

ATTACHMENT NUMBER H1

Air

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Attachment H1.1

Impact on Air Quality

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H1.1 IMPACT ON AIR QUALITY

1. CONSTRUCTION IMPACTS AND MITIGATION

The potential for the dust to be generated during construction activities on site is confined to the preliminary earth works and earth movement phase of the development, which will last for no more than three months. During this phase, if hot dry weather conditions prevailed, excavated soil could dry and become friable and susceptible to being transported off site by wind. It should be noted that only small particles are susceptible to airborne transport.

This potential exists at all construction sites and the mitigation measures and good housekeeping and site management practices necessary to minimise this potential are well known. Such measures which will be applied are described below.

The principal potential source of dust emissions from a construction site is the movement of vehicles on the site (on roads and off roads) and on external roads, as vehicles can carry soil onto the roads where it can dry and the passage of vehicles over these roads creates and raises small particles of dust.

The potential for dust to be generated in this manner will be mitigated against by watering the site roads to prevent the formation of dry dust particles and by the provision of wheel washing facilities to prevent soil from being transported onto the local road network.

A lesser potential for dust generation is presented by the movement of earth on and off site and within the site. However, as the majority of soil excavated on site will be used for the construction of berms around the site, the only movement of material on and off site will be for the construction of the percolation area. This will only be a limited quantity of material.

While the movement of excavated material on site can lead to airborne dust emissions in exceptionally dry conditions the clayey nature of the soil on the site will effectively eliminate this potential. Furthermore, the berms around the site will be constructed and planted at the earliest possible stage of the development and there will be limited temporary storage of spoil on site. When the berms are constructed and planted there will be no potential for airborne dust emissions.

Where temporary storage of spoil is necessary, it will be stored in specifically designated areas and these will be damped with water if necessary. During the material transfer within the site minimum drop heights will be specified to prevent the generation of dust. Again, the clayey nature of the soil on site will tend to prevent the formation of dust particles.

In view of the above considerations and mitigation measures, it is concluded that the potential for airborne dust emissions during construction is minor and temporary in nature.

2. OPERATIONAL IMPACTS AND MITIGATION

2.1 STACK EMISSIONS

There will be one main stack on site through which atmospheric emissions will be discharged. Air emission limit values for the incineration of waste have been specified in the new EU Directive on the Incineration of Waste (2000/76/EC). These limit values are listed in Tables 2.1 and 2.2 overleaf. The typical emission concentrations in the flue gas are expected to be well below the limits specified in the new directive. The only other emission to atmosphere will be occasional emissions from the back-up gas-fired electricity generator. The locations of the atmospheric emission points are shown on Drawing No. 2666-22-DR-009 in Attachment H1.4. The substances emitted from the waste to energy plant via the main stack will include the following:

- Oxides of nitrogen (NO_x)
- Sulphur dioxide (SO₂)
- Carbon monoxide (CO)
- Particulates (Dust)
- Hydrocarbons (expressed as Total Organic Carbon (TOC))
- Hydrogen Chloride (HCl)
- Hydrogen Fluoride (HF)
- Poly-Chlorinated Dibenzo Dioxins (PCDD) and Poly-Chlorinated Dibenzo Furans (PCDF)
- Heavy metals: Cadmium (Cd), Thallium (Tl), Mercury (Hg), Antimony (Sb), Arsenic (As), Lead (Pb), Chromium (Cr), Cobalt (Co), Copper (Cu), Manganese (Mn), Nickel (Ni), Vanadium (V).

The waste licence application form tables 1.1, 1.2 and 1.4 have been completed and are included in Attachment H1.5.

Table 2.1 Air Emission Limit Values as per 2000/76/EC

Emission	Daily average values (mg/m ³)	Half-hourly average values ¹ (mg/m ³)	
		Column A	Column B
Total Dust	10	30	10
TOC	10	20	10
HCL	10	60	10
HF	1	4	2
SO ₂	50	200	50
(NO _x) as NO ₂	200	400	200
Dioxins and Furans ²	0.1 ng/m ³		
Cadmium & Thallium ³	Total 0.05 mg/m ³		
Mercury ³	0.05 mg/m ³		
Sum of 9 heavy metals ³ ; (Sb), (As), (Pb), (Cr), (Co), (Cu), (Mn), (Ni), (V).	Total 0.5 mg/m ³		

Notes:

1. The emission limit values shall be regarded as being complied with if none of the half hourly average values exceeds any of the emission limit values set out in Column A, or, 97% of the half hourly average values over a year do not exceed any of the emission limit values set out in Column B.
2. Average values shall be measured over a sample period of a minimum of 6 hours and a maximum of 8 hours. The emission limit value refers to the total concentration of dioxins and furans calculated using the concept of toxic equivalency in accordance with Annex I of the directive.
3. All average values over the sample period of a minimum of 30 minutes and a maximum of 8 hours.

Table 2.2 Carbon Monoxide Emission Limit Values as per 2000/76/EC

Emission	Daily average value	Half hourly average values ¹	10 minute average value ²
CO	50 mg/m ³	100 mg/m ³	150 mg/m ³

Notes:

1. All measurements to be taken in any 24 hour period
2. At least 95% of all measurements determined as 10 minute values.

Both the maximum and typical emission concentrations and resultant mass emission rates from the stack are listed in Table 2.3.

Table 2.3 Emission Data

Emission	Maximum Values ¹		Typical Values ²	
	Emission Concentration (mg/Nm ³)	Emission Rate (g/s)	Emission Concentration (mg/Nm ³)	Emission Rate (g/s)
NO _x (as NO ₂)	200	8.389	150	5.25
SO ₂	50	3.097	20	0.7
Dust	10	0.419	1	0.035
CO	100	4.2	100	3.5
TOC	10	0.419	1	0.035
HCl	10	0.419	1	0.035
HF	1	0.042	1	0.035
PCDD / PCDF	0.1 (ng/m ³)	4.19 x 10 ⁻⁹	0.01 (ng/m ³)	3.5 x 10 ⁻¹⁰
Cd & Tl	0.05	0.002	0.025	0.000875
Hg	0.05	0.002	0.025	0.000875
Sum of 9 Heavy Metals: Sb, As, Pb, Cr, Co, Cu, Mn, Ni, V	0.5	0.021	0.25	0.00875

Notes:

1. Emission concentrations (mg/Nm³) based on maximum concentrations permitted. Emission rates (g/s) based on maximum capacity of Waste to Energy Plant (180,000 tonnes per annum).
2. Emission concentrations (mg/Nm³) based on typical emission concentrations emitted. There will be short term fluctuations during the operation of the facility. However, these will be below the maximum concentrations permitted. Emission rates (g/s) based on nominal capacity of Waste to Energy Plant (150,000 tonnes per annum).

As can be seen from the above, the typical emission concentrations in the flue gas are expected to be well below the limits specified in the new EU Directive on the Incineration of Waste (2000/76/EC). However, there will be short term fluctuations during the operation of the facility. These fluctuations will be below the maximum concentrations permitted under the above directive.

2.2 ABATEMENT/TREATMENT/RECOVERY SYSTEMS

There will be a number of abatement, treatment and recovery process steps within the waste to energy plant process to treat the atmospheric emissions described above. These steps are listed in Table 2.4 below, along with the emissions that will be treated and the relevant section where the technique is described in detail in Attachment D2.1.

Table 2.4 Abatement/Treatment/Recovery Systems within Waste to Energy Plant

Emission Treatment / Recovery	Abatement /Treatment / Recovery System	Relevant Section
Odour	Primary Air Supply taken from Waste Acceptance Hall	3.1 & 4.2
Litter	Enclosed Waste Acceptance Hall	3.1 & 4.2
Oxides of nitrogen (NO _x)	Injection of Ammonia Solution/Urea to Boiler	4.4
Hydrocarbons (expressed as Total Organic Carbon (TOC))	Furnace	4.4
Poly-Chlorinated Dibenzo Dioxins (PCDD) and Poly-Chlorinated Dibenzo Furans (PCDF)	Minimum temperature of 850 °C for 2 seconds in first pass of Boiler	4.5
Energy Recovery	Boiler	4.5
Process Effluent	Evaporating Spray Tower	4.6
Hydrocarbons (expressed as Total Organic Carbon (TOC)), Particulates (Dust), Poly-Chlorinated Dibenzo Dioxins (PCDD) and Poly-Chlorinated Dibenzo Furans (PCDF), Heavy Metals	Activated Carbon/Lime Mixture Injection and Baghouse Filter and Tail End Flue Gas Cleaning	4.7 & 4.9
Sulphur Dioxide (SO ₂), Hydrogen Chloride (HCl), Hydrogen Fluoride (HF), Heavy Metals	Wet Flue Gas Cleaning	4.8
Plume Abatement	Heat Exchanger	4.10

2.3 OTHER EMISSIONS TO ATMOSPHERE

Other air emissions will consist of occasional emissions from the back-up gas-fired electricity generator. The back-up gas-fired generator will only be used in the unlikely circumstance of both the plant not producing electricity and no power supply being available from the national grid. It will also be used for a period of half an hour once per month for testing purposes. The expected emissions from the back-up generator, at 5% excess air, are as follows:

Table 2.5 Anticipated Emissions from Back-up Electricity Generator

Parameter	Emission Concentration (mg/Nm ³)
NO _x	<500
CO	650
TOC	150
Dust	100

The activated carbon/lime mixture silo will be located externally and will be equipped with High Efficiency Particulate Abatement (HEPA) filters to prevent fugitive emissions from the silo.

The silos for the purposes of storage of flue gas cleaning residues and boiler ash will be located within the waste to energy plant and will also be fitted with high quality dust filters to ensure that there are no fugitive dust emissions. Bottom ash will be discharged into trucks in an enclosed area. These trucks will be covered to prevent the potential for windblown ash.

Another source of potential air emissions from the facility would be odours from the waste collection areas. The waste bunker which will receive all incoming waste to be treated in the waste to energy plant will be maintained under negative pressure to prevent any odorous emissions by treating them in the waste to energy plant.

Collection areas will be provided in the community recycling park for a number of wastes including newspaper, glass, waste oils, used batteries, etc. from members of the public. The community recycling park will not provide for the collection of any organic/putrescible waste which could give rise to odours. The area will be properly maintained and good housekeeping will minimise the potential for the generation of odours.

The construction and operational phases of the development will generate additional traffic on the surrounding road network. Traffic can contribute to ground level concentrations of certain substances, particularly NO_x. However, the amount of additional traffic generated will not be significant and therefore emissions from traffic will not have a significant impact on air quality.

2.4 AIR DISPERSION MODELLING

Air dispersion modelling was carried out to determine effects of atmospheric emissions from the waste to energy plant on ground level concentrations in the surrounding atmosphere. A screening exercise was first carried out to determine a stack height, which would adequately disperse the atmospheric emissions without creating any undue impact. A detailed assessment of the impacts of atmospheric emissions from the chosen stack height was then carried out. Three different scenarios were modelled, as described in Table 2.6 below:

Table 2.6 Scenarios Modelled

Scenario	Characteristics
Scenario 1	Emission concentrations (mg/Nm ³) based on maximum concentrations permitted. Emission rates (g/s) based on maximum capacity of Waste to Energy Plant (180,000 tonnes per annum)
Scenario 2	Emission concentrations (mg/Nm ³) based on typical emission concentrations emitted. Emission rates (g/s) based on nominal capacity of Waste to Energy Plant (150,000 tonnes per annum)
Scenario 3	Emission concentrations (mg/Nm ³) based on maximum emission concentrations emitted. Emission rates (g/s) based on 50% of maximum capacity of Waste to Energy Plant (90,000 tonnes per annum)

Scenario 1 would be considered the worst case scenario with the waste to energy plant operating at its maximum design capacity and worst case emission concentrations.

Scenario 2 would be considered a more realistic scenario, with the waste to energy plant operating at its nominal capacity and typical emission concentrations.

An additional scenario, Scenario 3, was modelled for NO_x, SO₂, particulates, HCl, HF and TOC, as recommended in the USEPA Guidelines on Air Quality Models.

Finally, the cumulative impact of emissions from the waste to energy plant and two other developments in the vicinity was assessed using the dispersion model. Scenario 1, the worst case scenario, was used for this cumulative air dispersion modelling.

Modelling of emissions from the back-up gas-fired generator was not carried out due to the infrequency of use of the generator.

A full copy of the Air Dispersion Modelling report is included in Attachment H1.2.

The US EPA-approved Industrial Source Complex (ISC 3) computer model, a Gaussian dispersion model, was used to carry out the dispersion modelling. This short term model (ISCST 3) uses hourly meteorological data and calculates a range of hourly, daily and annual average concentrations from which percentiles of hourly and daily concentrations can be calculated for comparison to all relevant ambient Air Quality Standards (AQS) limit values. AQS limit values are often expressed as percentiles which allow the specified ground level concentration (GLC) to be exceeded a set number of times in the monitoring period, e.g. the 99.8th percentile of a years hourly average values (this means that the AQS can only be exceeded for 0.2% of the time or 18 hours per year). The meteorological data required by the dispersion model is wind speed, wind direction, Pasquill-Gifford stability category, boundary layer height and ambient temperature. The most recent available five years (1993-1997) of meteorological data for Dublin Airport was used in the model. The model takes all known factors which influence dispersion of plumes into account, such as building downwash, stack tip downwash, terrain effects etc. The most significant of these is

building downwash whereby the turbulence created by buildings tends to increase the ground level concentrations experienced. The main buildings on the site were therefore incorporated into the Building Profile Input Program (BPIP) module of ISCST3.

Elevated terrain may increase the ground level concentrations by reducing the vertical dimension within which the plume can disperse. ISCST3 uses two algorithms to treat terrain based on the relative height variation between the sources' stack and surrounding terrain. Simple terrain is defined as terrain below stack height while complex terrain is defined as when the plume centreline height is below the terrain height. Intermediate terrain is defined as when terrain exceeds the height of release but is below the plume centreline height. In the model, for intermediate terrain, concentrations from both the simple terrain algorithm and the complex terrain algorithm are obtained and the higher of the two concentrations is used.

To calculate ground level concentrations, either rural or urban dispersion parameters must be specified for the model. US EPA guidelines were used to determine whether the area is urban or rural. According to these guidelines if the land use categories within a circle of 3 km radius comprise less than 50% of the following categories: heavy or medium industrial, commercial or multi family residential, the area should be classified as rural. It was found that this is the case at the proposed site and rural dispersion parameters were chosen.

Two nested receptor grids were used in the dispersion model, mapping at sufficient resolution to ensure all localised "hot spots" were identified. The first grid extended to 1,500 m based on a Cartesian grid with the site at the centre. Concentrations were calculated at 100 m intervals. The second grid extended to 5,000 m based on a Cartesian grid with the site at the centre. Concentrations were calculated at 1,000 m intervals. In addition, boundary receptor locations were placed along the boundary of the site, at 100 m intervals, giving a total of 1,100 calculation points for each model case.

In the comparison of predicted ground level concentrations with the appropriate Air Quality Standard (AQS), background concentrations for each substance have been included in the assessment. Background concentrations have been derived from a worst-case analysis of the cumulative sources in the region in the absence of the development. These have been derived from the baseline air quality assessment carried out at the site (See Attachment 4 of the EIS), modelling of traffic emissions and significant releases from nearby sites (i.e. the existing Platin Cement Works and the proposed Marathon power plant).

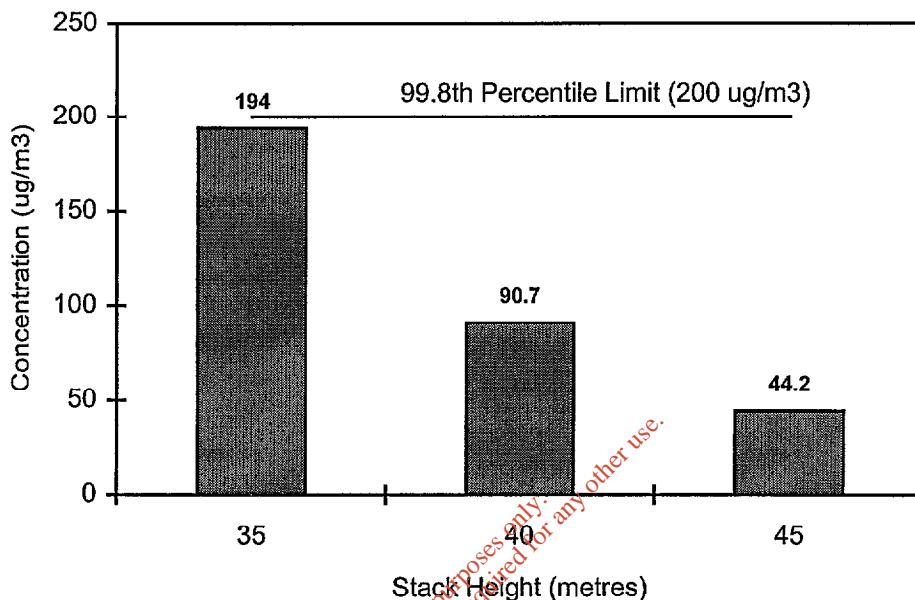
2.5 STACK HEIGHT DETERMINATION

Dispersion modelling was carried out for stack heights at 5m intervals from 35m to 45m. This screening model was based on Scenario 1 (i.e. max. plant capacity of 180,000 of tonnes per annum).

The highest concentration of any emission from the stack will be NO_x (modelled as NO₂) and therefore the stack height determination was carried out with respect to NO_x emissions. The maximum 99.8th percentile hourly average ground level NO₂ concentrations were calculated for the range of stack heights.

The results are shown in Figure 2.1 below. The new 99.8th percentile (not to be exceeded for more than 18 hours per annum) limit value as per EU Directive 99/30/EC is also indicated on Figure 2.1 for reference.

The maximum ground level concentration of NO₂ decreases steadily as the stack height increases. At forty metres the maximum ground level concentration is less than half of that for a 35m stack. It is also well below the 200 µg/m³ limit value. Although the concentrations arising from a 45m stack are lower again, the criteria for choosing a stack height are based on providing adequate emission dispersion without creating an



adverse visual impact, and therefore a 40m stack height was chosen for the waste to energy plant.

Figure 2.1 Maximum 99.8th Percentile Hourly Average Ground Level NO₂ Concentrations

2.6 POTENTIAL EFFECTS OF EMISSIONS VIA A 40M STACK

Atmospheric emissions can have adverse impacts on human health, if present at a sufficiently high concentration. This section outlines the principal effects on human health, both acute and chronic, that the emissions from the waste to energy plant can have. Exposure to the emissions could be as a result of:

- Direct inhalation
- Skin absorption (of little importance)
- Ingestion through water and food intake as a result of contamination of surface water, soil or crops

A large amount of research has been carried out on the potential health effects of exposure to high concentrations of emissions, most notably by the WHO. This research has enabled the Air Quality Standards listed in Attachment C1.1 to be

devised and set at a level to eliminate potential health effects. The following sections summarise the potential effects of all substances emitted from the plant, when present at high concentrations.

2.6.1 Air Dispersion Modelling Results

The maximum predicted Ground Level Concentrations (GLCs) of emissions for all scenarios along with the relevant air quality standards are presented in the sections below. Contour plots of the dispersion modelling results are included in the Air Dispersion Modelling Report (see Attachment H1.2).

2.6.2 Nitrogen Dioxide

Nitrogen dioxide can act as a respiratory irritant at elevated concentrations, and it has been noted that the incidence of asthma and bronchitis is increased by exposure to NO₂ at high concentrations.

The EU limit values and WHO guideline values for NO₂ have been set at levels which ensure that no such health effects would occur.

For Scenario 1, the maximum predicted ambient NO₂ concentration, including background concentrations, is 43% of the EU hourly limit value (measured as a 99.8th percentile) and is 45% of the EU annual limit. For Scenario 2, the maximum predicted ambient concentration, including background concentrations, is 33% of the EU hourly limit value and is 40% of the EU annual limit. For Scenario 3, the maximum predicted ambient concentration, including background concentrations, is 36% of the EU hourly limit value and is 43% of the EU annual limit. See Table 1.9 of the Air Dispersion Modelling Report in Attachment H1.2.

