STRATEGIC INFRASTRUCTURE DEVELOPMENT
APPLICATION TO AN BORD PLEANÁLA
(REG NO. PL04.PA0045)

RINGASKIDDY RESOURCE RECOVERY CENTRE, RINGASKIDDY, COUNTY CORK

REQUEST FOR ADDITIONAL INFORMATION

PLUME MODELLING ASSESSMENT

1. Qualifications and Experience

My name is Edward Porter. I hold a Bachelor of Science degree (1st Class (Hons)) in Chemistry (1991) from the University of Sussex and a Ph.D. in Chemistry (Air Quality) from University College Dublin (1997). I am a Chartered Chemist and a full member of the Institute of Air Quality Management (MIAQM) and the Royal Society of Chemistry (C Chem MRSC), a requirement of membership being that I am active in the field of professional chemistry and satisfy the Society's requirements with regard to level of qualifications and experience.

I have been active in the field of air quality and climate for 23 years, the last 19 years as an Environmental Consultant. I have considerable experience in the areas of planning of proposed developments with regard to air quality and climate, assessment of air quality for compliance purposes and air quality mitigation measures in relation to both construction sites and operational developments. I am currently Director of Air Quality and Climate with AWN Consulting. My experience includes:

- Dublin Waste To Energy Facility (2008)
- Ringaskiddy Waste Management Facility (2009)
- Slane Bypass (2010)
- M11 Gorey to Enniscorthy (2009)
- College Proteins Meat & Bone Meal CHP (2009)
- Carranstown Waste Management Facility Expansion (2012)
- Drehid MBT Facility (2012)
- M7 Widening (2013)
- N5 Castlebar to Westport (2014)
- National Children's Hospital (2015)
- Dun Laoghaire Cruise Berth (2015).

2. Request From An Bord Pleanála

An Bord Pleanála [the Board] has requested that the applicant respond to the contents of the submission from the Department Of Defence dated 11th May 2016. The Board request that the following matters should be addressed:

- The matters raised by the Department of Defence,
- Low gradient flight paths on take-off from and landing at the naval base,
- The impact of local climatic conditions including occasions of atmospheric pressure inversions in Cork Harbour on the character of the plume from the proposed stack, and;
- The possible requirement, based on best international practice, for an exclusion zone around the naval base.

These issues, in so far as they relate to air quality have been addressed below.

2.1 Oral Hearing Evidence

The issue of plume characteristics and the effect on the operation of helicopters in the region of the Ringaskiddy RRC facility was addressed at the Oral Hearing for the project in April / May 2016 in response to issues raised by the DoD during the course of the Hearing. An assessment was undertaken (entitled "*Assessment Of The Risk To Aircraft From Ringaskiddy Resource Recovery Centre Exhaust Plumes*") to

determine the region surrounding the facility where levels of excess temperature, turbulence (vertical velocity) and reduced oxygen could potentially be encountered. The assessment was based on reviewing dispersion modelling work undertaken by the MITRE Corporation[1] and outlined in the user manual for the "Exhaust-Plume-Analyzer" model.

The user guide[1] detailed 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.

Based on a worst-case analysis of the range of distances applicable to much larger emission sources (such as large power stations), the maximum risk height / distance for each of the three parameters was conservatively derived / extrapolated from the report. Very conservative heights were derived ranging from 100 metres for the risk height for elevated temperature, 70 metres for the risk height for depleted oxygen to 50 metres for the risk height for severe turbulence. These conservative heights, in the absence of a site-specific study at that time, were based on sources, such as coal fired power stations, with much greater buoyancy and significantly higher exit temperatures.

The current study has built on the work previously undertaken and has replaced these conservative risk heights with risk heights based on detailed site-specific information. The site-specific study, using the Cambridge Environmental Research Consultants (CERC) AMDS-5[2] model, allows the actual emission data for the Ringaskiddy RCC to be used as input into the model. In addition, meteorological data for the region, based on five years of data from Cork Airport (2010 – 2014), receptor locations 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 3.5 metres from the stack top and this current study thus supersedes the very conservative risk heights previously stated at the Oral Hearing.

