
Appendix 5A
Description of the
AERMOD Model

APPENDIX 5A

Description of the AERMOD Model

The AERMOD dispersion model has been recently developed in part by the U.S. Environmental Protection Agency (USEPA)^(A1). 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^(A2).

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.

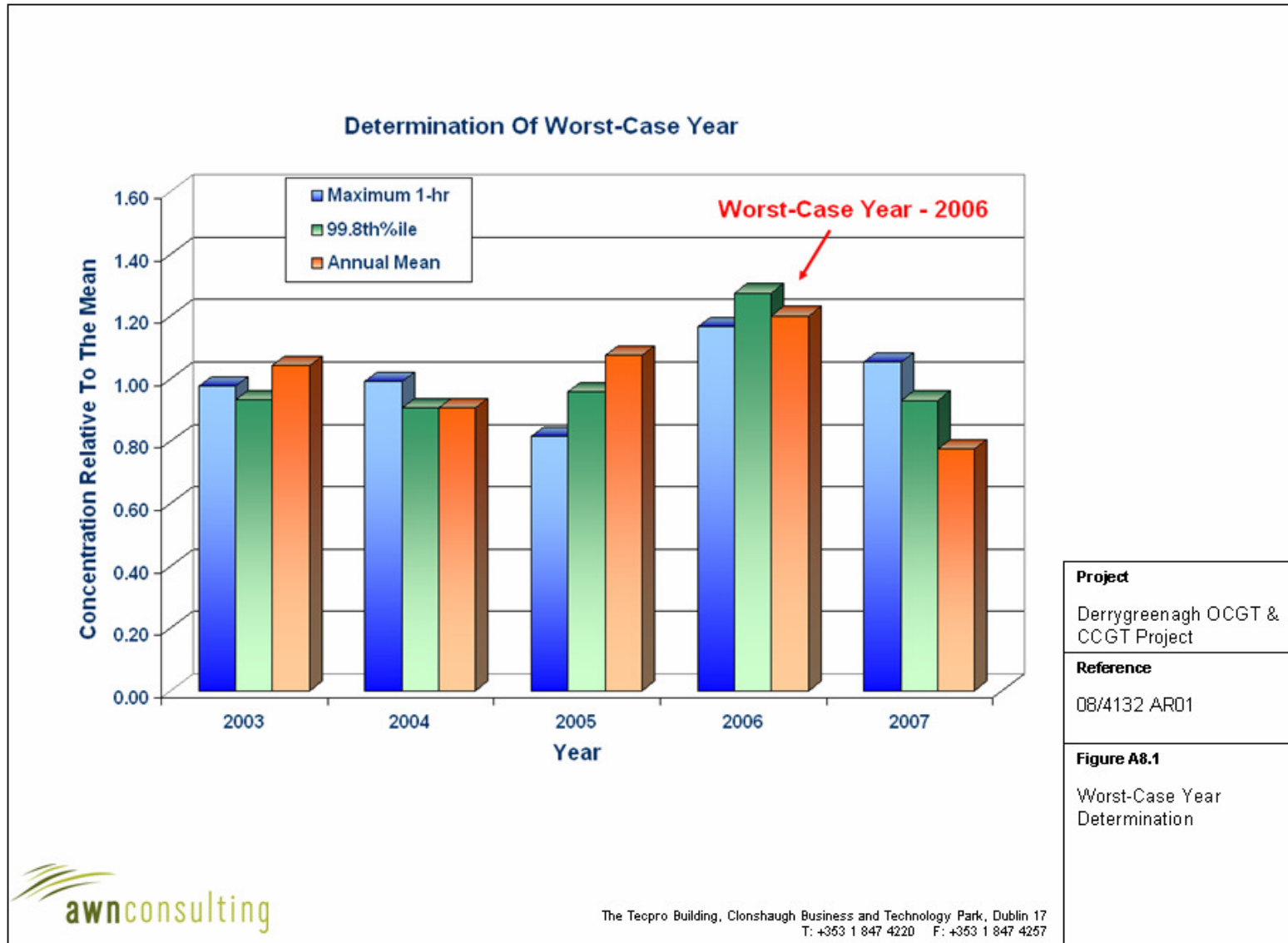
The immediate zone in the lee of the building is termed the cavity or near wake and is characterised by high intensity turbulence and an area of uniform low pressure. Plume mass captured by the cavity region is re-emitted to the far wake as a ground-level volume source. The volume source is located at 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^(A1). 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^(A1). 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 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.

