Appendix 8.8

Air Quality Helicopter Risk Assessment

APPENDIX 8.8

8.8.1 Air Quality Helicopter Risk Assessment

During the course of the assessment of the planning application by An Bord Pleanála (the Board) in 2018 the Department of Defence raised concerns about potential impacts on Air Corps operations at the Haulbowline Naval Base from the stack plume. As outlined below, this report confirms that the extent of plume in terms of risk levels of oxygen, vertical velocity and temperature is limited to a region much lower than 150m and thus this report confirms that there will be no impact on Air Corps operations. Other submissions were also received by the Board which raised the following matters:

- The plume modelling was undertaken using ADMS whereas AERMOD was used in the EIS,
- The modelling ignored the vertical extent of the plume,
- The vertical extent of the vertical velocity, temperature and oxygen has been underestimated,
- The meteorological data used in the model (Cork Airport) is not appropriate,
- The effect of plume dispersion due to the wind turbine has not been assessed,
- The effect of the velocity deficit of the wind turbine and associated eddy currents (turbulence) has not been assessed.

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

8.8.2 ADMS vs AERMOD Air Dispersion Models

Both ADMS and AERMOD are given equal weighting by the EPA in the guidance document "*Air Dispersion Modelling From Industrial Installations Guidance Note*" (EPA, 2020). However, ADMS has several advantages over AERMOD in terms of determining the parameters of interest (vertical velocity, temperature and oxygen):

8.8.2.1 Vertical Velocity

AERMOD does not produce the parameters required to determine the vertical velocity (change in vertical height of plume with time) and thus cannot be used to determine vertical velocity. ADMS does have this capability and thus was selected to undertake the study of the change in vertical velocity with height.

8.8.2.2 Temperature

AERMOD cannot track the path of the plume with distance from the stack for the parameters of interest for each hour of the year. ADMS produces a .cen file for every hour of the year which outputs the parameters (temperature, concentration, change of plume height with distance). Thus, actual direct changes in temperature of the plume could be tracked for every hour of the day downwind of the release.

A requirement of the temperature assessment is the need to know the ambient temperature for every hour of the year. A submission has suggested that an ambient level of 30°C would be appropriate for every hour of the year. However, this would be a gross over-estimation of reality (i.e. the highest temperature ever recorded at Roches Point is 28°C with an average temperature of 10.5°C). Unfortunately, AERMOD is not formulated to extract, even indirectly, the change in temperature of the plume with distance from the stack on an hourly basis.

The report entitled "*Plume Modelling Assessment*" (May 2017) assessed the temperature of the plume as a function of downwind distance from the stack. Shown in Section 8.8.5 is the temperature of the plume as a function of vertical distance from stack top (i.e. distance directly above stack top). Results indicate the vertical distance where the temperature is greater than 50°C is limited to 6.8m in the worst-case year assessed (Year 2014) which is slightly greater than the x-y plane results of 3.5m. However, both results should be compared to the physical restriction zone of 150m for context.

8.8.3 Oxygen

Again, for ADMS, the oxygen concentration can be tracked as a function of distance downstream of the plume which then allows one to determine the change in oxygen % of the plume as a function of distance for each hour.

AERMOD can be used to indirectly calculate the oxygen concentration for a 3-dimensional grid of receptors as the ambient oxygen level is fixed at 20.95%. In order to address concerns raised, the oxygen concentration using AERMOD has been derived below in Section 8.8.3.1 based on a high resolution 3-D grid (2m resolution in horizontal, 1m resolution in the vertical, grid from 65m – 95m above local ground level, 40m x 40m, 13,230 receptors).

8.8.3.1 Oxygen / Plume Interaction Using AERMOD

As outlined in the report entitled "*Plume Modelling Assessment*" (May 2017), CERC, the developers of the EPA approved ADMS-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):

