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DISPERSION MODELLING ASSESSMENT OF EMISSIONS FROM PROPOSED EXHAUST EMISSION POINT OF BIOMASS BOILER AND TWO GAS UTILISATION ENGINES TO BE LOCATED IN PANDA WASTE, BAUPARC BUSINESS PARK, NAVAN, CO. MEATH.

PERFORMED BY ODOUR MONITORING IRELAND ON THE BEHALF OF PANDA WASTE LTD.

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EXECUTIVE SUMMARY

Odour Monitoring Ireland was commissioned by Panda Waste to perform a dispersion modelling assessment of exhaust gas emissions from the operation of Biomass boiler and two gas utilisation engines to be located in Panda Waste, Beauparc Business Park, Navan, Co. Meath. Emissions from the biogas flare were not accounted for in the model as this is a standby plant and will only operate when one of the gas utilisation engines is in maintenance. Emissions from the gas utilisation engine would be greater than the biogas flare (see Table 3.3) and therefore worst case is taken into account by assuming the gas utilisation engines operate 24/7/365 days per year. Emission limit values of specific compounds namely Carbon monoxide, Oxides of nitrogen, Sulphur dioxide, Total particulates, Hydrogen chloride and Hydrogen fluoride and source characteristics were inputted into the dispersion modelling to allow for the assessment of air quality in the vicinity of the proposed emissions points when in operation.

Dispersion modelling assessment was performed utilising AERMOD Prime (12060) dispersion model. Five years of hourly sequential meteorological data from Dublin Airport (2002 to 2006 inclusive) was used within the dispersion model. The dispersion modelling assessment was performed in accordance with requirements contained in AG4 – Irish EPA Guidance for dispersion modelling. The total proposed mass limit emission rate of each pollutant was inputted with the source characteristics into the dispersion model in order to assess the maximum predicted ground level concentrations of each pollutant in the vicinity of the facility. This was then compared with statutory guideline limit values for such pollutants.

The following conclusions are drawn from the study:

1. The assessment was carried out to provide information in line with standard information to be provided to the EPA for license reviews for such projects.

2. Specific dispersion modelling was performed for Carbon monoxide, Oxides of nitrogen, Sulphur dioxide, Particulate matter, Hydrogen chloride and Hydrogen fluoride. The combined cumulative impact of odour for the facility has been dealt with in another document which has been submitted to the EPA.

3. With regards to Carbon monoxide, the maximum GLC+Baseline for CO from the operation of the facility is 810 $\mu g\ m^{-3}$ for the maximum 8-hour mean concentration at the 100th percentile. When combined predicted and baseline conditions are compared to the Irish guideline/limit values and EU Limit values set out in SI 271 of 2002 and Directive 2008/50/EC, this is 8.10% of the impact criterion. In addition, the predicted ground level concentration of Carbon monoxide at each of the 10 sensitive receptors is presented in *Table 4.3*. As can be observed, all predicted ground level concentrations are well within the ground level concentration limit values contained in *Tables 2.1 and 2.2.*

4. With regards to Oxides of nitrogen, the maximum GLC+Baseline for NO_2 from the operation of the facility is 119 $\mu g\ m^{-3}$ for the maximum 1-hour mean concentration at the 99.79th percentile. When combined predicted and baseline conditions are compared to SI 271 of 2002 and Directive 2008/50/EC, this is 59.50 % of the impact criterion. An annual average was also generated to allow comparison with values contained in SI 271 of 2002 and Directive 2008/50/EC. The maximum predicted annual average ground level concentration in the vicinity of the facility was 22.30$\mu g/m^3$. When compared the annual average NO_2 air quality impact criterion is 55.75% of the impact criterion. In addition, the predicted ground level concentration of Oxides of nitrogen at each of the 10 sensitive receptors is presented in *Table 4.3*. As can be observed, all predicted ground level concentrations are well within the ground level concentration limit values contained in *Tables 2.1 and 2.2*.

5. With regards to Sulphur dioxide, the maximum GLC+Baseline for SO_2 from the operation of the facility is 120 and 50 $\mu g\ m^{-3}$ for the maximum 1-hour and 24 hr mean

concentration at the 99.73th and 99.18th percentile respectively. When combined predicted and baseline conditions are compared to SI 271 of 2002 and Directive 2008/50/EC, this is 36 and 42.40% of the set target limits established for the 1 hour and 24 hour assessment criteria. An annual average was also generated to allow comparison with SI 271 of 2002 and Directive 2008/50/EC. The maximum predicted annual average ground level concentration in the vicinity of the facility was 12 $\mu g/m^3$. When compared the annual average SO_2 air quality impact criterion is 60% of the impact criterion. In addition, the predicted ground level concentration of Sulphur dioxide at each of the 10 sensitive receptors is presented in *Table 4.3*. As can be observed, all predicted ground level concentrations are well within the ground level concentration limit values contained in *Tables 2.1 and 2.2*.

6. With regards to Particulate matter, the maximum GLC+Baseline for Particulate matter 10μm from the operation of the facility is 31$\mu g\ m^{-3}$ for the maximum 24-hour mean concentration at the 90.40th percentile. When combined predicted and baseline conditions are compared to Directive 2008/50/EC, this is 62% of the impact criterion. An annual average was also generated to allow comparison with the SI 271 of 2002 and Directive 2008/50/EC. The maximum predicted annual average ground level concentration in the vicinity of the facility was 21$\mu g/m^3$. When compared, the annual average Particulate matter air quality impact is 52.50 % of the impact criterion. An annual average was also generated for $PM_{2.5}$ to allow comparison with Directive 2008/50/EC. The maximum predicted annual average ground level concentration in the vicinity of the facility was 16$\mu g/m^3$. When compared, the annual average $PM_{2.5}$ air quality impact is 64% of the impact criterion. In addition, the predicted ground level concentration of Particulate matter at each of the 10 sensitive receptors is presented in *Table 4.3*. As can be observed, all predicted ground level concentrations are well within the ground level concentration limit values contained in *Tables 2.1 and 2.2*.

7. With regards to Hydrogen chloride, emissions at maximum operations equate to ambient HCl concentrations (including background concentrations) which are from 1.56 to 15.5% of the maximum impact criterion for both the 1 hr and annual average period. In addition, the predicted ground level concentration of Particulate matter at each of the 10 sensitive receptors is presented in *Table 4.3*. As can be observed, all predicted ground level concentrations are well within the ground level concentration limit values contained in *Tables 2.1 and 2.2*.

8. With regards to Hydrogen fluoride emissions at maximum operations equate to ambient HF concentrations (including background concentrations) which are from 1.59% to 60% of the maximum impact criterion for both the 1 hr and annual average period. In addition, the predicted ground level concentration of Particulate matter at each of the 10 sensitive receptors is presented in *Table 4.3*. As can be observed, all predicted ground level concentrations are well within the ground level concentration limit values contained in *Tables 2.1 and 2.2*.

9. Emissions from the biogas flare were not accounted for in the model as this is a standby plant and will only operate when one of the gas utilisation engines is in maintenance. Emissions from the gas utilisation engine would be greater than the biogas flare as per *Table 3.3* and therefore worst case is taken into account by assuming the gas utilisation engines operate 24/7/365 days per year.

10. The overall modelling indicates that the facility will not result in any significant impact on air quality in the surrounding area with all ground level concentrations of pollutants well within their respective ground level concentration limit values.

1. Introduction and scope

1.1 Introduction

Odour Monitoring Ireland was commissioned by Panda Waste Ltd to perform a dispersion modelling assessment of proposed emission limit values for a range of pollutants which could potentially be emitted from the proposed RDF and AD facility to be located in Panda Waste Ltd facility, Bauparc Business Park, Navan, Co. Meath.

The assessment allowed for the examination of proposed short and long term ground level concentrations (GLC's) of compounds as a result of the operation of proposed emission points –biomass boiler (A2-2) and two gas utilisation engines (A2-4 and A2-5). Emissions from the biogas flare (A2-3) were not accounted for in the model as this is a standby plant and will only operate when one of the gas utilisation engines is in maintenance. Emissions from the gas utilisation engine would be greater than the biogas flare (*see Table 3.3*) and therefore worst case is taken into account by assuming the gas utilisation engines operate 24/7/365 days per year.

Predicted dispersion modelling GLC's were compared to proposed regulatory / guideline ground level limit values for each pollutant.

The materials and methods, results, discussion of results and conclusions are presented within this document.

1.2 Scope of the work

The main aims of the study included:

- Air dispersion modelling assessment in accordance with AG4 guidance of proposed mass emission limits of specified pollutants to atmosphere from the facility to be located in Beauparc business Park, Navan, Co. Meath.
- Assessment whether the predicted ground level concentrations are in compliance with ground level concentration limit values as taken from SI 271 of 2002 – Air Quality Regulations, CAFÉ Directive 2008/50/EC, TaLuft, 2002 and Environment Agency H1 Guidance Environmental Assessment levels.

The approach adopted in this assessment is considered a worst-case investigation in respect of emissions to the atmosphere from proposed emission points A2-2 to A2-5. These predictions are therefore most likely to over estimate the GLC's that may actually occur for each modelled scenario. These assumptions are summarised and include:

- Emissions to the atmosphere from the emission points – A2-4 to A2-5 process operation were assumed to occur 24 hours each day / 7 days per week over a standard year at 100% output. Emissions from A2-2 were assumed to occur 24 hours each day / 6 days per week over a standard year at 100% output. Emissions from emission point A2-3 will only occur on a intermittent basis when either emission point A2-4 and / or A2-5 are out of operation (in maintenance), therefore by assuming emissions occur from either of A2-4 and A2-5 for 100% of the time assumes worst case air quality impact as concentration of pollutants will be greater for these emissions point in comparison to emission point A2-3.
- Five years of hourly sequential meteorological data from Dublin Airport 2002 to 2006 inclusive was screened to assess worst case dispersion year which will provide statistical significant results in terms of the short and long term assessment. This is in keeping with current national and international recommendations. The worst case year Dublin 2004 for used for data presentation.
- Maximum GLC's + Background were compared with relevant air quality objects and limits;
- All emissions were assumed to occur at maximum potential emission concentration and mass emission rates for each scenario.

- AERMOD Prime (12060) dispersion modelling was utilised throughout the assessment in order to provide the most conservative dispersion estimates.
- Five years of hourly sequential meteorological data from Dublin 2002 to 2006 inclusive was used in the modelling screen which will provide statistical significant results in terms of the short and long term assessment. The worst case year for Dublin met station was 2004 and was used for contour plot presentation. This is in keeping with current national and international recommendations (EPA Guidance AG4 and EA Guidance H4). In addition, AERMOD incorporates a meteorological pre-processor AERMET PRO. The AERMET PRO meteorological preprocessor requires the input of surface characteristics, including surface roughness (z0), 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.
- All building wake effects on all applicable emission points were assessed within the dispersion model using the building prime algorithm (e.g. all buildings / structures / tanks were included).

2. Materials and methods

This section describes the materials and methods used throughout the dispersion modelling assessment.

2.1 Dispersion modelling assessment

2.1.1 Atmospheric dispersion modelling of air quality: What is dispersion modelling?

Any material discharged into the atmosphere is carried along by the wind and diluted by wind turbulence, which is always present in the atmosphere. This process has the effect of producing a plume of air that is roughly cone shaped with the apex towards the source and can be mathematically described by the Gaussian equation. Atmospheric dispersion modelling has been applied to the assessment and control of emissions for many years, originally using Gaussian form ISCST 3. Once the compound emission rate from the source is known, (g s^{-1}), the impact on the vicinity can be estimated. These models can effectively be used in three different ways:

- Firstly, to assess the dispersion of compounds;
- Secondly, in a “reverse” mode, to estimate the maximum compound emissions which can be permitted from a site in order to prevent air quality impact occurring;
- And thirdly, to determine which process is contributing greatest to the compound impact and estimate the amount of required abatement to reduce this impact within acceptable levels (McIntyre et al. 2000).

In this latter mode, models have been employed for imposing emission limits on industrial processes, control systems and proposed facilities and processes (Sheridan et al., 2002).