2.6.3 Sulphur Dioxide and Particulates

As with NO₂, sulphur dioxide (SO₂) can affect the respiratory system, primarily by causing the bronchi to constrict, and very high concentrations of SO₂ have been linked with increased hospital admissions.

Only fine suspended particulate matter (SPM) such as PM₁₀ (< 10µm, 1µm = 0.001 mm) or PM_{2.5} (< 2.5µm) can penetrate deeply into the lung and therefore the health effects of SPM in humans depends very much on particle size and concentration. As with NO₂ and SO₂, fine particulates can irritate the respiratory system.

The EU limit values and WHO guideline values for SO₂ and particulates have been set at levels which ensure that no such health effects would occur.

For Scenario 1, predicted maximum ambient SO₂ concentrations, including background concentrations, are 17% of the ambient 1 hour limit value (measured as a 99.7th percentile) and are 19% of the daily average limit value (measured as a 99.2th percentile). For Scenario 2, predicted SO₂ concentrations, including background concentrations, are 8% of the ambient 1 hour limit value and are 9% of the daily average limit value. For Scenario 3, predicted SO₂ concentrations, including background concentrations, are 14% of the ambient 1 hour limit value and are 15% of the daily average limit value. See Table 1.13 of the Air Dispersion Modelling Report.

Based on the conservative assumption that all particulate emissions from the plant will be in the form of PM₁₀, the predicted ambient concentrations for Scenario 1, including background concentrations, are 44% of the ambient 24 hour limit value (measured as a 90.5th percentile) and 51% of the annual average limit value. For Scenario 2, predicted concentrations, including background concentrations, are 40% of the ambient 24 hour limit value and are 50% of the annual average limit value. For Scenario 3, predicted concentrations, including background concentrations, are 43% of the ambient 24 hour limit value and are 51% of the annual average limit value. See Table 1.14 of the Air Dispersion Modelling Report.

2.6.4 Total Organic Carbon and Acid Gases

For Scenario 1, the maximum ambient hourly concentration of hydrocarbons (Total Organic Carbons or TOC), including background concentrations, is only 11% of the TA Luft Immission Standard of 1,000 µg/Nm³ (measured as a 98th percentile). For Scenario 2, the maximum ambient hourly average GLC of TOC, including background concentrations, is 10% of the above standard. For Scenario 3, the maximum ambient hourly average GLC of TOC, including background concentrations, is 11% of the above standard. See Table 1.17 of the Air Dispersion Modelling Report.

HCl and HF can also cause irritation of the respiratory system and can also cause irritation of the eyes, nose and throat.

For Scenario 1, the predicted ambient HCl concentration, including background concentrations, is 7% of the hourly TA Luft Immission Standard of 100 µg/Nm³ (measured as a 98th percentile). For Scenario 2, the maximum ambient hourly average HCl GLC, including background concentrations, is 1% of the above standard. For Scenario 3, the maximum ambient hourly average GLC of HCl, including background concentrations, is 6% of the above standard. See Table 1.18 of the Air Dispersion Modelling Report.

For Scenario 1, the predicted HF concentrations, including background concentrations, are 23% of the hourly TA Luft Immission Standard of 3 µg/Nm³ (measured as a 98th percentile) and 19% of the WHO annual average limit value. For Scenario 2, the predicted HF concentrations, including background concentrations, are 22% of the hourly limit value and 19% of the WHO annual average value respectively. For Scenario 3, the predicted HF concentrations, including background concentrations, are 19% of the hourly limit value and 17% of the WHO annual average value respectively. See Table 1.19 of the Air Dispersion Modelling Report.

2.6.5 Dioxins

Dioxins refer to a large group of structurally similar compounds which include both dioxins and furans. The polychlorinated-dibenzo-dioxins (PCDDs) include 75 individual compounds and the polychlorinated-dibenzo-furans (PCDFs) include 135 different compounds. These individual compounds are referred to as congeners. The most toxic of these compounds and also the most widely researched is 2,3,7,8-tetrachloro-dibenzo-dioxin (TCDD). The toxicity of the other congeners is assessed relative to TCDD which is used as a reference compound. Only 7 of the 75 congeners

of CDDs and only 10 of the 135 congeners of CDFs are thought to have dioxin like toxicity.

Very little of the toxicity data available for dioxins relates to exposure through inhalation and the majority of studies carried out have been for oral exposure in animals. These data indicate that TCDD is one of the most toxic compounds known and it produces a wide spectrum of toxic effects following both short-term and long-term exposure.

The most noted health effect in people exposed to large amounts of dioxin is chloracne, which is a skin disease with acne-like condition that occur mainly on the face and upper body. Other effects of exposure to large amounts of dioxin include skin rashes, skin discoloration, excessive body hair, and possibly mild liver damage. TCDD is a human carcinogen and long term exposure may result in a number of different cancers. Studies have also shown dioxins to have a number of other effects including dermal toxicity, immunotoxicity, endocrine disruption, reproductive effects and teratogenicity. Reproductive or developmental effects have not been seen in human studies however there is concern that exposure to low levels of dioxins over long periods might result in these effects including weakened immune responses and behaviour changes in offspring.

The proposed plant will meet EU legislation for the control of dioxin emissions. Namely a minimum combustion temperature of 850 °C for waste with a halogenated organic content (expressed as chlorine) of less than 1%, maintained for at least 2 seconds in the presence of at least 6% oxygen. These conditions for the combustion of waste will minimise the formation of dioxins. For the stack emissions the EU has set an emission discharge limit of 0.1 ng I-TEQ/m³, where 1 nanogramme (ng) is equal to 1/ 1,000,000,000 of a gramme. The I-TEQ or International Toxic Equivalent is a means of ranking the complex mixtures of dioxin compounds based on their relative toxicity.

In October 1999 the EU produced a summary report on the Compilation of EU Dioxin Exposure and Health Data. The report concluded that dioxin exposure is decreasing within the EU, and regulatory activity already applied to the stack emissions of waste incinerators, is now moving towards industrial processes, such as ferrous and non ferrous metal production processes and other sources.

As part of this work for the EU Commission, the German State Environment Agency of North Rhine-Westphalia produced an inventory of dioxin air emissions in 1997. This report was the outcome of a two year research programme which is currently being extended to include all dioxin emissions in addition to those to air. The report collected information for the 15 EU members and Norway and Switzerland for the reference period 1993 to 1995 and concluded that an annual PCDD/F air emission of 6,500 g I-TEQ/a is released by all known sources in the 17 countries considered.

With regard to emissions from incineration facilities the report concluded that these could be decreased to near zero level by burning the waste entirely in plants complying to the 0.1 ng I-TEQ/m³ limit.

For Europe as a whole the Commission now estimate that with the full implementation of the new directive in 2005 that the total emission from incineration plants will be less than 10 g/a or less than 1% of total European dioxin emissions.

A European dioxin inventory in 2000 demonstrates that 25 g I-TEQ dioxins was produced in Ireland and of this 22 g came from non-industrial sources primarily home heating and transport.

There are no Irish, European or World Health Organisation AQS limit values or deposition standards for dioxins or furans. However, for maximum operating conditions (Scenario 1), the predicted maximum annual average GLC of dioxins is 0.005 pg/m^3 , which accounts for less than 10% of the existing background dioxin/furan concentration of 0.028 pg/m^3 . As can be seen from the above, dioxins/furans emissions from the waste to energy plant will not lead to a perceptible increase over background levels and will thus not any impact on human health or the environment. See Table 1.28 of the Air Dispersion Modelling Report.

2.6.6 Mercury

Exposure to high concentrations of mercury vapour can damage the nervous system, and also the oral mucosa and the kidneys. The WHO has set a guideline value of $1 \text{ } \mu\text{g/m}^3$ as an annual average for mercury. For Scenario 1, the predicted GLC from the plant is only 7% of this guideline value. For Scenario 2, the predicted GLC is only 6% of the guideline value. See Table 1.38 of the Air Dispersion Modelling Report.

2.6.7 Heavy Metals (excluding Mercury)

The waste to energy plant will not produce heavy metals but may emit heavy metals if present in the waste stream. Notwithstanding this, modelling was carried out based on the assumption that heavy metals are continuously emitted at the EU emission limit value.

The predicted GLCs are significantly lower than the AQS limit values for all heavy metals for Scenarios 1 and 2. Furthermore, unless particular wastes (containing individual heavy metals) are present in the waste stream, individual heavy metals will rarely be emitted at significant concentrations.

Exposure to high levels of cadmium primarily affects the kidneys. The International Agency for Research on Cancer (IARC) has classified cadmium as a Group 2B carcinogen on the basis that there was sufficient evidence of it being carcinogenic in animals and there is limited evidence of cadmium being a human carcinogen. Acute exposure to thallium can cause gastrointestinal effects (abdominal pain, vomiting, diarrhoea). An EU working group has proposed emission standards for nickel, cadmium and arsenic (see Table 1.46 of air dispersion modelling report in Attachment H1.2). This group has set a guideline value of $0.005 \text{ } \mu\text{g/m}^3$ as an annual average limit for cadmium. For Scenario 1, the maximum predicted cadmium GLC (assuming that cadmium and thallium emissions are 100% cadmium) is only 24% of this guideline limit value. Background concentrations have been excluded. See Table 1.46 of the Air Dispersion Modelling Report.

Acute exposure to antimony can cause abdominal pain, vomiting and weakness. Antimony is not a proven human carcinogen but inhalation of high levels has been shown to cause lung cancer in animal studies.

The toxicity of lead may be attributed to its interference with different enzyme systems. Because of this almost all organs may be considered potential targets for

lead and a wide range of biological effects of lead have been documented. Exposure to high levels is linked to cognitive dysfunctions in children such as IQ deficit, impairment of eye-hand co-ordination and attention details. According to IARC evidence of carcinogenicity of lead and lead compounds in humans is inadequate.

Acute exposure to certain chromium compounds causes irritation of the eyes, respiratory system (breathing difficulties) and skin as well as liver and kidney damage. Certain chromium compounds are thought to be human carcinogens.

Acute exposure to cobalt can irritate the respiratory system and skin.

Exposure to copper dusts can irritate the eyes, nose and mouth and may cause headaches, dizziness, nausea and diarrhoea.

Exposure to manganese can result in effects on the lungs (leading to coughing and breathing difficulties) and effects on the nervous system.

Exposure to vanadium can result in irritation of the respiratory system, mucous membranes, eyes and skin.

For Scenario 1, the maximum hourly ambient concentration, including background concentrations, is 16% of the antimony Environmental Assessment Level (EAL) limit value, which is the most stringent limit value for this averaging period. The maximum annual average ambient concentration, including background concentrations, is 23% of the manganese Environmental Assessment Level (EAL) limit value, which is the most stringent limit value for this averaging period.

For Scenario 2, the maximum hourly ambient concentration, including background concentrations, is 9% of the relevant limit value, while the maximum annual average ambient concentration, including background concentrations, is 16% of the relevant limit value. See Table 1.49 of the Air Dispersion Modelling Report.

Arsenic is a cellular and tissue poison. Acute exposure to arsenic can result in irritation of the respiratory system and skin, gastrointestinal effects (nausea, vomiting, abdominal pain, diarrhoea) and circulatory effects. Arsenic is also classified as a human carcinogen. As stated above, an EU working group has proposed emission standards for nickel, cadmium and arsenic. This group has set a guideline value of $0.004 \mu\text{g}/\text{m}^3$ as an annual average limit for arsenic. For Scenario 1, the maximum predicted GLC of $0.0008 \mu\text{g}/\text{m}^3$ is 20% of this guideline limit value. See Table 1.53 of the Air Dispersion Modelling Report.

Exposure to nickel can cause skin irritation and dermatitis (due to sensitisation), and skin ulcers. Nickel and certain nickel compounds are probable human carcinogens of the lung and nasal passages. The EU group referred to above has set a guideline value of $0.01 \mu\text{g}/\text{m}^3$ as an annual average limit for nickel. For Scenario 1, the maximum predicted GLC is only 8% of this guideline limit value. See Table 1.53 of the Air Dispersion Modelling Report.

2.6.8 Dioxin Inhalation Modelling Results

An assessment has been undertaken to determine the potential dioxin/furan intake through inhalation due to the operation of the waste to energy plant. This assessment expresses the intake of dioxins by inhalation in terms of drinking additional glasses of milk.

The potential inhaled dioxin/furan dose for a theoretical individual living continuously (i.e. 24 hours a day, 365 days a year) at the point where ambient ground level dioxin/furan concentrations are predicted to be highest when the proposed waste to energy plant is operational, was determined. The assessment is based on the waste to energy plant operating at the maximum dioxin/furan emission limit of 0.1ng/m^3 I-TEQ as per the waste incineration directive 2000/76/EC. Indaver will operate a two stage dioxin removal process as part of the combustion gas cleaning process and typical dioxin emissions are expected to be well below this maximum limit.

The dioxin/furan intake by inhalation was then expressed in terms of unit volumes of milk produced in the Meath and Dublin area. The emissions from the proposed waste to energy plant are predicted to increase the inhaled daily dioxin/furan dose to the theoretical individual by the equivalent of an additional 0.38 – 0.43 glasses per month (4.6 – 5.3 glasses per year) of milk produced within the Meath/Dublin area, assuming a glass volume of 300 ml.

A copy of the full report is included in Attachment H1.3.

2.7 ASSESSMENT OF CUMULATIVE IMPACTS

As the region around Carranstown is partly industrialised and this has several other potentially significant sources of air emissions (the existing Platin Cement factory and the proposed Marathon Combined Cycle Gas Turbine power plant), a detailed cumulative assessment has been carried out using the methodology outlined by the USEPA.

In order to assess the potential for a cumulative impact, air dispersion modelling was carried out based on the emission data contained in the Platin Cement IPC Application and the Marathon Power Project EIS.

As the emissions of particulates from the proposed Marathon power plant are insignificant and the predicted particulate GLCs from the waste to energy plant are at most 2% of the AQSs, cumulative particulate emissions were not modelled as recommended by the USEPA guidelines. Therefore air dispersion modelling was carried out to assess the cumulative impact of the three developments on ground level concentrations of NO_2 and SO_2 .

Contours plots of the GLCs are included in the Air Dispersion Modelling report.

The cumulative impact modelling results are based on the Marathon power plant running on distillate oil (rather than natural gas) which results in much higher emissions of NO_2 and SO_2 . According to the Marathon EIS, distillate oil will be only be used as a short term backup fuel in case of an interruption in the natural gas supply.

During normal operation on natural gas much lower levels of NO₂ and SO₂ will be emitted and consequently any cumulative impact will be greatly reduced.

The cumulative modelling is based on the worst case discharge conditions occurring at the three plants at the same time and also at the same time as the worst case meteorological conditions. The maximum predicted GLCs are therefore based on a worst case scenario which is unlikely to arise and the modelling is therefore very conservative.

The results demonstrate that the predicted maximum GLCs of NO₂ and SO₂ of emissions from the proposed waste to energy plant, Platin cement factory and the proposed Marathon power plant are below all Air Quality Standard limit values or guidelines, as can be seen in the sections below.

2.7.1 Nitrogen Dioxide

In the area of the maximum impact of each nearby source, the impact from Indaver Ireland was very small. In relation to the 99.8th percentile of maximum one-hour concentrations, the impact of Indaver Ireland at the point of maximum impact of each nearby source was always less than 12% of the limit value.

The annual average cumulative assessment was likewise minor at the area of the maximum impact of each individual source. The overall impact leads to an increase of 3% in the annual average level of the worst-case nearby source. See Table A1.8 of Appendix 1.3 of the Air Dispersion Modelling Report.

2.7.2 Sulphur Dioxide

In the area of the maximum impact of each nearby source, the impact from Indaver Ireland was very small. In relation to the 99.7th percentile of maximum one-hour concentrations, the impact of Indaver Ireland at the point of maximum impact of each nearby source was always less than 5% of the limit value. In the region where all sources combine to cause the maximum impact, an examination of the impact of Indaver Ireland reveals no significant impact at all. See Table A1.8 of Appendix 1.3 of the Air Dispersion Modelling Report.

In summary, the cumulative atmospheric emissions of NO₂ and SO₂ from the waste to energy plant, Platin cement factory and Marathon power plant will not cause ground level concentrations to exceed the relevant Air Quality Standard limit values or guidelines.

2.8 OPERATIONAL MITIGATION MEASURES

A number of measures have been incorporated into the design of the waste to energy plant to ensure that emissions from the plant do not exceed regulatory emission limit values and the impact on human health or the environment would be insignificant. These are summarised as follows.

Emissions of nitrogen oxides (NO_x) will be minimised by optimising combustion conditions in the furnace to minimise the formation of NO_x and using a DeNO_x urea injection system to reduce NO_x to nitrogen and water vapour. Two wet scrubbers using a lime (or limestone) based neutralisation agent will be used in sequence to

remove acidic compounds (HCl and HF), sulphur dioxide (SO₂) and traces of heavy metals. A small amount of activated carbon will be injected into the flue gases leaving the evaporating spray tower, which will react with and adsorb trace levels of organic compounds and heavy metals. These carbon granules as well as other dust and particulates in the flue gases will be removed the baghouse filters. The plant will remove dioxins and furans from the flue gases using a two-stage process. The first stage involves the injection of activated carbon/ lime mixture into the flue gases as previously mentioned which will adsorb dioxins and furans. The second stage will involve passing the flue gases from the wet scrubbers through a lignite coke filter or second activated carbon/lime mixture injection and baghouse filter which will remove dioxins and furans as well as other hydrocarbons, acids and heavy metals. These design measures will ensure that emissions do not exceed regulatory emission limit values.

There is a second option for the wet scrubbing treatment process which would involve removing the first scrubbing tower and instead adding the lime/limestone solution into the evaporating spray tower.

Continuous monitoring of dust, Total Organic Carbon (TOC), Hydrochloric acid (HCl), Sulphur dioxide (SO₂), Nitrogen oxides (NO_x), Oxygen (O₂), Carbon monoxide (CO), temperature and water content will be carried out at different stages throughout the waste to energy plant. Fixed installed emissions monitoring equipment will be provided at the stack for continuous monitoring of the above emissions.

Continuous sampling of dioxins will also be carried out at the stack. The AMESA dioxin/furan monitoring system, or equivalent, will be installed, which is used for measuring dioxins/furans in other plants that comply with the German Environmental Regulation 17Blm SchV and TA Luft. Further details on the AMESA dioxin/furan monitoring system are included in Attachment J1.2.

3. CONCLUSIONS

The only emissions from the proposed facility that has the potential to affect air quality are the flue gases discharged via the 40m stack.

The existing air quality in the area is good as would be expected of the rural area in which the site is located. Emissions from the waste to energy plant, at sufficiently high concentrations, could have a number of adverse impacts on human health and the environment. The concentrations of these emissions from the proposed waste to energy plant will be well below regulatory limit values. Air dispersion modelling has shown that the ground level concentrations of these emissions will be well below Air Quality Standard limit values, which are designed for the protection of human health and the environment as a result of atmospheric emissions from the waste to energy plant.

Dispersion modelling has also shown that there will be no adverse cumulative impact on air quality as a result of atmospheric emissions from the waste to energy plant or other developments in the vicinity. A number of design and mitigation measures will be put in place to minimise the impacts that the construction and operational phases of the development have on air quality and therefore the waste to energy plant is not predicted to have any significant adverse impacts on air quality.

Attachment H1.2

**Air Dispersion Modelling Report for EPA
Waste Licence Application, AWN Consulting
Ltd, November 2001**

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1 Air Quality Study

Executive Summary

Air dispersion modelling was carried out using the United States Environmental Protection Agency's (USEPA) regulatory model ISCST3. The aim of the study was to assess the impact of typical emissions and at the emission limits outlined in Council Directive 2000/76/EC, in the ambient environment. The study demonstrates that all substances which will be emitted from Indaver Ireland will be at levels that are well below even the most stringent ambient air quality standards and guidelines. The dispersion model study consisted of the following components:

- Review of design emission levels and other relevant information needed for the modelling study;
- Identification of the significant substances which are released from the site;
- Review of background ambient air quality in the vicinity of the plant;
- Air dispersion modelling of significant substance concentrations released from the site;
- Deposition modelling of dioxin and heavy metals released from the site;
- Identification of predicted ground level concentrations of released substances beyond the site boundary and at sensitive receptors in the immediate environment;
- A full cumulative assessment of significant releases from the site taking into account the releases from all other significant industry in the area based on the USEPA's Prevention of Significant Deterioration (PSD) approach;
- Evaluation of the significance of these predicted concentrations, including consideration of whether these ground level concentrations are likely to exceed the most stringent ambient air quality standards and guidelines.