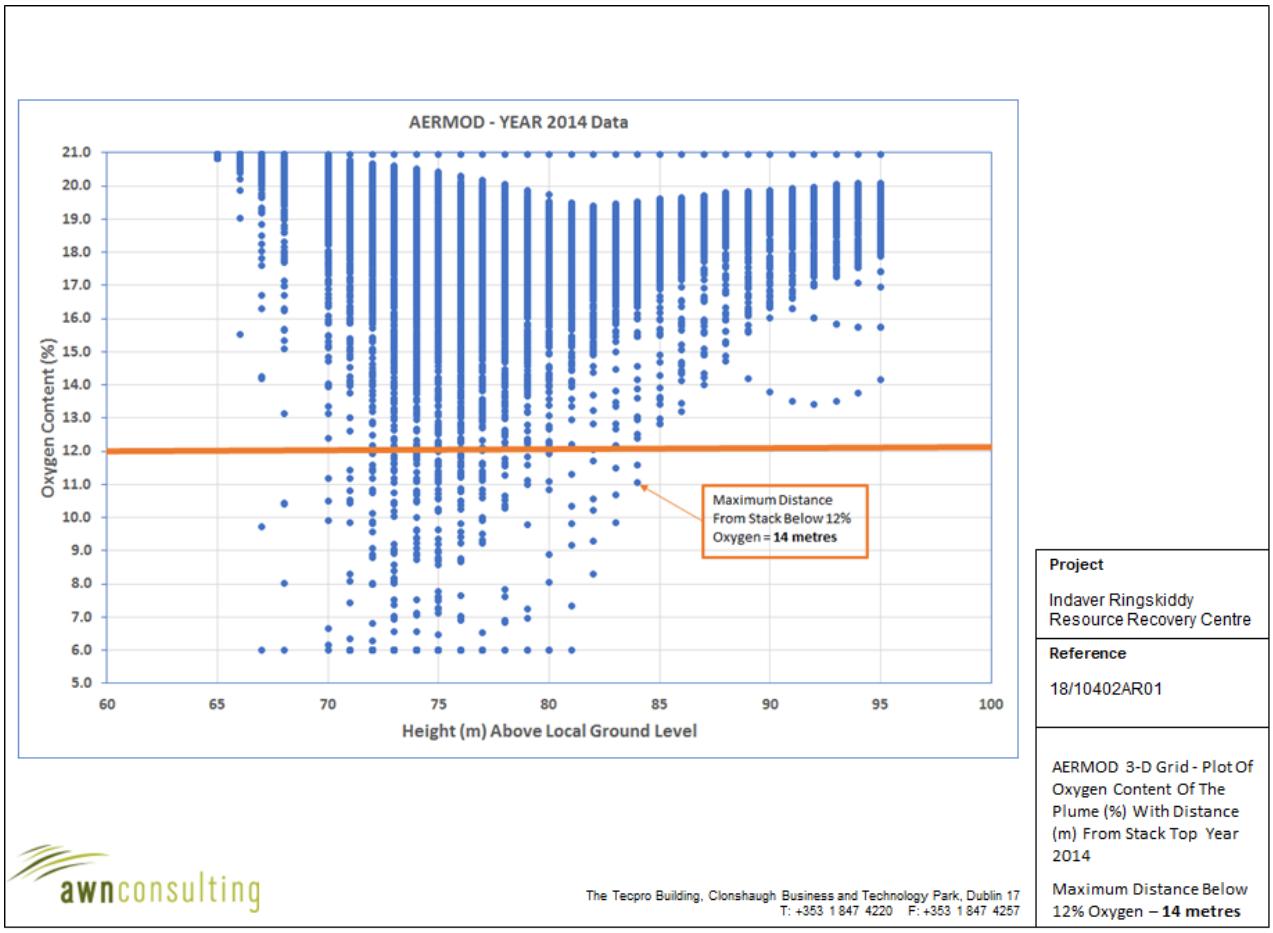
$$\boldsymbol{c / e = (20.95-O) / (20.95-6.0)}$$

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:

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

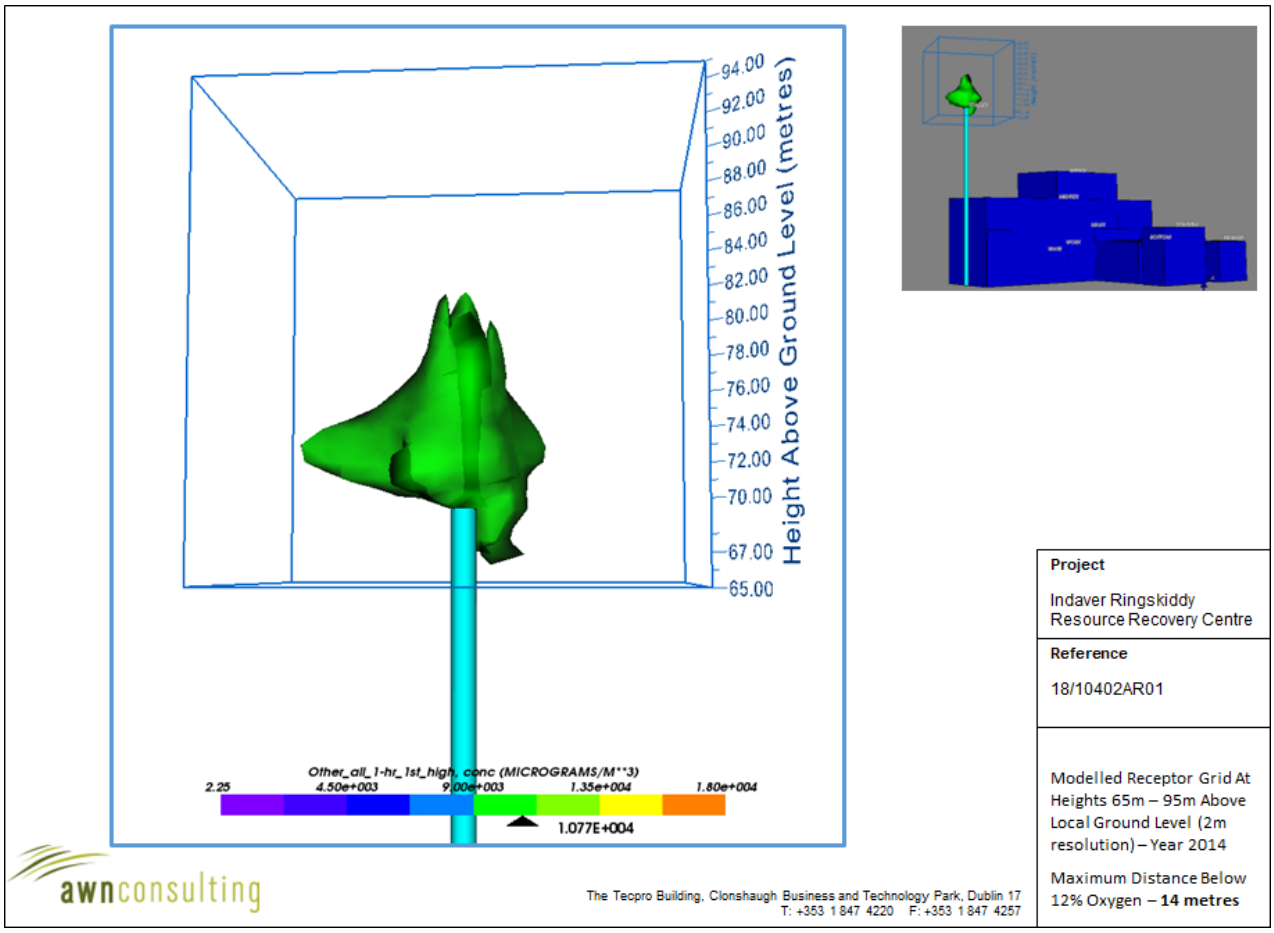
AERMOD has now been used in this report to calculate the pollutant concentration and identify the distance, represented as a dense 3-D grid of receptors, where the 12% oxygen level was exceeded. Modelling was undertaken using Cork Airport data over the period 2010 – 2014 with the worst-case year selected. Shown in Figure A8.10 is the result for the worst-case year (Year 2014).

