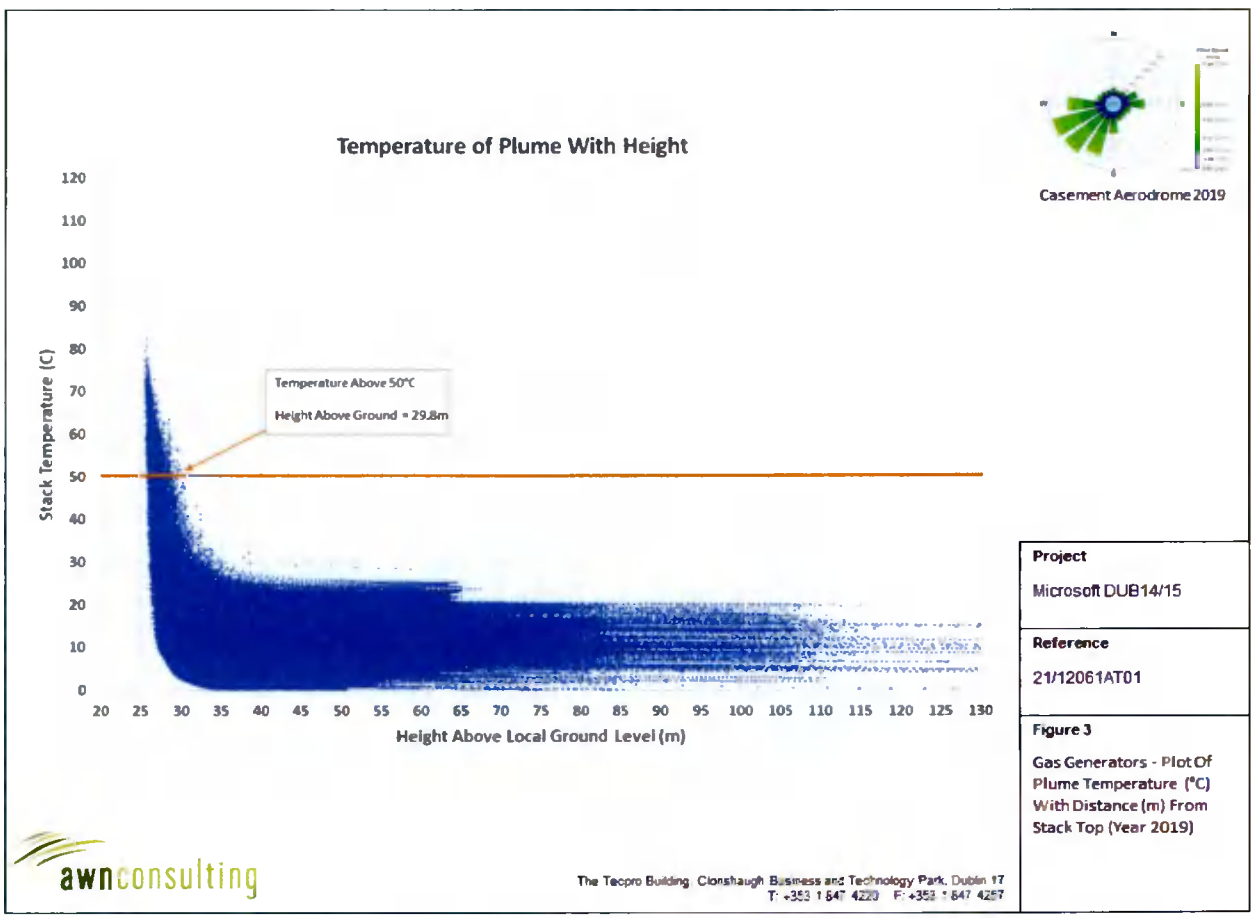

Figure 3 Temperature Of The Plume (°C) With Distance From Stack Top – Gas Generators