Modelling and a subsequent impact assessment was undertaken for the following substances released from the site:

- Nitrogen dioxide (NO₂)
- Sulphur Dioxide (SO₂)
- Total Dust (as PM₁₀)
- Gaseous and vaporous organic substances expressed as total organic carbon (TOC)
- Hydrogen Chloride (HCl)
- Hydrogen Fluoride (HF)
- PCDD/PCDFs (Dioxins)
- Mercury (Hg)
- Cadmium (Cd) and Thallium (Tl)
- Sum of Antimony (Sb), Arsenic (As), Lead (Pb), Chromium (Cr), Cobalt (Co), Copper (Cu), Manganese (Mn), Nickel (Ni) and Vanadium (V).

Assessment Approach

Emissions from the site have been assessed under firstly typical operations and secondly under maximum operating conditions. Maximum operations are based on those outlined in EU Directive 2000/76/EC. Predicted ambient air concentrations have also been identified at the most sensitive residential receptors and in Carranstown and the surrounding geographical area as far away as Duleek, Drogheda and Newgrange.

Modelling Under Typical & Maximum Operations

In order to assess the possible impact from Indaver Ireland under typical and maximum operations, a conservative approach was adopted, that is designed to over-predict ground level concentrations. This cautious approach will ensure that an over-estimation of impacts will occur and that the resultant emission standards adopted are protective of ambient air quality. The approach incorporated several conservative assumptions regarding operation conditions at Indaver Ireland. This approach incorporated the following features:

- For the maximum operating scenario, it has been assumed that the emission point is continuously operating at its maximum operating volume flow. This will over-estimate the actual mass emissions from the site.
- For both scenarios, it has been assumed that the emission point is operating for 24-hrs/day over the course of the full year.
- Typical emissions are the expected annual average expected emissions from the plant when operating at 100% of its design capacity.
- Worst-case meteorological conditions have been used in all assessments. The worst-case year leads to annual average concentrations which are 30% higher than the five-year average. The year of meteorological data for the years between 1993 and 1997 that gave rise to the highest predicted ground level concentrations of nitrogen dioxide has been reported in this study (Year 1994).
- A comparison with more advanced modelling formulations (AERMOD and AERMOD-PRIME) has indicated that the current model (ISCST3) is conservative and particularly so for long-term averaging periods.

As a result of these conservative assumptions, there will be an over-estimation of the emissions from the site and the impact of Indaver Ireland in the surrounding environment.

Modelled Locations

In relation to the spatial assessment of emissions from the site, modelling has been carried out to cover locations at the boundary of the site and beyond, regardless of whether any sensitive receptors are located in the area. Ambient air quality legislation designed to protect human health is generally based on assessing ambient air quality at locations where the exposure of the population is significant relevant to the averaging time of the pollutant. However, in the current assessment, ambient legislation has been applied to all locations regardless of whether any sensitive receptors (such as residential locations) are present for significant periods of time. Thus, again, this represents a worst-case approach, an examination of the corresponding concentrations at the nearest sensitive receptors relative to the actual quoted maximum concentration indicates that these receptors generally experience ambient concentrations significantly lower than that reported for the maximum value.

Baseline Air Quality Review

An extensive baseline survey was carried out in the region of the site between June and October 2000 (see Section 4 – Air Quality of the main body of the EIS). The survey focussed on the significant pollutants likely to be emitted from the source and which have been regulated in Council Directive 2000/76/EC.

NO₂ concentrations measured over the monitoring period were significantly less than the EU limit value. Smoke concentrations measured over the period averaged 4 µg/m³, which is significantly lower than the PM₁₀ annual limit value of 40 µg/m³. Similarly, levels of SO₂, HF and HCl were all significantly below the respective limit values.

Background levels of PCDD/PCDFs cannot be compared to ambient air quality concentration or deposition standards. However, levels of dioxins and furans can be compared to existing levels measured sporadically in Ireland and continuously in the UK as part of the TOMPS network. Existing levels in Carranstown are typical of the range of values encountered in rural locations in the UK and Continental Europe and significantly lower than urban locations in the UK and Europe.

Average concentrations of cobalt, cadmium, nickel, chromium, copper, mercury, lead, vanadium, antimony, and thallium measured were significantly below their respective annual limit values. Arsenic was below the detection limit for each of the four weeks in the monitoring period. However, the monitoring methodology's detection limits could not achieve the stringent limits of the proposed ambient standard for As. However, no significant local sources of this compound could be identified and thus, it may be expected that background levels of this compound is likely to be minor.

Study Conclusions

The main study conclusions are presented below for each substance in turn:

NO₂

NO₂ modelling results indicate that the ambient ground level concentrations are below the relevant air quality standards for nitrogen dioxide under both typical and maximum operation of the site. Thus, no adverse environmental impact is envisaged to occur under these conditions at or beyond the site boundary. Emissions at maximum operations equate to ambient NO₂ concentrations (including background concentrations) which are 43% of the maximum ambient 1-hour limit value (measured as a 99.8th percentile) at the worst-case boundary receptor.

SO₂ & PM₁₀

Modelling results indicate that the ambient ground level concentrations are below the relevant air quality standards for sulphur dioxide and PM₁₀ under both typical and maximum operation of the site. Thus, no adverse environmental impact is envisaged to occur under these conditions at or beyond the site boundary. Emissions at maximum operations equate to ambient concentrations (including background concentrations) ranging from 17% - 51% of the respective limit values at the worst-case receptors.

TOC, HCl & HF

Modelling results indicate that the ambient ground level concentrations are below the relevant air quality guidelines for TOC and HCl under both typical and maximum operation of the site. Thus, no adverse environmental impact is envisaged to occur under these conditions at or beyond the site boundary. Emissions at maximum operations equate to ambient concentrations (including background concentrations) for HCl and TOC of only 7% and 11% respectively of the maximum ambient 1-hour limit value (measured as a 98th percentile).

HF modelling results indicate that emissions at maximum operations equate to ambient HF concentrations (including background concentrations) which are 23% of the maximum ambient 1-hour limit value (measured as a 98thile) and 19% of the annual limit value.

PCDD / PCDFs

Currently, no internationally recognised ambient air quality concentration or deposition standards exist for PCDD/PCDFs. Both the USEPA and WHO recommended approach to assessing the risk to human health from PCDD/PCDFs entails a detailed risk assessment analysis involving the determination of the impact of PCDD/PCDFs in terms of the TDI (Tolerable Daily Intake) approach. The WHO currently proposes a maximum TDI of between 1-4 pgTEQ/kg of body weight per day.

Background levels of PCDD/PCDFs occur everywhere and existing levels in the surrounding area have been extensively monitored as part of this study. Modelling results indicate that the existing levels are significantly lower than urban areas and typical of rural areas in the UK and Continental Europe. The contribution from the site in this context is minor, with levels under maximum operation remaining significantly below levels which would be expected in urban areas at the worst-case boundary receptor to the south of the site. Levels at the nearest residential receptor will be minor, with the annual contribution from Indaver Ireland accounting for less than 10% of the existing background concentration under maximum operating conditions.

Hg

Hg modelling results indicate that the ambient ground level concentrations are below the relevant air quality standards under both typical and maximum operation of the site. Thus, no adverse environmental impact is envisaged to occur under these conditions at or beyond the site boundary. Emissions at maximum operations equate to ambient mercury concentrations (excluding background concentrations) which are only 2% of the annual average limit value at the worst-case receptor.

Cd and Tl

Modelling results indicate that the ambient ground level concentrations will be below the relevant air quality standards for cadmium under expected maximum levels (based on data from a similar site in Belgium) from the site. Emissions at expected maximum levels equate to ambient Cd concentrations (excluding background concentrations) which are 24% of the suggested annual limit value close to the site boundary. In addition, levels from Indaver Ireland are below the respective PSD increment (less than 25% of the ambient limit value).

Sum of Sb, Pb, Cr, Co, Cu, Mn and V

Modelling results indicate that the ambient ground level concentrations are below the relevant air quality standards for manganese and antimony (the metals with the most stringent limit values) under both typical and maximum emissions from the site. Thus, no adverse environmental impact is envisaged to occur under these conditions at or beyond the site boundary. Emissions at maximum operations equate to ambient Mn concentrations (excluding background concentrations) which are only 23% of the annual limit value at the worst-case boundary receptor whilst emissions at maximum operations equate to ambient Sb concentrations (excluding background concentrations) which are only 16% of the maximum 1-hour limit value at the worst-case boundary receptor.

As

Modelling results indicate that the ambient ground level concentrations will be below the relevant air quality standards for arsenic under expected maximum levels (based on data from a similar site in Belgium) from the site. Thus, no adverse environmental impact is envisaged to occur under these conditions at or beyond the site boundary. Emissions at expected maximum levels equate to ambient As concentrations (excluding background concentrations) which are 20% of the suggested annual EU limit value at the site boundary. Background concentrations of As were monitored over a one-month period. However, the monitoring methodology's detection limits could not achieve the stringent limits of the proposed ambient standard for As. However, no significant local sources of this compound could be identified in a detailed cumulative assessment of nearby sources. Thus, it may be expected that background levels of this compound are likely to be minor.

Ni

Modelling results indicate that the ambient ground level concentrations (excluding background concentrations) will be below the relevant air quality standards for nickel at the expected maximum levels from the site. Emissions at these levels (based on data from a similar site in Belgium) equate to ambient Ni concentrations (excluding background concentrations) which are 8% of the suggested annual EU limit value at the site boundary. In addition, levels from Indaver Ireland are below the respective PSD increment (less than 25% of the ambient limit value).

Summary

Modelling results indicate that the ambient ground level concentrations are below the relevant air quality standards or guidelines for all compounds under both typical and maximum operations of the site. The modelling results indicate that this maximum occurs at or near the site's northern boundary. Maximum operations are based on the emission concentrations outlined in EU Directive 2000/76/EC.

An appropriate stack height has been determined based on ensuring that ambient air quality standards will not be approached even under worst-case operating scenarios. The stack height determined by air dispersion modelling which will lead to adequate dispersion was 40 metres.

Concentrations fall off rapidly away from this maximum and the short-term limit values at the nearest residential receptor will be less than 30% of the worst-case concentration. The annual average concentration has an even more dramatic decrease in maximum concentration away from the site with concentrations from emissions at Indaver Ireland accounting for less than 6% of the limit value (not including background concentrations) at worst case sensitive receptors near the site. Thus, the results indicate that the impact from Indaver Ireland is minor and limited to the immediate environs of the site.

In the surrounding main population centres, Duleek and Drogheda, levels are significantly lower than background sources with the concentrations from emissions at Indaver Ireland accounting for less than 1% of the annual limit values for all pollutants.

1.1 Introduction

Indaver Ireland commissioned an extensive and detailed examination of air emissions from the proposed waste management facility in Carranstown, Co. Meath. As described in detail elsewhere, the waste management facility will be based on conventional grate incineration technology. The waste is tipped into a bunker prior to being fed into the furnace. In the furnace the waste is incinerated, producing heat, ash and combustion gases.

The combustion of waste produces a number of emissions, the discharges of which is regulated by the EU Directive on Waste Incineration (2000/76/EC). The emissions to atmosphere which have been regulated are:

- Nitrogen Dioxide (NO₂)
- Sulphur Dioxide (SO₂)
- Total Dust
- Carbon Monoxide (CO)
- Total Organic Carbon (TOC)
- Hydrogen Fluoride (HF) and Hydrogen Chloride (HCl)
- Dioxins/Furans (PCDD/PCDFs)
- Cadmium (Cd) & Thallium (Tl)
- Mercury (Hg)
- and the sum of Antimony (Sb), Arsenic (As), Lead (Pb), Chromium (Cr), Cobalt (Co), Copper (Cu), Manganese (Mn), Nickel (Ni) and Vanadium (V).

This scope of the study consists of the following components:

- Review of both maximum and typical emission levels and other relevant information needed for the modelling study;
- Identification of the significant substances which are released from the site;
- Review of background ambient air quality in the vicinity of the plant;
- Air dispersion modelling of significant substances concentrations released from the site;
- Air dispersion and deposition modelling of dioxin and heavy metals released from the site;
- Identification of predicted ground level concentrations of released substances at the site boundary and at sensitive receptors in the immediate environment;
- A full cumulative assessment of significant releases from the site taking into account the releases from all other significant industry in the area based on the Prevention of Significant Deterioration (PSD) approach.
- Evaluation of the significance of these predicted concentrations, including consideration of whether these ground level concentrations are likely to exceed the most stringent ambient air quality standards and guidelines.

1.2 Study Methodology

1.2.1 Introduction

The air dispersion modelling input data consists of detailed information on the physical environment (including building dimensions and terrain features), design details from all emission points on-site and a full year of worst-case meteorological data. Using this input data, the model predicts ambient ground level concentrations beyond the site boundary for each hour of the modelled meteorological year. The model post-processes the data to identify the location and

maximum of the worst-case ground level concentration in the applicable format for comparison with the relevant limit values. This worst-case concentration is then added to the existing background concentration to give the worst-case predicted ambient concentration. The worst-case ambient concentration is then compared with the relevant ambient air quality standard to assess the significance of the releases from the site.

Throughout this study a worst-case approach was taken. This will most likely lead to an over-estimation of the levels that will arise in practice. The worst-case assumptions are outlined below:

- Emissions from all emission points in the cumulative assessment were assumed to be operating at their maximum emission level, 24 hours/day over the course of a full year.
- All emission points were assumed to be operating at their maximum volume flow, 24 hours/day over the course of a full year.
- Maximum predicted ambient concentrations were reported in this study even though, in most case, no residential receptors were near the location of this maximum.
- Worst-case background concentrations were used to assess the baseline levels of substances released from the site
- Worst-case meteorological conditions have been used in all assessments. The worst-case year leads to annual concentrations, which are 30% higher than the five-year average.
- A comparison with more advanced modelling formulations (AERMOD and AERMOD-PRIME) has indicated that the current model (ISCST3) is conservative and particularly so for long-term averaging periods.

1.2.2 Meteorological Considerations

Meteorological data is an important input into the air dispersion model. The local airflow pattern will be greatly influenced by the geographical location. Important features will be the location of hills and valleys or land-water-air interfaces and whether the site is located in simple or complex terrain.

The selection of the appropriate meteorological data has followed the guidance issued by the USEPA⁽¹⁾. A primary requirement is that the data used should have a data capture of greater than 90% for all parameters. Two meteorological stations were identified near the site – Casement Aerodrome and Dublin Airport. Data collection of greater than 90% for all parameters is required for air dispersion model. Both Casement Aerodrome and Dublin Airport fulfil this requirement.

The additional requirements of the selection process depend on the representativeness of the data. The representativeness can be defined as “the extent to which a set of measurements taken in a space-time domain reflects the actual conditions in the same or different space-time domain taken on a scale appropriate for a specific application”⁽²⁾. The meteorological data should be representative of conditions affecting the transport and dispersion of pollutants in the area of interest as determined by the location of the sources and receptors being modelled.

The representativeness of the data is dependent on⁽¹⁾:

- 1) the proximity of the meteorological monitoring site to the area under consideration

- 2) the complexity of the terrain
- 3) the exposure of the meteorological monitoring site (surface characteristics around the meteorological site should be similar to the surface characteristics within the modelling domain)
- 4) the period of time during which data is collected

In the region of the site, Dublin Airport is the nearest suitable meteorological station to the site and thus the weather pattern experienced would be expected to be similar to the current site. On account of the modest terrain features to the north of the site, some channelling of wind may be expected to occur along the direction of the Boyne Valley. However, this would not be expected to be significant at stack height due to the modest nature of this terrain feature.

The windrose from Dublin Airport for the years 1993-97 is shown in Figure 1.1. The windrose indicates the prevailing wind speed and direction over the five-year period. The prevailing wind direction is generally from the W-SW direction. In the worst-case year of 1994, wind speeds were generally moderately strong, averaging around 5-6 m/s.

1.2.3 Modelling Methodology

Emissions from the Indaver Ireland site have been modelled using the ISCST3 dispersion model which has been developed by the U.S. Environmental Protection Agency (USEPA)⁽³⁾. The model is a steady-state Gaussian plume model used to assess pollutant concentrations associated with industrial sources. The model has been designated the regulatory model by the USEPA for modelling emissions from industrial sources in both flat and rolling terrain⁽¹⁾. An overview of the model is outlined in Appendix 1.1.

As part of an on-going program to improve the theoretical basis and accuracy of air dispersion models, the USEPA has recently reassessed the regulatory status of ISCST3. At the recently convened 7th Conference on Air Dispersion Modelling (2000)⁽⁴⁾, a new modelling formulation was suggested as a replacement for ISCST3 – AERMOD. This model has more advanced algorithms and gives better agreement with monitoring data in extensive validation studies⁽⁵⁻⁶⁾. Although AERMOD is a new generation model, the building downwash algorithm is similar to ISCST3. In recognition of this shortcoming, the USEPA are currently reviewing the possibility of incorporating a more advanced building downwash algorithm (PRIME Module) into the AERMOD modelling platform⁽⁷⁻⁹⁾. Thus, the current status of this model is still under review and it has not been granted regulatory approval at the current time.

In order to ensure that the current assessment is protective of air quality into the future and does not under-estimate air concentrations in the current application, a comparison of emissions from Indaver Ireland has been made with AERMOD and AERMOD-PRIME (Appendix 1.1). Results have indicated that the current model (ISCST3) is conservative and particularly so for short-term averaging periods. Thus, modelling results reported here should be viewed as upper limits.

1.2.4 Assessment Methodology

Council Directive 2000/76/EC

The assessment methodology used in the current study was developed following the recommendations outlined in the recently enacted Council Directive 2000/76/EC on the Incineration of Waste.

The Directive has outlined air emission limit values, which are to be complied with as set out in Table 1.1. The Directive has also outlined stringent operating conditions in order to ensure sufficient combustion of waste thus ensuring that dioxin formation is minimised. Specifically, the combustion gases must be maintained at a temperature of 850°C for at least two seconds under normal operating conditions for non-hazardous waste whilst for hazardous waste containing more than 1% halogenated organic substances, the temperature should be raised to 1100°C for at least two seconds. These measures will ensure that dioxins, PCBs and PAHs are minimised through complete combustion of waste.

Specific emission measurement requirements have been outlined in the directive for each pollutant:

- 1) continuous measurements of the following substances; NO_x, CO, total dust, TOC, HCl, and SO₂.
- 2) bi-annual measurements of heavy metals, dioxins and furans.

Indaver Ireland are committed, as a minimum, to meeting all the requirements of Council Directive 2000/76/EC. Indeed, due to the advanced post-combustion flue gas cleaning technology employed, expected average emission values will be significantly lower than these values. The maximum and typical emission concentrations and mass emission rates have been detailed in Table 1.2.

Very low levels of dioxin will be emitted under typical operating conditions from the incineration process. Typical emissions will be well below the stringent limit value set out in Council Directive 2000/76/EC. This rigorous limit value will be achieved through a targeted removal system over several stages of the flue gas cleaning system. Prior to abatement, the formation of dioxins will be minimised by the maintenance of high combustion temperatures (over 850°C at all times) for a period of two seconds followed by rapid cooling of gases from 400°C to 200°C which is the critical temperature range for dioxins formation in combustion systems. Post-combustion, dioxins will be removed via a two-stage removal process. The first stage involves the injection of activated carbon into the combustion gas duct, directly after the evaporator coolers. The large surface area of the activated carbon helps to adsorb dioxins, furans, hydrocarbons and heavy metals. In the second stage, the exhaust gas from the wet scrubbers undergoes a final gas-cleaning step in an activated wet lignite coke bed or by the injection of activated carbon and by removal in the baghouse filter. The combined efficiency of these filters will ensure that emission concentrations will be less than the EU Council Directive 2000/76/EC. In order to confirm this efficiency target, a continuous dioxin sampler will be employed to determine average fortnightly concentrations, thus allowing an accurate comparison with the emission limit values.