Figure A8.10 AERMOD 3-D Grid - Plot Of Oxygen Content Of The Plume (%) With Distance (m) From Stack Top Year 2014



The modelling results determined a maximum vertical and horizontal distance of 14 metres from the stack top where 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. The values for the other four years ranged from 9m – 13m. As shown in Figure A8.11, the isosurface plot shows that the maximum extent of the plume is similar in both the vertical direction and horizontal direction.

Figure A8.11 Modelled Receptor Grid At Heights 65m – 95m Above Local Ground Level (2m resolution) – Year 2014



Some differences in the results between ADMS and AERMOD are to be expected for several reasons:

- The models work best at 50m – 100m from stack and thus very close to the stack exit minor differences in formulations will be exaggerated.
- If all input parameters are consistent, models are expected to agree within a factor of two.
- The ADMS modelling and the AERMOD modelling differ in that ADMS is tracking the plume downstream of its release whilst AERMOD is using a fixed grid at which the model concentrations are determined.

Although the ADMS and AERMOD results differ, the use of both models confirms that the region of risk due to reduced oxygen levels is significantly below the physical restriction zone of 150m.

8.8.4 The meteorological data used in the model (Cork Airport) is not appropriate.

A submission has suggested that Cork Airport data is inappropriate and that Roches Point data should be used for assessing dispersion in the vicinity of the facility. Roches Point station is unmanned and thus does not have all relevant meteorological parameters such as cloud cover. However, wind speed, wind direction, temperature and relative humidity are available and have been used for Year 2014 with the missing parameters such as cloud cover supplemented by Cork Airport 2014 data. Results for Roches Point 2014 are shown in Figure A8.12 and Figure A8.13 and confirm that the results are similar for both Cork Airport and Roches Point. The maximum distance is 13 metres from the stack top where the oxygen content of the plume will be 12% or greater. Thus, for Year 2014, Roches Point indicates a slightly lower distance where oxygen is below 12% compared to Cork Airport.

Figure A8.12 AERMOD 3-D Grid - Plot Of Oxygen Content Of The Plume (%) With Distance (m) From Stack Top Year 2014 Roches Point