Any dispersion modelling approach will exhibit variability between the predicted values and the measured or observed values due to the natural randomness of atmospheric environment. A model prediction can, at best, represent only the most likely outcome given the apparent environmental conditions at the time. Uncertainty depends on the completeness of the information used as input to the model as well as the knowledge of the atmospheric environment and the ability to represent that process mathematically. Good input information (emission rates, source parameters, meteorological data and land use characteristics) entered into a dispersion model that treats the atmospheric environment simplistically will produce equally uncertain results as poor information entered into a dispersion model that seeks to simulate the atmospheric environment in a robust manner. It is assumed in this discussion that pollutant emission rates are representative of maximum emission events, source parameters accurately define the point of release and surrounding structures, meteorological conditions define the local atmospheric environment and land use characteristics describe the surrounding natural environment. These conditions are employed within the dispersion modelling assessment therefore providing good confidence in the generated predicted exposure concentration values.

2.1.2 Atmospheric dispersion modelling of air quality: dispersion model selection

The AERMOD model was developed through a formal collaboration between the American Meteorological Society (AMS) and U.S. Environmental Protection Agency (U.S. EPA). AERMOD is a Gaussian plume model and replaced the ISC3 model in demonstrating compliance with the National Ambient Air Quality Standards (Porter et al., 2003) AERMIC (USEPA and AMS working group) is emphasizing development of a platform that includes air turbulence structure, scaling, and concepts; treatment of both surface and elevated sources; and simple and complex terrain. The modelling platform system has three main components: AERMOD, which is the air dispersion model; AERMET, a meteorological data pre-processor; and AERMAP, a terrain data pre-processor (Cora and Hung, 2003).

AERMOD is a Gaussian steady-state model which was developed with the main intention of superseding ISCST3 (NZME, 2002). The AERMOD modeling system is a significant departure from ISCST3 in that it is based on a theoretical understanding of the atmosphere rather than depend on empirical derived values. The dispersion environment is characterized by turbulence theory that defines convective (daytime) and stable (nocturnal) boundary layers instead of the stability categories in ISCST3. Dispersion coefficients derived from turbulence theories are not based on sampling data or a specific averaging period. AERMOD was especially designed to support the U.S. EPA's regulatory modeling programs (Porter at al., 2003)

Special features of AERMOD include its ability to treat the vertical in-homogeneity of the planetary boundary layer, special treatment of surface releases, irregularly-shaped area sources, a three plume model for the convective boundary layer, limitation of vertical mixing in the stable boundary layer, and fixing the reflecting surface at the stack base (Curran et al., 2006). A treatment of dispersion in the presence of intermediate and complex terrain is used that improves on that currently in use in ISCST3 and other models, yet without the complexity of the Complex Terrain Dispersion Model-Plus (CTDMPLUS) (Diosey et al., 2002).

Input data from stack emissions, and source characteristics will be used to construct the basis of the modelling scenarios.

2.2 Air quality impact assessment criteria

The predicted air quality impact from the operation of proposed emission point – biomass boiler for each scenario is compared to relevant air quality objectives and limits. Air quality standards and guidelines referenced in this report include:

- SI 271 of 2002 – Air Quality Standards Regulations 2002.
- EU limit values laid out in the EU Daughter directives on Air Quality 99/30/EC and 2000/69/EC.
- Ta Luft of 2002 Air Quality Regulations,
- Horizontal guidance Note, IPPC H1, Environmental assessment and appraisal of BAT, UK Environment Agency.
- EH40 Notes, Occupational exposure limits (2002).

Air quality is judged relative to the relevant Air Quality Standards, which are concentrations of pollutants in the atmosphere, which achieve a certain standard of environmental quality. Air quality Standards are formulated on the basis of an assessment of the effects of the pollutant on public health and ecosystems.

In general terms, air quality standards have been framed in two categories, limit values and guideline values. Limit values are concentrations that cannot be exceeded and are based on WHO guidelines for the protection of human health. Guideline values have been established for long-term precautionary measures for the protection of human health and the environment. European legislation has also considered standard for the protection of vegetation and ecosystems.

Where ambient air quality criteria do not exist as in the case for some of the speciated substances of interest, it is usual to use:

- $1/100^{th}$ of the 8-hour time weighted average occupational exposure limit (OEL)-Long term EAL as an annual average.
- $1/500^{th}$ of the 8 hour MEL time weighted average occupational exposure limit (OEL) - Long term EAL as an annual average.
- $1/10^{th}$ of the 15-minute time weighted average occupational exposure limit (OEL)-Short term EAL as an hourly average.
- $1/50^{th}$ of the 15 minute MEL time weighted average occupational exposure limit (OEL) –short term EAL as an hourly average.

Occupational exposure limits are published by the Occupational Safety and Heath Authority EH 40 notes and subsequent reviews.

The relevant air quality standards for proposed emission sources A2-2 to A2-5 are presented in *Tables 2.1 and 2.2*.

2.2.1 Air Quality Guidelines value for air pollutants

Table 2.1 illustrates the guideline and limit values for classical air quality pollutants in Ireland.

Table 2.1. EU and Irish Limit values laid out in the EU Daughter directive on Air Quality 99/30/EC, SI 271 of 2002 and CAFÉ directive 2008/50/EC

POLLUTANT	Objective				TO BE ACHIEVED BY[4]
	Concentration[2]	Maximum No. Of exceedences allowed[3]	Exceedence expressed as percentile[3]	Measured as	
Nitrogen dioxide and oxides of nitrogen	300 $\mu g\ m^{-3}$ NO_2 200 $\mu g\ m^{-3}$ NO_2 40 $\mu g\ m^{-3}$ NO_2	18 times in a year 18 times in a year --	99.79th percentile 99.79th percentile --	1 hour mean 1 hour mean Annual mean	19 Jul 1999[4] 1 Jan 2010 1 Jan 2010
Particulates (PM_{10}) (2008/50/EC)	50 $\mu g\ m^{-3}$ 40 $\mu g\ m^{-3}$ 20 $\mu g\ m^{-3}$	35 times in a year None None	90.40th percentile --	24 hour mean Annual mean Annual mean	1 Jan 2010[6] 1 Jan 2005 1 Jan 2010[6]
Particulates ($PM_{2.5}$) (2008/50/EC)	25 $\mu g\ m^{-3}$ – Stage 1 20 $\mu g\ m^{-3}$ – Stage 2	None None	-- --	Annual mean Annual mean	1 Jan 2015 1 Jan 2020
Carbon monoxide (CO)	10 $mg\ m^{-3}$	None	100th percentile	Running 8 hour mean	31st Dec 2003
Sulphur dioxide (SO_2)	350 $\mu g\ m^{-3}$ 125 $\mu g\ m^{-3}$ 20 $\mu g\ m^{-3}$	24 times in a year 3 times in a year --	99.73th percentile 99.18th percentile --	1 hour mean 24 hour mean Annual mean and winter mean (1st Oct to 31st March	1st Jan 2005 1st Jan 2005 19th Jul 2001[5]

Table 2.2 illustrates the guideline and limit values for specified pollutants as taken from specified reference document including TaLuft 2002 and H1 Part 2 – Environmental Risk Assessment, EPA 2002, etc. These values set out minimum ground level concentration requirements to be attained in the vicinity of the proposed facility for these pollutants.

Table 2.2. Guideline ground concentration limit values pollutant range from Panda Waste Ltd facility proposed emission points A2-2 to A2-5.

Pollutant	Objective				Source
	Concentration[2]	Maximum No. Of exceedence allowed[3]	Exceedence expressed as percentile[3]	Measured as	
HCL	≤100 μg m^{-3}	175 times in a year	98^{th} percentile	1 hour mean	TaLuft 2002- Hourly limit for protection of human health
HCL	≤750 μg m^{-3}	0	100^{th} percentile	1 hour mean	H1 Part 2 – Environmental Risk Assessment.
HCL	≤20 μg m^{-3}	-	-	Annual average	H1 Part 2 – Environmental Risk Assessment..
HF	≤3.0 μg m^{-3}	175 times in a year	98^{th} percentile	1 hour mean	TaLuft 2002- Hourly limit for protection of human health
HF	≤0.30 μg m^{-3}	-	-	Annual average	TaLuft 2002- Gaseous fluoride (as HF) as an annual average for protection of vegetation
HF	≤160 μg m^{-3}	0	100^{th} percentile	1 hour mean	H1 Part 2 – Environmental Risk Assessment.
Fluoride	≤1.0 μg m^{-3}	-	-	Annual average	H1 Part 2 – Environmental Risk Assessment.

Source: Horizontal guidance Note, IPPC H1 Part 2, Environmental assessment and appraisal of BAT, UK Environment Agency.

EH40 notes, National Authority for Occupational Safety and Health (2002).

Ta Luft 2002 – Technical instructions on air Quality Control.

2.3 Existing Baseline Air Quality

The EPA has been monitoring national Air quality from a number of sites around the country. This information is available from the EPA's website. The values presented for PM_{10}, SO_2, NO_2, and CO give an indication of expected rural imissions of the compounds listed in *Table 2.1 and 2.2*. *Table 2.3* illustrates the baseline data expected to be obtained from rural areas for classical air pollutants. Since the proposed facility is located in a rural area, it would be considered located in a Zone D area according to the EPA's classification of zones for air quality. Traffic and industrial related emissions would be medium.

The results of $PM_{2.5}$ monitoring at Station Road in Cork City in 2007 (EPA, 2007) indicated an average $PM_{2.5}/PM_{10}$ ratio of 0.53 while monitoring in Heatherton Park in 2008 (EPA, 2008) indicated an average $PM_{2.5}/PM_{10}$ ratio of 0.60. Based on this information, a conservative ratio of 0.60 was used to generate a background $PM_{2.5}$ concentration in 2008 of 9.0 µg/m^3 (*see Table 2.3*)

The monitoring of baseline levels of Hydrogen chloride and Hydrogen fluoride is limited to a number of sites in Ireland including Ringaskiddy, Co. Cork. Since this area is heavily industrialised, it would be reasonable to assume that the levels measured here would be considered worst case in this instance. *Table 2.4* presents the available baseline data for Hydrogen chloride and Hydrogen fluoride as measured over the period November 2006 to February 2007 and April 2008 to July 2008. All monitoring was performed in accordance with European and international standards.

Table 2.3. Baseline air quality data used to assess air quality impact criterion in a number of Zone D region - Navan.

Reference air quality data – Source identity	Sulphur dioxide-SO_2 ($\mu g\ m^{-3}$)	Nitrogen dioxide-NO_x as NO_2 ($\mu g\ m^{-3}$)	Particulate matter-PM_{10} ($\mu g\ m^{-3}$)	Carbon monoxide – CO ($mg\ m^{-3}$)	Details
Shannon town, Clare – Annual average	1	6	11	0.20	Measured 2011
Glashaboy, Cork – Annual average	-	9	-	0.30 (Old station Rd)	Measured 2011
Castlebar, Mayo – Annual average	-	8	14	-	Measured 2011
Kilkitt, Monaghan – Annual average	3	3	9	-	Measured 2011
Shannon Estuary - Annual average	3		--	-	Measured 2011
Zone B - Heatherton Park – Annual mean $PM_{2.5}$	-	-	9.0 ($PM_{2.5}$) (Heatherton Park)	-	Measured 2008[3]

Notes: [1] denotes taken from Air quality monitoring report 2008 - Navan, www.epa.ie.

Table 2.4. Baseline air quality data for Hydrogen chloride and Hydrogen fluoride.

Pollutant	Averaging Period	Maximum Measured conc	Notes
HCL ($\mu g\ m^{-3}$)	4 week average	2.70	Ref: Porter et al., 2008 – Air quality monitoring report Ringaskiddy Waste to Energy Facility
HF ($\mu g\ m^{-3}$)	4 week average	<0.050	Ref: Porter et al., 2008 – Air quality monitoring report Ringaskiddy Waste to Energy Facility

2.4 Meteorological data

Five years of hourly sequential meteorological data was chosen for the modelling exercise (i.e. Dublin airport 2002 to 2006 inclusive). A schematic wind rose and tabular cumulative wind speed and directions of all seven years are presented in *Section 7*. All five years of met data was screened to provide more statistical significant result output from the dispersion model. This is in keeping with national and international recommendations on quality assurance in operating dispersion models and will provide a worst case assessment of predicted ground level concentrations based on the input emission rate data. Surface roughness, Albedo and Bowen ratio were assessed and characterised around each met station for AERMET Pro processing.

2.5 Terrain data

Topography effects were not accounted for within the dispersion modelling assessment due to the absence of complex terrain in the immediate vicinity of the site and due to the fact that the stack heights are in excess of 16 metres. In order for terrain features to have an influence on the dispersion model output, the topographical feature would need to be in excess of the stack height and be in close proximity to the site in this instance. Individual sensitive receptors were inputted into the model at their specific height in order to take account of any effects of elevation on GLC's at there specific locations. This is in keeping with good practice.