USEPA Guidelines On Air Quality Models

In the absence of detailed guidance, the selection of appropriate modelling methodology has followed the guidance from the USEPA which has issued detailed and comprehensive guidance on the selection and use of air quality models^(1,3,10-11).

Based on guidance from the USEPA, the most appropriate regulatory model for the current application is the ISCST3 model (Version 3.4). The model is applicable in both flat and rolling terrain, urban or rural locations and for all averaging periods^(1,3).

ISCST3 uses two algorithms to treat terrain based on the relative height variation between the source's stacks and surrounding terrain. In simple terrain, which is defined in ISCST3 as terrain below stack height, the ISCST3 simple terrain algorithm is used to model concentrations. In complex terrain, which is defined as when the plume centreline height is below the terrain height for that modelled hour, the COMPLEX1 complex terrain screening algorithm is used to model concentrations. In areas of intermediate terrain, which occur with terrain that exceeds the height of the release but is below the plume centreline height, concentrations from both the simple terrain algorithm and the complex terrain algorithm are obtained and the higher of the two concentrations is used for that hour and that source. For deposition calculations, the intermediate terrain analysis is first applied to the concentrations at a given receptor, and the algorithm (simple or complex) that gives the highest concentration at that receptor is used to calculate the deposition value.

The selection of urban/rural classification is based on the land use procedure of Auer⁽¹²⁾ as recommended by the USEPA⁽¹⁾. If 50% of the land use within a 3km circumference of the source is classified as high density residential, medium to heavy industry or commercial, urban dispersion coefficients should be used; otherwise rural dispersion coefficients should be used. An examination of the land-use type around the site indicated that rural dispersion coefficients were appropriate.

The USEPA has outlined guidance in order to establish the operating conditions that causes the maximum ground level concentration. The guidance indicates that a range of operating conditions should be assessed in the initial screening analysis. Table 1.3 outlines the recommended range of operating conditions to be assessed and which was adopted in the current assessment.

Cumulative Assessment

As the region around Carranstown is partly industrialised and thus has several other potentially significant sources of pollutants, a detailed cumulative assessment has been carried out using the methodology outlined by the USEPA. Table 1.4 outlines the recommended range of operating conditions to be assessed in the cumulative assessment.

The impact of nearby sources should be examined where interactions between the plume of the point source under consideration and those of nearby sources can occur. These include:

- 1) the area of maximum impact of the point source,
- 2) the area of maximum impact of nearby sources,
- 3) the area where all sources combine to cause maximum impact⁽¹⁾.

Background concentrations for the area, based on natural, minor and distant major sources need also to be taken into account in the modelling procedure. A major baseline monitoring program (see Section 4 - Air Quality of the main body of the EIS) was undertaken over several months which, in conjunction with other available baseline data, was used to determine conservative background concentrations in the region (see Table 1.6).

The methodology adopted in the cumulative assessment was based on the USEPA recommended Prevention of Significant Deterioration (PSD) Increment approach⁽¹³⁾. The PSD increment is the maximum increase in concentration that is allowed to occur above a baseline concentration for each pollutant. However, no exceedence of the ambient air quality limit values (or NAAQS in the USA) is allowed even if not all of the PSD increment is consumed.

The PSD has three classifications of land use as outlined below:

- Class I Areas:** Class I areas include national parks, national wilderness areas and other areas of special national or regional value.
- Class II Areas:** Attainment areas that are neither industrialised nor meet the specific requirements for classification as Class I areas.
- Class III Areas:** Industrialised attainment areas.

The current location would be considered a Class II area and thus the PSD applicable to Class II areas has been applied in the current case. Due to the variations in pollutant averaging times and standards between the USA and the EU, only relative PSD Increments can be derived. The relative PSD Increment, as a percentage of the respective NAAQS, is shown in Table 1.4 with the corresponding concentration as it would be applied to the EU ambient air quality standards. In the current context, the PSD increment has been applied only to zones where significant overlap occurs between plumes from each of the sources.

In the context of the cumulative assessment, all significant sources should be taken into account. The USEPA has defined "significance" in the current context as an impact leading to a $1\mu\text{g}/\text{m}^3$ annual increase in the annual average concentration of the applicable criteria pollutant (PM_{10} , NO_2 , and SO_2)⁽¹³⁾. However, no significant ambient impact levels have been established for non-criteria pollutants (defined as all pollutants except PM_{10} , NO_2 , SO_2 , CO and lead). The USEPA does not require a full cumulative assessment for a particular pollutant when emissions of that pollutant from a proposed source would not increase ambient levels by more than the significant ambient impact level (annual average of $1\mu\text{g}/\text{m}^3$). An assessment of releases from Indaver Ireland has indicated that releases of CO, PM_{10} and TOC are not significant and thus no cumulative assessment has been carried out for these substances (see Table A1.6 in Appendix 1.3).

The project impact area for the cumulative assessment is the geographical area for which the required air quality analysis for PSD increments are carried out. The USEPA has defined the "impact area" as a circular area with a radius extending from the source to the most distant point where dispersion modelling predicts a significant ambient impact will occur irrespective of pockets of insignificant impact occurring within it. Within this impact area, all nearby sources should be modelled, where "nearby" is defined as any point source expected to cause a significant concentration gradient in the vicinity of the proposed new source.

In order to determine compliance, the predicted ground level concentration (based on the full impact analysis and existing air quality data) at each model receptor is compared to the applicable ambient air quality limit value or PSD increment. If the predicted pollutant concentration increase over the baseline concentration is below the applicable increment, and the predicted total ground level concentrations are below the ambient air quality standards, then the applicant has successfully demonstrated compliance.

When an air quality standard or PSD increment is predicted to be exceeded at one or more receptor in the impact area, it should be determined whether the net emissions increase from the proposed source will result in a significant ambient impact at the point of each violation, and at the

time the violation is predicted to occur. The source will not be considered to cause or contribute to the violation if its own impact is not significant at any violating receptor at the time of each violation⁽¹³⁾.

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Table 1.1 Council Directive 2000/76/EC, Annex V Air Emission Limit Values

Daily Average Values	Concentration	
Total Dust	10 mg/m ³	
Gaseous & vaporous organic substances expressed as total organic carbon (TOC)	10 mg/m ³	
Hydrogen Chloride (HCl)	10 mg/m ³	
Hydrogen Fluoride (HF)	1 mg/m ³	
Sulphur Dioxide (SO ₂)	50 mg/m ³	
Nitrogen Oxides (as NO ₂) ⁽¹⁾	200 mg/m ³	
Half-hourly Average Values	Concentration	
	(100%)	(97%)
Total Dust ⁽²⁾	30 mg/m ³	10 mg/m ³
Gaseous & vaporous organic substances expressed as total organic carbon (TOC)	20 mg/m ³	10 mg/m ³
Hydrogen Chloride (HCl)	60 mg/m ³	10 mg/m ³
Hydrogen Fluoride (HF)	4 mg/m ³	2 mg/m ³
Sulphur Dioxide (SO ₂)	200 mg/m ³	50 mg/m ³
Nitrogen Oxides (as NO ₂)	400 mg/m ³⁽¹⁾	200 mg/m ³
Average Value Over 30 mins to 8 Hours	Concentration ⁽³⁾	
Cadmium and its compounds, expressed as Cd	Total 0.5 mg/m ³	
Thallium and its compounds, expressed as Tl		
Mercury and its compounds, expressed as Hg		
Antimony and its compounds, expressed as Sb		
Arsenic and its compounds, expressed as As		
Lead and its compounds, expressed as Pb		
Chromium and its compounds, expressed as Cr		
Cobalt and its compounds, expressed as Co		
Copper and its compounds, expressed as Cu		
Manganese and its compounds, expressed as Mn		
Nickel and its compounds, expressed as Ni		
Vanadium and its compounds, expressed as V		
Average Values Over 6 – 8 Hours	Concentration	
Dioxins and furans	0.1 ng/m ³	
Average Value	Concentration ⁽⁴⁾	
	Daily Average Value	30 Min Average Value
Carbon Monoxide	50 mg/m ³	100 mg/m ³

(1) Until 1/1/2007 the emission limit value for NO_x does not apply to plants only incinerating hazardous waste

(2) Total dust emission may not exceed 150 mg/m³ as a half-hourly average under any circumstances

(3) These values cover also the gaseous and vapour forms of the relevant heavy metals as well as their compounds

(4) Exemptions may be authorised for incineration plants using fluidised bed technology, provided that emission limit values do not exceed 100 mg/m³ as an hourly average value.

Table 1.2 Air Emission Values From Indaver Ireland, Carranstown, Co. Meath

Daily Average Values	EU Maximum Emission Concentration	Maximum Operating Values	Typical Emission Concentration	Expected Operating Values
		Emission Rate (g/s)		
Total Dust	10 mg/m ³	0.419	1 mg/m ³	0.035
Gaseous & vaporous organic substances expressed as total organic carbon (TOC)	10 mg/m ³	0.419	1 mg/m ³	0.035
Hydrogen Chloride (HCl)	10 mg/m ³	0.419	1 mg/m ³	0.035
Hydrogen Fluoride (HF)	1 mg/m ³	0.042	1 mg/m ³	0.035
Sulphur Dioxide (SO ₂)	50 mg/m ³	2.10	20 mg/m ³	0.7
Nitrogen Oxides (as NO ₂)	200 mg/m ³	8.39	150 mg/m ³	5.25
Hourly Average Value	Emission Concentration	Emission Rate (g/s)	Emission Concentration	Emission Rate (g/s)
Cadmium and its compounds, expressed as Cd	Total 0.05 mg/m ³	0.0021	Total 0.025 mg/m ³	0.000875
Thallium and its compounds, expressed as Tl				
Mercury and its compounds, expressed as Hg	0.05 mg/m ³	0.0021	0.025 mg/m ³	0.000875
Antimony and its compounds, expressed as Sb	Total 0.5 mg/m ³	0.021	Total 0.25 mg/m ³	0.00875
Arsenic and its compounds, expressed as As				
Lead and its compounds, expressed as Pb				
Chromium and its compounds, expressed as Cr				
Cobalt and its compounds, expressed as Co				
Copper and its compounds, expressed as Cu				
Manganese and its compounds, expressed as Mn				
Nickel and its compounds, expressed as Ni				
Vanadium and its compounds, expressed as V				
Average Values Over 6 – 8 Hours				
Dioxins and furans	0.1 ng/m ³	4.19 x 10 ⁻⁹	0.01 ng/m ³	3.5 x 10 ⁻¹⁰
Average Value	Emission Concentration	Emission Rate (g/s)	Emission Concentration	Emission Rate (g/s)
Carbon Monoxide	100 mg/m ³	4.2	20 mg/m ³	0.7

Tonnes per annum can be calculated based on operating conditions of 24 hours per day at design volume flow for 7500 hours/annum.

Table 1.3 Model Input Data For Point Sources For PSD Compliance⁽¹⁾

Average Time	Emission Limit (mg/m ³)	X Operating Level (mg/hr)	X Operating Factor (hr/year)
Proposed Major New Source			
Annual	Maximum allowable emission limit	Design capacity	Continuous operation
Short term (≤ 24 hrs)	Maximum allowable emission limit	Design capacity	Continuous operation
Nearby Major Source			
Annual	Maximum allowable emission limit	Design capacity	Actual Operating Factor averaged over 2 years
Short term (≤ 24 hrs)	Maximum allowable emission limit	Design capacity	Continuous operation

Table 1.4 PSD Increments Relative To NAAQS (US) and As Applied To EU Directives

Pollutant	Averaging Period	Class II PSD Increment µg/m ³	% of NAAQS (& % of EU Directives)	PSD Increment as applied to EU Standards (µg/m ³) / Averaging Periods
PM ₁₀	Annual	34	25%	Annual - 10 / 24-Hour – 12.5
SO ₂	24-Hour	182	25%	24-Hour – 31.3 / 1-Hour – 87.5
NO ₂	Annual	50	25%	Annual - 10 / 1-Hour - 50

1.3 Modelling Results

1.3.1 Introduction

Emissions from the Indaver Ireland site has been modelled using the ISCST3 dispersion model which is the USEPA's regulatory model used to assess pollutant concentrations associated with industrial sources⁽¹⁾. Emissions have been assessed, firstly under typical operating conditions and secondly under the maximum emissions limits of the EU Directive 2000/76/EC.

1.3.2 Process Emissions

Indaver Ireland has one main process emission point (stack). The operating details of this major emission point has been taken from information supplied by Indaver Ireland and are outlined in Table 1.5. Full details of emission concentrations and mass emissions are given in Appendix 1.4.

Table 1.5 Process Emission Design Details

Stack Reference	Stack Height (m)	Exit Diameter (m)	Cross-Sectional Area (m ²)	Temp (K)	Volume Flow (Nm ³ /hr)	Exit Velocity (m/sec actual)
Stack	40	2.0	3.14	373	126000 – Typical 150980 – Maximum	17.2 20.5

Emissions from the site have been assessed using the approach recommended by the USEPA⁽¹⁾. The approach involved identifying the operating conditions which will give rise to the maximum ground level concentrations. Maximum operating conditions will be 1.2 times typical operating conditions. Both these above conditions, in addition to 50% loading were modelled, in order to confirm that the worst-case operating conditions were being modelled.

The ISCST3 model was run using a unitised emission rate of 1 g/s. The unitised concentration and deposition output has then been adjusted for each substance based on the specific emission rate of each.

1.3.3 Background Concentrations

The ambient concentrations detailed in the following sections include both the emissions from the site and the ambient background concentration for that substance. Background concentrations have been derived from a worst-case analysis of the cumulative sources in the region in the absence of the development. Firstly, a detailed baseline air quality assessment (see Section 4 – Air Quality of the main body of the EIS) was carried out to assess background levels of those pollutants, which are likely to be significant releases from the site. Secondly, modelling of traffic emissions (see Appendix 1.4) was carried out both with and without the scheme to assess the impact of traffic emissions in the region. Thirdly, a detailed cumulative assessment of all significant releases from nearby sites was carried out based on an analysis of their IPC Licences (see Appendix 1.3). Appropriate background values have been outlined in Table 1.6. In arriving at the combined annual background concentration, cognisance has been taken of the accuracy of the approach and the degree of double counting inherent in the assessment. In relation to NO₂, the baseline monitoring program will have taken into account both the existing traffic levels and existing industrial sources. However, some increases in traffic levels will occur due to the development which has been incorporated into the final combined background levels. Again, in recognition of the various inaccuracies in this approach, the values have been rounded accordingly. A similar approach has been adopted for the other pollutants. In relation to the

baseline heavy metals and dioxins, a range of concentrations has been given in recognition of the influence that non-detects have on the reported values.

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 DETR⁽¹⁴⁾ 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.

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Table 1.6 Estimated annual background concentrations in Carranstown Region ($\mu\text{g}/\text{m}^3$).

	NO ₂	SO ₂	PM ₁₀	CO	TOC	HCl	HF	Dioxins ⁽¹⁾	Cd ⁽¹⁾	Hg ⁽¹⁾	Sb ⁽¹⁾	As ⁽¹⁾	Mn ⁽³⁾	Ni ⁽¹⁾
Baseline Monitoring Program ⁽¹⁾	8	3	4	-	-	0.01	0.005	0.046 $\mu\text{g}/\text{m}^3$ 0.028 $\mu\text{g}/\text{m}^3$	< 0.023 < 0.012	< 0.005 < 0.0025	0.012 < 0.0003	< 0.02 < 0.01	0.012	0.006 0.005
Traffic Impact Assessment	1	-	2	200	8	-	-	-	-	-	-	-	-	-
Cumulative Assessment	1	1	-(2)	-(2)	-(2)	-(2)	-(2)	-(2)	-(2)	-(2)	-(2)	-(2)	-(2)	-(2)
Annual Background Concentration	10	4	20⁽⁴⁾	200	100	0.01	0.005	0.046 $\mu\text{g}/\text{m}^3$ 0.028 $\mu\text{g}/\text{m}^3$	0.023 0.012	0.005 0.0025	0.012 0.0003	0.02 0.01	0.012	0.006 0.005

- (1) Baseline results for dioxins and metals given as firstly (i) Non-detects = limit of detection, (ii) Non-detects = 50% of limit of detection.
- (2) No cumulative assessment carried out as emissions from the site are less than significance criteria (defined as greater than 2% of ambient limit value)
- (3) No baseline measurements carried out for Manganese.
- (4) Conservative estimate based on typical rural background values and the existing industrial sources of PM₁₀ in the region.

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1.4 Nitrogen Dioxide Emissions and Results

1.4.1 Source Information

Source information including emission release heights, volume flows, locations and stack diameters has been summarised in Appendix 1.5.

1.4.2 Modelling of Nitrogen Dioxide

Nitrogen oxides (NO_x), containing both nitrogen oxide (NO) and nitrogen dioxide (NO_2) are emitted from the combustion process on-site, although it is the latter which is considered the more harmful to human health. These combustion processes lead to emissions which are mainly in the form of nitrogen oxide (NO) (typically 95%) with small amounts of the more harmful nitrogen dioxide.

NO_2 has been modelled following the approach outlined by the USEPA⁽¹⁾ for assessing the impact of NO_x from point sources. The approach involves assessing the air quality impact through a three tiered screening technique. The initial analysis, termed the Tier 1 approach, assumes a worst-case scenario that there is total conversion of NO_x to NO_2 . The guidance indicates that if this worst-case assumption leads to an exceedance of the appropriate limit value, the user should proceed to the next Tier, as in the current case.

Tier 2 is appropriate for estimating the annual average NO_2 concentration. The Tier 2 approach indicates that the annual average concentration should either be derived from an empirically derived NO_2/NO_x ratio or alternatively to use the default value of 0.75. This default value has been used in the current assessment.

In order to determine the maximum one-hour value, the Tier 3 approach is recommended by the USEPA. The Tier 3 approach involves the application of a detailed screening method on a case-by-case basis. The suggested methodologies include the ozone-limiting method or a site-specific NO_2/NO_x ratio. In the current assessment, no site-specific ratio has been developed because the monitoring data obtained by Indaver Ireland measured much lower concentrations than that predicted to occur very occasionally during operations at the boundary of the site. However, empirical evidence suggests that a conservative estimate of this ratio would be 0.30 (see Appendix 1.2). Thus, a ratio of 0.30 for NO_2/NO_x has been used in the current assessment for the 99.8th percentile of one-hour maximum concentrations.

Ambient Ground Level Concentrations (GLCs) of Nitrogen Dioxide have been predicted for the following scenarios in Table 1.7.

Table 1.7 Emission Scenario for Nitrogen Dioxide

Pollutant	Scenario	Concentration	Emission Rate (g/s)
NO_2	Max	200 mg/m^3	8.39
	Typical	150 mg/m^3	5.25
	50% of Maximum	200 mg/m^3	4.19

1.4.3 Comparison with Standards and Guidelines

The relevant air quality standards for Nitrogen Dioxide has been detailed in Table 1.8. In this report the ambient air concentrations have been referenced to Council Directive 1999/30/EC, which will shortly come into force. The directive also details margins of tolerance, which are trigger levels for certain types of action in the period leading to the attainment date. The margin of tolerance is 50% for both the hourly and annual limit value for NO₂. The margin of tolerance will start to reduce from 1 January 2001 and every 12 months thereafter by equal annual percentages to reach 0% by the attainment date of 2010. However, reflecting a worst-case approach, results have been compared with the applicable limit value which will be enforceable in 2010.

Table 1.8 EU Ambient Air Standards - Council Directive 1999/30/EC

Pollutant	Regulation	Limit Type	Margin of Tolerance	Value
Nitrogen Dioxide	1999/30/EC	Hourly limit for protection of human health - not to be exceeded more than 18 times/year	50% until 2001 reducing linearly to 0% by 2010	200 µg/m ³ NO ₂
		Annual limit for protection of human health	50% until 2001 reducing linearly to 0% by 2010	40 µg/m ³ NO ₂
		Annual limit for protection of vegetation	None	30 µg/m ³ NO + NO ₂

1.4.4 Modelling Results

Modelling was carried out for the three scenarios described in Section 1.4.2. Table 1.9 details the predicted Tier 2 (applied to the annual average) & Tier 3 (applied to the maximum one-hour) NO₂ GLC for each scenario at the worst-case boundary locations whereas Table 1.10 details the spatial variation in nitrogen dioxide concentrations at specific locations in the surrounding region.