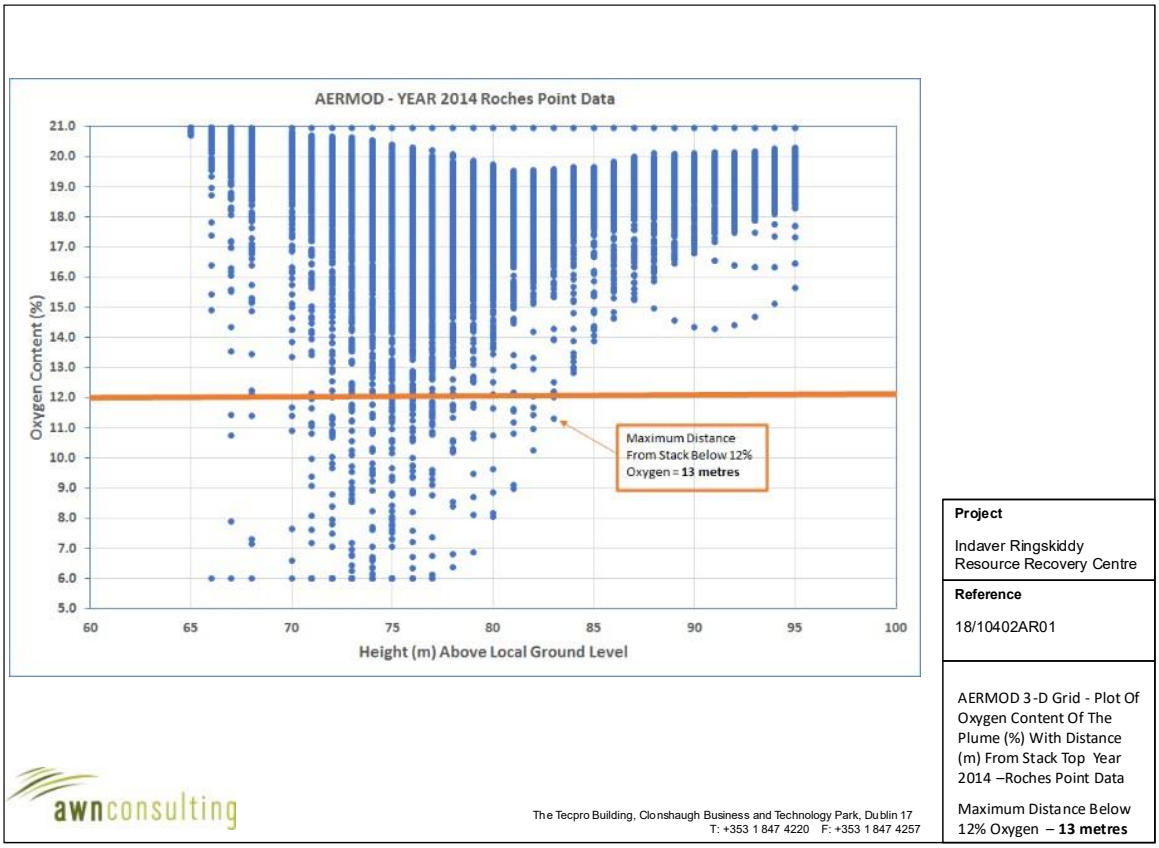
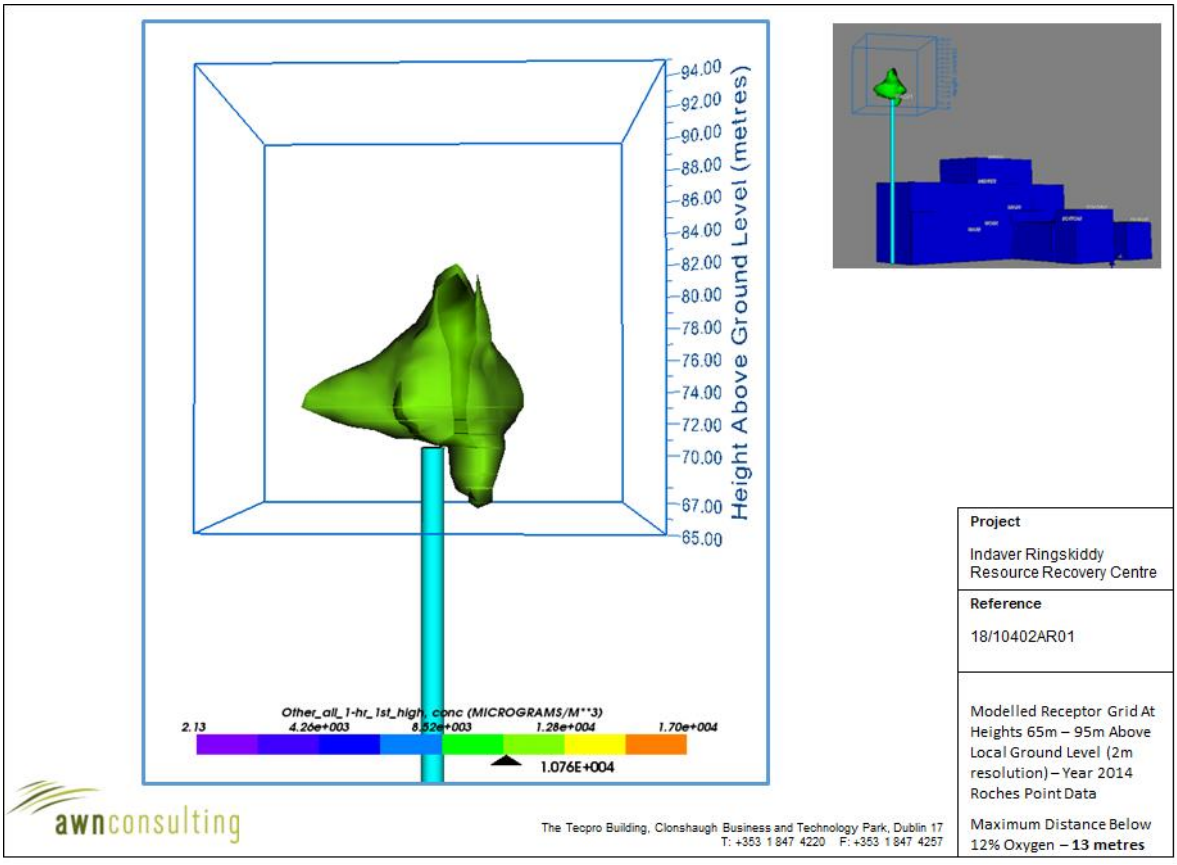