Worst-case meteorological conditions have been used in all assessments. The worst-case year with regard to the maximum 1-hour concentration (as a 99.8th%ile) was selected for modelling all pollutants (Year 2006). The maximum 1-hour concentrations (as a 99.8th%ile) using year 2006 meteorological data is 20% higher than the five-year average. This year is also the worst-case year in terms of the annual mean as shown in Figure A8.1.



Appendix 5B
AERMET PRO

APPENDIX 5B

AERMET PRO

AERMOD incorporates a meteorological pre-processor AERMET PRO^(A3). AERMET PRO allows AERMOD to account for changes in the plume behaviour with height. AERMET PRO 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 PRO meteorological pre-processor 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 PRO 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 PRO 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 type was carried out to a distance of 3km from Casement Aerodrome in line with USEPA recommendations^(A3). In relation to wind direction, a minimum sector arc of 30 degrees is recommended. In the current model, the surface characteristics for the site were assessed and two sectors identified with distinctly varying land use characteristics.

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 an area-weighted average of the 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 3km from Casement Aerodrome is shown in Table B1.

Table B1 Surface Roughness based on an area-weighted average of the land use within a 3km radius of Casement Aerodrome

Sector	Area Weighted Land Use Classification	Spring	Summer	Autumn	Winter ⁽¹⁾
205 - 0	1.0 (grassland)	0.050	0.100	0.010	0.010
0 - 205	0.3 (grassland) + 0.7 (urban)	0.715	0.730	0.703	0.703

(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))^(A4). Thus for the current location autumn more accurately defines “winter” conditions.

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 albedo derived from the land use classification within a radius of 3km from Casement Aerodrome is shown in Table B2.

Table B2 Albedo based on an area-weighted average of the land use within a 3km radius of Casement Aerodrome

Sector	Area Weighted Land Use Classification	Spring	Summer	Autumn	Winter ⁽¹⁾
205 - 0	1.0 (grassland)	0.180	0.180	0.200	0.200
0 - 205	0.3 (grassland) + 0.7 (urban)	0.152	0.166	0.186	0.186

(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))^(A4). Thus for the current location autumn more accurately defines “winter” conditions.

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 Bowen ratio derived from the land use classification within a radius of 3km from Casement Aerodrome is shown in Table B3.

Table B3 Bowen ratio based on an area-weighted average of the land use within a 3km radius of Casement Aerodrome

Sector	Area Weighted Land Use Classification	Spring	Summer	Autumn	Winter ⁽¹⁾
205 - 0	1.0 (grassland)	0.400	0.800	1.000	1.000
0 - 205	0.3 (grassland) + 0.7 (urban)	0.820	1.640	1.700	1.700

(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))^(A4). Thus for the current location autumn more accurately defines “winter” conditions.

REFERENCES

- (A1) USEPA (2005) AERMOD Description of Model Formulation
- (A2) USEPA (2005) Federal Register, 40 CFR Part 51 “Revisions on the Guidelines on Air Quality Models: Adoption of a Preferred General Purpose (Flat and Complex Terrain) Dispersion Model and Other Revisions: Final Rule”
- (A3) USEPA (2005) User’s Guide to the AERMOD Meteorological Preprocessor (AERMET)
- (A4) Auer Jr, (1978) Correlation of Land Use and Cover with Meteorological Anomalies, Journal of Applied Meteorology 17(5):636-643.