Table 1.9 Dispersion Model Results – Nitrogen Dioxide

Pollutant / Scenario	Annual Mean Background ($\mu\text{g}/\text{m}^3$) ⁽¹⁾	Averaging Period	Process Contribution ($\mu\text{g}/\text{m}^3$)	Predicted Emission Concentration ($\mu\text{g}/\text{Nm}^3$)	Standard ⁽²⁾ ($\mu\text{g}/\text{Nm}^3$)	Indaver emissions as a % of ambient limit value
NO ₂ / Maximum	10	Annual Mean ⁽³⁾	8	18	40	20%
		99.8 th ile of 1-hr means ⁽⁴⁾	65	85	200	33%
NO ₂ / Typical	10	Annual Mean ⁽³⁾	5.8	15.8	40	15%
		99.8 th ile of 1-hr means ⁽⁴⁾	46	66	200	23%
NO ₂ / 50% of maximum	10	Annual Mean ⁽³⁾	7	17	40	18%
		99.8 th ile of 1-hr means ⁽⁴⁾	52	72	200	26%

(1) Includes contribution from traffic and background sources (based on results from continuous monitor and diffusion tubes) and incorporating the cumulative assessment results.

(2) Directive 1999/30/EC

(3) Conversion factor following guidance from USEPA (Tier 2 analysis, annual average) based on the default ratio of 0.75 (worst-case).

(4) Conversion factor, following guidance from USEPA (Tier 3 analysis), based on empirically derived site-specific maximum 1-hour value for NO₂ / NO_x of 0.30

Table 1.10 Dispersion Model Results – Nitrogen Dioxide Maximum Operation, Specific Receptors

Pollutant / Location	Annual Mean Background ($\mu\text{g}/\text{m}^3$) ⁽¹⁾	Averaging Period	Process Contribution ($\mu\text{g}/\text{m}^3$)	Predicted Emission Concentration ($\mu\text{g}/\text{Nm}^3$)	Standard ⁽²⁾ ($\mu\text{g}/\text{Nm}^3$)	Indaver emissions as a % of ambient limit value
NO ₂ Typical / Worst-case Residential Receptor	10	Annual Mean ⁽³⁾	2.3	12.3	40	6%
		99.8 th ile of 1-hr means ⁽⁴⁾	31	51	200	15%
NO ₂ Typical / Donore School	10	Annual Mean ⁽³⁾	0.64	10.6	40	2%
		99.8 th ile of 1-hr means ⁽⁴⁾	13	33	200	7%
NO ₂ Typical / Duleek	10	Annual Mean ⁽³⁾	0.09	10.1	40	0.2%
		99.8 th ile of 1-hr means ⁽⁴⁾	2.8	23	200	1%
NO ₂ Typical / Drogheda	10	Annual Mean ⁽³⁾	0.19	10.2	40	0.5%
		99.8 th ile of 1-hr means ⁽⁴⁾	2.2	22	200	1%
NO ₂ Typical / Newgrange Cemetery	10	Annual Mean ⁽³⁾	0.09	10.1	40	0.2%
		99.8 th ile of 1-hr means ⁽⁴⁾	2.2	22	200	1%

(1) Includes contribution from traffic and background sources (based on results from continuous monitor and diffusion tubes) and incorporating the cumulative assessment results.

(2) Directive 1999/30/EC

(3) Conversion factor following guidance from USEPA (Tier 2 analysis, annual average) based on site-specific ratio of 0.75 (worst-case).

(4) Conversion factor, following guidance from USEPA (Tier 3 analysis), based on empirically derived site-specific maximum 1-hour value for NO₂ / NO_x of 0.30

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1.4.5 Concentration Contours

The geographical variation in NO₂ ground level concentrations beyond the site boundary are illustrated as concentration contours in Figures 1.2 to 1.3. The figures have been expressed as a percentage of the appropriate ambient air quality standard or guideline. The contents of each figure are described below.

Figure 1.2 Maximum Operations: Predicted Tier 3 NO₂ 99.8th Percentile Concentration

Figure 1.3 Maximum Operations: Predicted Tier 2 NO₂ Annual Average Concentration

1.4.6 Result Findings

In relation to the maximum one-hour limit value, NO₂ Tier 3 modelling results indicate that the ambient ground level concentrations are below these ambient standards under both typical and maximum operation of the site. Thus, no adverse environmental impact is envisaged to occur under these conditions at or beyond the site boundary. Emissions at maximum operations equate to ambient NO₂ concentrations (including background concentrations) which are 43% of the maximum ambient 1-hour limit value (measured as a 99.8th percentile) at the worst-case receptor (near the northern site-boundary). Annual averages (including background concentrations) are also significantly below the limit value accounting for 45% of the annual limit value at the worst-case receptor.

The modelling results indicate that the maximum 1-hour and annual average concentrations occur at or near the site's north and east boundary. Concentrations fall off rapidly away from this maximum and for the maximum 1-hour concentration (as a 99.8th percentile) will be only 15% of the limit value (not including background concentrations) at the nearest sensitive receptor to the site (see Table 1.10). The annual average concentration decreases in maximum concentration away from the site with concentrations from emissions at Indaver Ireland accounting for only 6% of the limit value (not including background concentrations) at worst case sensitive receptors near the site. Thus, the results indicate that the impact from Indaver Ireland is minor and limited to the immediate environs of the site.

In the surrounding main population centres, Drogheda and Duleek, levels are significantly lower than background sources with the concentrations from emissions at Indaver Ireland accounting for less than 1% of the annual limit value.

1.5 Sulphur Dioxide and Total Dust (as PM₁₀) Emissions and Results

1.5.1 Source Information

Source information including emission release heights, volume flows, locations and stack diameters has been summarised in Appendix 1.5.

Ambient Ground Level Concentrations (GLC's) of Sulphur Dioxide (SO₂) and Total Dust (as PM₁₀) have been predicted for the following scenarios in Table 1.11.

Table 1.11 Emission Scenario for Sulphur Dioxide and Total Dust

Pollutant	Scenario	Concentration	Emission Rate (g/s)
SO ₂	Max	50 mg/m ³	2.1
	Typical	20 mg/m ³	0.70
	50% of maximum	50 mg/m ³	1.0
Total Dust	Max	10 mg/m ³	0.42
	Typical	1 mg/m ³	0.04
	50% of maximum	10 mg/m ³	0.21

1.5.2 Comparison with Standards And Guidelines

The relevant air quality standards for Sulphur Dioxide and PM₁₀ have been detailed in Table 1.12. In this report the ambient air concentrations for SO₂ and PM₁₀ have been referenced to Council Directive 1999/30/EC, which will come into force shortly. The margin of tolerance is 43% for the hourly limit value for SO₂ and 50% for the 24-hr limit value for PM₁₀. However, reflecting a worst-case approach, results have been compared with the applicable limit value which will be enforceable in 2005.

Table 1.12 EU Ambient Air Standard - Council Directive 1999/30/EC

Pollutant	Regulation	Limit Type	Margin of Tolerance	Value
Sulphur Dioxide	1999/30/EC	Hourly limit for protection of human health - not to be exceeded more than 24 times/year	43% until 2001 reducing linearly until 0% by 2005	350 µg/m ³
		Daily limit for protection of human health - not to be exceeded more than 3 times/year	None	125 µg/m ³
		Annual & Winter limit for the protection of ecosystems	None	20 µg/m ³
Particulate Matter Stage 1	1999/30/EC	24-hour limit for protection of human health - not to be exceeded more than 35 times/year	50% until 2001 reducing linearly to 0% by 2005	50 µg/m ³
		Annual limit for protection of human health	20% until 2001 reducing linearly to 0% by 2005	40 µg/m ³
Particulate Matter Stage 2 ¹	1999/30/EC	24-hour limit for protection of human health - not to be exceeded more than 7 times/year	To be derived from data and to be equivalent to Stage 1 limit value	50 µg/m ³
		Annual limit for protection of human health	50% until 2005 reducing linearly to 0% by 2010	20 µg/m ³

(1) Indicative limit values to be reviewed in the light of further information on health and environmental effects, technical feasibility and experience in the application of Stage 1 limit values in the Member States

1.5.3 Modelling Results

Modelling was carried out for the three scenarios described in Section 1.5.1.

Tables 1.13 – 1.14 details the predicted SO₂ and PM₁₀ GLC for each scenario.

Table 1.13 Dispersion Model Results – Sulphur Dioxide

Pollutant / Scenario	Background (µg/m ³)	Averaging Period	Process Contribution (µg/m ³)	Predicted Emission Concentration (µg/Nm ³)	Standard ⁽¹⁾ (µg/Nm ³)
SO ₂ / Maximum	4	99.7 th ile of 1-hr means	52	60	350
		99.2 th ile of 24-hr means	20	24	125
SO ₂ / Typical	4	99.7 th ile of 1-hr means	20	28	350
		99.2 th ile of 24-hr means	7	11	125
SO ₂ / 50% of maximum	4	99.7 th ile of 1-hr means	42	50	350
		99.2 th ile of 24-hr means	15	19	125

(1) Directive 1999/30/EC

Table 1.14 Dispersion Model Results – Total Dust (referenced to PM₁₀)

Pollutant / Scenario	Annual Mean Background (µg/m ³)	Averaging Period	Process Contribution (µg/m ³)	Predicted Emission Concentration (µg/Nm ³)	Standard ⁽¹⁾ (µg/Nm ³)
PM ₁₀ / Maximum	20	90.5 th ile of 24-hr means	1.9	21.9	50
		Annual mean	0.51	20.5	40
PM ₁₀ / Typical	20	90.5 th ile of 24-hr means	0.18	20.2	50
		Annual mean	0.05	20.1	40
PM ₁₀ / 50% of maximum	20	90.5 th ile of 24-hr means	1.38	21.4	50
		Annual mean	0.45	20.5	40

(1) Directive 1999/30/EC

1.5.4 Concentration Contours

The geographical variation in SO₂ and PM₁₀ ground level concentrations beyond the site boundary are illustrated as concentration contours in Figures 1.4 to 1.7. The figures have been expressed as a percentage of the appropriate ambient air quality standard or guideline. The contents of each figure are described below.

Figure 1.4 Maximum Operations: Predicted SO₂ 99.7th Percentile of Hourly Concentrations

Figure 1.5 Maximum Operations: Predicted SO₂ 99.2th Percentile of 24-Hourly Concentrations

Figure 1.6 Maximum Operations: Predicted PM₁₀ 90.5th Percentile of 24-Hourly Concentrations

Figure 1.7 Maximum Operations: Predicted PM₁₀ Annual Concentrations

1.5.5 Result Findings

SO₂

SO₂ modelling results indicate that the ambient ground level concentrations are below the relevant air quality standards for sulphur dioxide under both typical and maximum operation of the site. Thus, no adverse environmental impact is envisaged to occur under these conditions at or beyond the site boundary. Emissions at maximum operations equate to ambient SO₂ concentrations (including background concentrations) which are 17% of the maximum ambient 1-hour limit value (measured as a 99.7th percentile) and 19% of the maximum ambient 24-hour limit value (measured as a 99.2th percentile) at the worst-case boundary receptor.

PM₁₀

PM₁₀ modelling results indicate that the ambient ground level concentrations are below the relevant air quality standards for PM₁₀ under both typical and maximum operation of the site. Thus, no adverse environmental impact is envisaged to occur under these conditions at or beyond the site boundary. Emissions at maximum operations equate to ambient PM₁₀ concentrations (including background concentrations) which are 44% of the maximum ambient 24-hour limit value (measured as a 90.5th percentile) and 51% of the annual average limit value at the worst-case boundary receptor.

1.6 Total Organic Carbon (TOC), Hydrogen Chloride and Hydrogen Fluoride Emissions and Results

1.6.1 Source Information

Source information including emission release heights, volume flows, locations and stack diameters has been summarised in Appendix 1.5.

Ambient Ground Level Concentrations (GLC's) of Total Organic Carbon (TOC), Hydrogen Chloride (HCl) and Hydrogen Fluoride (HF) have been predicted for the following scenarios in Table 1.15.

Table 1.15 Emission Scenario for TOC, HCl and HF

Pollutant	Scenario	Concentration	Emission Rate (g/s)
TOC	Max	10 mg/m ³	0.42
	Typical	1 mg/m ³	0.035
	50% of maximum	10 mg/m ³	0.21
HCl	Max	10 mg/m ³	0.42
	Typical	1 mg/m ³	0.035
	50% of maximum	10 mg/m ³	0.21
HF	Max	1 mg/m ³	0.042
	Typical	1 mg/m ³	0.035
	50% of maximum	1 mg/m ³	0.021

1.6.2 Comparison With Standards And Guidelines

TA Luft standards have been proposed for TOC, HCl and HF. The TA-Luft standard is based on a 30-minute averaging period. As the meteorological data used in the modelling is collated on an averaging period of one hour, the dispersion model can only predict concentrations for averaging periods of one hour or above. Predicted hourly-average concentrations have subsequently been compared against the standard. Typically the peak 30-minute average will be 10 to 20% higher than the corresponding 1-hour period average.

Table 1.16 Air Standards for TOC, HCl and HF

Pollutant	Regulation	Limit Type	Class	Value
TOC	TA Luft	Hourly limit for protection of human health – expressed as a 98 th ile	Class III	1000 µg/m ³
			Class II	200 µg/m ³
			Class I	50 µg/m ³
HCl	TA Luft	Hourly limit for protection of human health – expressed as a 98 th ile	100 µg/m ³	
HF	TA Luft	Hourly limit for protection of human health – expressed as a 98 th ile	3 µg/m ³	
HF	WHO	Gaseous fluoride (as HF) as an annual average.	0.3 µg/m ³	
HF	Dutch	Mean fluoride (as HF) concentration during the growing season (April to September)	0.4 µg/m ³	
HF	Dutch	Ambient gaseous fluoride (as HF) as a 24-hour average concentration.	2.8 µg/m ³	

1.6.3 Modelling Results

Modelling was carried out for the three scenarios described in Section 1.6.1 for each pollutant.

Tables 1.17 – 1.19 details the predicted TOC, HCl and HF GLC for each scenario.

Table 1.17 Dispersion Model Results – TOC

Pollutant / Scenario	Annual Mean Background ($\mu\text{g}/\text{m}^3$)	Averaging Period	Process Contribution ($\mu\text{g}/\text{m}^3$)	Predicted Emission Concentration ($\mu\text{g}/\text{Nm}^3$)	Standard ⁽¹⁾ ($\mu\text{g}/\text{Nm}^3$)
TOC / Maximum	100	98 th ile of 1-hr means	6.7	107	1000
TOC / Typical	100	98 th ile of 1-hr means	0.65	101	1000
TOC / 50% of maximum	100	98 th ile of 1-hr means	5.6	106	1000

(1) TA Luft Immission Standard

Table 1.18 Dispersion Model Results – HCl

Pollutant / Scenario	Annual Mean Background ($\mu\text{g}/\text{m}^3$)	Averaging Period	Process Contribution ($\mu\text{g}/\text{m}^3$)	Predicted Emission Concentration ($\mu\text{g}/\text{Nm}^3$)	Standard ⁽¹⁾ ($\mu\text{g}/\text{Nm}^3$)
HCl / Maximum	0.01	98 th ile of 1-hr means	6.7	6.7	100
HCl / Typical	0.01	98 th ile of 1-hr means	0.65	0.66	100
HCl / 50% of maximum	0.01	98 th ile of 1-hr means	5.6	5.6	100

(1) TA Luft Immission Standard

Table 1.19 Dispersion Model Results – HF

Pollutant / Scenario	Annual Mean Background ($\mu\text{g}/\text{m}^3$)	Averaging Period	Process Contribution ($\mu\text{g}/\text{m}^3$)	Predicted Emission Concentration ($\mu\text{g}/\text{Nm}^3$)	Standard ($\mu\text{g}/\text{Nm}^3$)
HF / Maximum	0.005	98 th ile of 1-hr means	0.68	0.69	3.0 ⁽¹⁾
		Maximum 24-hr	0.59	0.60	2.8 ⁽²⁾
		Annual Average	0.051	0.056	0.3 ⁽³⁾
HF / Typical	0.005	98 th ile of 1-hr means	0.65	0.66	3.0 ⁽¹⁾
		Maximum 24-hr	0.59	0.60	2.8 ⁽²⁾
		Annual Average	0.052	0.057	0.3 ⁽³⁾
HF / 50% of maximum	0.005	98 th ile of 1-hr means	0.56	0.57	3.0 ⁽¹⁾
		Maximum 24-hr	0.46	0.47	2.8 ⁽²⁾
		Annual Average	0.045	0.050	0.3 ⁽³⁾

(1) TA Luft Immission Standard

(2) Netherlands Emission Regulations Staff Office

(3) World Health Organisation

1.6.4 Concentration Contours

The geographical variation in TOC, HCl and HF ground level concentrations beyond the site boundary is illustrated as concentration contours in Figures 1.8 – 1.11. The figures have been expressed as a percentage of the appropriate ambient air quality guideline. The content of the figures is described below.

Figure 1.8 Maximum Operations: Predicted TOC Maximum 1-Hour Concentration (as a 98thile)

Figure 1.9 Maximum Operations: Predicted HCl Maximum 1-Hour Concentration (as a 98thile)

Figure 1.10 Maximum Operations: Predicted HF 98th Percentile Of Hourly Concentrations

Figure 1.11 Maximum Operations: Predicted HF Annual Average Concentration

1.6.5 Result Findings

TOC

TOC modelling results indicate that the ambient ground level concentrations are below the relevant air quality guidelines for TOC under both typical and maximum operation of the site. Thus, no adverse environmental impact is envisaged to occur under these conditions at or beyond the site boundary. Emissions at maximum operations equate to ambient TOC concentrations (including background concentrations) which are 11% of the maximum ambient 1-hour limit value (measured as a 98thile).

HCl

HCl modelling results indicate that the ambient ground level concentrations are below the relevant air quality guideline for HCl under both typical and maximum operation of the site. Thus, no adverse environmental impact is envisaged to occur under these conditions at or beyond the site boundary. Emissions at maximum operations equate to ambient HCl concentrations (including background concentrations) which are 7% of the maximum ambient 1-hour limit value (measured as a 98thile).

HF

HF modelling results indicate that the ambient ground level concentrations are below the relevant air quality standards and guidelines for HF under both typical and maximum operation of the site. Thus, no adverse environmental impact is envisaged to occur under these conditions at or beyond the site boundary. Emissions at maximum operations equate to ambient HF concentrations (including background concentrations) which are 23% of the maximum ambient 1-hour limit value (measured as a 98thile) and 19% of the annual limit value.

1.7 Dioxin-Like Compounds

1.7.1 Description of Dioxin-Like Compounds

The term "Dioxin-like Compounds" generally refers to three classes of compounds; polychlorinated dibenzo-p-dioxins (PCDDs or CDDs), polychlorinated dibenzofurans (PCDFs or CDFs), and polychlorinated biphenyls (PCBs). PCDDs include 75 individual compounds, or congeners, PCDFs include 135 congeners and PCBs include 209 congeners (see Table X.20). Both PCDDs and PCDFs are usually formed as unintentional by-products through a variety of chemical reactions and combustion processes. These compounds are lipophilic that bind to sediment and organic matter in the environment and tend to be absorbed in animal and human fatty tissue. They are also generally extremely resistant towards chemical and biological degradation processes, and, consequently, persist in the environment and accumulate in the food chain⁽¹⁵⁾.

The toxic effects of dioxins are initiated at the cellular level, by the binding of the dioxin to a specific protein in the cytoplasm of the body cells, the aryl hydrocarbon receptor (AhR). The binding of TCDD to the Ah receptor constitutes a first and necessary step to initiate the toxic and biochemical effects of this compound. Dioxins effects in humans include increased prevalence of diabetes, immunotoxic effects and effects on neurodevelopment and neurobehaviour in children. Studies have shown TCDD to be carcinogenic but a lack of direct DNA-damaging effects indicates that TCDD is not an initiator but a promoter of carcinogenesis⁽¹⁶⁾.