Figure A8.13 Modelled Receptor Grid At Heights 65m – 95m Above Local Ground Level (2m resolution) – Year 2014

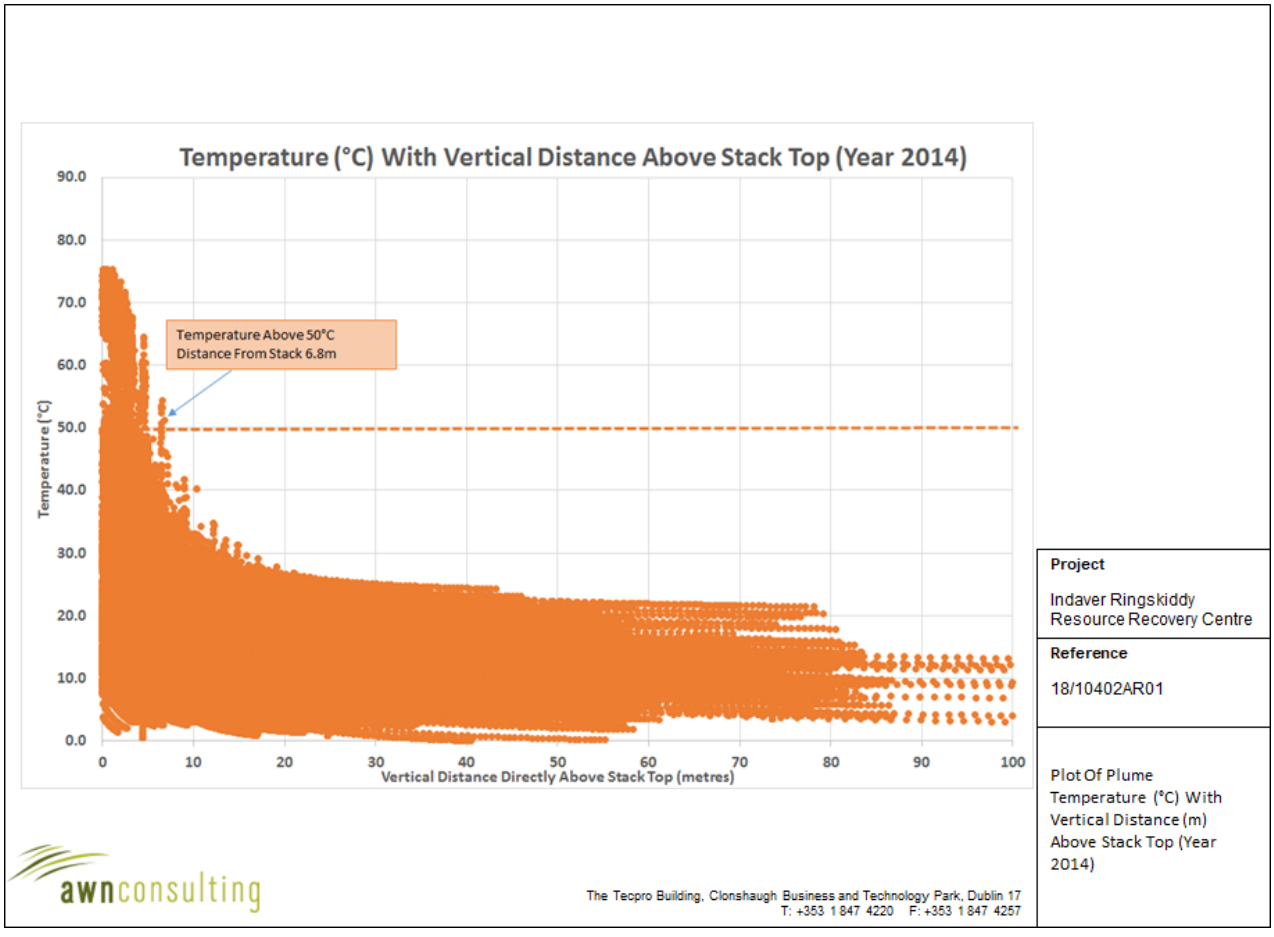


8.8.5 Vertical Temperature / Plume Interaction

As outlined in the "*Plume Modelling Assessment*" (May 2017), temperatures in excess of 50°C are potentially hazardous to helicopters and thus the decrease in the initial temperature of the plume (145°C) with distance from the stack was investigated. Modelling of the temperature of the plume with distance from the stack was been undertaken using the CERC ADMS-5 model for every hour of the year based on Cork Airport 2010 - 2014 meteorological data. The model found that the plume would be below 50°C within 3.5 metres downwind of the stack tip for every hour over a five-year period covering all meteorological conditions including pressure / temperature inversions.