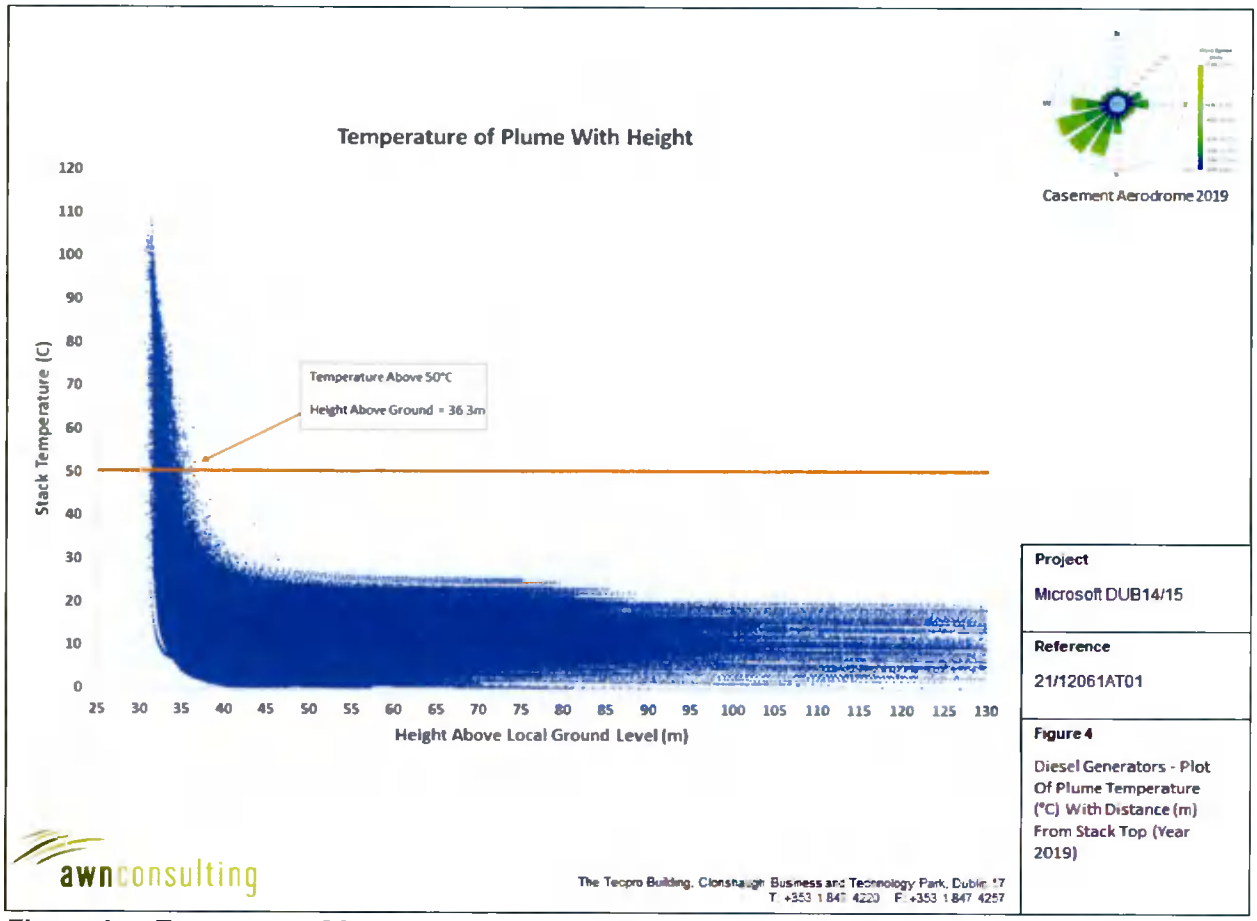

Figure 4 Temperature Of The Plume (°C) With Distance From Stack Top – Diesel Generators

The results confirm that the plume will be below 50°C within 4.8 metres of the stack top for every hour over the year for the gas generators and the plume will be below 50°C within 5.55 metres of the stack tip for every hour over the year for the diesel generators, including all meteorological conditions including pressure / temperature inversions.

4.3 Vertical Velocity / Plume Interaction

High vertical velocities are also relevant when considering helicopter / plume interactions. The Australian CASA (CASA, 2012) consider that the critical level for vertical velocity is 4.3 m/s. Thus, modelling has been undertaken to understand the vertical velocity of the plume with distance from the stack.

Cambridge Environmental Research Consultants (CERC), the developers of the EPA approved AMDS-5 model, were contacted to determine whether vertical velocity could be derived indirectly from the travel time of the plume with distance from the stack. CERC confirmed that the vertical velocity (in m/s) could be derived from an analysis of the plume centreline height (in metres) and the plume travel time (in seconds). The vertical velocity has been calculated for every hour of the year using Casement Aerodrome 2019 as presented in Figure 5 below for the gas generators and in Figure 6 for the diesel generators.