130 of the 209 PCB congeners have historically been manufactured for a variety of uses including dielectric fluids in transformers and capacitors and as lubricants and adhesives. However, the marketing, use and disposal of PCBs has been severely restricted in the EU through Directives 85/467/EC and 96/59/EC⁽¹⁵⁾.

The toxicity of dioxins varies widely with 2,3,7,8-TCDD being the most potent dioxin congener and with only particular configurations of these compounds thought to have dioxin-like toxicity (See Table X.20). For PCDDs, only 7 of the 75 congeners have dioxin-like toxicity; these are the ones with chlorine substitutions in, at least, the 2,3,7 and 8 positions. For PCDFs, only 10 of the 135 congeners have dioxin-like toxicity; these are again the ones with chlorine substitutions in, at least, the 2,3,7 and 8 positions. In relation to PCBs, only 13 of the 209 congeners are likely to have dioxin-like toxicity; these are the PCBs with four or more chlorines with just one or no substitutions in the ortho position (coplanar)^(15,17).

As dioxin-like compounds have varying degrees of toxicity, a toxicity equivalency procedure has been developed to describe the cumulative toxicity of these mixtures. The procedure involved assigning individual Toxicity Equivalency Factors (TEFs) to the 2,3,7,8- substituted PCDD and PCDF congeners and to selected coplanar and mono-ortho PCBs. The TEFs are referenced to 2,3,7,8-TCDD, which is assigned a TEF of 1.0. Calculation of the toxic equivalency (TEQ) of a mixture involves multiplying the concentration of individual congeners by their respective TEF. The sum of the TEQ concentrations for the individual congeners is the TEQ concentration for the mixture.

Since 1989, three different TEF schemes have been developed⁽¹⁷⁾:

I-TEQ_{DF} – Developed by NATO/CCMS in 1988, the I-TEQ_{DF} (DF = dioxin, furan, I = International) procedure assigns TEFs only for the 7 dioxins (PCDDs) and 10 furans (PCDFs). This scheme does not include dioxin-like PCBs. This scheme has been adopted in Council Directive 2000/76/EC and has been applied in the current assessment.

TEQ_{DFP}-WHO₉₄ – In 1994, the WHO added 13-dioxin-like PCBs to the TEF scheme for dioxins and furans. However, no changes were made to the TEFs for dioxins and furans I-TEQ_{DF} (DFP = dioxin, furan, PCBs).

TEQ_{DFP}-WHO₉₈ – In 1998, the WHO re-evaluated the TEF scheme for dioxins, furans and dioxin-like PCBs. Changes were made to the TEFs for dioxins, furans and dioxin-like PCBs. Table X.21 outlines the TEF for the most recent scheme for comparison with the scheme recommended in Council Directive 200/76/EC (I-TEQ_{DF}).

1.7.2 Modelling Strategy

The emissions of dioxin-like compounds from the waste-to-energy plant have been evaluated in this chapter. Firstly, the stack emissions have been characterised in terms of mass of each PCDD/PCDF congener released, and the partitioning of these releases into a vapour and particle phase. Thereafter, air dispersion modelling has been used to translate these releases to ambient air vapour and particle phase concentrations, and wet vapour and wet and dry particulate deposition fluxes, in the vicinity of the release.

As recommended by the USEPA, individual dioxin congeners have been modelled from source to receptor. Only at the interface to human exposure, e.g., ingestion, inhalation, dermal absorption, etc., are the individual congeners recombined and converted into the toxic equivalence of 2,3,7,8-TCDD to be factored into a quantitative risk assessment.

Emission Rate

The dioxin emission factor is defined as the total mass (in vapour and particulate form) of dioxin-like compound emitted per mass of feed material combusted. For the current proposal, a test burn is not possible as the waste-to-energy plant has not been commissioned yet. However, Indaver Ireland has several flue gas cleaning systems similar to that proposed in the current scheme, in operation in Belgium. An analysis of these flue gas cleaning systems has suggested that the likely emission rate will out perform the most stringent limit value set by the EU in the recent Council Directive on Incineration (2000/76/EC).

Congener-specific emission data are needed for the analyses of the ambient air impacts and deposition flux of dioxin-like compounds using air dispersion and deposition models. As each specific congener has different physico-chemical properties, the proportion of each congener will affect the final result. Thus, the congener profile expected from the current facility must be derived. The congener profile will be dependent on various factors including the type of waste being burnt, the temperature of combustion, the type of combustion chamber being operated and the air pollution control devices (APCDs) installed. In the present case, no site-specific stack testing for specific congeners is possible as the facility is not yet built. Shown in Table 1.22 are typical relative PCDD/PCDF congener emission factors for a municipal waste incinerator similar to that proposed in the current scheme, a mass burn refractometry system with wet scrubbing (MB-REF WS) taken from the Database of Sources of Environmental Releases of Dioxin-Like Compounds in the United States (USEPA, 1998 (CD-ROM))⁽¹⁸⁾. It would be expected that the relative congener profiles for this type of waste-to-energy plant would be somewhat similar to the current case. Figures 1.12 – 1.13 show the ratio of congeners and the TEQ equivalent releases from this type of facility corrected to the maximum emission limit outlined in Council Directive 2000/76/EC.

Vapour / Particulate Partitioning

In order to accurately model emissions of PCDD/PCDFs and mercury, the partitioning of stack emissions into the vapour and particle (V/P) state is required.

In relation to PCDD/PCDFs, V/P partitioning based on stack tests data is highly uncertain⁽¹⁰⁾. Research has indicated that higher temperatures favour the vaporous states for the lower chlorinated congeners and the particulate state for the higher chlorinated congeners⁽¹⁰⁾. However, measured data has indicated significant variability in the V/P partitioning. For these reasons, the USEPA has indicated that V/P distributions obtained from stack sampling should not be used.

Data can also be obtained from ambient air sampling using a glass fibre particulate filter and polyurethane foam (PUF) absorbent trap. As the sampler is not subjected to artificial heating or cooling, the method can be used to imply the vapour phase and particle bound partitioning of PCDD/Fs in ambient air. However, the results will be only approximate as mass transfer between the particulate matter on the filter and the vapour trap cannot be ruled out⁽¹⁰⁾.

The recommended USEPA approach to obtaining the vapour/particulate partitioning at the current time is theoretical and based on the Junge-Pankow model for estimating the particle/gas distribution of PCDD/PCDFs⁽¹⁰⁾. This model is the one most commonly used for estimating the adsorption of semi-volatile compounds to aerosols:

$$\Phi = c\Theta / (\rho^{\circ}_L + c\Theta)$$

where:

Φ = fraction of compound adsorbed to aerosol particles

c = constant (assumed 17.2 Pa-cm)

Θ = particle surface area per unit volume of air, cm² aerosol/cm³ air

ρ°_L = saturation liquid phase vapour pressure, Pa

The particulate fraction can also be expressed by:

$$\Phi = C_p(\text{TSP}) / (C_g + C_p(\text{TSP}))$$

where:

Φ = fraction of compound adsorbed to aerosol particles

C_p = concentration of semivolatile compounds associated with aerosols, ng/ μ g particles

C_g = gas-phase concentration, ng/m³

TSP = total suspended particle concentration, μ g/m³

In the above calculations, it is assumed that all compounds emitted from the combustion sources are freely exchangeable between vapour and particle fractions. This may be a simplification as some of the particulate fraction may be trapped and be unavailable for exchange.

As the ρ°_L is referenced to 25°C and an ambient temperature of 10°C has been assumed which is appropriate for average annual temperatures in Ireland, the ρ°_L has been converted to the ambient temperature as indicated in Table 1.23. Other relevant data used in the calculations and the derived particle fraction at 10°C is also shown in Table 1.23.

The advantages of the theoretical approach is that it is based on current adsorption theory, considers the molecular weight and degree of halogenation of the congeners and uses the availability of surface area for adsorption of atmospheric particles corresponding to specific airsheds (background plus local sources used in the current case).

1.7.3 Modelling of Vapours and Particles Concentrations

PCDD/PCDFs have a range of vapour pressures and thus exist in both vapour and particle-bound states to various degrees. In order to adequately model dispersion and deposition of PCDD/PCDFs, modelling of both vapour and particle-bound states is thus necessary. For the vapour phase modelling, no dry deposition was assumed, as recommended by the USEPA^(10,11). Using the congener profile from Table 1.22 and the vapour – particle partitioning from Table 1.23, the vapour concentrations of the respective dioxin congeners was determined as outlined in Tables 1.25 for a default MWI (MS-Ref WS) profile and diagrammatically in Figure 1.14. Results are shown under maximum operating conditions. The impact of wet deposition on the modelled vapour concentration has also been reported in Table 1.25 and diagrammatically in Figure 1.15.

When modelling semi-volatile organics (such as PCDD/PCDFs) and mercury (Hg) the surface area weighting rather than mass weighting is used for deposition. The surface weighting reflects the mode of formation where volatiles condense on the surface of particulates in the post-combustion chamber (see Column 6 of Table 1.24). Thus, the apportionment of emissions by particle size becomes a function of the surface area of the particle which is available for chemical adsorption.

For the particle-phase concentration, the congener profile from Table 1.22 and the vapour – particle partitioning from Table 1.23 were used to give the particulate concentrations of the respective dioxin congeners as determined in Table 1.26 and diagrammatically in Figure 1.14. Results are shown under maximum operating conditions.

1.7.4 Deposition Modelling of Particulates

Deposition refers to a range of mechanisms which can remove emissions from the atmosphere. These include Brownian motion of aerosol particles and scavenging of particles and vapours by precipitation.

Dry Deposition

Dry deposition of particles refers to the transfer of airborne particles to the surface by means of the forces of gravity and turbulent diffusion followed by diffusion through the laminar sub-layer (thickness of 10^{-1} to 10^{-2} cm) to the surface (collectively known as the deposition flux)⁽¹⁰⁾. The meteorological factors which most influence deposition include the friction velocity and aerodynamic surface roughness. The ISCST3 model uses an algorithm which relates the deposition flux to functions of particle size, density, surface roughness and friction velocity.

In order to model dry deposition using ISCST3, the particle-size distribution from the stack must be derived. In the absence of a site-specific particle-size distribution, a generalised distribution recommended by the USEPA has been outlined in Table 1.24. This distribution is suitable as a default for some combustion facilities equipped with either electrostatic precipitators (ESPs) or fabric filters (such as the current case), because the distribution is relatively typical of particle size arrays that have been measured at the outlet to advanced equipment designs⁽¹¹⁾. As described above, the particles are apportioned based on the fraction of available surface area (see Column 6 of Table 1.24).

Dry gaseous deposition, although considered in the ISCST3 model, has not been calibrated for the estimation of the deposition flux of dioxin-like compounds into vegetation and thus the USEPA has recommended that this algorithm should not be used for site-specific applications^(10,11).

Wet Deposition

Wet deposition physically washes out the chemically contaminated particulate and vapours from the atmosphere. Vapour scavenging is not yet well understood and is not integrated fully into the ISCST3 model. However, for informational purposes, the impact of vapour scavenging on both vapour concentration and total deposition has been reported.

Wet deposition flux depends on the fraction of the time precipitation occurs and the fraction of material removed by precipitation per unit of time by particle size. The ISCST3 model uses a scavenging ratio approach which is the product of the scavenging coefficient and precipitation rate. The scavenging coefficient depends on the size distribution for particles and the nature or form of the precipitation, i.e., liquid or frozen^(10,11).

Modelling Approach

For the deposition modelling of PCDD/PCDFs, both wet and dry particulate deposition were calculated. The modelling also incorporated wet and dry depletion into the calculations to ensure that the conservation of mass was maintained, as recommended by the USEPA.

For the particle-phase deposition, the congener profile from Table 1.22 and the vapour – particle partitioning from Table 1.23 were used to give the particulate emission rate of the respective dioxin congeners as determined in Table 1.27. The deposition flux for each congener was calculated by multiplying the emission rate of each congener by the unitised deposition flux as shown in Table 1.27 and diagrammatically in Figure 1.15. Results are shown under maximum operating conditions.

1.7.5 Comparison with Standards And Guidelines

Currently, no internationally recognised ambient air quality concentration or deposition standards exist for PCDD/PCDFs. Both the USEPA and WHO recommended approach to assessing the risk to human health from PCDD/PCDFs entails a detailed risk assessment analysis involving the determination of the impact of PCDD/PCDFs in terms of the TDI (Tolerable Daily Intake) approach^(19,20). A TDI has been defined by the WHO as “an estimate of the intake of a substance over a lifetime that is considered to be without appreciable health risk”⁽²⁰⁾. Occasional short term excursions above the TDI would have no health consequences provided the long-term average is not exceeded. The WHO currently proposes a maximum TDI of between 1-4 pgTEQ/kg of body weight per day. A TDI of 4 pgTEQ/kg of body weight per day should be considered a maximal tolerable intake on a provisional basis and that the ultimate goal is to reduce human intake levels of below 1 pgTEQ/kg of body weight per day. This reflects the concept that guidance values for the protection of human health should consider total exposure to the substance including air, water, soil, food and other media sources.

Table 1.20 The number of dioxin-like and total congeners within dioxin, furan, and coplanar PCB Homologue groups⁽¹⁾.

Homologue Group	n: Number of Dioxin-Like Congeners	N: Number of Congeners	1/N
I. Dioxins			
Tetra-CDD	1	22	0.022
Penta-CDD	1	14	0.071
Hexa-CDD	3	10	0.100
Hepta-CDD	1	2	0.500
Octa-CDD	1	1	1.000
II. Furans			
Tetra-CDF	1	38	0.026
Penta-CDF	2	28	0.036
Hexa-CDF	4	16	0.063
Hepta-CDF	2	4	0.250
Octa-CDF	1	1	1.000
III. Mono-ortho coplanar PCBs			
Tetrachloro-PCBs	1	42	0.024
Pentachloro-PCBs	5	46	0.022
Hexachloro-PCBs	4	42	0.024
Heptachloro-PCBs	3	24	0.042

(1) USEPA (2000) Estimating Exposure to Dioxin-Like Compounds Volume II, Chapter 3

Table 1.21 The TEF scheme for TEQ_{DFP}-WHO₉₈ and I-TEQ_{DF}⁽¹⁾.

Dioxin Congeners	TEF	Furan Congeners	TEF
2,3,7,8-TCDD	1.0	2,3,7,8-TCDF	0.1
1,2,3,7,8-PeCDD	1.0 (0.5) ⁽²⁾	1,2,3,7,8-PeCDF	0.05
1,2,3,4,7,8-HxCDD	0.1	2,3,4,7,8-PeCDF	0.5
1,2,3,6,7,8-HxCDD	0.1	1,2,3,4,7,8-HxCDF	0.1
1,2,3,7,8,9-HxCDD	0.1	1,2,3,6,7,8-HxCDF	0.1
1,2,3,4,6,7,8-HpCDD	0.01	1,2,3,7,8,9-HxCDF	0.1
OCDD	0.0001 (0.001) ⁽²⁾	2,3,4,6,7,8-HxCDF	0.1
PCB Chemical Structure	TEF	1,2,3,4,6,7,8-HpCDF	0.01
3,3',4,4'-TeCB	0.0001	1,2,3,4,7,8,9-HpCDF	0.01
3,4,4',5-TCB	0.0001	OCDF	0.0001 (0.001) ⁽²⁾
2,3,3',4,4'-PeCB	0.0001		
2,3,4,4',5-PeCB	0.0005		
2,3',4,4',5-PeCB	0.0001		
2',3,4,4',5-PeCB	0.0001		
3,3',4,4',5-PeCB	0.1		
2,3,3',4,4',5-HxCB	0.0005		
2,3,3',4,4',5'-HxCB	0.0005		
2,3',4,4',5,5'-HxCB	0.00001		
3,3',4,4',5,5'-HxCB	0.01		
2,3,3',4,4',5,5'-HpCB	0.0001		

(1) USEPA (2000) Estimating Exposure to Dioxin-Like Compounds Volume II, Chapter 1

(2) Values in parentheses are those given in Annex 1, Council Directive 2000/76/EC and equate to I-TEQ_{DF}.

Table 1.22 PCDD/PCDF Relative Emission Factors for Municipal Waste Incinerator (MB-Ref WS)⁽¹⁾

	Emission Factor (relative to sum of toxic congeners)	Emission Concentration (ng/m ³ from stack)	Emission Factor (ng/sec from stack)
Congener Group	Nondetects set to zero	Nondetects set to zero	Nondetects set to zero
2,3,7,8-TCDD	0.0009	0.00231	0.09663
1,2,3,7,8-PeCDD	0.0068	0.00896	0.37559
1,2,3,4,7,8-HxCDD	0.0117	0.00307	0.12880
1,2,3,6,7,8-HxCDD	0.0235	0.00620	0.25975
1,2,3,7,8,9-HxCDD	0.0284	0.00747	0.31281
1,2,3,4,6,7,8-HpCDD	0.2063	0.00543	0.22757
OCDD	0.3152	0.00083	0.03477
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2,3,7,8-TCDF	0.0310	0.00817	0.34222
1,2,3,7,8-PeCDF	0.0062	0.00082	0.03438
2,3,4,7,8-PeCDF	0.0163	0.02150	0.90081
1,2,3,4,7,8-HxCDF	0.0484	0.01275	0.53433
1,2,3,6,7,8-HxCDF	0.0161	0.00423	0.17705
1,2,3,7,8,9-HxCDF	0.0032	0.00085	0.03553
2,3,4,6,7,8-HxCDF	0.0535	0.01409	0.59045
1,2,3,4,6,7,8-HpCDF	0.0878	0.00231	0.09680
1,2,3,4,7,8,9-HpCDF	0.0267	0.00070	0.02950
OCDF	0.1178	0.00031	0.01300
Total PCDD/PCDF	1.0	0.1 ng/m³	4.19 ng/sec

(1) Database of Sources of Environmental Releases of Dioxin-Like Compounds in the United States (1998, USEPA (CD-ROM)).

Table 1.23 PCDD/PCDF Particle Fraction, Φ , at 10°C In Airshed (Background plus Local Sources)⁽¹⁾

Congener Group	E-Hp ^o _L (25°C)	E-Hp ^o _L (10°C) ⁽²⁾	Particle Fraction
2,3,7,8-TCDD	1.14 x 10 ⁻⁴	1.87 x 10 ⁻⁵	0.763
1,2,3,7,8-PeCDD	1.74 x 10 ⁻⁵	2.47 x 10 ⁻⁶	0.961
1,2,3,4,7,8-HxCDD	3.96 x 10 ⁻⁶	4.98 x 10 ⁻⁷	0.992
1,2,3,6,7,8-HxCDD	3.96 x 10 ⁻⁶	4.98 x 10 ⁻⁷	0.992
1,2,3,7,8,9-HxCDD	3.96 x 10 ⁻⁶	4.98 x 10 ⁻⁷	0.992
1,2,3,4,6,7,8-HpCDD	1.02 x 10 ⁻⁶	1.18 x 10 ⁻⁷	0.998
OCDD	2.77 x 10 ⁻⁷	2.91 x 10 ⁻⁸	0.9995
2,3,7,8-TCDF	1.23 x 10 ⁻⁴	2.01 x 10 ⁻⁵	0.75
1,2,3,7,8-PeCDF	3.64 x 10 ⁻⁵	5.46 x 10 ⁻⁶	0.917
2,3,4,7,8-PeCDF	2.17 x 10 ⁻⁵	3.11 x 10 ⁻⁶	0.951
1,2,3,4,7,8-HxCDF	8.09 x 10 ⁻⁶	1.09 x 10 ⁻⁶	0.982
1,2,3,6,7,8-HxCDF	8.09 x 10 ⁻⁶	1.09 x 10 ⁻⁶	0.982
1,2,3,7,8,9-HxCDF	4.99 x 10 ⁻⁶	6.49 x 10 ⁻⁷	0.989
2,3,4,6,7,8-HxCDF	4.99 x 10 ⁻⁶	6.49 x 10 ⁻⁷	0.989
1,2,3,4,6,7,8-HpCDF	2.24 x 10 ⁻⁶	2.77 x 10 ⁻⁷	0.995
1,2,3,4,7,8,9-HpCDF	1.31 x 10 ⁻⁶	1.56 x 10 ⁻⁷	0.9974
OCDF	2.60 x 10 ⁻⁷	2.71 x 10 ⁻⁸	0.9995

(1) USEPA (2000) Estimating Exposure to Dioxin-Like Compounds Volume II, Chapter 3

(2) Background plus local sources default values: $\Theta = 3.5 \times 10^{-6} \text{ cm}^2 \text{ aerosol/cm}^3 \text{ air}$, TSP = 42 $\mu\text{g/m}^3$.