2.2 Impact Of Local Climatic Conditions On The Character Of The Plume From The Proposed Stack

The plume from the proposed stack will be released into the atmosphere at a height of 70m (75m OD) and will be influenced by the meteorological conditions which are occurring in the region. The stack will have the characteristics as outlined in Table 8.4 of Chapter 8 of the EIS (referred to as Table 1 below). The oxygen content associated with normal operation is approximately 6.4% oxygen.

Stack Reference	Stack Height (m)	Exit Diameter (m)	Cross-Sectional Area (m^2)	Temp (K)	Volume Flow (Nm^3/hr)(1)	Exit Velocity (m/sec actual)(2)
Grate	70	2.30	4.15	418	142,000 – Maximum 106,900 – Nominal	14.0 10.5

(1) Normalised to 11% O_2, dry, 273K.

(2) Actual, 418K

Table 1 Process Emission Design Detail (taken from Chapter 8 of the Ringaskiddy RRC EIS)

[1] MITRE (2012) Expanded Model For Determining The Effects Of Vertical Plumes On Aviation Safety
[2] CERC (2016) ADMS-5 User Guide

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)[1]. These parameters have been reviewed below.

Oxygen

The Mitre Corporation report confirms that oxygen levels below 12% are potentially hazardous to helicopters[1] and thus the oxygen content of the plume with distance from the stack has been investigated. The oxygen content of the plume at stack top will typically be 6.4% but may potentially reduce to 6% and thus this level 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[1] and thus the decrease in the initial temperature of the plume (145°C) with distance from the stack has been investigated.

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[3] 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 the 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, five years of meteorological conditions has been used in the analysis including periods of atmospheric pressure / temperature inversions. Meteorological years 2010 - 2014 for Cork Airport has been used in the analysis for all scenarios outlined below which is consistent with the meteorological years used in the Ringaskiddy RCC EIS. 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.

The model was also run with a very high density receptor grid based on 2m spacing in the region of the stack top to determine the changes in the parameters above over very short distances. The receptor spacing of 2m was selected as the change with distance in oxygen, temperature and vertical velocity from the stack top is rapid and would be difficult to determine with a coarser grid resolution.

The receptor grid is shown in Figure 1.

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

Figure 1 High Resolution Receptor Grid (2m resolution)

2.3 Oxygen / Plume Interaction

The Mitre Corporation report[(1)] confirms that depleted oxygen is generally of greatest concern when considering helicopter / plume interactions. The Mitre Corporation report[1] 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 the plume with distance from the stack.

CERC, the developers of the EPA approved AMDS-5 model, were contacted to determine whether the oxygen concentration in the plume could be derived indirectly from the reduction in the emission concentration of the plume with distance from the stack. CERC developed the following equation which can be 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):

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

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:

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

ADMS-5 was thus run to calculate the pollutant concentration and identify the distance from the plume centreline where the 12% oxygen level was exceeded. Modelling was undertaken using Cork Airport data over the period 2010 – 2014 with the worst-case year selected. Shown in Figure 2 is the result for the worst-case year (Year 2013).