2.6 Building wake effects

Building wake effects are accounted for in modelling scenarios through the use of the Prime algorithm (i.e. all building features located within the facility) as this can have a significant effect on the compound plume dispersion at short distances from the source and can significantly increase GLC's in close proximity to the facility.

3. Results

This section describes the results obtained for the dispersion modelling exercise. All input data and source characteristics were developed in conjunction with engineering drawings for the development.

3.1. Dispersion model input data – Source characteristics

Table 3.1 illustrates the source characteristics utilised within the dispersion model. Grid reference location, stack height (A.G.L), maximum volume flow and temperature of the emission point are presented within this table for reference purposes.

Table 3.1. Source characteristics for proposed emission points A2-2 to A2-5**.**

Parameter	Emission point A2-2 – Biomass[1]	Emission point A2-3– Biogas flare 1[3]	Emission point A2-4– gas utilisation engine 1[2]	Emission point A2-5–gas utilisation engine 2[2]
X coordinate	297519.963	297499.9	297497.9	297494.6
Y coordinate	269092.271	269148.4	269155.9	269164.3
Elevation (A.O.D) (m)	56	56	56	56
Stack height (m)	16	8	17	17
Orientation	Vertical	Vertical	Vertical	Vertical
Temperature (K)	523	1273	473	473
Efflux velocity (m/s)	20.32	12	19.0	19.0
Max volume flow (Nm^3/hr)	21,670	3,000 (ref 3%O_2)	5,500	3,800
Stack tip diameter (m)	0.85	1.10	0.42	0.35
Max building height (m)	13	--	13	13
Max building ground level (m)	56	56	56	56

Notes: [1]denotes referencing conditions for emission point A2-2 is 273.15K, 101.3KPa, dry gas, 11% O_2.
[2]denotes referencing conditions for emission point A2-4 to A2-5 are 273.15K, 101.3KPa, dry gas, 5% O_2.
[3]denotes referencing conditions for emission point A2-3 are 273.15K, 101.3KPa, dry gas, 3% O_2.

3.2 Process emissions - Volume flow rate and flue gas concentrations

The input mass emission rate data used in the dispersion model for each emission point is presented in *Tables 3.2, 3.3, 3.4, and 3.5* for each scenario*.* All source characteristics and location are reported in *Table 3.1*.

Table 3.2. Emission values from exhaust stack of the emission source A2-2.

Parameters – RTO exhaust stacks (A2-2)	Conc. Limit Values	Units	Volume flow (Nm^3/hr ref 11% O_2)	Mass emission rate (g/s)
Carbon monoxide (CO)	800	mg/Nm^3 11% O_2	21,670	4.82
Oxides of nitrogen (NOx as NO_2)	400	mg/Nm^3 11% O_2	21,670	1.20
Sulphur dioxide (SO_2)	150	mg/Nm^3 11% O_2	21,670	1.20
Total particulates	200	mg/Nm^3 11% O_2	21,670	1.204
Hydrogen chloride	10	mg/Nm^3 11% O_2	21,670	0.060
Hydrogen fluoride	3	mg/Nm^3 11% O_2	21,670	0.018

Table 3.3. Emission values from exhaust stack of the emission source A2-3.

Parameters – Biogas flare exhaust stacks (A2-3)	Conc. Limit Values	Units	Volume flow (Nm^3/hr ref 3% O_2)
Carbon monoxide (CO)	50	mg/Nm^3 3% O_2	3,000
Oxides of nitrogen (NOx as NO_2)	150	mg/Nm^3 3% O_2	3,000
Sulphur dioxide (SO_2)	250	mg/Nm^3 3% O_2	3,000
Hydrogen chloride	10	mg/Nm^3 3% O_2	3,000
Hydrogen fluoride	3	mg/Nm^3 3% O_2	3,000

Table 3.4. Emission values from exhaust stack of the emission source A2-4.

Parameters – Gas engine 1 exhaust stacks (A2-4)	Conc. Limit Values	Units	Volume flow (Nm^3/hr ref 5% O_2)	Mass emission rate (g/s)
Carbon monoxide (CO)	1,400	mg/Nm^3 5% O_2	5,500	2.14
Oxides of nitrogen (NOx as NO_2)	500	mg/Nm^3 5% O_2	5,500	0.76
Sulphur dioxide (SO_2)	250	mg/Nm^3 5% O_2	5,500	0.38
Total particulates	130	mg/Nm^3 5% O_2	5,500	0.199
Hydrogen chloride	10	mg/Nm^3 5% O_2	5,500	0.015
Hydrogen fluoride	3	mg/Nm^3 5% O_2	5,500	0.005

Table 3.5. Emission values from exhaust stack of the emission source A2-5.

Parameters – Gas engine 2 exhaust stacks (A2-5)	Conc. Limit Values	Units	Volume flow (Nm^3/hr ref 5% O_2)	Mass emission rate (g/s)
Carbon monoxide (CO)	1,400	mg/Nm^3 5% O_2	3,800	1.48
Oxides of nitrogen (NOx as NO_2)	500	mg/Nm^3 5% O_2	3,800	0.53
Sulphur dioxide (SO_2)	250	mg/Nm^3 5% O_2	3,800	0.26
Total particulates	130	mg/Nm^3 5% O_2	3,800	0.137
Hydrogen chloride	10	mg/Nm^3 5% O_2	3,800	0.011
Hydrogen fluoride	3	mg/Nm^3 5% O_2	3,800	0.0030

3.3 Dispersion modelling assessment

AERMOD Prime (12060) was used to determine the overall ground level impact of proposed emission points A2-2, A2-4 and A2-5 to be located in the Panda Waste, Bauparc Business Park, Navan, Co. Meath. Emissions from the biogas flare were not accounted for in the model as this is a standby plant and will only operate when one of the gas utilisation engines is in maintenance. Emissions from the gas utilisation engine would be greater than the biogas flare (see Table 3.3) and therefore worst case is taken into account by assuming the gas utilisation engines operate 24/7/365 days per year. These computations give the relevant GLC's at each 50-meter X Y Cartesian grid receptor location that is predicted to be exceeded for the specific air quality impact criteria. Individual receptor elevations were established at their specific height above ground and also included a 1.80 m normal breathing zone. A total Cartesian + individual receptors of 1,691 points was established giving a total grid coverage area of 4.0 square kilometres around the emission point.

Five years of hourly sequential meteorological data from Dublin Airport (Dublin Airport 2002 to 2006 inclusive) and source characteristics (*see Table 3.1*), including emission date contained in *Tables 3.2 to 3.5* were inputted into the dispersion model.

In order to obtain the predicted environmental concentration (PEC), background data was added to the process emissions. In relation to the annual averages, the ambient background concentration was added directly to the process concentration. However, in relation to the short-term peak concentrations, concentrations due to emissions from elevated sources cannot be combined in the same way. Guidance from the UK Environment Agency advises that an estimate of the maximum combined pollutant concentration can be obtained by adding the maximum short-term concentration due to emissions from the source to twice the annual mean background concentration.

3.4 Dispersion model Scenarios

AERMOD Prime (USEPA ver. 12060) was used to determine the overall air quality impact of the five combined emission points while in operation at 100% capacity for named air pollutants.

Impacts from the five stack emission points were assessed in accordance with the impact criterion contained in Directive 2008/50/EC, SI 271 of 2002, TaLuft 2002 and H1 Guidance.

Nine scenarios were assessed within the dispersion model examination for each of the classical air pollutants.

The dispersion modelling is carried out in line with the requirements of guidance document AG4- Dispersion modelling.

The output data was analysed to calculate the following:

Ref Scenario 1: Predicted cumulative ground level concentration of Carbon monoxide emission contribution of cumulative emissions for the 100th percentile of 8 hour averages for Dublin meteorological station year 2004 for an Carbon monoxide concentration of less than or equal to 500 µg/m^3 (*see Figure 6.2*).

Ref Scenario 2: Predicted cumulative ground level concentration of Oxides of nitrogen emission contribution of cumulative emissions for the 99.79th percentile of 1 hour averages for Dublin meteorological station year 2004 for an Oxides of nitrogen concentration of less than or equal to 101 µg/m^3 (*see Figure 6.3*).

Ref Scenario 3: Predicted cumulative ground level concentration of Oxides of nitrogen emission contribution of cumulative emissions for the Annual average for Dublin meteorological station year 2004 for an Oxides of nitrogen concentration of less than or equal to 13.30 µg/m^3 (*see Figure 6.4*).

Ref Scenario 4: Predicted cumulative ground level concentration of Sulphur dioxide emission contribution of cumulative emissions for the 99.73th percentile of 1 hour averages for Dublin meteorological station year 2004 for an Sulphur dioxide concentration of less than or equal to 110 µg/m^3 (*see Figure 6.5*).

Ref Scenario 5: Predicted cumulative ground level concentration of Sulphur dioxide emission contribution of cumulative emissions for the 99.18th percentile of 24 hour averages for Dublin meteorological station year 2004 for an Sulphur dioxide concentration of less than or equal to 50 µg/m^3 (*see Figure 6.6*).

Ref Scenario 6: Predicted cumulative ground level concentration of Sulphur dioxide emission contribution of cumulative emissions for the Annual average for Dublin meteorological station year 2004 for a Sulphur dioxide concentration of less than or equal to 9 µg/m^3 (*see Figure 6.7*).

Ref Scenario 7: Predicted cumulative ground level concentration of Total particulates as PM_{10} emission contribution of cumulative emissions for the 90.40th percentile of 24 hour averages for Dublin meteorological station year 2004 for an Total particulates as PM_{10} concentration of less than or equal to 17 µg/m^3 (*see Figure 6.8*).

Ref Scenario 8: Predicted cumulative ground level concentration of Total particulates as PM_{10} emission contribution of cumulative emissions for the Annual average for Dublin meteorological station year 2004 for an Total particulates as PM_{10} concentration of less than or equal to 6.0 µg/m^3 (*see Figure 6.9*).

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Ref Scenario 9: Predicted cumulative ground level concentration of Total particulates as $PM_{2.5}$ emission contribution of cumulative emissions for the Annual average for Dublin meteorological station year 2004 for an Total particulates as $PM_{2.5}$ concentration of less than or equal to 6.0 µg/m^3 (*see Figure 6.10*).

Ref Scenario 10: Predicted cumulative ground level concentration of Hydrogen chloride emission contribution of cumulative emissions for the 100th percentile of 1 hour averages for Dublin meteorological station year 2004 for an Hydrogen chloride concentration of less than or equal to 8 µg/m^3 (*see Figure 6.11*).

Ref Scenario 11: Predicted cumulative ground level concentration of Hydrogen chloride emission contribution of cumulative emissions for the 98th percentile of 1 hour averages for Dublin meteorological station year 2004 for an Hydrogen chloride concentration of less than or equal to 5 µg/m^3 (*see Figure 6.12*).

Ref Scenario 12: Predicted cumulative ground level concentration of Hydrogen chloride emission contribution of cumulative emissions for the Annual average for Dublin meteorological station year 2004 for an Hydrogen chloride concentration of less than or equal to 0.40 µg/m^3 (*see Figure 6.13*).

Ref Scenario 13: Predicted cumulative ground level concentration of Hydrogen fluoride emission contribution of cumulative emissions for the 100th percentile of 1 hour averages for Dublin meteorological station year 2004 for an Hydrogen fluoride concentration of less than or equal to 2.50 µg/m^3 (*see Figure 6.14*).

Ref Scenario 14: Predicted cumulative ground level concentration of Hydrogen fluoride emission contribution of cumulative emissions for the 98th percentile of 1 hour averages for Dublin meteorological station year 2004 for an Hydrogen fluoride concentration of less than or equal to 1.50 µg/m^3 (*see Figure 6.15*).

Ref Scenario 15: Predicted cumulative ground level concentration of Hydrogen fluoride emission contribution of cumulative emissions for the Annual average for Dublin meteorological station year 2004 for an Hydrogen fluoride concentration of less than or equal to 0.13 µg/m^3 (*see Figure 6.16*).

4. Discussion of results

This section will present the results of the dispersion modelling.

AERMOD GIS Pro Prime (Ver. 12060) was used to determine the overall named air pollutant air quality impact of the proposed emission points A2-2, A2-4 and A2-5 during operation.