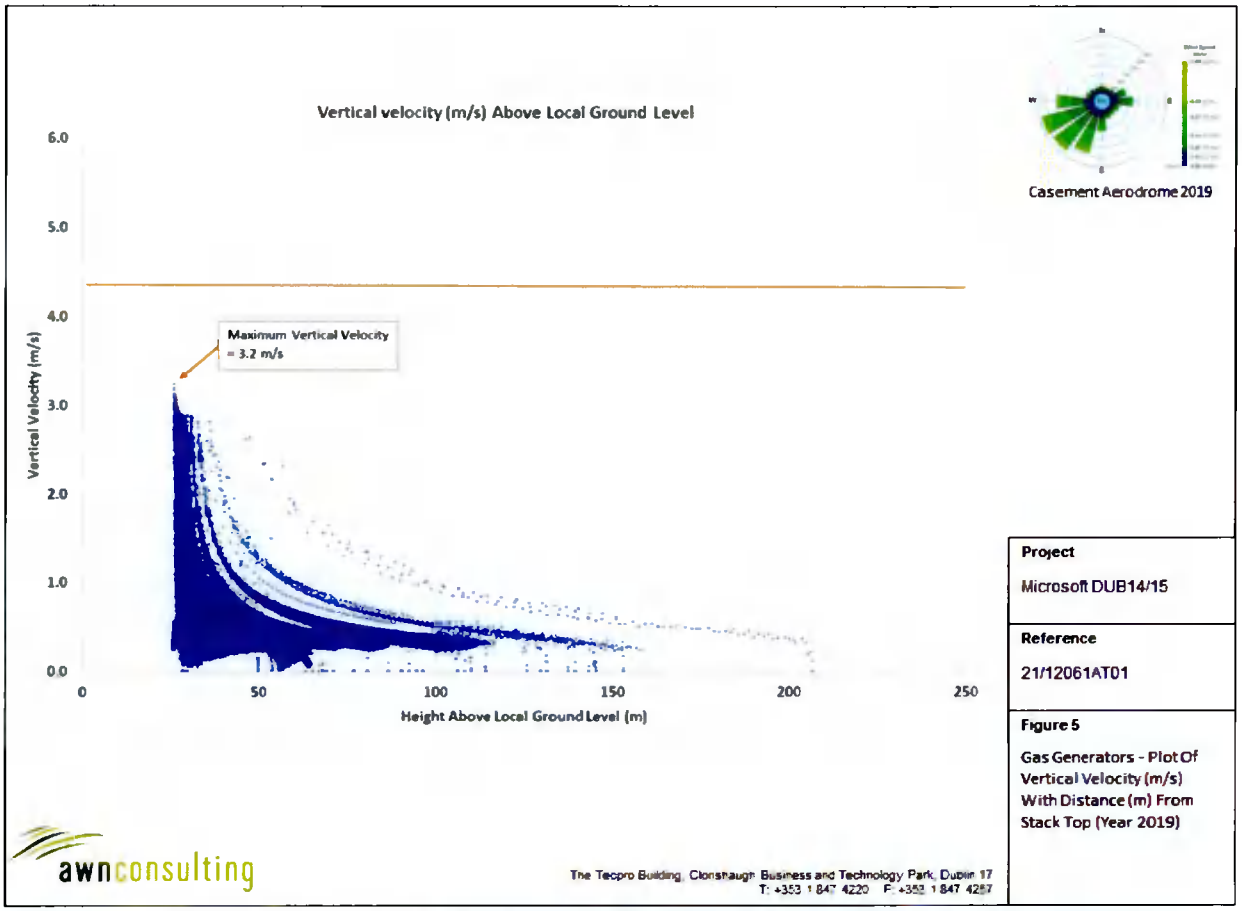

Figure 5 Vertical Velocity Of The Plume (m/s) With Distance From Stack Top – Gas Generators