Appendix 5C
Emission Data for
Proposed Power Plant
Facility, Derrygreenagh,
Co. Offaly

APPENDIX 5C Emission Data for Proposed Power Plant Facility, Derrygreenagh, County Offaly

Stack Reference	Stack Height (m)	Exit Diameter (m)	Cross-Sectional Area (m ²)	Temperature (K)	Max Volume Flow (Nm ³ /hr)	Exit Velocity (m/sec actual)	Concentration (mg/Nm ³)	Mass Emission (g/s)
CCGT - Diesel	50	6.9	37.4	414	2,698,312	31.9	120	94.3
OCGT - Diesel	40	5.5	23.7	543	1,684,072	39.1	120	56.1
CCGT - Gas	50	6.9	37.4	350	2,730,818	24.8	50	36.2
OCGT - Gas	40	5.5	23.7	543	1,667,825	38.8	50	23.2

Table C1: Source NO_x Emission Data for Proposed Power Plant Facility, Derrygreenagh, County Offaly.

Stack Reference	Stack Height (m)	Exit Diameter (m)	Cross-Sectional Area (m ²)	Temperature (K)	Max Volume Flow (Nm ³ /hr)	Exit Velocity (m/sec actual)	Concentration (mg/Nm ³)	Mass Emission (g/s)
CCGT - Diesel	50	6.9	37.4	414	2,698,312	31.9	51	40.1
OCGT - Diesel	40	5.5	23.7	543	1,684,072	39.1	51	23.9

Table C2: Source SO₂ Emission Data for Proposed Power Plant Facility, Derrygreenagh, County Offaly.

Stack Reference	Stack Height (m)	Exit Diameter (m)	Cross-Sectional Area (m ²)	Temperature (K)	Max Volume Flow (Nm ³ /hr)	Exit Velocity (m/sec actual)	Concentration (mg/Nm ³)	Mass Emission (g/s)
CCGT - Diesel	50	6.9	37.4	414	2,698,312	31.9	5	3.9
OCGT - Diesel	40	5.5	23.7	543	1,684,072	39.1	5	2.3

Table C3: Source PM₁₀ / PM_{2.5} Emission Data for Proposed Power Plant Facility, Derrygreenagh, County Offaly.

Appendix 5D
Dust Minimisation Plan

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Dust Minimisation Plan

A dust minimisation plan will be formulated for the construction phase of the project, as construction activities are likely to generate some dust emissions. The potential for dust to be emitted depends on the type of construction activity being carried out in conjunction with environmental factors including levels of rainfall, wind speeds and wind direction. The potential for impact from dust depends on the distance to potentially sensitive locations and whether the wind can carry the dust to these locations. The majority of any dust produced will be deposited close to the potential source and any impacts from dust deposition will typically be within several hundred metres of the construction area.

In order to ensure that no dust nuisance occurs, a series of measures will be implemented. Site roads shall be regularly cleaned and maintained as appropriate. Hard surface roads shall be swept to remove mud and aggregate materials from their surface while any un-surfaced roads shall be restricted to essential site traffic only. Furthermore, any road that has the potential to give rise to fugitive dust must be regularly watered, as appropriate, during dry and/or windy conditions.

Vehicles using site roads shall have their speed restricted, and this speed restriction must be enforced rigidly. Indeed, on any un-surfaced site road, this shall be 20 km per hour, and on hard surfaced roads as site management dictates.

All vehicles exiting the site shall make use of a wheel wash facility, preferably automatic, prior to entering onto public roads, to ensure mud and other wastes are not tracked onto public roads. Public roads outside the site shall be regularly inspected for cleanliness, and cleaned as necessary.

Material handling systems and site stockpiling of materials shall be designed and laid out to minimise exposure to wind. Water misting or sprays shall be used as required if particularly dusty activities are necessary during dry or windy periods.

At all times, the procedures put in place will be strictly monitored and assessed. In the event of dust emissions occurring outside the site boundary, movement of these soils will be immediately terminated and satisfactory procedures implemented to rectify the problem before the resumption of the operations.

The dust minimisation plan shall be reviewed at regular intervals during the construction phase to ensure the effectiveness of the procedures in place and to maintain the goal of minimisation of dust through the use of best practise and procedures.