Various averaging intervals were chosen to allow direct comparison of predicted GLC's with the relevant the relevant air quality assessment criteria as outline in *Section 2.2.1*. In particular, 1-hour, 24 hour and annual average GLC's of the specified pollutants were calculated at 50 metres distances from the site over a fine and coarse grid extent of 4.0 kilometres squared. Relevant percentiles of these GLC's were also computed for comparison with the relevant pollutant Air Quality Standards to include Directive 2008/50/EC*.*

In modelling air dispersion of NOx from combustion sources, the source term should be expressed as NO_2, e.g., NOx mass (expressed as NO_2). Some of the exhaust air is made up of NO while some is made up of NO_2. NO will be converted in the atmosphere to NO_2 but this will depend on a number of factors to include Ozone and VOC concentrations. In order to take account of this conversion the following screening can is performed.

Use the following phased approach for assessment:

Worse case scenario treatment

35% for short-term and 70% for long-term average concentration should be considered to assess compliance with the relevant air quality objective.

This is in accordance with recommendations from the Environmental Agency UK for the dispersion modelling of NO_2 emissions from combustion processes, www.environmentagency.gov.uk and guidance received from the OEE air unit, Richview, Dublin 14.

Table 4.1 illustrates the tabular results obtained from the assessment for Dublin meteorological station for:

- Worse case scenario and treatment for NO_x only as detailed above.

Maximum predicted GLC's are presented within this table to allow for comparison with Directive 2008/50/EC and SI 271 of 2002. In addition, the predicted ground level concentrations at the selected residential receptors are presented in the Discussion of Results section of the document for all pollutants. A total of 10 individual sensitive receptors were included within the dispersion model and the location of same is presented in *Figure 6.1*. Illustrative contour plots for information purposes only are presented in *Section 6* of this report for each modelled scenario.

Table 4.1. Predicted ground level concentrations for various averaging periods for proposed emission points A2-2, A2-4 and A2-5 for each pollutant at or beyond the boundary of the facility.

Averaging period	Maximum ground level conc (GLC)
Carbon monoxide - 8 hr maximum GLC (μg/m^3)	510
Oxides of nitrogen - 1 hr max 99.79th percentile (μg/m^3)	101
Oxides of nitrogen - Max Annual average (μg/m^3)	13.3
Sulphur dioxide - 1 hr Max 99.73th percentile (μg/m^3)	120
Sulphur dioxide - 24 hr Max 99.18th percentile (μg/m^3)	50
Sulphur dioxide – Max annual average (μg/m^3)	9
Total particulates - 24 hr Max 90.40th percentile (μg/m^3)	17
Total Particulates as PM_{10} - Max annual average (μg/m^3)	7
Total Particulates as $PM_{2.5}$ - Max annual average (μg/m^3)	7
Hydrogen chloride - 1 hr Max 100th percentile (μg/m^3)	9
Hydrogen chloride - 1 hr Max 98th percentile (μg/m^3)	5
Hydrogen chloride - Max annual average (μg/m^3)	0.4
Hydrogen fluoride - 1 hr Max 100th percentile (μg/m^3)	2.5
Hydrogen fluoride - 1 hr Max 98th percentile (μg/m^3)	1.5
Hydrogen fluoride - Max annual average (μg/m^3)	0.13

Table 4.2 presents the comparison between model predictions for air quality impacts, baseline air quality concentrations for the compounds and the percentage impact of the air quality impact criterion anywhere in the vicinity of the facility.

4.1 Assessment of air quality impacts for pollutants from proposed emission points A2-2, A2-4 and A2-5

Predictive air dispersion modelling was used to ascertain the maximum ground level concentrations at or beyond the boundary of the facility of selected worst case pollutant concentration to allow for comparison with the ground level limit values contained in *Tables 2.1 and 2.2*. *Table 4.2* illustrates the results of the dispersion modelling assessment for each pollutant and comparison with the air quality guideline and limit values contained in *Tables 2.1 and 2.2*.

Table 4.2. Comparison between predicted GLC's + baseline national air quality data and limit values contained in *Tables 2.1 and 2.2*.

Identity	Predicted %ile GLC - (µg m^{-3})	Baseline concentration value (µg m^{-3})[1]	Baseline + Maximum predicted GLC (µg m^{-3})	Impact criterion (µg m^{-3})[2]	% of Criterion
Carbon monoxide - 8 hr maximum GLC (µg/m^3)	510	300	810	10,000	8.10
Oxides of nitrogen - 1 hr max 99.79th percentile (µg/m^3)	101	18 (Twice annual mean as per EA)	119	200	59.50
Oxides of nitrogen - Max Annual average (µg/m^3)	13.3	9	22.3	40	55.75
Sulphur dioxide - 1 hr Max 99.73th percentile (µg/m^3)	120	6 (Twice annual mean as per EA)	126	350	36.00
Sulphur dioxide - 24 hr Max 99.18th percentile (µg/m^3)	50	3.0	53	125	42.40
Sulphur dioxide – Max annual average (µg/m^3)	9	3.0	12	20	60.00
Total particulates - 24 hr Max 90.40th percentile (µg/m^3)	17	14	31	50	62.00
Total Particulates as PM_{10} - Max annual average (µg/m^3)	7	14	21	40	52.50
Total Particulates as $PM_{2.5}$ - Max annual average (µg/m^3)	7	9.0	16	25	64.00
Hydrogen chloride - 1 hr Max 100th percentile (µg/m^3)	9	2.70	11.7	750	1.56
Hydrogen chloride - 1 hr Max 98th percentile (µg/m^3)	5	2.70	7.7	100	7.70
Hydrogen chloride - Max annual average (µg/m^3)	0.4	2.70	3.1	20	15.50
Hydrogen fluoride - 1 hr Max 100th percentile (µg/m^3)	2.5	0.050	2.55	160	1.59
Hydrogen fluoride - 1 hr Max 98th percentile (µg/m^3)	1.5	0.050	1.55	3.0	51.67
Hydrogen fluoride - Max annual average (µg/m^3)	0.13	0.050	0.18	0.30	60.00

Notes: [1] denotes based on data presented in *Tables 3.1, 3.2, 3.3, 3.4, 3.5 and 4.1,*
[2] denotes for impact criterion *see Tables 2.1 and 2.2*

As can be observed in *Table 4.2*, the predicted maximum averaging ground level concentration and baseline concentration are presented as a % of the impact criterion contained in *Tables 2.1 and 2.2*.

4.1.1 Carbon monoxide – Ref Scenario 1

The results for the potential air quality impact for dispersion modelling of CO based on the emission rates in *Tables 3.2 to 3.5* are presented in *Tables 4.1 and 4.2.* Results are presented for the maximum predicted percentile emission regime. As can be observed in *Tables 4.1 and 4.2,* the maximum GLC+Baseline for CO from the operation of the facility is 810 μg m^{-3} for the maximum 8-hour mean concentration at the 100th percentile. When combined predicted and baseline conditions are compared to the Irish guideline/limit values and EU Limit values set out in SI 271 of 2002 and Directive 2008/50/EC, this is 8.10% of the impact criterion.

In addition, the predicted ground level concentration of Carbon monoxide at each of the 10 sensitive receptors is presented in *Table 4.3*. As can be observed, all predicted ground level concentrations are well within the ground level concentration limit values contained in *Tables 2.1 and 2.2*.

4.1.2 Oxides of nitrogen – Ref Scenario 2 and 3

The results for the potential air quality impact for dispersion modelling of NO_X as NO_2 based on the emission rates in *Tables 3.2 to 3.5* are presented in *Tables 4.1 and 4.2.* Results are presented for the maximum predicted percentile emission regime. As can be observed in *Tables 4.1 and 4.2,* the maximum GLC+Baseline for NO_2 from the operation of the facility is 119 μg m^{-3} for the maximum 1-hour mean concentration at the 99.79th percentile. When combined predicted and baseline conditions are compared to SI 271 of 2002 and Directive 2008/50/EC, this is 59.50% of the impact criterion.

An annual average was also generated to allow comparison with values contained in SI 271 of 2002 and Directive 2008/50/EC. The maximum predicted annual average ground level concentration in the vicinity of the facility was 22.30μg/m^3. When compared the annual average NO_2 air quality impact criterion is 55.75% of the impact criterion.

In addition, the predicted ground level concentration of Oxides of nitrogen at each of the 10 sensitive receptors is presented in *Table 4.3*. As can be observed, all predicted ground level concentrations are well within the ground level concentration limit values contained in *Tables 2.1 and 2.2*.

4.1.3 Sulphur dioxide – Ref Scenario 4, 5 and 6

The results for the potential air quality impact for dispersion modelling of SO_2 based on the emission rates in *Tables 3.2 to 3.5* are presented in *Tables 4.1 and 4.2.* Results are presented for the maximum predicted percentile emission regime. As can be observed in *Tables 4.1 and 4.2,* the maximum GLC+Baseline for SO_2 from the operation of the facility is 120 and 50 μg m^{-3} for the maximum 1-hour and 24 hr mean concentration at the 99.73th and 99.18th percentile respectively. When combined predicted and baseline conditions are compared to SI 271 of 2002 and Directive 2008/50/EC, this is 36 and 42.40% of the set target limits established for the 1 hour and 24 hour assessment criteria.

An annual average was also generated to allow comparison with SI 271 of 2002 and Directive 2008/50/EC. The maximum predicted annual average ground level concentration in the vicinity of the facility was 12μg/m^3. When compared the annual average SO_2 air quality impact criterion is 60% of the impact criterion.

In addition, the predicted ground level concentration of Sulphur dioxide at each of the 10 sensitive receptors is presented in *Table 4.3*. As can be observed, all predicted ground level concentrations are well within the ground level concentration limit values contained in *Tables 2.1 and 2.2*.

4.1.4 Particulate matter – Ref Scenario 7, 8 and 9

The results for the potential air quality impact for dispersion modelling of Particulate matter based on the emission rates in *Tables 3.2 to 3.5* are presented in *Tables 4.1 and 4.2.* Results are presented for the maximum predicted percentile emission regime. As can be observed in *Tables 4.1 and 4.2,* the maximum GLC+Baseline for Particulate matter 10μm from the operation of the facility is 31μg m^{-3} for the maximum 24-hour mean concentration at the 90.40^{th} percentile. When combined predicted and baseline conditions are compared to Directive 2008/50/EC, this is 62% of the impact criterion.

An annual average was also generated to allow comparison with the SI 271 of 2002 and Directive 2008/50/EC. The maximum predicted annual average ground level concentration in the vicinity of the facility was 21μg/m^3. When compared, the annual average Particulate matter air quality impact is 52.50% of the impact criterion.

An annual average was also generated for $PM_{2.5}$ to allow comparison with Directive 2008/50/EC. The maximum predicted annual average ground level concentration in the vicinity of the facility was 16μg/m^3. When compared, the annual average $PM_{2.5}$ air quality impact is 64% of the impact criterion.

In addition, the predicted ground level concentration of Particulate matter at each of the 10 sensitive receptors is presented in *Table 4.3*. As can be observed, all predicted ground level concentrations are well within the ground level concentration limit values contained in *Tables 2.1 and 2.2*.

4.1.5 Hydrogen chloride – Ref Scenario 10, 11 and 12

The results for the potential air quality impact for dispersion modelling of HCL based on the emission rates in *Tables 3.2 to 3.5* are presented in *Tables 4.1 and 4.2*. HCl modelling results indicate that the ambient ground level concentrations are below the relevant air quality guideline for the protection of human health for HCl when the facility is in operation. Thus, no adverse impact on public health or the environment is envisaged to occur under these conditions at or beyond the facility boundary. Emissions at maximum operations equate to ambient HCl concentrations (including background concentrations) which are from 1.56 to 15.50% of the maximum impact criterion for both the 1 hr and annual average period.

In addition, the predicted ground level concentration of Hydrogen chloride at each of the 10 sensitive receptors is presented in *Table 4.3*. As can be observed, all predicted ground level concentrations are well within the ground level concentration limit values contained in *Tables 2.1 and 2.2*.

4.1.6 Hydrogen fluoride – Ref Scenario 13, 14 and 15

The results for the potential air quality impact for dispersion modelling of HF based on the emission rates in *Tables 3.2 to 3.5* are presented in *Tables 4.1 and 4.2*. HF modelling results indicate that the ambient ground level concentrations are below the relevant air quality guideline for the protection of human health for HF when the facility is in operation. Thus, no adverse impact on public health or the environment is envisaged to occur under these conditions at or beyond the facility boundary. Emissions at maximum operations equate to ambient HF concentrations (including background concentrations) which are from 1.59% to 60% of the maximum impact criterion for both the 1 hr and annual average period.

In addition, the predicted ground level concentration of Hydrogen fluoride at each of the 10 sensitive receptors is presented in *Table 4.3*. As can be observed, all predicted ground level concentrations are well within the ground level concentration limit values contained in *Tables 2.1 and 2.2*.