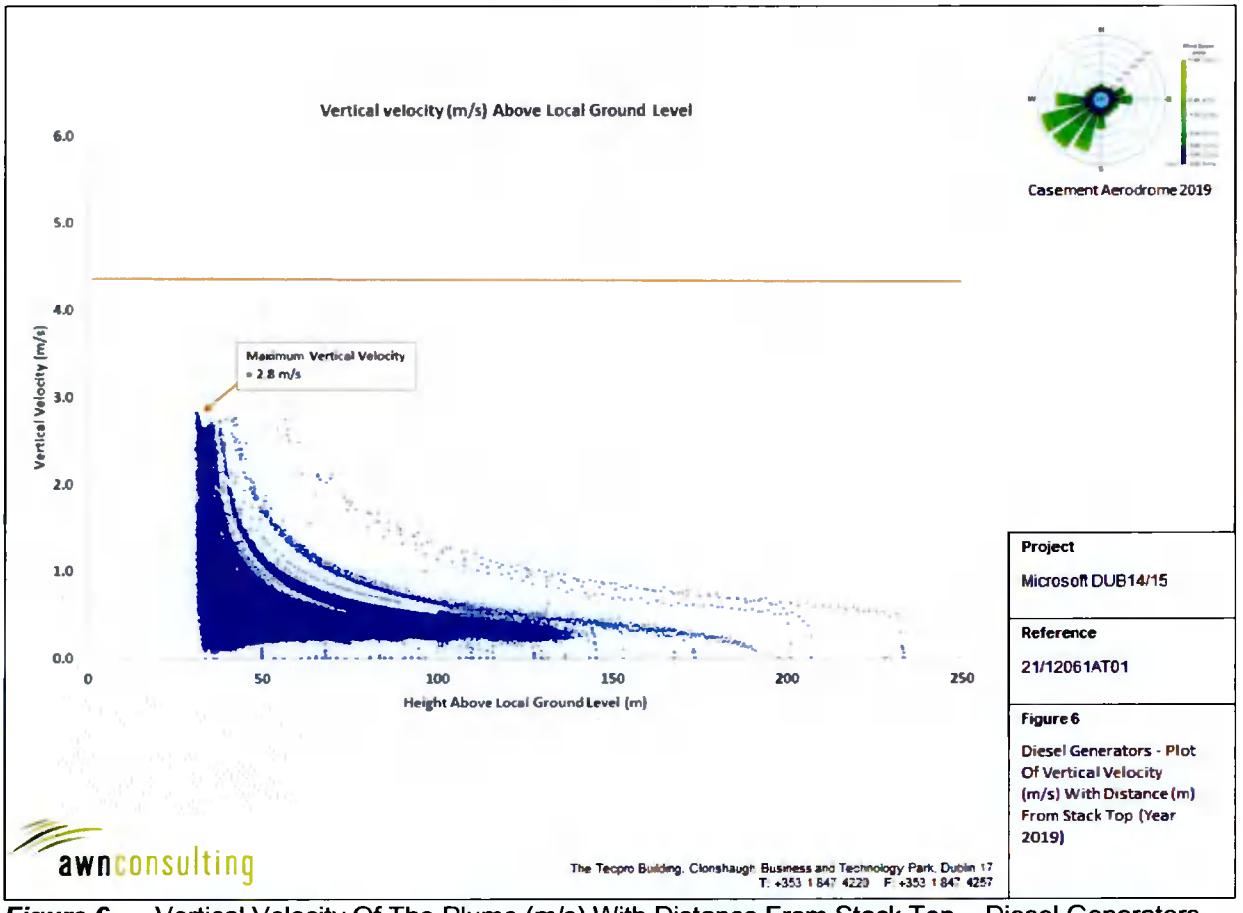

Figure 6 Vertical Velocity Of The Plume (m/s) With Distance From Stack Top – Diesel Generators

The results confirm that the velocity of both the gas generators and diesel generators plume will be below 4.3 m/s within 0.5 metres from each stack for every hour of the year based on Casement Aerodrome 2019 data and includes all meteorological conditions including pressure / temperature inversions.

5.0 SUMMARY

Thus, in summary the results of the analysis are as follows:

- **Oxygen Content** – within 6.0 metres of the stack top the oxygen concentration will increase above the 12% risk level for oxygen.
- **Temperature** – the temperature of the plume will drop to less than 50°C within 5.5 metres of the stack.
- **Vertical Velocity** – the critical vertical velocity of 4.3 m/s will not be exceeded beyond 0.5 metres from the stack top.

Thus, the maximum extent of the risk zone of the plume for each parameter is shown below based on a full year of meteorological data covering all meteorological conditions including pressure / temperature inversions:

- Risk Zone for Oxygen – **6.0 metres**
- Risk Zone for Temperature – **5.5 metres**
- Risk Zone for Vertical Velocity – **< 0.5 metres**
- **COMBINED RISK ZONE – 6.0 metres above stack top and 103.55m OD**

6.0 REFERENCES

CASA (2012) Guidelines For Conducting Plume Rise Assessments AC139-05(1) April 2012

CERC (2016) ADMS-5 User Guide

EPA (2020) Air Dispersion Modelling from Industrial Installations Guidance Note (AG4)

MITRE (2012) Expanded Model For Determining The Effects Of Vertical Plumes On Aviation Safety

USEPA (2018) AERMOD Description of Model Formulation