Table 1.24 Generalized Particle Size Distribution & Proportion of Available Surface Area⁽¹⁾

Mean Particle Diameter (μm)	Particle Radius (μm)	Surface Area/Volume (μm^{-1})	Fraction of Total Mass ⁽²⁾	Proportion Available Surface Area	Fraction of Total Surface Area ⁽³⁾
>15.0	7.50	0.400	0.128	0.0512	0.0149
12.5	6.25	0.480	0.105	0.0504	0.0146
8.1	4.05	0.741	0.104	0.0771	0.0224
5.5	2.75	1.091	0.073	0.0796	0.0231
3.6	1.80	1.667	0.103	0.1717	0.0499
2.0	1.00	3.000	0.105	0.3150	0.0915
1.1	0.55	5.455	0.082	0.4473	0.1290
0.7	0.40	7.500	0.076	0.5700	0.1656
>0.7	0.40	7.500	0.224	1.6800	0.4880

(1) USEPA (1998) Chapter 3: Air Dispersion and Deposition Modelling, Human Health Risk Assessment Protocol, Region 6 Centre for Combustion Science and Engineering

(2) Used in the deposition modelling of metals (except Hg)

(3) Used in the deposition modelling of PCDD/PCDFs and Hg.

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1.7.6 Modelling Results

Tables 1.25 – 1.29 details the predicted PCDD/PCDFs GLC and deposition flux for the maximum scenario.

Table 1.25 PCDD/PCDF Annual Vapour Concentrations & Wet Vapour Deposition (Based on a Default MWI Profile (MB-Ref WS)) Under Maximum Operating Conditions

Congener Group	Vapour Fraction	Vapour Emission Rate (ng/sec)	Annual Vapour Concentration (fg/m ³)	Annual Wet Vapour Deposition (ng/m ²)
2,3,7,8-TCDD	0.237	0.02290	0.02769	0.00653
1,2,3,7,8-PeCDD	0.039	0.01465	0.01771	0.00417
1,2,3,4,7,8-HxCDD	0.008	0.00103	0.00125	0.00029
1,2,3,6,7,8-HxCDD	0.008	0.00208	0.00251	0.00059
1,2,3,7,8,9-HxCDD	0.008	0.00250	0.00303	0.00071
1,2,3,4,6,7,8-HpCDD	0.002	0.00046	0.00055	0.00013
OCDD	0.0005	0.00002	0.00002	0.000005
2,3,7,8-TCDF	0.25	0.08556	0.10344	0.02438
1,2,3,7,8-PeCDF	0.083	0.00285	0.00345	0.00081
2,3,4,7,8-PeCDF	0.049	0.04414	0.05337	0.01258
1,2,3,4,7,8-HxCDF	0.018	0.00962	0.01163	0.00274
1,2,3,6,7,8-HxCDF	0.018	0.00319	0.00385	0.00091
1,2,3,7,8,9-HxCDF	0.011	0.00039	0.00047	0.00011
2,3,4,6,7,8-HxCDF	0.011	0.00649	0.00785	0.00185
1,2,3,4,6,7,8-HpCDF	0.005	0.00048	0.00059	0.00014
1,2,3,4,7,8,9-HpCDF	0.0026	0.00008	0.00009	0.00002
OCDF	0.0005	0.00001	0.00001	0.000002
Sum			0.24 fg/m³	0.056 ng/m²

Table 1.26 PCDD/PCDF Annual Particulate Concentrations (Based on a Default MWI Profile (MB-Ref WS)) Under Maximum Operating Conditions

Congener Group	Particulate Fraction	Particulate Emission Rate (ng/sec)	Annual Particulate Concentration (fg/m ³)
2,3,7,8-TCDD	0.763	0.07373	0.08737
1,2,3,7,8-PeCDD	0.961	0.36094	0.42772
1,2,3,4,7,8-HxCDD	0.992	0.12777	0.15141
1,2,3,6,7,8-HxCDD	0.992	0.25767	0.30534
1,2,3,7,8,9-HxCDD	0.992	0.31030	0.36771
1,2,3,4,6,7,8-HpCDD	0.998	0.22712	0.26914
OCDD	0.9995	0.03475	0.04118
2,3,7,8-TCDF	0.75	0.25667	0.30415
1,2,3,7,8-PeCDF	0.917	0.03153	0.03736
2,3,4,7,8-PeCDF	0.951	0.85667	1.01516
1,2,3,4,7,8-HxCDF	0.982	0.52472	0.62179
1,2,3,6,7,8-HxCDF	0.982	0.17387	0.20603
1,2,3,7,8,9-HxCDF	0.989	0.03514	0.04164
2,3,4,6,7,8-HxCDF	0.989	0.58395	0.69199
1,2,3,4,6,7,8-HpCDF	0.995	0.09632	0.11414
1,2,3,4,7,8,9-HpCDF	0.9974	0.02943	0.03487
OCDF	0.9995	0.01299	0.01539
Sum			4.73 fg/m³

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Table 1.27 PCDD/PCDF Annual Particulate Deposition Fluxes (Based on a Default MWI Profile (MB-Ref WS)) Under Maximum Operating Conditions

Congener Group	Particulate Emission Rate (ng/sec)	Dry Particulate Deposition Flux (ng/m ²)	Wet Particulate Deposition Flux (ng/m ²)	Combined Particulate Deposition Flux (ng/m ²)
2,3,7,8-TCDD	0.07373	0.01710	0.01423	0.02064
1,2,3,7,8-PeCDD	0.36094	0.08374	0.06966	0.10106
1,2,3,4,7,8-HxCDD	0.12777	0.02964	0.02466	0.03578
1,2,3,6,7,8-HxCDD	0.25767	0.05978	0.04973	0.07215
1,2,3,7,8,9-HxCDD	0.31030	0.07199	0.05989	0.08688
1,2,3,4,6,7,8-HpCDD	0.22712	0.05269	0.04383	0.06359
OCDD	0.03475	0.00806	0.00671	0.00973
2,3,7,8-TCDF	0.25667	0.05955	0.04954	0.07187
1,2,3,7,8-PeCDF	0.03153	0.00731	0.00608	0.00883
2,3,4,7,8-PeCDF	0.85667	0.19875	0.16534	0.23987
1,2,3,4,7,8-HxCDF	0.52472	0.12173	0.10127	0.14692
1,2,3,6,7,8-HxCDF	0.17387	0.04034	0.03356	0.04868
1,2,3,7,8,9-HxCDF	0.03514	0.00815	0.00678	0.00984
2,3,4,6,7,8-HxCDF	0.58395	0.13548	0.11270	0.16351
1,2,3,4,6,7,8-HpCDF	0.09632	0.02235	0.01859	0.02697
1,2,3,4,7,8,9-HpCDF	0.02943	0.00683	0.00568	0.00824
OCDF	0.01299	0.00301	0.00251	0.00364
Sum		0.93 ng/m²	0.77 ng/m²	1.12 ng/m²
Equivalent Daily Deposition Flux		2.55 pg/m²/day	2.11 pg/m²/day	3.07 pg/m²/day

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Table 1.28 Dispersion Model Summary of Combined Vapour and Particulate Concentrations – PCCD/PCDFs.

Pollutant / Scenario	Annual Mean Background ⁽¹⁾ (pg/m ³)	Averaging Period	Process Contribution (pg/m ³)	Predicted Emission Concentration (pg/Nm ³)
PCCD/PCDFs / Maximum	0.028	Annual Average	0.005	0.033
	0.046			0.051
PCCD/PCDFs / Typical	0.028	Annual Average	0.0004	0.0284
	0.046			0.0464

⁽¹⁾ Baseline results for dioxins given as sum of cumulative impacts (in the absence of Indaver Ireland) and baseline monitoring data firstly as (i) Non-detects = zero, (ii) Non-detects = limit of detection.

Table 1.29 Deposition Model Summary of Combined Particulate Deposition Flux – PCCD/PCDFs.

Pollutant / Scenario	Averaging Period	Process Contribution (pg/m ² /day)	Predicted Total Particulate Deposition Flux (pg/m ² /day)
PCCD/PCDFs / Maximum	Annual Average	3.07	3.07

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Table 1.30 I-TEQ values derived from measurements of airborne dioxins in various locations.

Location	Site Type	I-TEQ ⁽¹⁾ (fg/m ³)
Kilcock, Co. Meath (1998) ⁽²⁾	Rural	Range 2.8 – 7
Ireland ⁽²⁾	Baseline	Mean – 26
	Potential Impact Areas	Mean – 49
Ringaskiddy (2001) ⁽³⁾	Rural	Range 4 – 16
Germany (1992) ⁽⁴⁾	Rural	< 70
	Urban	71 – 350
	Close to Major Source	351 – 1600
UK ⁽⁵⁾	London (1993)	Mean – 50
	Manchester (1993)	Mean – 100
	Cardiff (1993)	Mean – 100
	Stevenage (1993)	Mean – 70
Sweden ⁽⁵⁾	Urban/Suburban	13 – 24
	Remote/Coastal	3 – 4
Manchester (1999) ⁽⁶⁾	Urban	Lower Limit – 16 ⁽⁷⁾
Middlesbrough (1999) ⁽⁶⁾	Urban	Lower Limit – 7.9 ⁽⁷⁾
Hazelrigg (1999) ⁽⁶⁾	Semi-rural	Lower Limit – 2.8 ⁽⁷⁾
Stoke Ferry (1999) ⁽⁶⁾	Rural	Lower Limit – 1.9 ⁽⁷⁾
High Muffles (1999) ⁽⁶⁾	Rural	Lower Limit – 0.26 ⁽⁷⁾
Ringaskiddy (2001)	Industrial	Lower Limit – 4.0 ⁽⁷⁾ Upper Limit – 16.4 ⁽⁸⁾

(1) I-TEQ_{DF} values based on NATO/CCMS (1988) and as used in Annex 1, Council Directive 2000/76/EC.

(2) Taken from Chapter 8 of Thermal Waste Treatment Plant, Kilcock EIS, Air Environment (1998)

(3) Taken from Chapter 9 of Waste Management Facility, Indaver Ireland Ringaskiddy EIS, Baseline Dioxin Survey (2001)

(4) Raffe, C (1996) Sources and environmental concentrations of dioxins and related compounds, *Pure & Appl. Chem* Vol. 68, No. 9, pp 1781-1789

(5) Duarte-Davidson et al (1994) Polychlorinated Dibenzo-*p*-Dioxins (PCDDs) and Furans (PCDFs) in Urban Air and Deposition, *Environ. Sci. & Pollut. Res.*, 1 (4), 262-270

(6) Taken from TOMPS Network website, WWW.aeat.co.uk/netcen/airqual.

(7) Lower Limit TEQ calculated assuming non-detects are equal to zero.

(8) Upper limit assuming non-detects are equal to limit of detection.

Table 1.31 Mean I-TEQ Deposition Fluxes Of Dioxins In Various Locations

Location	Site Type	Mean I-TEQ ⁽¹⁾ (pg/m ² / day)
Germany (1992) ⁽²⁾	Rural	5 -22
	Urban	10 – 100
	Close to Major Source	123 - 1293
UK ⁽³⁾	Stevenage	3.2
	London	5.3
	Cardiff	12
	Manchester	28

(1) I-TEQ_{DF} values based on NATO/CCMS (1988) and as used in Annex 1, Council Directive 2000/76/EC.

(2) Raffe, C (1996) Sources and environmental concentrations of dioxins and related compounds, *Pure & Appl. Chem* Vol. 68, No. 9, pp 1781-1789

(3) Duarte-Davidson et al (1994) Polychlorinated Dibenzo-*p*-Dioxins (PCDDs) and Furans (PCDFs) in Urban Air and Deposition, *Environ. Sci. & Pollut. Res.*, 1 (4), 262-270

1.7.7 Concentration Contours

The geographical variation in PCCD/PCDFs ground level concentrations and deposition fluxes beyond the site boundary are illustrated as concentration contours in Figures 1.16-1.19. The content of the figure is described below.

Figure 1.16 Maximum Operations: Predicted PCCD/PCDFs Annual Average Vapour Concentration

Figure 1.17 Maximum Operations: Predicted PCCD/PCDFs Annual Average Particulate Concentration

Figure 1.18 Maximum Operations: Predicted PCCD/PCDFs Annual Average Wet Gas Deposition

Figure 1.19 Maximum Operations: Predicted PCCD/PCDFs Annual Average Total Particulate Deposition

1.7.8 Result Findings

Background levels of PCDD/PCDFs occur everywhere and existing levels in the surrounding area have been extensively monitored as part of this study. Modelling results indicate that the existing levels are significantly lower than urban areas and typical of rural areas in the UK and Continental Europe. The contribution from the site in this context is minor with levels under maximum operation remaining significantly below levels which would be expected in urban areas even at the worst-case boundary receptor to the south of the site (see Table 1.30). Levels at the nearest residential receptor will be minor, with the annual contribution from Indaver Ireland accounting for less than 10% of the existing background concentration under maximum operating conditions.

Shown in Table 1.29 is the maximum dioxin deposition rate. Modelled total dioxin particulate deposition flux indicate that deposition levels would be expected to be significantly less than that experienced in urban locations and similar to rural locations (< 5 pg/m²/day) (see Table 1.31).

1.8 Mercury

1.8.1 Mercury's Environmental Transport & Fate

Mercury exists in three oxidation states; metallic or elemental (Hg⁰); mercurous (Hg₂²⁺); and mercuric (Hg²⁺). Elemental Hg is a liquid at room temperature with low volatility. Other forms of mercury are solids with low vapour pressures. It is naturally occurring and cycles between the atmosphere, land and water through a series of complex transformations. Elemental mercury is the most common form of mercury found in the atmosphere whereas in all other environmental media, mercury is found in the form of inorganic mercuric salts and organo-mercury compounds⁽²¹⁾.

USEPA methodology relating to waste-to-energy plants assumes that stack emissions containing mercury include both vapour and particle-bound phases. Additionally, the USEPA assumes that mercury exits the stack in only the elemental and divalent species. Of the total mercury in the stack, 80% is estimated to be in the vapour phase and 20% is particle-bound. In addition, the USEPA assumes that speciation of the total mercury is 80% divalent (20% in the

particle-bound and 60% in the vapour phase) and 20% elemental (all 20% in the vapour phase)⁽²¹⁾. Although the USEPA allows a loss to the global cycle for each form of mercury (99% of the elemental vapour form, 32% of the divalent vapour form, and 64% of the particle-bound form are assumed lost to the global cycle and do not deposit within the localized study area), this has not been incorporated into the current assessment in keeping with the worst-case approach adopted in this assessment.

1.8.2 Modelling Strategy

The emissions of mercury from the waste-to-energy plant have been evaluated in terms of mass of release into both vapour and particle-bound phases. Thereafter, air dispersion and deposition modelling has been employed to translate these releases to ambient air vapour and particle phase concentrations, and wet vapour & wet and dry particulate deposition amounts, in the vicinity of the release. Both typical and maximum scenarios have been modelled as outlined in Table 1.32

Vapour / Particulate Partitioning

In order to adequately model dispersion and deposition of mercury, modelling of both vapour and particle-bound states is thus necessary. For the vapour phase modelling, no dry deposition was assumed, as recommended by the USEPA^(11,21). Using the vapour – particle partitioning described in Section 1.8.2, the vapour concentrations of mercury was determined as outlined in Table 1.33. Results are shown under maximum operating conditions.

When modelling mercury (Hg) the surface area weighting rather than mass weighting is used for deposition. The surface weighting reflects the mode of formation where volatiles condense on the surface of particulates in the flue gas cleaning system (see Column 6 of Table 1.24). Thus, the apportionment of emissions by particle size becomes a function of the surface area of the particle which is available for chemical adsorption.

For the particle-phase concentration, the vapour – particle partitioning described in Section 1.8.2 was used to give the particulate concentrations of mercury as determined in Table 1.34. Results are shown under both maximum and typical operating conditions.

1.8.3 Deposition Modelling of Particulates

In order to model dry deposition, using ISCST3, the generalised particle-size distribution recommended by the USEPA has been used as outlined in Table 1.24⁽¹¹⁾. This distribution is suitable as a default for some combustion facilities equipped with either ESPs or fabric filters (such as the current case), because the distribution is relatively typical of particle size arrays that have been measured at the outlet to advanced equipment designs. As described above, the particles are apportioned based on the fraction of available surface area (see Column 6 of Table 1.24).

Dry gaseous deposition, although considered in the ISCST3 model, has not been adequately calibrated for the estimation of the deposition flux into vegetation and thus the USEPA has recommended that this algorithm should not be used for site-specific applications⁽¹⁰⁾.

Wet Deposition

Wet deposition physically washes out the chemically contaminated particulate and vapours from the atmosphere. The impact of vapour scavenging on both vapour concentration and deposition has been reported.

Wet deposition flux depends on the fraction of the time precipitation occurs and the fraction of material removed by precipitation per unit of time by particle size. The ISCST3 model uses a scavenging ratio approach which is the product of the scavenging coefficient and precipitation rate. The scavenging coefficient depends on the size distribution for particles and the nature or form of the precipitation, i.e., liquid or frozen.

Modelling Approach

For the deposition modelling of mercury both wet and dry particulate deposition were calculated in addition to wet vapour deposition. The modelling also incorporated wet and dry depletion into the calculations to ensure that the conservation of mass was maintained, as recommended by the USEPA⁽¹¹⁾. Results are shown in Tables 1.34 and 1.35 for both maximum and typical operating conditions.

For the particle-phase deposition, the emission rate of particle bound mercury was multiplied by the unitised deposition flux as shown in Tables 1.36 and 1.37.

Table 1.32 Emission Scenario for Mercury

Pollutant	Scenario	Emission Concentration	Emission Rate (g/s)
Hg	Max	0.05 mg/m ³	0.002
	Typical	0.025 mg/m ³	0.00088

1.8.4 Comparison With Standards And Guidelines

Predicted GLCs have been compared with the applicable WHO ambient air quality guideline for mercury as set out in Table 1.33.

Table 1.33 Hg Ambient Air Quality Standards & Guidelines

Pollutant	Regulation	Limit Type	Value
Inorganic Mercury (as Hg)	WHO	Annual Average	1.0 µg/m ³

1.8.5 Modelling Results

Tables 1.34 – 1.38 details the predicted mercury GLC for each vapour and particulate concentration and deposition scenario.