Table 4.3. Predicted ground level concentration (excluding baseline) of each pollutant at each identified sensitive receptor locations R1 to R10 for Scenarios 1 to 8 (*see Section 4 and Figure 6.1*).

Receptor identity	X coord (m)	Y coord (m)	Scen 1 - (μg/m^3)	Scen 2 - (μg/m^3)	Scen 3 - (μg/m^3)	Scen 4 - (μg/m^3)	Scen 5 - (μg/m^3)	Scen 6 - (μg/m^3)	Scen 7 - (μg/m^3)	Scen 8 -(μg/m^3)
R1	297498.3	269436.6	113.58	31.38	1.38	37.30	7.04	0.87	2.33	0.73
R2	297573.5	269493.2	130.23	29.56	1.49	34.59	7.94	0.94	2.66	0.79
R3	297654.7	269498.3	143.58	29.84	2.12	33.06	9.84	1.33	4.25	1.11
R4	297395.3	269510.8	90.31	18.91	1.19	23.49	6.09	0.76	1.80	0.61
R5	297355.4	269515	94.35	16.88	1.24	20.74	6.22	0.79	2.06	0.65
R7	297281.2	269519.7	95.97	17.07	1.44	21.25	6.33	0.91	2.79	0.75
R8	297299.3	269380.5	140.08	38.43	2.78	46.37	11.95	1.74	5.54	1.48
R9	297744.7	269499.2	138.65	27.64	2.49	30.97	10.98	1.56	4.38	1.33
R10	297629.6	268891.5	133.41	23.78	1.48	26.96	6.69	0.91	3.14	0.82

Table 4.3 continued. Predicted ground level concentration (excluding baseline) of each pollutant at each identified sensitive receptor locations R1 to R10 for Scenarios 9 to 15 (*see Section 4 and Figure 6.1*).

Receptor identity	X coord (m)	Y coord (m)	Scen 9 - (μg/m^3)	Scen 10 - (μg/m^3)	Scen 11 - (μg/m^3)	Scen 12 - (μg/m^3)	Scen 13 - (μg/m^3)	Scen 14 - (μg/m^3)	Scen 15 - (μg/m^3)
R1	297498.3	269436.6	0.73	4.09	0.61	0.04	1.24	0.18	0.01
R2	297573.5	269493.2	0.79	3.82	0.76	0.05	1.16	0.23	0.01
R3	297654.7	269498.3	1.11	3.58	0.98	0.07	1.08	0.30	0.02
R4	297395.3	269510.8	0.61	1.54	0.54	0.04	0.47	0.16	0.01
R5	297355.4	269515	0.65	1.28	0.54	0.04	0.39	0.16	0.01
R7	297281.2	269519.7	0.75	2.02	0.60	0.05	0.61	0.18	0.01
R8	297299.3	269380.5	1.48	3.88	1.17	0.09	1.18	0.35	0.03
R9	297744.7	269499.2	1.33	3.35	0.97	0.08	1.02	0.29	0.02
R10	297629.6	268891.5	0.82	1.76	0.73	0.05	0.53	0.22	0.01

5. Conclusions

Odour Monitoring Ireland was commissioned by Panda Waste to perform a dispersion modelling study in order to provide supporting information for a license review of new processes to be located in Bauparc Business Park, Navan, Co. Meath. Following a detailed impact and dispersion modelling assessment, it was demonstrated that no significant environmental impact will exist if the source characteristics and emission limit value in the waste gases are achieved.

The following conclusions are drawn from the study:

1. The assessment was carried out to provide information in line with standard information to be provided to the EPA for license reviews for such projects.

2. Specific dispersion modelling was performed for Carbon monoxide, Oxides of nitrogen, Sulphur dioxide, Particulate matter, Hydrogen chloride and Hydrogen fluoride. The combined cumulative impact of odour for the facility has been dealt with in another document which has been submitted to the EPA.

3. With regards to Carbon monoxide, the maximum GLC+Baseline for CO from the operation of the facility is 810 $\mu g\ m^{-3}$ for the maximum 8-hour mean concentration at the 100th percentile. When combined predicted and baseline conditions are compared to the Irish guideline/limit values and EU Limit values set out in SI 271 of 2002 and Directive 2008/50/EC, this is 8.10% of the impact criterion. In addition, the predicted ground level concentration of Carbon monoxide at each of the 10 sensitive receptors is presented in *Table 4.3*. As can be observed, all predicted ground level concentrations are well within the ground level concentration limit values contained in *Tables 2.1 and 2.2.*

4. With regards to Oxides of nitrogen, the maximum GLC+Baseline for NO_2 from the operation of the facility is 119 $\mu g\ m^{-3}$ for the maximum 1-hour mean concentration at the 99.79th percentile. When combined predicted and baseline conditions are compared to SI 271 of 2002 and Directive 2008/50/EC, this is 59.50 % of the impact criterion. An annual average was also generated to allow comparison with values contained in SI 271 of 2002 and Directive 2008/50/EC. The maximum predicted annual average ground level concentration in the vicinity of the facility was 22.30$\mu g/m^3$. When compared the annual average NO_2 air quality impact criterion is 55.75% of the impact criterion. In addition, the predicted ground level concentration of Oxides of nitrogen at each of the 10 sensitive receptors is presented in *Table 4.3*. As can be observed, all predicted ground level concentrations are well within the ground level concentration limit values contained in *Tables 2.1 and 2.2*.

5. With regards to Sulphur dioxide, the maximum GLC+Baseline for SO_2 from the operation of the facility is 120 and 50 $\mu g\ m^{-3}$ for the maximum 1-hour and 24 hr mean concentration at the 99.73th and 99.18th percentile respectively. When combined predicted and baseline conditions are compared to SI 271 of 2002 and Directive 2008/50/EC, this is 36 and 42.40% of the set target limits established for the 1 hour and 24 hour assessment criteria. An annual average was also generated to allow comparison with SI 271 of 2002 and Directive 2008/50/EC. The maximum predicted annual average ground level concentration in the vicinity of the facility was 12 $\mu g/m^3$. When compared the annual average SO_2 air quality impact criterion is 60% of the impact criterion. In addition, the predicted ground level concentration of Sulphur dioxide at each of the 10 sensitive receptors is presented in *Table 4.3*. As can be observed, all predicted ground level concentrations are well within the ground level concentration limit values contained in *Tables 2.1 and 2.2*.

6. With regards to Particulate matter, the maximum GLC+Baseline for Particulate matter 10μm from the operation of the facility is 31$\mu g\ m^{-3}$ for the maximum 24-hour mean concentration at the 90.40th percentile. When combined predicted and baseline conditions are compared to Directive 2008/50/EC, this is 62% of the impact criterion.

An annual average was also generated to allow comparison with the SI 271 of 2002 and Directive 2008/50/EC. The maximum predicted annual average ground level concentration in the vicinity of the facility was 21$\mu g/m^3$. When compared, the annual average Particulate matter air quality impact is 52.50 % of the impact criterion. An annual average was also generated for $PM_{2.5}$ to allow comparison with Directive 2008/50/EC. The maximum predicted annual average ground level concentration in the vicinity of the facility was 16$\mu g/m^3$. When compared, the annual average $PM_{2.5}$ air quality impact is 64% of the impact criterion. In addition, the predicted ground level concentration of Particulate matter at each of the 10 sensitive receptors is presented in *Table 4.3*. As can be observed, all predicted ground level concentrations are well within the ground level concentration limit values contained in *Tables 2.1 and 2.2*.

7. With regards to Hydrogen chloride, emissions at maximum operations equate to ambient HCl concentrations (including background concentrations) which are from 1.56 to 15.5% of the maximum impact criterion for both the 1 hr and annual average period. In addition, the predicted ground level concentration of Particulate matter at each of the 10 sensitive receptors is presented in *Table 4.3*. As can be observed, all predicted ground level concentrations are well within the ground level concentration limit values contained in *Tables 2.1 and 2.2*.

8. With regards to Hydrogen fluoride emissions at maximum operations equate to ambient HF concentrations (including background concentrations) which are from 1.59% to 60% of the maximum impact criterion for both the 1 hr and annual average period. In addition, the predicted ground level concentration of Particulate matter at each of the 10 sensitive receptors is presented in *Table 4.3*. As can be observed, all predicted ground level concentrations are well within the ground level concentration limit values contained in *Tables 2.1 and 2.2*.

9. Emissions from the biogas flare were not accounted for in the model as this is a standby plant and will only operate when one of the gas utilisation engines is in maintenance. Emissions from the gas utilisation engine would be greater than the biogas flare as per *Table 3.3* and therefore worst case is taken into account by assuming the gas utilisation engines operate 24/7/365 days per year.

10. The overall modelling indicates that the facility will not result in any significant impact on air quality in the surrounding area with all ground level concentrations of pollutants well within their respective ground level concentration limit values.

6. *Appendix I* - Air dispersion modelling contour plots (Process contributions and illustrative purposes only).

These contour maps are for illustrative purposes only.

6.1 Site layout drawing and location of proposed emission points – A2-2 to A2-5

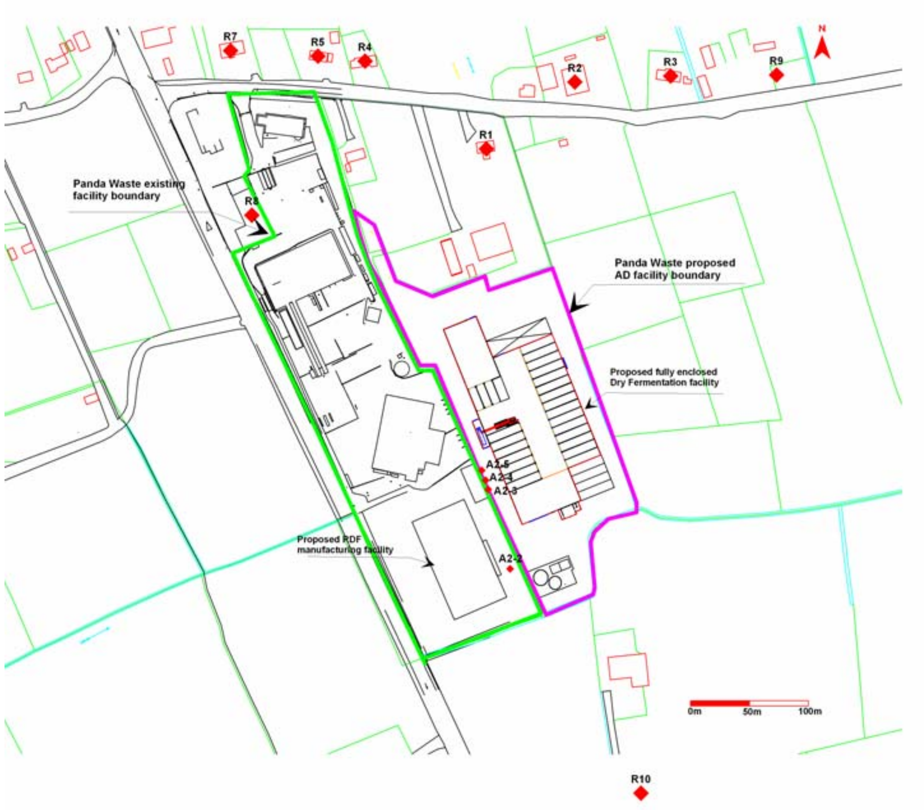

Figure 6.1. Plan view facility layout drawings for Panda Waste Ltd facility including specific location of proposed emission points A2-2 to A2-5 and nearest sensitive receptors R1 to R10.