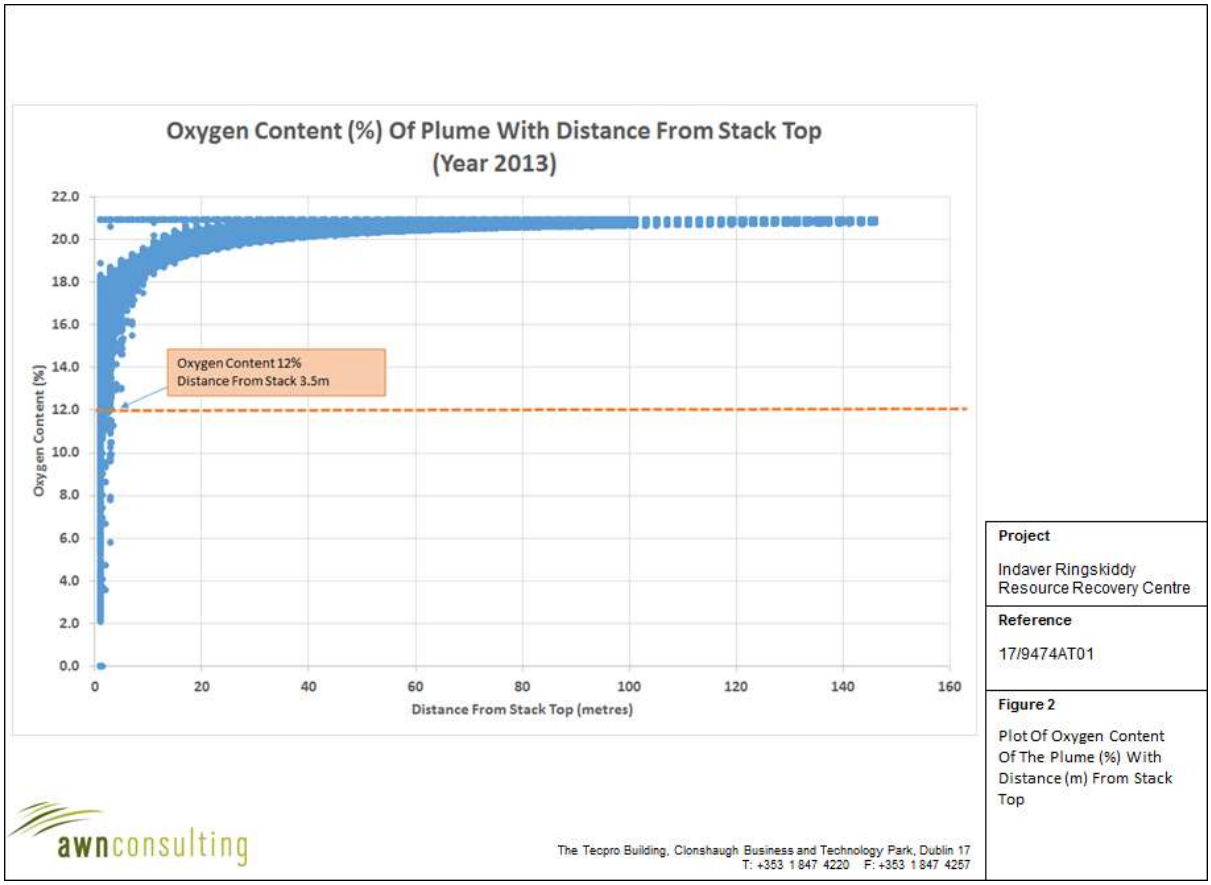

Figure 2 Oxygen Content Of The Plume (%) With Distance From Stack Top

The modelling results confirm that within a distance of 3.5 metres from the stack top the oxygen content of the plume will be 12% or greater. This analysis is based on every hour of the year for each year over a five-year period (Cork Airport 2010 – 2014) and includes all meteorological conditions including pressure / temperature inversions.

2.4 Temperature / Plume Interaction

Temperatures in excess of 50°C are potentially hazardous to helicopters[1] and thus the decrease in the initial temperature of the plume (145°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 Cork Airport 2010 - 2014 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 the worst-case year (Year 2013). The results confirm that the plume will be below 50°C within 3.5 metres of the stack tip for

every hour over a five-year period and includes all meteorological conditions including pressure / temperature inversions.