Table 1.34 Mercury Vapour Concentrations Under Both Maximum and Typical Operating Conditions

Oxidation State	Vapour Fraction	Vapour Emission Rate (g/sec)	Vapour Concentration ($\mu\text{g}/\text{m}^3$)
Elemental Hg	0.20	Maximum - 0.00040	0.00048
Divalent Hg^{2+}	0.60	Maximum - 0.00120	0.00145
Sum			0.0019 $\mu\text{g}/\text{m}^3$
Elemental Hg	0.20	Typical - 0.00018	0.00025
Divalent Hg^{2+}	0.60	Typical - 0.00053	0.00076
Sum			0.0010 $\mu\text{g}/\text{m}^3$

Table 1.35 Mercury Particulate Concentrations Under Both Maximum & Typical Operating Conditions

Oxidation State	Particulate Fraction	Particulate Emission Rate (g/sec)	Particulate Concentration ($\mu\text{g}/\text{m}^3$)
Divalent Hg^{2+}	0.20	Maximum - 0.00040	0.00047
Divalent Hg^{2+}	0.20	Typical - 0.00018	0.00025

Table 1.36 Mercury Deposition Fluxes – Maximum Operating Conditions

Oxidation State	Fraction	Emission Rate (g/sec)	Annual Deposition Flux ($\mu\text{g}/\text{m}^2$)
Elemental Hg	Wet Vapour	0.00040	114
Divalent Hg^{2+}	Wet Vapour	0.00120	342
Divalent Hg^{2+}	Dry particulate	0.00040	93
	Wet particulate		77
	Total particulate		112
Sum of Total Particulate & Vapour Deposition⁽¹⁾			568 $\mu\text{g}/\text{m}^2$

⁽¹⁾ Worst-case as maximum of total particulate deposition and wet vapour deposition are at different locations

Table 1.37 Mercury Deposition Fluxes – Typical Operating Conditions

Oxidation State	Fraction	Emission Rate (g/sec)	Annual Deposition Flux ($\mu\text{g}/\text{m}^2$)
Elemental Hg	Wet Vapour	0.00023	50
Divalent Hg^{2+}	Wet Vapour	0.00069	150
Divalent Hg^{2+}	Dry particulate	0.00023	45
	Wet particulate		34
	Total particulate		53
Sum of Total Particulate & Vapour Deposition⁽¹⁾			253 $\mu\text{g}/\text{m}^2$

⁽¹⁾ Worst-case as maximum of total particulate deposition and wet vapour deposition are at different locations

Table 1.38 Dispersion Model Summary Of Combined Vapour And Particulate Hg Concentrations Under Both Maximum And Typical Operating Conditions.

Pollutant / Scenario	Annual Mean Background ($\mu\text{g}/\text{m}^3$)	Averaging Period	Process Contribution ($\mu\text{g}/\text{m}^3$)	Predicted Emission Concentration ($\mu\text{g}/\text{Nm}^3$)	Standard ($\mu\text{g}/\text{Nm}^3$)
Hg / Maximum	0.005	Annual mean	0.0024	0.0074	0.1
Hg / Typical	0.005	Annual mean	0.0013	0.0063	0.1

⁽¹⁾ Baseline results for mercury including cumulative impact given as firstly (i) Non-detects = zero, (ii) Non-detects = limit of detection.

1.8.6 Concentration Contours

The geographical variation in vapour mercury ground level concentrations beyond the site boundary is illustrated as concentration contours in Figure 1.20. The geographical variation in mercury total particle-bound deposition beyond the site boundary is illustrated as concentration contours in Figure 1.21.

Figure 1.20 Maximum Operations: Predicted Mercury Annual Average Vapour Concentration

Figure 1.21 Maximum Operations: Predicted Mercury Annual Average Total Particle-Bound Deposition

1.8.7 Result Findings

Hg modelling results indicate that the ambient ground level concentrations are significantly below the WHO guideline under both typical and maximum operation of the site. Thus, no adverse environmental impact is envisaged to occur under these conditions at or beyond the site boundary. Emissions at maximum operations equate to ambient mercury combined concentration (both vapour and particle-bound) (excluding background concentrations) which are only 2% of the annual average limit value at the boundary of the site.

1.9 Heavy Metal Emissions and Results (excl. Mercury)

1.9.1 Modelling Approach

The emissions of heavy metals (except Hg) from the waste-to-energy plant have been evaluated in terms of mass of release into the particulate phase only as recommended by the USEPA^(10,11). Thereafter, air dispersion and deposition modelling has been employed to translate these releases to ambient particle phase concentrations, and wet and dry particulate deposition amounts, in the vicinity of the release.

When modelling heavy metals (except Hg) the mass weighting rather than surface weighting is used for deposition as it is assumed that the metals are all in the particulate state (see Column 4 of Table 1.24). Results are shown under both maximum and typical operating conditions.

Deposition Modelling of Particulates

For the deposition modelling of heavy metals (except Hg) both wet and dry particulate deposition were calculated. The modelling also incorporated wet and dry depletion into the calculations to ensure that the conservation of mass was maintained, as recommended by the USEPA⁽¹¹⁾.

Ambient ground level concentrations and deposition values (GLCs) of the Sum of antimony (Sb), arsenic (As), lead (Pb), chromium (Cr), cobalt (Co), copper (Cu), manganese (Mn), nickel (Ni) and vanadium (V) have been investigated using the concentration limits outlined in Council Directive 2000/76/EC (see Table 1.39) and using expected typical concentrations from the site.

In relation to cadmium (Cd), nickel (Ni) and arsenic (As), modelling has been carried out at concentrations which would be considered upper levels based on an existing similar Waste Management Facility. Data is available from a similar Indaver site in Belgium (see Table 1.40) indicating low emission levels of these metals and thus the modelled emission scenarios would be considered conservative upper emission levels.

Table 1.39 Emission Scenario for Heavy Metals Taken From Council Directive 2000/76/EC

Pollutant	Scenario	Concentration	Emission Rate (g/s)
Sum of Sb, As, Pb, Cr, Co, Cu, Mn, Ni and V	Max	0.5 mg/m ³	0.021
	Typical	0.25 mg/m ³	0.0088

Table 1.40 Actual Measured Emission Data From An Indaver Site In Belgium (mg/Nm³)

BEVEREN	Monitoring Period 1	Monitoring Period 2	Monitoring Period 3	Monitoring Period 4	Monitoring Period 5
Arsenic	0.013	<0.0080	<0.0060	<0.020	<0.013
Cadmium	<0.00040	<0.0010	0.0005	<0.0011	<0.00080
Nickel	<0.0040	<0.0050	<0.0050	0.0009	<0.010
BEVEREN	Monitoring Period 6	Monitoring Period 7	Monitoring Period 8	Monitoring Period 9	Monitoring Period 10
Arsenic	<0.010	<0.017	<0.0050	<0.017	<0.016
Cadmium	<0.00080	<0.0010	<0.00050	<0.0012	<0.0010
Nickel	0.001	0.002	<0.0040	0.0005	0.0008

1.9.2 Comparison with Standards And Guidelines

Predicted GLCs have been compared with the applicable ambient air quality guidelines and standards as set out in Table 1.41 and 1.42.

In the absence of statutory standards, ambient air quality guidelines can also be derived from occupational exposure limits (OEL). The OEL for each compound (where available) divided by an appropriate safety factor may be used. This factor accounts for increased exposure time and susceptibility of the general population in comparison to on-site personnel. The OEL can be expressed on the basis of two averaging periods; an eight-hour average and a fifteen-minute average (the short term exposure limit or STEL). The OEL (8-hour reference) divided by a factor of 100 may be applied to generate an ambient air quality guideline or Environmental Assessment Level (EAL) for comparison with predicted annual averages and the STEL divided by 40 may be applied for comparison with the one-hour concentrations.

Table 1.41 Cd and TI Ambient Air Quality Standards & Guidelines

Pollutant	Regulation	Limit Type	Value
Cd	TA Luft	Annual Average	0.04 µg/m ³
Cd	WHO	Annual Average	0.005 µg/m ³
Cd	EU	Annual Average	0.005 µg/m ³⁽¹⁾
TI	EAL	Annual Average	1.0 µg/m ³

(1) Proposed standard recommended by majority of the EU working group for setting emission factors⁽²⁾

Table 1.42 Sb, As, Pb, Cr, Co, Cu, Mn, Ni and V Ambient Air Quality Standards & Guidelines

Pollutant	Regulation	Limit Type	Value
Sb (organic compounds)	EAL	Maximum One-Hour	5 µg/m ³
Sb (organic compounds)	EAL	Annual Average	1.0 µg/m ³
As	WHO	Annual Average	0.005 µg/m ³
As	EU	Annual Average	0.004 µg/m ³⁽¹⁾
Pb	EU	Annual Average	0.5 µg/m ³
Cr (except VI)	EAL	Annual Average	5.0 µg/m ³
Cr (VI)	EAL	Annual Average	0.5 µg/m ³
Co	EAL	Annual Average	1.0 µg/m ³
Cu (fumes)	EAL	Annual Average	2.0 µg/m ³
Cu (dust & mists)	EAL	Annual Average	10 µg/m ³
Mn	WHO	Annual Average	0.15 µg/m ³
Mn (fume)	EAL	Maximum One-Hour	75 µg/m ³
Ni	EU	Annual Average	0.01 µg/m ³⁽¹⁾
V (fume & respirable dust)	EAL	Annual Average	0.4 µg/m ³
V	WHO	24-Hour Average	1.0 µg/m ³

(1) Proposed standard recommended by majority of the EU working group for setting emission factors⁽²²⁾

1.9.3 Modelling Results

Air dispersion and deposition modelling was carried out for the three scenarios described in Section 1.9.1. Table 1.43 outlines the expected emission levels and Table 1.44 – 1.46 details the predicted Cd & TI GLC and deposition value for each scenario and averaging period.

Table 1.43 Expected Maximum Emission Levels for Cd & TI

Heavy Metal	Limit Type	Value
Cd & TI	Expected Maximum Levels ⁽¹⁾	0.025 mg/m ³

(1) Based conservatively on upper limit of measured emission data from a similar site (see Table 1.40)

Table 1.44 Cd & Tl Particulate Concentrations Under Expected Maximum Levels

Heavy Metal	Emission Rate (g/sec)	Concentration ($\mu\text{g}/\text{m}^3$)
Cd & Tl	Expected Maximum Levels - 0.001	0.0012

Table 1.45 Cadmium Deposition Fluxes – Expected Maximum Levels

Heavy Metal	Fraction	Emission Rate (g/sec)	Annual Deposition Flux (g/m^2)
Cd & Tl / Expected Maximum Levels	Dry particulate	0.001	0.0011
	Wet particulate		0.0005
Sum of Total Deposition			0.0012 g/m^2

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Table 1.46 Cadmium & Thallium Particulate Concentration Summary

Heavy Metal	Annual Mean Background ⁽¹⁾ (µg/m ³)	Averaging Period	Process Contribution (µg/m ³)	Applicable PSD Increment (µg/Nm ³)	Predicted Emission Concentration (µg/Nm ³)	Standard ⁽³⁾ (µg/Nm ³)
Cd & Tl / Expected Maximum Level	< 0.012	Annual mean	0.0012	0.00125 ⁽²⁾	< 0.013	0.005
	< 0.023				< 0.024	

(1) Baseline results including cumulative impact given as firstly (i) Non-detects = 50% of limit of detection, (ii) Non-detects = limit of detection

(2) PSD Increment for a Class II Area – 25% of the applicable limit value

(3) Proposed standards recommended by majority of the EU working group for setting emission factors⁽²²⁾

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Tables 1.47 – 1.49 details the predicted GLC and deposition values for each scenario for the sum of Sb, Pb, Cr, Co, Cu, Mn and V.

Table 1.47 Sum of Sb, Pb, Cr, Co, Cu, Mn and V Particulate Concentrations Under Both Maximum & Typical Operating Conditions

Heavy Metal	Emission Rate (g/sec)	Maximum 1-hour Concentration ($\mu\text{g}/\text{m}^3$)	Maximum 24-hour Concentration ($\mu\text{g}/\text{m}^3$)	Annual Concentration ($\mu\text{g}/\text{m}^3$)
Sum of Sb, Pb, Cr, Co, Cu, Mn and V	Maximum - 0.021	0.77	0.27	0.023
Sum of Sb, Pb, Cr, Co, Cu, Mn and V	Typical - 0.0088	0.41	0.13	0.012

Table 1.48 Sum of Sb, Pb, Cr, Co, Cu, Mn and V Deposition Fluxes – Maximum and Typical Operating Conditions

Heavy Metal	Fraction	Emission Rate (g/sec)	Annual Deposition Flux (g/m^2)
Sum of Sb, Pb, Cr, Co, Cu, Mn and V / Maximum	Dry particulate	0.021	0.024
	Wet particulate		0.011
Sum of Total Deposition			0.026 g/m^2
Sum of Sb, Pb, Cr, Co, Cu, Mn and V / Typical	Dry particulate	0.0088	0.011
	Wet particulate		0.0044
Sum of Total Deposition			0.012 g/m^2

Table 1.49 Dispersion Model Results – Sum of Sb, Pb, Cr, Co, Cu, Mn and V

Heavy Metal / Scenario	Annual Mean Background ($\mu\text{g}/\text{m}^3$) ⁽¹⁾	Averaging Period	Process Contribution ($\mu\text{g}/\text{m}^3$)	Predicted Emission Concentration ($\mu\text{g}/\text{Nm}^3$)	Standard ($\mu\text{g}/\text{Nm}^3$)
Sum of metals / Maximum	0.012 ⁽²⁾	Annual mean	0.023	0.035	0.15 ⁽³⁾
Sum of metals / Maximum	0.024 ⁽⁴⁾	Maximum One-Hour	0.77	0.79	5.0 ⁽⁵⁾
Sum of metals / Typical	0.012 ⁽²⁾	Annual mean	0.012	0.024	0.15 ⁽³⁾
Sum of metals / Typical	0.024 ⁽⁴⁾	Maximum One-Hour	0.41	0.43	5.0 ⁽⁵⁾

(1) Baseline results for metal including cumulative impact given as firstly (i) Non-detects = zero, (ii) Non-detects = limit of detection.

(2) Background concentration for manganese including cumulative impact

(3) Ambient standard for manganese which is the most stringent applicable limit value for this averaging period

(4) Background concentration for antimony including cumulative impact

(5) Ambient standard for antimony which is the most stringent applicable limit value for this averaging period.

In relation to nickel (Ni) and arsenic (As), modelling has been carried out at concentrations which would be considered upper levels based on data from an existing Waste Management Facility. Data is available from a similar Indaver site in Belgium (see Table 1.40) which indicates typically low levels of these metals and thus the modelled emission scenarios would be considered conservative upper emission levels. Table 1.50 outlines the expected emission levels and Table 1.51 – 1.53 outlines the corresponding ambient concentrations and deposition rates which will result from emissions at these levels.

Table 1.50 Expected Maximum Emission Levels for As and Ni

Heavy Metal	Limit Type	Value
Arsenic	Expected Maximum Emission Levels ⁽¹⁾	0.015 mg/m ³
Nickel	Expected Maximum Emission Levels ⁽¹⁾	0.015 mg/m ³

(1) Based conservatively on upper limit of measured emission data from a similar site (see Table 1.40)

Table 1.51 Particle-phase Concentrations Under Expected Maximum Emission Levels

Heavy Metal	Emission Rate (g/sec)	Concentration (µg/m ³)
As	0.00063	0.0008
Ni	0.00063	0.0008

Table 1.52 Deposition Fluxes - Expected Maximum Emission Levels

Heavy Metal	Fraction	Emission Rate (g/sec)	Annual Deposition Flux (g/m ²)
As	Dry particulate	0.00063	0.0007
	Wet particulate		0.0003
Sum of Total Deposition			0.0008 g/m²
Ni	Dry particulate	0.00063	0.0007
	Wet particulate		0.0003
Sum of Total Deposition			0.0008 g/m²

Table 1.53 Particle Phase Concentration Under Expected Maximum Emission Levels for Arsenic and Nickel

Heavy Metal	Annual Mean Background ⁽¹⁾ ($\mu\text{g}/\text{m}^3$)	Averaging Period	Process Contribution ($\mu\text{g}/\text{m}^3$)	Applicable PSD Increment ($\mu\text{g}/\text{Nm}^3$)	Predicted Emission Concentration ($\mu\text{g}/\text{Nm}^3$)	Standard ⁽³⁾ ($\mu\text{g}/\text{Nm}^3$)
As / Expected Maximum Level	< 0.01	Annual mean	0.0008	0.0010 ⁽²⁾	< 0.0108	0.004
	< 0.02				< 0.0208	
Ni / Expected Maximum Level	0.006	Annual mean	0.0008	0.0025 ⁽²⁾	0.0068	0.010
	0.005				0.0058	

(1) Baseline results including cumulative impact given as firstly (i) Non-detects = zero, (ii) Non-detects = limit of detection

(2) PSD Increment for a Class II Area – 25% of the applicable limit value

(3) Proposed standards recommended by majority of the EU working group for setting emission factors⁽²²⁾

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1.9.4 Concentration Contours

The geographical variations in heavy metal ground level concentrations and deposition flux beyond the site boundary are illustrated as a concentration and deposition contours in Figures 1.22 to 1.28. The figure has been expressed as a percentage of the appropriate ambient air quality guideline. The content of the figure is described below.

Figure 1.22 Expected Maximum Levels: Predicted Cd Annual Average Concentration

Figure 1.23 Expected Maximum Levels: Predicted Cd Annual Deposition Flux

Figure 1.24 Maximum Operations: Predicted Sum of Sb, Pb, Cr, Co, Cu, Mn and V Annual Average Concentration

Figure 1.25 Expected Maximum Levels: Predicted As Annual Average Concentration

Figure 1.26 Expected Maximum Levels: Predicted As Annual Deposition Flux

Figure 1.27 Expected Maximum Levels: Predicted Ni Annual Average Concentration

Figure 1.28 Expected Maximum Levels: Predicted Ni Annual Deposition Flux

1.9.5 Result Findings

Cd and TI

Modelling results indicate that the ambient ground level concentrations will be below the relevant air quality standards for cadmium under expected maximum levels (based on data from a similar site in Belgium) from the site. Emissions at expected maximum levels equate to ambient Cd concentrations (excluding background concentrations) which are 24% of the suggested annual limit value close to the site boundary. In addition, levels from Indaver Ireland are below the respective PSD increment (less than 25% of the ambient limit value).

Sum of Sb, Pb, Cr, Co, Cu, Mn and V

Modelling results indicate that the ambient ground level concentrations are below the relevant air quality standards for manganese and antimony (the metals with the most stringent limit values) under both typical and maximum emissions from the site. Thus, no adverse environmental impact is envisaged to occur under these conditions at or beyond the site boundary. Emissions at maximum operations equate to ambient Mn concentrations (excluding background concentrations) which are 23% of the annual limit value at the worst-case boundary receptor whilst emissions at maximum operations equate to ambient Sb concentrations (excluding background concentrations) which are only 16% of the maximum 1-hour limit value at the worst-case boundary receptor.

As

Modelling results indicate that the ambient ground level concentrations will be below the relevant air quality standards for arsenic under expected maximum levels (based on data from a similar site in Belgium) from the site. Thus, no adverse environmental impact is envisaged to occur under these conditions at or beyond the site boundary. Emissions at expected maximum levels equate to ambient As concentrations (excluding background concentrations) which are 20% of the suggested annual EU limit value at the site boundary. Background concentrations of As were monitored over a one-month period. However, the monitoring methodology's detection limits could not achieve the stringent limits of the proposed ambient standard for As. However, no significant local sources of this compound could be identified in a detailed cumulative assessment of nearby sources. Thus, it may be expected that background levels of this compound are likely to be minor.

Ni

Modelling results indicate that the ambient ground level concentrations (excluding background concentrations) will be below the relevant air quality standards for nickel at the expected maximum levels from the site. Emissions at these levels (based on data from a similar site in Belgium) equate to ambient Ni concentrations (excluding background concentrations) which are 8% of the suggested annual EU limit value at the site boundary. In addition, levels from Indaver Ireland are below the respective PSD increment (less than 25% of the ambient limit value).

1.9.6 Summary Of Impacts

Based on the emission guidelines outlined in Council Directive 2000/76/EC an appropriate stack height has been determined through detailed air dispersion modelling to ensure that the most stringent ambient air quality standards are not exceeded. In respect of Cd, As and Ni, individual expected maximum levels have been derived (based on data from a similar site in Belgium) which would be considered conservative upper emission levels.

The modelling results indicate that the maximum ambient GLC occurs at or near the site's northern and eastern boundaries. Concentrations fall off rapidly away from this maximum and for the short-term limit values at the nearest residential receptors will be less than 30% of the worst-case concentration. The annual average concentration has an even more dramatic decrease in maximum concentration away from the site with concentrations from emissions at Indaver Ireland accounting for less than 6% of the limit value (not including background concentrations) at worst case sensitive receptors near the site. Thus, the results indicate that the impact from Indaver Ireland is minor and limited to the immediate environs of the site.

In the surrounding main population centres, Duleek and Drogheda, levels are significantly lower than background sources with the concentrations from emissions at Indaver Ireland accounting for less than 1% of the annual limit values for most pollutants.