This modelling has been supplemented in this section in order to determine the vertical zone, directly above the stack, where the temperatures is in excess of 50°C. Modelling of the temperature of the plume with vertical distance above 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 found that the plume will be below 50°C within 6.8 metres directly above the stack tip for every hour over a five-year period and covers all meteorological conditions including pressure / temperature inversions as shown in Figure A8.14 for the worst-case year (Year 2014).

Figure A8.14 Plot Of Plume Temperature (°C) With Vertical Distance (m) Above Stack Top (Year 2014)

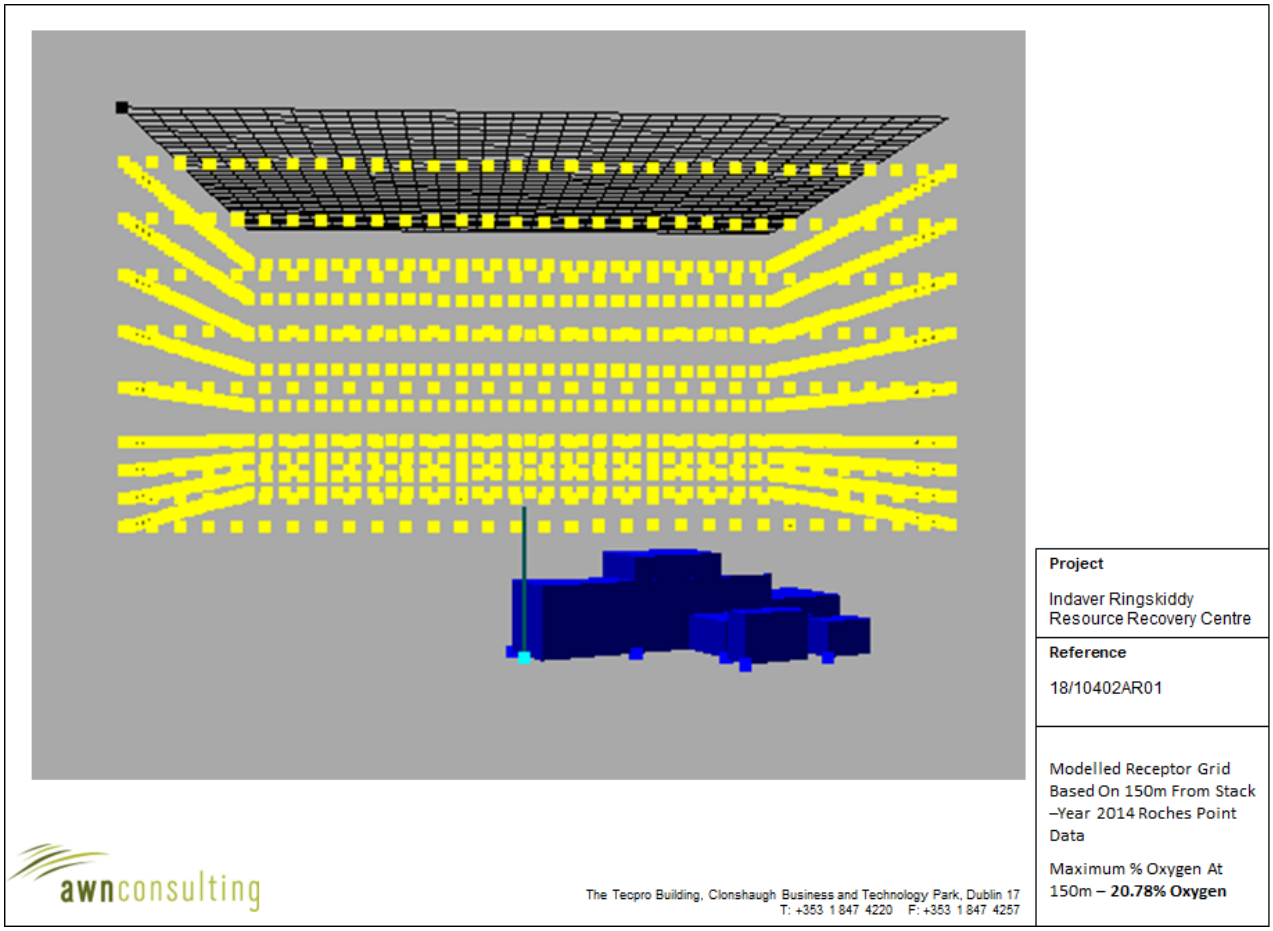


8.8.6 Oxygen / Plume Using AERMOD At 150m From Stack

The AERMOD model has been run with a receptor grid placed at a distance of 150m from the stack top, both horizontally and vertically as shown in Figure A8.15 using Roches Point data for 2014. 150m has been selected as this is the physical restriction zone to which the Air Corps operate. The receptor spacing is 5m in the horizontal with the grid spacing in the vertical increasing from 5m to 20m with altitude.