6.2. Dispersion modelling contour plots for Scenarios 1 to 15 – Worst case meteorological year Dublin 2004

6.2.1 Scenario 1 - Carbon monoxide

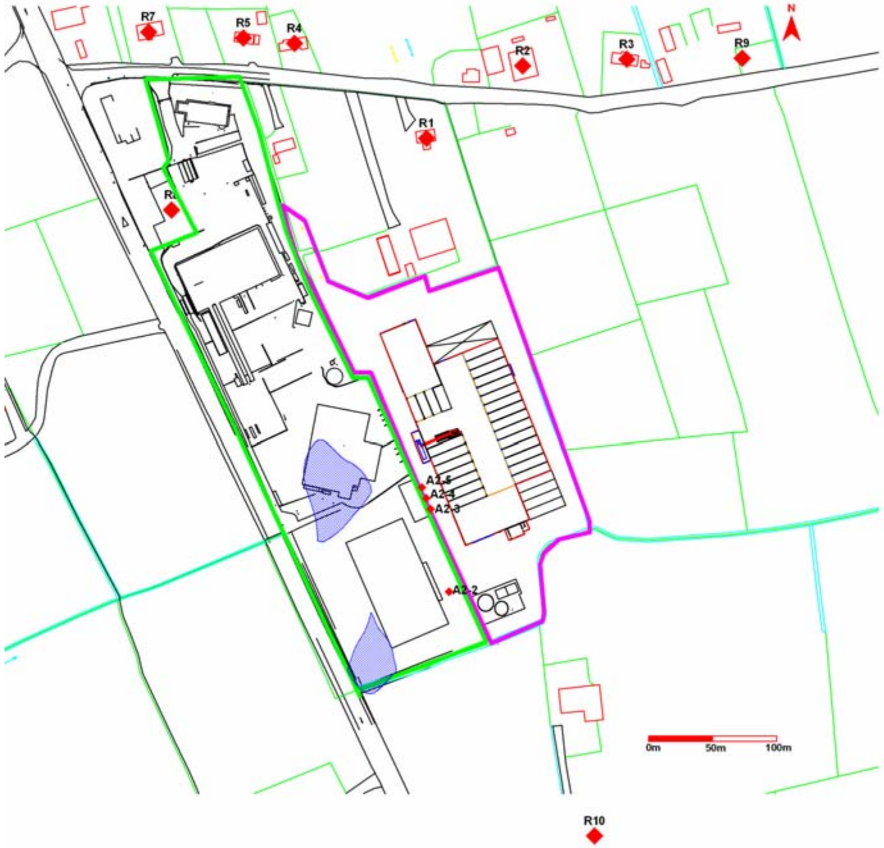

Figure 6.2. Predicted 8 hr average CO ground level concentration of 500 µg/m^3 (▬▬) for cumulative emissions from emission points for Scenario 1 for Dublin Airport meteorological station (worst case year 2004).

6.2.2 Scenario 2 and 3 - Oxides of nitrogen

Figure 6.3. Predicted 99.79th percentile of 1 hr averages for NO_2 ground level concentration of 101 µg/m^3 ( ) for cumulative emission for Scenario 2 for Dublin Airport meteorological station (worst case year 2004).

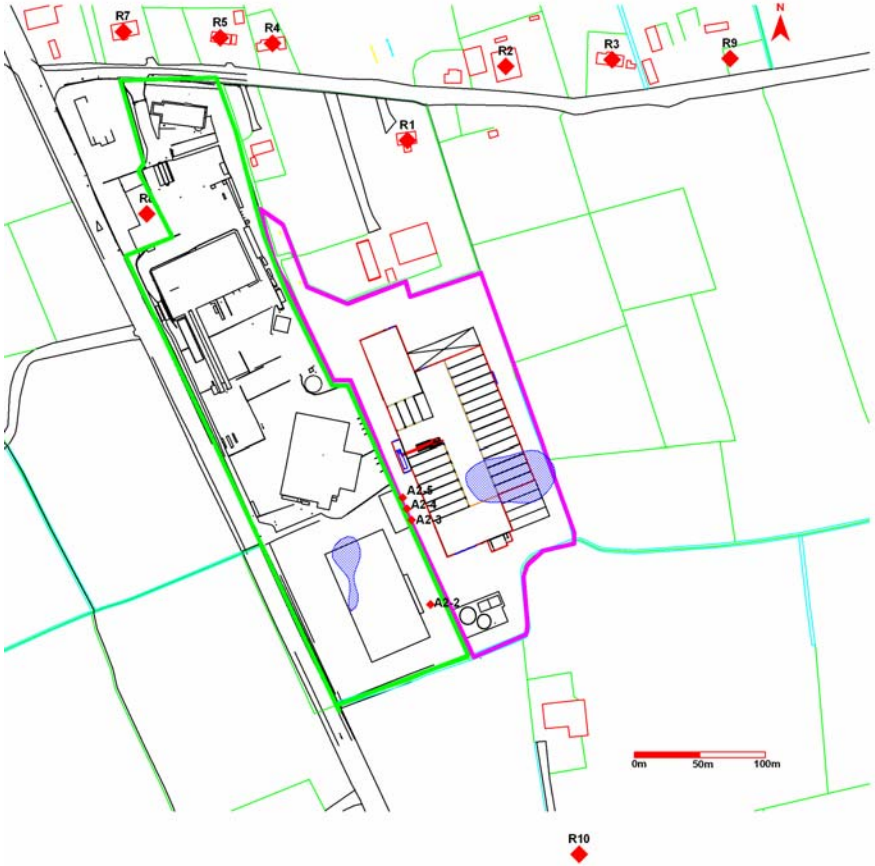

Figure 6.4 Predicted annual average NO_2 ground level concentration of 13.3 $\mu g/m^3$ (▬) for cumulative emissions for Scenario 3 for Dublin Airport meteorological station (worst case year 2004).

6.2.3 Scenario 4, 5 and 6 - Sulphur dioxide

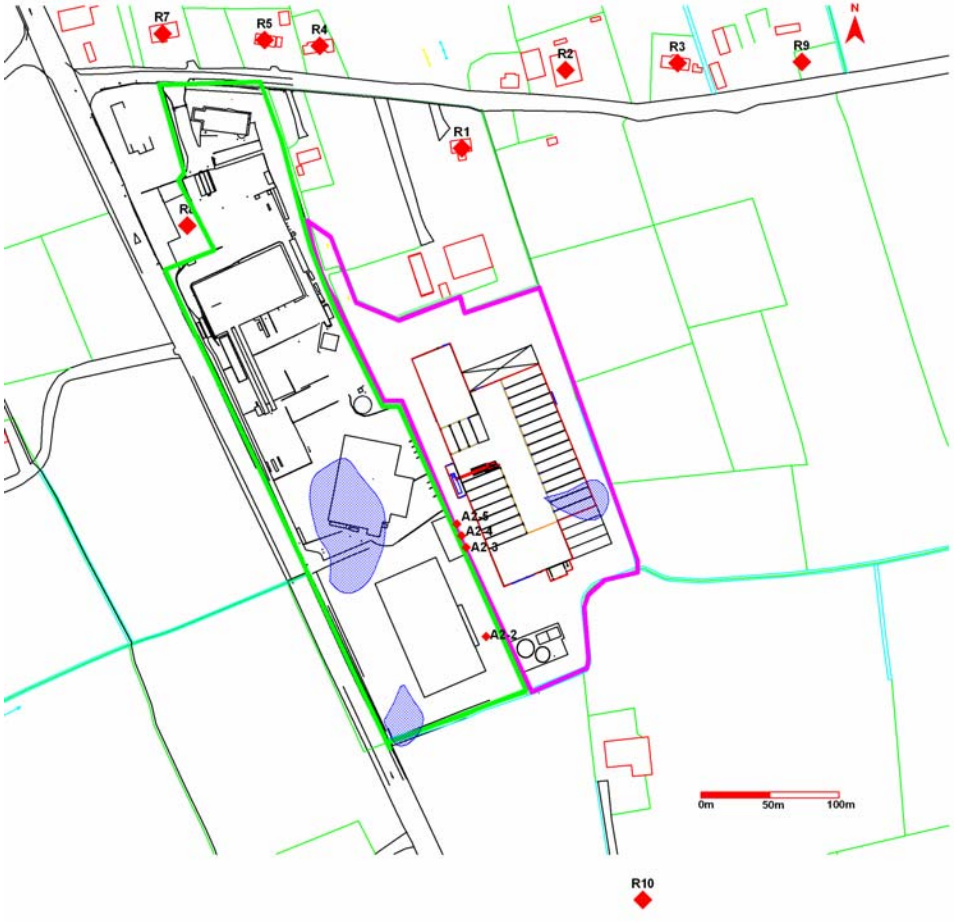

Figure 6.5. Predicted 99.73th percentile of 1 hr averages for SO_2 ground level concentration of 110 μg/m^3 (▬▬) for cumulative emission for Scenario 4 for Dublin Airport meteorological station (worst case year 2004).

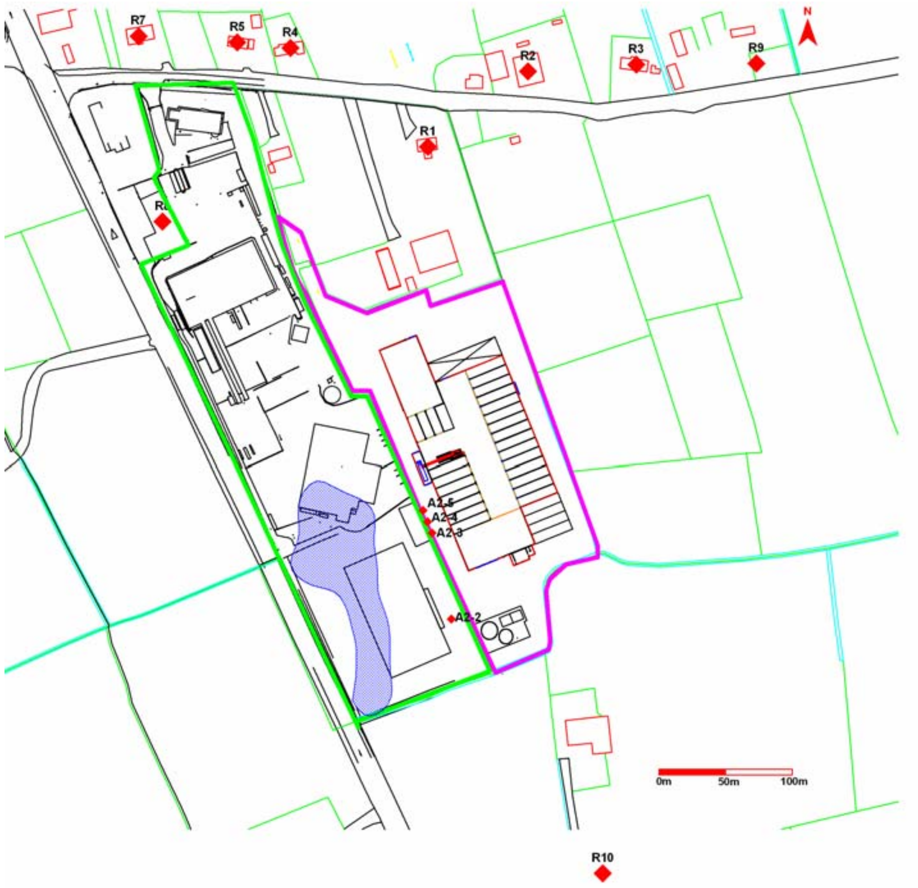

Figure 6.6. Predicted 99.18th percentile of 24 hr averages for SO_2 ground level concentration of 50 µg/m^3 (▬) for cumulative emission for Scenario 5 for Dublin Airport meteorological station (worst case year 2004).

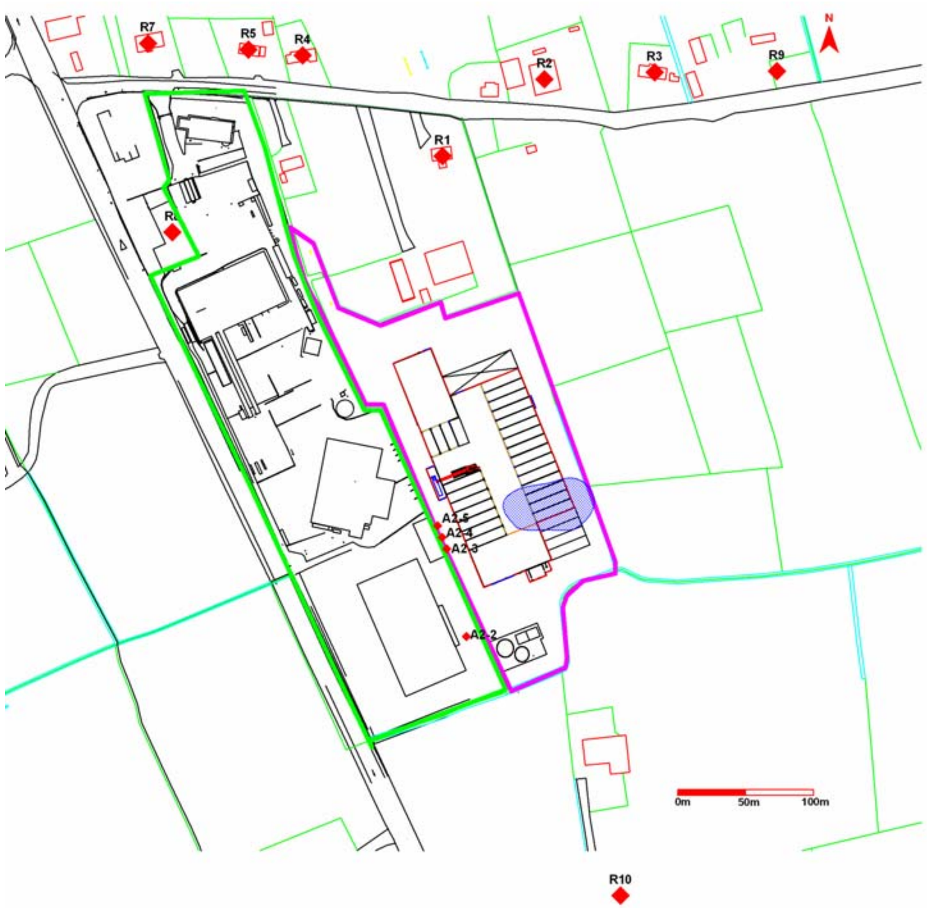

Figure 6.7. Predicted annual average SO_2 ground level concentration of 9 μg/m^3 (▬) for cumulative emissions for Scenario 6 for Dublin Airport meteorological station (worst case year 2004).