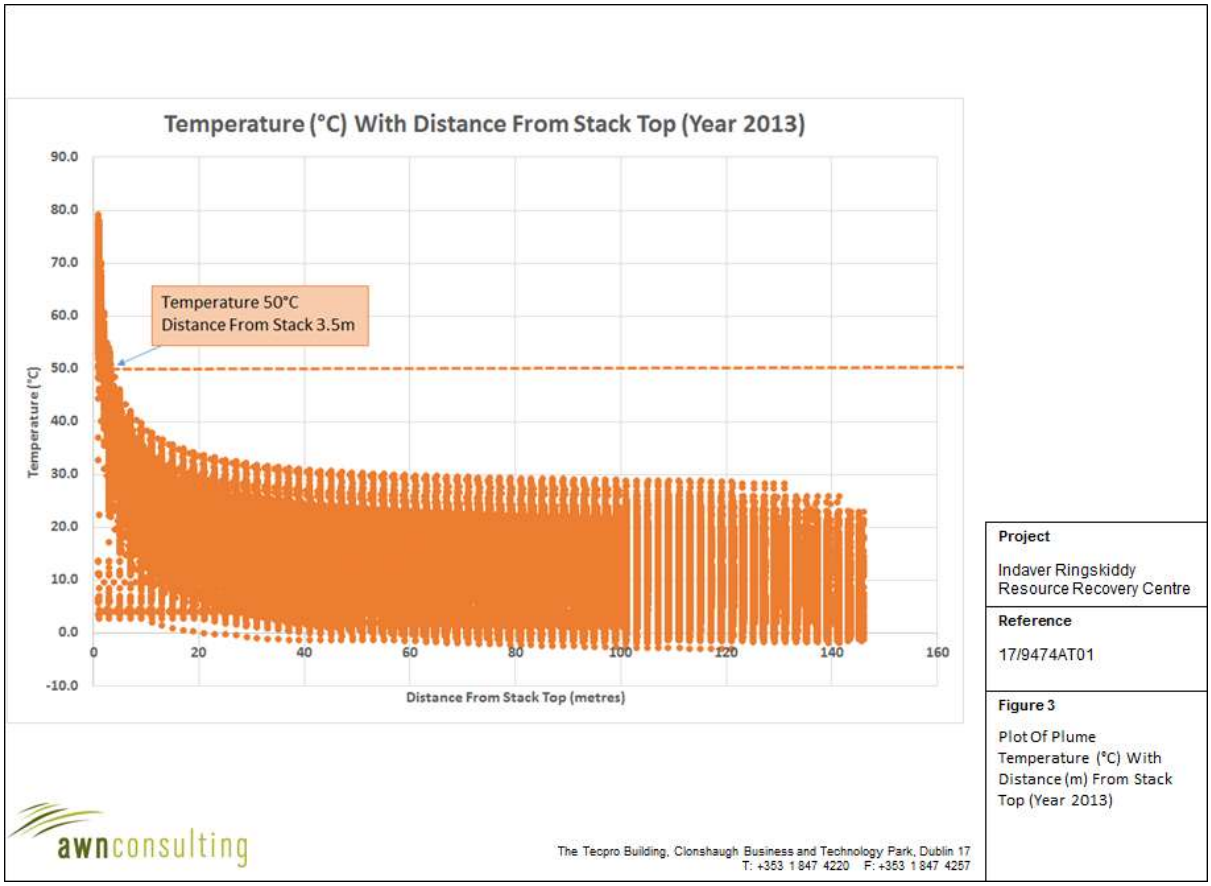

Figure 3 Temperature Of The Plume (°C) With Distance From Stack Top

2.5 Vertical Velocity / Plume Interaction

High vertical velocities are also relevant when considering helicopter / plume interactions. The Australian CASA[3] 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 again 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 over a five-year period (Cork Airport 2010 – 2014 data) with the worst-case year (Year 2014) presented in Figure 4 below.

The results confirm that the velocity of the plume will be below 4.3 m/s within 3.4 metres from the stack for every hour over a five-year period based on Cork Airport data for 2010 – 2014 and includes all meteorological conditions including pressure / temperature inversions.