The results indicate that at a distance of 150m from the stack top, the minimum 1-hour oxygen concentration, over the course of a full year is **20.78% oxygen** compared to an ambient level of 20.95% oxygen. For this particular hour (23:00, 02/09/2014), the predicted temperature is 15.1°C compared to an ambient level of 13.6°C. The results should also be compared to the risk level of 12% oxygen and a temperature risk level of 50°C. Thus, should a helicopter approach the facility at a distance of 150m from the stack top the minimum oxygen level experienced is predicted to be 20.78% oxygen.

Figure A8.15 Modelled Receptor Grid Based On 150m From Stack –Year 2014 Roches Point Data



8.8.7 Updated Oxygen / Plume Using AERMOD At 150m From Stack

As outlined in Section 8.8.3, at a distance of 150m from the stack top, the minimum 1-hour oxygen concentration, over the course of a full year (Roches Point 2014) is 20.78% oxygen compared to an ambient level of 20.95% oxygen.

The AERMOD model has been updated also to reflect the changes to the volume flow as outlined in Table A8.16 of Appendix 8.6 of the EIS. The model run had the same receptor spacing with a receptor grid placed at a distance of 150m from the stack top, both horizontally and vertically using Roches Point data for 2014. The receptor spacing is 5m in the horizontal with the grid spacing in the vertical increasing from 5m to 20m with altitude.

The updated results indicate that at a distance of 150m from the stack top, the minimum 1-hour oxygen concentration, over the course of a full year is **20.75% oxygen** compared to an ambient level of 20.95% oxygen. The results should be compared to the risk level of 12% oxygen. Thus, should a helicopter approach the facility at a distance of 150m from the stack top the minimum oxygen level experienced is predicted to be 20.75% oxygen.

8.8.8 Updated Oxygen / Plume Interaction Using AERMOD

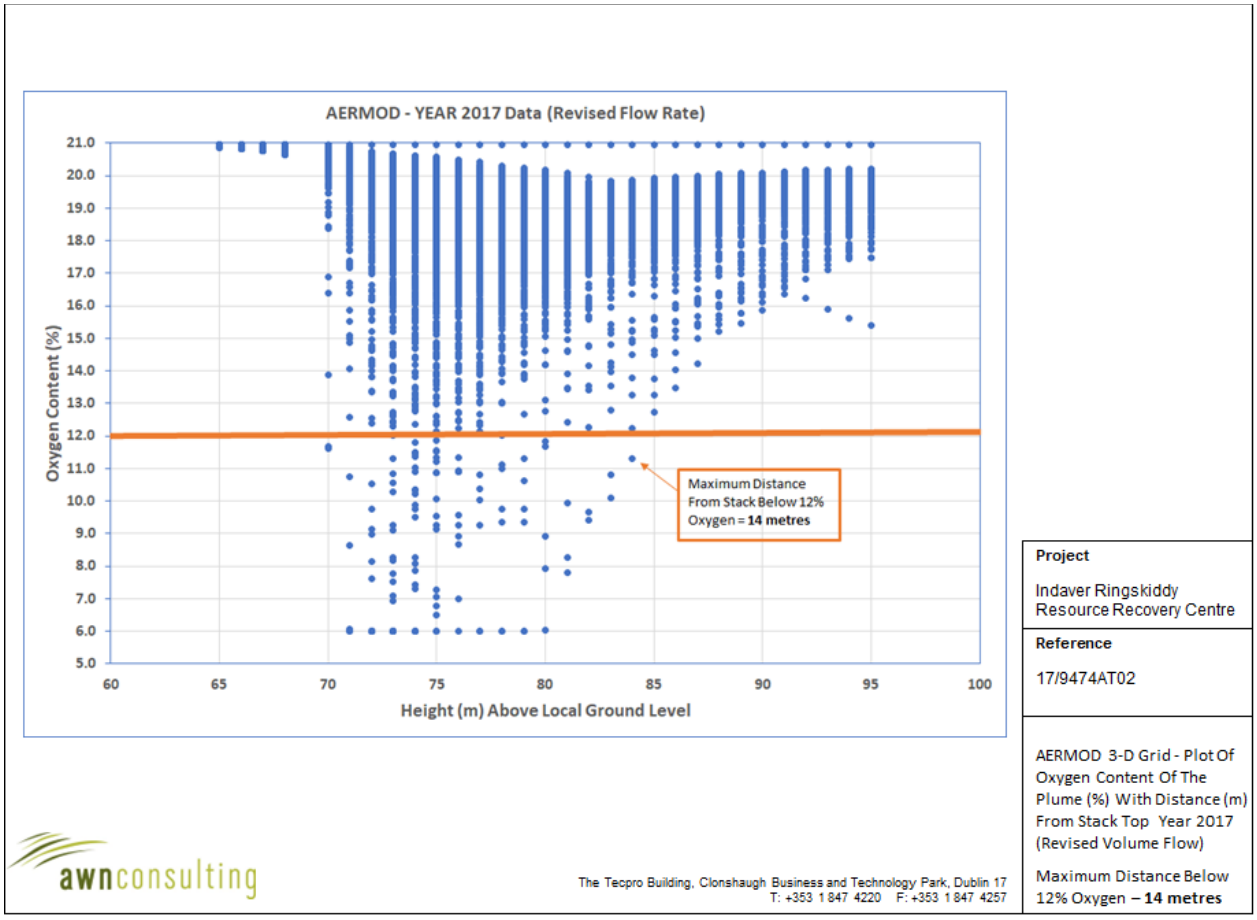
The modelling based on both ADMS and AERMOD has confirmed that the maximum extent of the risk zone of the plume for each parameter is shown below based on five years of meteorological data (Cork Airport 2010 – 2014) (and Roches Point 2014 data) covering all meteorological conditions including pressure / temperature inversions:

- Risk Zone for Oxygen (AERMOD) **– 14 metres**
- Risk Zone for Oxygen (ADMS) **– 3.5 metres**
- Risk Zone for Temperature **– 6.8 metres**
- Risk Zone for Vertical Velocity **– 3.4 metres**

As AERMOD indicates a greater maximum extent of the risk zone, compared to ADMS, the AERMOD modelling has been updated to reflect the changes to volume flow (as outlined in Table A8.16 of Appendix 8.6 of the EIS) and to incorporate more recent meteorological data (Cork Airport 2014 – 2018) (and Roches Point 2014 data).

The updated assessment has calculated the pollutant concentration and identifies the distance where the 12% oxygen level was exceeded. Modelling was undertaken using Cork Airport data over the period 2014 – 2018 with the worst-case year selected. Shown in Figure A8.16 is the result for the worst-case year (Year 2017).

Figure A8.16 Oxygen Content Of The Plume (%) With Distance From Stack Top - AERMOD



The updated modelling results determined a maximum vertical and horizontal distance of 14 metres from the stack top where 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 2014 – 2018) and

Roches Point for 2014 and includes all meteorological conditions including pressure / temperature inversions.

As the oxygen assessment using AERMOD was the determining factor in the assessment, in that it indicated the maximum extent of the risk zone, the AERMOD assessment was updated to confirm that the changes to the volume flow and more recent meteorological data did not change the original conclusions. As outlined above, the results of the updated assessment indicate that the maximum extent of the risk zone was unchanged at 14m and thus the other relevant parameters (temperature, vertical velocity) will remain significantly within the 14m maximum risk zone.

Given the range of meteorological conditions examined above the assessment is considered robust. Guidance from the EPA[9] (in AG4 (2020)) states that in relation to air dispersion modelling that "*the most recent year of the meteorological data set used should have been compiled within the last ten years*" (which is Year 2014), the fact that the most recent year assessed is Year 2018 complies with the EPA requirements for air modelling assessment.

8.8.9 Summary

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

- **Oxygen Content (ADMS) -** within 3.5 metres of the stack the oxygen concentration will increase above the 12% risk level for oxygen.
- **Oxygen Content (AERMOD) -** 14 metres of the stack the oxygen concentration will increase above the 12% risk level for oxygen.
- **Temperature (ADMS) –** the temperature of the plume will drop to less than 50°C within 3.5 metres in the x-y plane and 6.8 metres directly above stack top.
- **Vertical Velocity (ADMS) –** the critical vertical velocity of 4.3 m/s will not be exceeded beyond 3.4 metres, vertically, above 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 (and Roches Point 2014 data) covering all meteorological conditions including pressure / temperature inversions:

- Risk Zone for Oxygen **– 14 metres**
- Risk Zone for Temperature **– 6.8 metres**
- Risk Zone for Vertical Velocity **– 3.4 metres**
- **COMBINED RISK ZONE USING AERMOD & ADMS – 14 metres**

The assessment has also confirmed the following:

- At 150m from the stack top, the minimum predicted oxygen concentration is 20.75% compared to an ambient level of 20.95% and a risk level of 12% oxygen. For this worst-case hour, the associated temperature of the plume is 15.1°C compared to an ambient level of 13.6°C and a risk level of 50°C.

- Modelling of the effect of the wind turbine on dispersion of the plume from the Ringaskiddy RRC stack has found that the impact of the velocity deficit and associated turbulence (eddy diffusion) on ambient levels of pollutants is not significant and all pollutants will remain well below the ambient air quality standards.

- Modelling of the flow field in the region of the wind turbine has found that downwind of the wind turbine there will be some changes to the annual mean velocity, reducing to 3.5 m/s compared to levels of 6 m/s outside of this zone. However, levels in the region of the Ringaskiddy RRC will not be significantly changed on an annual basis.

- Similarly, modelling of the vertical turbulence in the region of the wind turbine has found that downwind of the wind turbine there will be some increase to the annual mean vertical turbulence,

increasing to 0.75 m/s compared to levels of 0.5 m/s outside of this zone. Levels in the region of the Ringaskiddy RRC will not be significantly affected on an annual basis increasing slightly to 0.55 m/s.

In summary, any risk from the Ringaskiddy RRC plume will be contained to well within 150m from the stack top and thus will not impact on the Air Corps operations.