6.2.4 Scenario 7, 8 and 9 - Total particulates

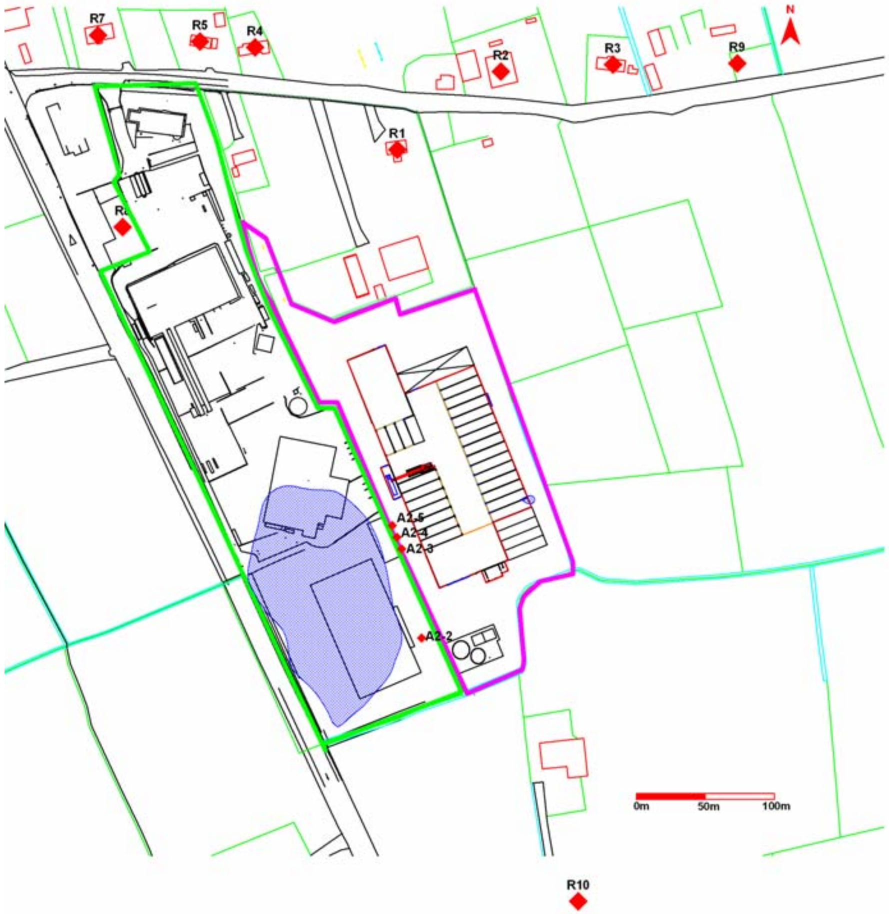

Figure 6.8. Predicted 90.40th percentile of 24 hr averages for Total particulates ground level concentration of 17 μg/m^3 (▬) for cumulative emission for Scenario 7 for Dublin Airport meteorological station (worst case year 2004).

Figure 6.9. Predicted annual average Total particulates ground level concentration of 6.0 μg/m^3 (▬) for cumulative emissions for Scenario 8 for Dublin Airport meteorological station (worst case year 2004).

Figure 6.10. Predicted annual average Total particulates as $PM_{2.5}$ ground level concentration of 6.0 $\mu g/m^3$ (▬) for cumulative emissions for Scenario 9 for Dublin Airport meteorological station (worst case year 2004).

6.2.5 Scenario 10, 11 and 12 – Hydrogen chloride

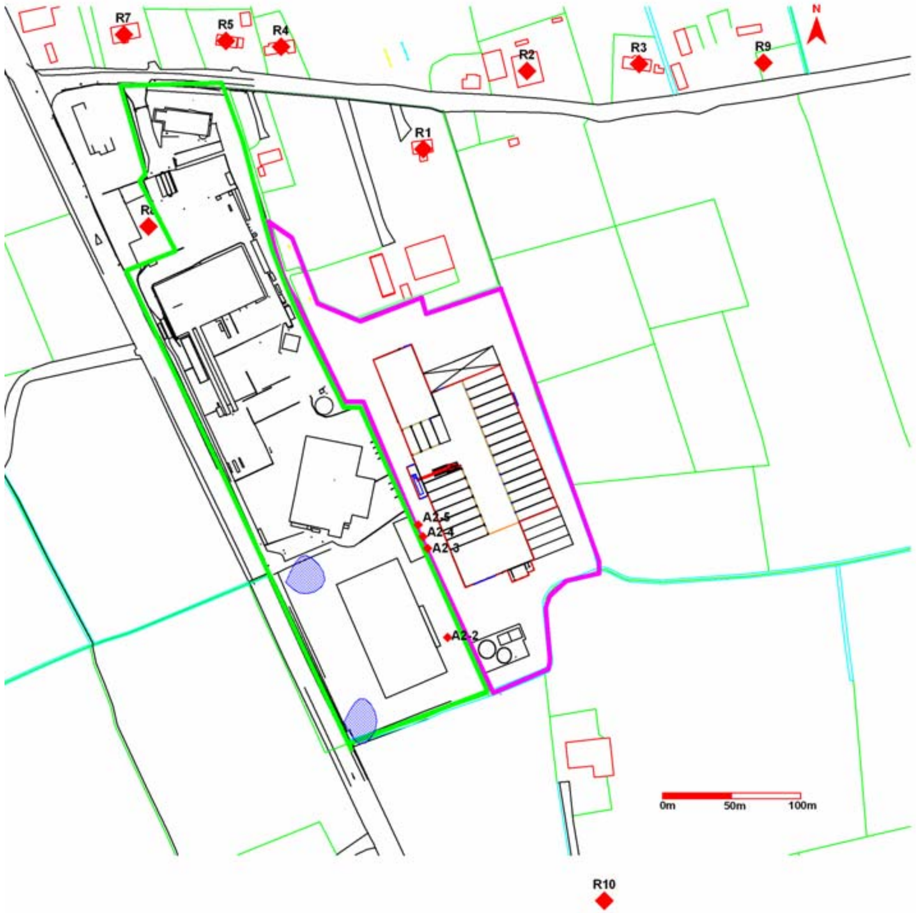

Figure 6.11. Predicted 100th percentile of 1 hr averages for Hydrogen chloride ground level concentration of 8 μg/m³ (▬) for cumulative emission for Scenario 10 for Dublin Airport meteorological station (worst case year 2004).

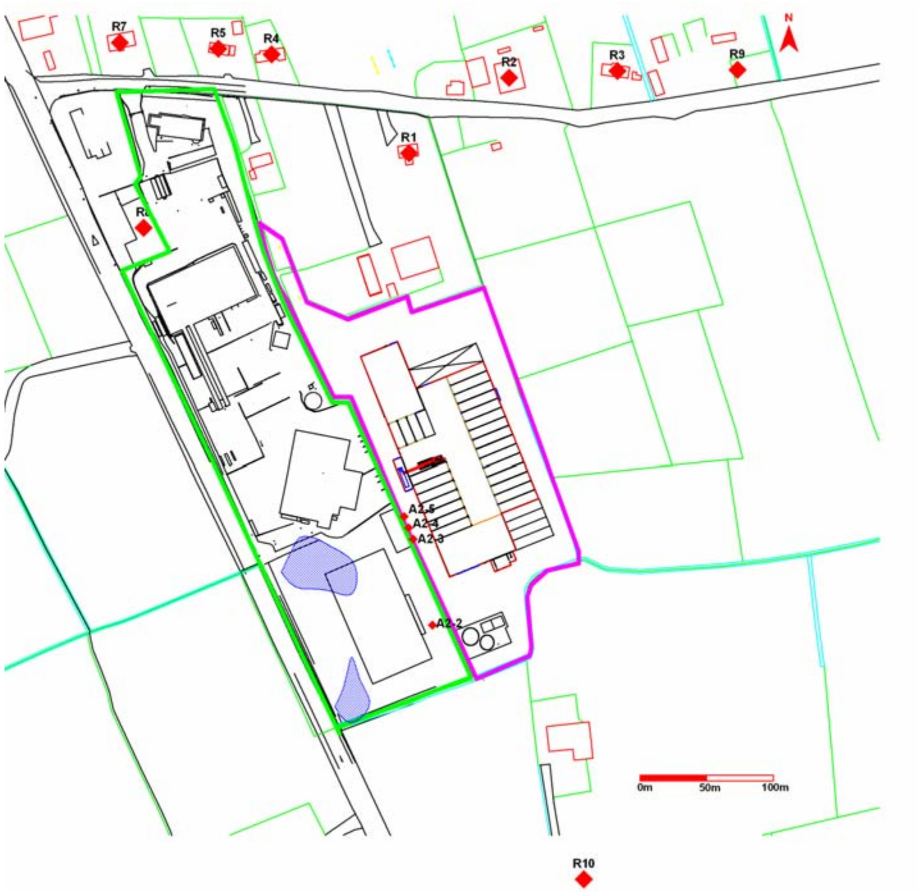

Figure 6.12. Predicted 98th percentile of 1 hr averages for Hydrogen chloride ground level concentration of 5 μg/m³ (▬) for cumulative emission for Scenario 11 for Dublin Airport meteorological station (worst case year 2004).

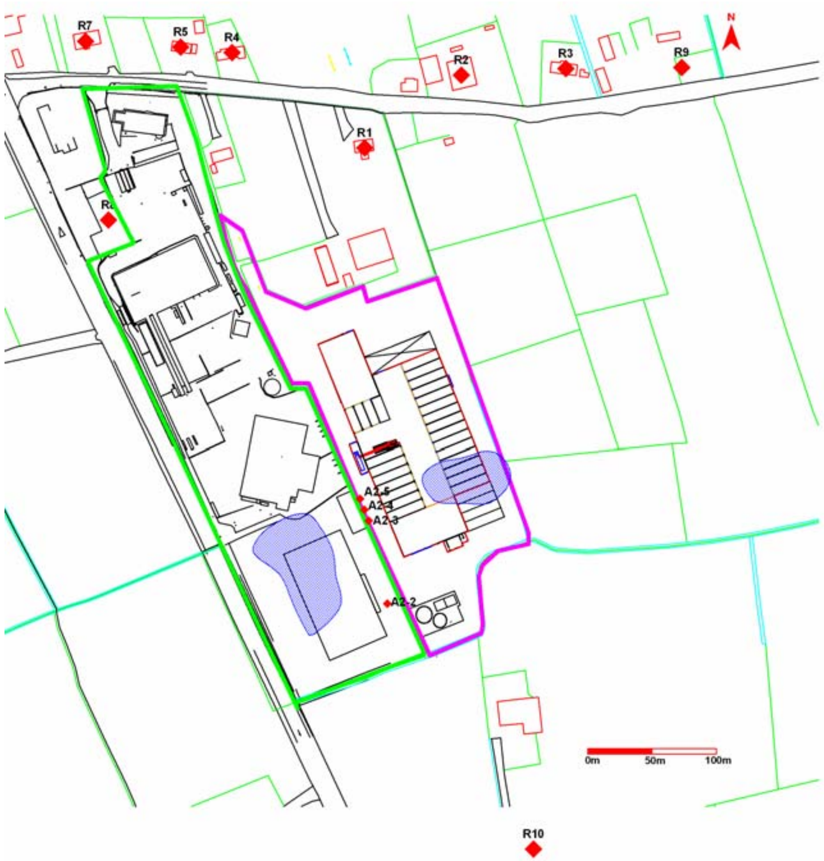

Figure 6.13. Predicted annual average Hydrogen chloride ground level concentration of 0.40 μg/m^3 (▬) for cumulative emissions for Scenario 12 for Dublin Airport meteorological station (worst case year 2004).