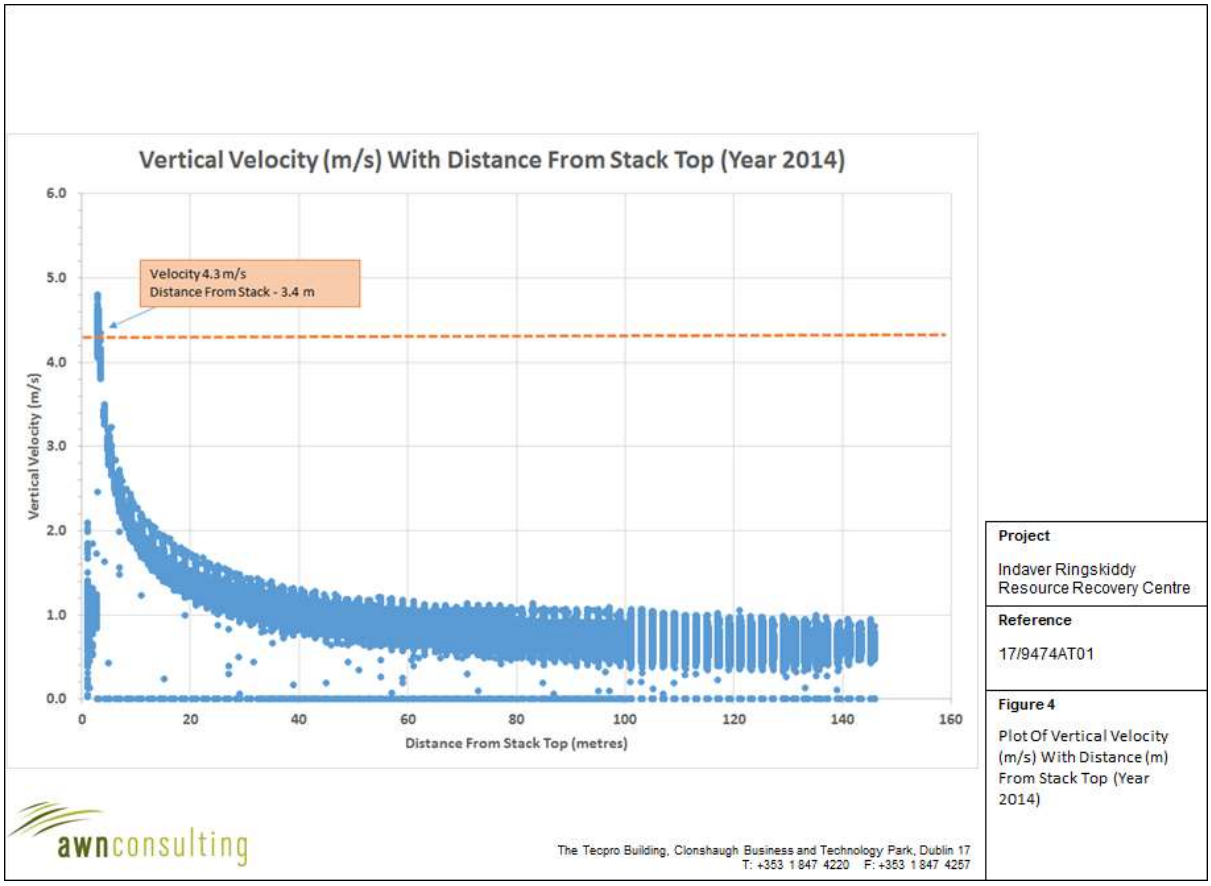

Figure 4 Vertical Velocity Of The Plume (m/s) With Distance From Stack Top

2.6 Summary

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

- **Oxygen Content –** within 3.5 metres of the stack 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 3.5 metres of the stack.
- **Vertical Velocity –** the critical vertical velocity of 4.3 m/s will not be exceeded beyond 3.4 metres from the stack top.

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

- Risk Zone for Oxygen **– 3.5 metres**
- Risk Zone for Temperature **– 3.5 metres**
- Risk Zone for Vertical Velocity **– 3.4 metres**
- **COMBINED RISK ZONE – 3.5 metres**