6.2.6 Scenario 13, 14 and 15 – Hydrogen fluoride

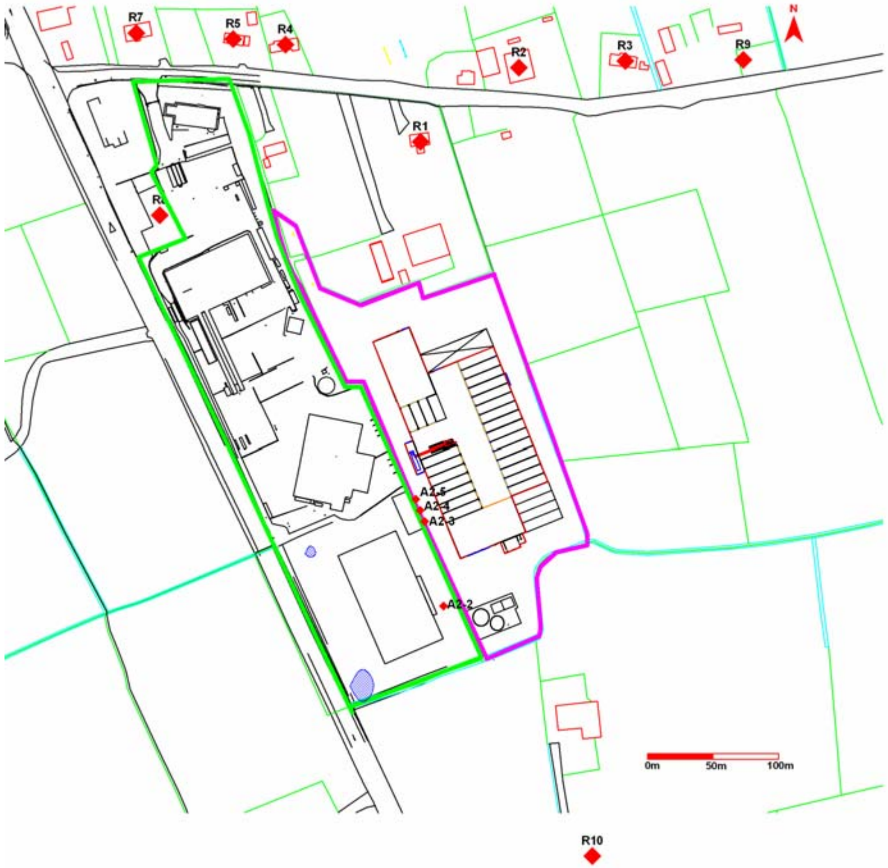

Figure 6.14 Predicted 100th percentile of 1 hr averages for Hydrogen fluoride ground level concentration of 2.5 μg/m³ (▬▬) for cumulative emission for Scenario 13 for Dublin Airport meteorological station (worst case year 2004).

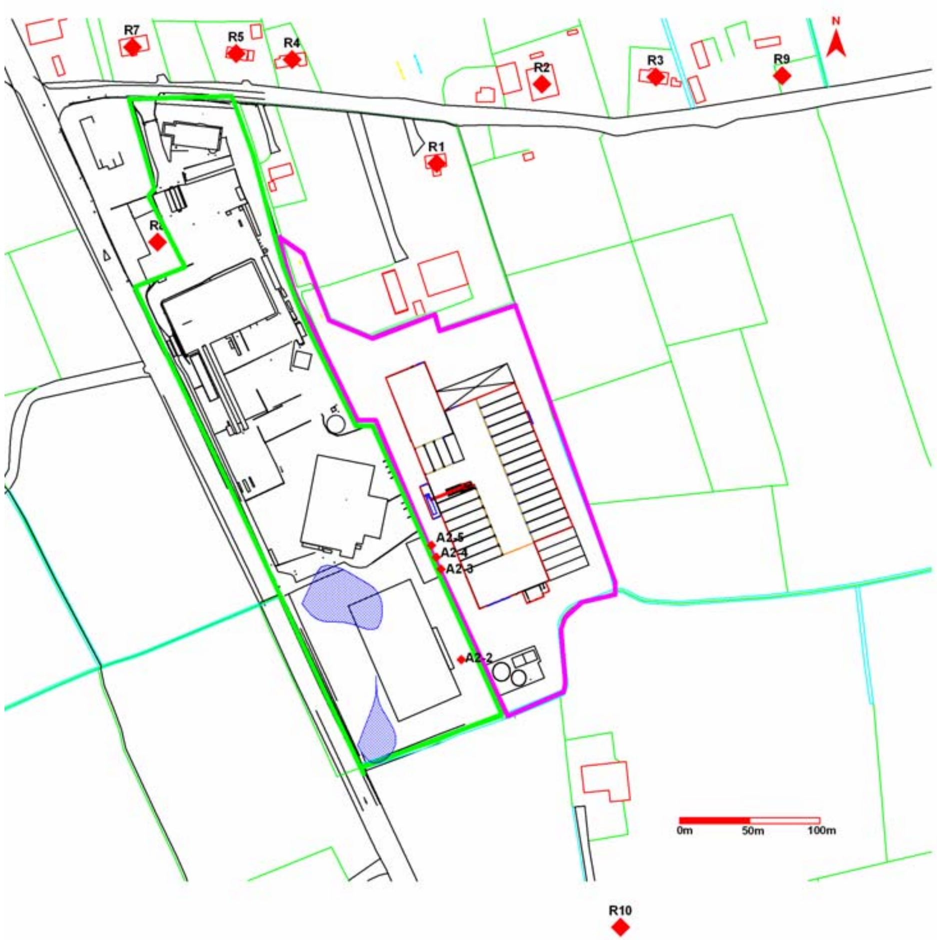

Figure 6.15. Predicted 98th percentile of 1 hr averages for Hydrogen fluoride ground level concentration of 1.5 μg/m^3 (▬) for cumulative emission for Scenario 14 for Dublin Airport meteorological station (worst case year 2004).

Figure 6.16. Predicted annual average Hydrogen fluoride ground level concentration of 0.13 μg/m^3 (▬▬) for cumulative emissions for Scenario 15 for Dublin Airport meteorological station (worst case year 2004).

7. *Appendix II* - Meteorological data used within the Dispersion modelling study.

Meteorological file Dublin Airport 2002 to 2006 inclusive

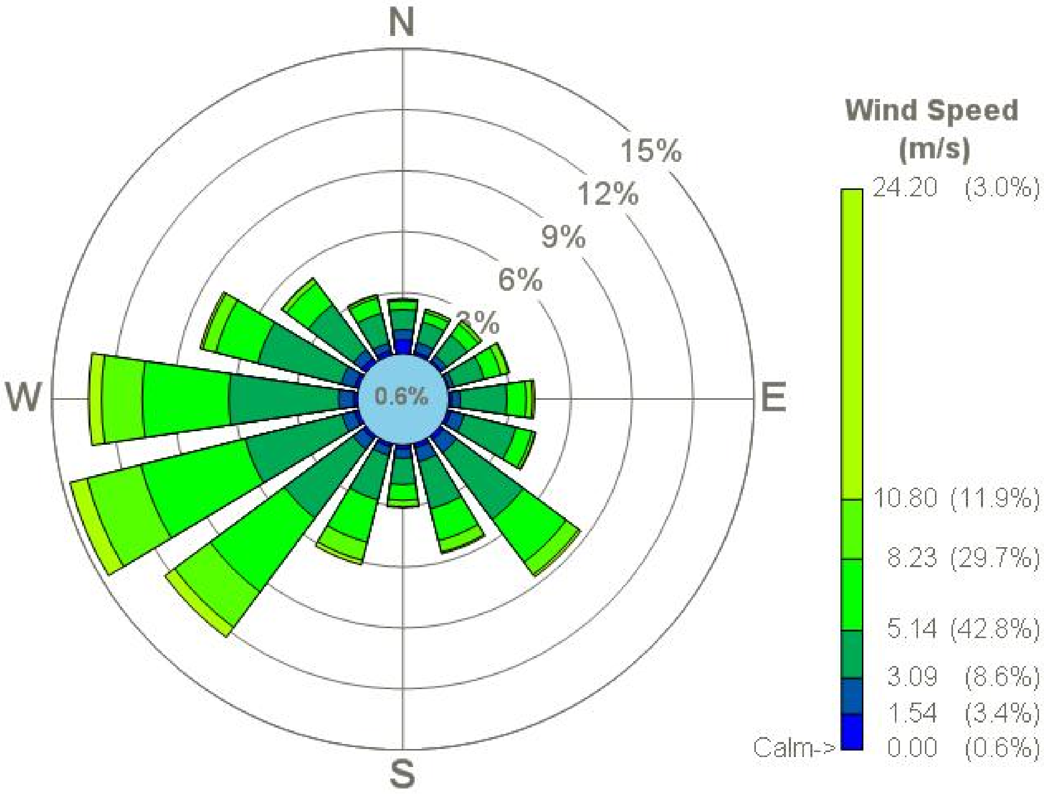

Figure 7.1. Schematic illustrating windrose for meteorological data used for atmospheric dispersion modelling, Dublin Airport 2002 to 2006 inclusive.

Table 7.1. Cumulative wind speed and direction for meteorological data used for atmospheric dispersion modelling Dublin Airport 2002 to 2006 inclusive.

Cumulative Wind Speed Categories							
Relative Direction	**> 1.54**	**>3.09**	**>5.14**	**>8.23**	**> 10.80**	**< 10.80**	**Total**
0	0.67	0.50	0.99	0.44	0.07	0.02	2.70
22.5	0.15	0.48	1.04	0.48	0.16	0.00	2.31
45	0.11	0.31	1.27	0.67	0.21	0.01	2.57
67.5	0.07	0.24	1.55	0.86	0.38	0.05	3.15
90	0.13	0.44	2.28	0.95	0.31	0.11	4.22
112.5	0.17	0.68	2.62	0.80	0.16	0.04	4.48
135	0.22	0.79	4.10	2.61	0.76	0.14	8.63
157.5	0.22	0.70	2.39	1.61	0.58	0.08	5.58
180	0.20	0.45	1.30	0.77	0.32	0.05	3.09
202.5	0.17	0.42	2.26	2.14	0.93	0.23	6.15
225	0.19	0.62	4.21	4.53	2.18	0.61	12.34
247.5	0.20	0.64	4.91	5.29	2.73	0.87	14.63
270	0.19	0.73	5.39	4.27	2.00	0.63	13.20
292.5	0.19	0.68	4.23	2.13	0.66	0.13	8.03
315	0.26	0.53	2.77	1.33	0.26	0.04	5.20
337.5	0.23	0.37	1.51	0.78	0.15	0.04	3.07
Total	**3.39**	**8.58**	**42.82**	**29.66**	**11.86**	**3.04**	**99.36**
Calms	--	-	-	-	-	-	**0.56**
Missing	-	-	-	-	-	-	**0.08**
Total	**-**	**-**	**-**	**-**	**-**	**-**	**100.00**

8. *Appendix III* - Checklist for EPA requirements for air dispersion modelling reporting

Table 8.1. EPA checklist as taken from their air dispersion modelling requirements report.

Item	Yes/No	Reason for omission/Notes
Location map	Section 6	-
Site plan	Section 6	-
List of pollutants modelled and relevant air quality guidelines	Yes	-
Details of modelled scenarios	Yes	-
Model description and justification	Yes	-
Special model treatments used	Yes	-
Table of emission parameters used	Yes	-
Details of modelled domain and receptors	Yes	-
Details of meteorological data used (including origin) and justification	Yes	-
Details of terrain treatment	Yes	-
Details of building treatment	Yes	-
Details of modelled wet/dry deposition	N/A	-
Sensitivity analysis	Yes	Five years of hourly sequential data screened from nearest valid met station-Dublin Airport 2002 to 2006. Due to the fact of simple terrain in the vicinity of the emission point no terrain effect required or accounted for within the model.
Assessment of impacts	Yes	Pollutant emissions assessment from process identified.
Model input files	No	DVD will be sent upon request. Files are a total of 2.2 GB in size.