Environmental RTDI Programme 2000 – 2006

INVENTORY OF DIOXIN & FURAN EMISSIONS TO AIR, LAND AND WATER IN IRELAND FOR 2000 AND 2010

Final Report

Prepared for the Environmental Protection Agency

By

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DISCLAIMER

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INVENTORY OF DIOXIN & FURAN EMISSIONS TO AIR, LAND AND WATER IN IRELAND FOR 2000 & 2010

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ACRONYMS

µg: Micrograms;
BE: Best Estimate;
BIM: Bord Iascaigh Mhara (Irish Sea Fisheries Board);
EAF: Electric Arc Furnace;
EU: European Union;
g: grams;
HFO: Heavy Fuel Oil;
HMIP: Her Majesty's Inspectorate of Pollution;
IPC: Integrated Pollution Control;
Ireland: Republic of Ireland
KJ: Kilojoules;
LUA: Landesumweltamt;
m^3: Cubic metre;
MDF: Medium Density Fibreboard;
mg: Milligrams;
MJ: Megajoules;
MTOE: Million Tonnes of Oil Equivalent;
MW: Megawatts;
NA: Not applicable
ND: Not determined
ng: Nanograms;
Nm^3: Normalised cubic metre (at standard temperature (0 ^{o}C) and pressure (101.3 kPa));
NRA: National Roads Authority;
PCB: Polychlorinated biphenyls;
PCDD: Polychlorinated dibenzo-p-dioxins;
PCDF: Polychlorinated dibenzo-p-furans;
PCP: Pentachlorophenol;
PCS: Pesticide Control Service;
pg: Picograms;
REPS: Rural Environmental Protection Scheme;
RTDI: Research, Technological Development and Innovation;
TEF: Toxicity Equivalency Factor;
TEQ: Toxic Equivalent;
TJ: Terajoules;
TOE: Tonnes of Oil Equivalent;
UNEP: United Nations Environment Programme;
USEPA: United States Environmental Protection Agency;
VOC: Volatile Organic Compound;

EXECUTIVE SUMMARY

This report presents the inventory estimate for releases of dioxins and furans to the Irish environment during the calendar years 2000 and 2010. The work has been completed by URS Dames & Moore on research project - EPA Project 2000-DS-2-M1, INVENTORY OF DIOXINS AND FURANS.

Where available, measured dioxin emissions data are employed in the inventory. However, dioxin emissions are only measured at a small number of facilities, normally dictated by a requirement for monitoring in Integrated Pollution Control (IPC) licences. Where dioxin measurements are not available emission factors generated by the United Nations Environment Programme 'Standardized Toolkit for Identification and Quantification of Dioxin and Furan Releases' are used. The methodology recommended in the UNEP Toolkit was also employed during the preparation of this inventory and sources of dioxin emissions are categorised as follows, with associated sub-categories:

1. *Waste Incineration*
2. *Ferrous and Non-Ferrous Metal Production*
3. *Power Generation and Heating*
4. *Mineral Products*
5. *Transport*
6. *Uncontrolled Combustion Processes*
7. *Production of Chemicals and Consumer Goods*
8. *Miscellaneous*
9. *Disposal/Landfill*

As little dioxin data are available, and activity statistics used in several of the sub-categories are estimates based on limited available data, the emission estimates included in this inventory should be consulted with care, and not taken as definitive estimates of emission from a given category.

Summary dioxin emissions data are presented in the following tables, which presents dioxin emissions data for each of the sub-categories. The category with the highest estimated emission is uncontrolled combustion, which is estimated to contribute nearly 80 % of total emissions to air. Emissions to land are also dominated by uncontrolled combustion processes. Data on emissions to water are limited, with the highest contribution estimated from the disposal/landfill category.

Total emissions to air and water are estimated to reduce between 2000 and 2010,while emissions to land are estimated to increase, though significant uncertainty exists with regard to estimated emissions for 2010. It should be noted that emissions to land include the deposit of waste under controlled conditions at licensed facilities.

Table I: Summary of Emissions to Air, Land and Water in Ireland for 2000 (Main Categories)

	AIR		WATER		LAND	
	Best estimate g/annum	% Contribution to total air emissions	Best estimate g/annum	% Contribution to total water emissions	Best estimate g/annum	% Contribution to total land emissions
Waste Incineration	0.0068	0.02	0.0034	0.16	0.0034	0.01
Ferrous and Non-ferrous Metal Production	2.0942	6.15	0.0000	0.00	1.6218	2.85
Power Generation and Heating	3.3203	9.76	0.0000	0.00	8.1066	14.22
Mineral Products	1.9969	5.87	0.0000	0.00	0.0000	0.00
Transport	0.9714	2.85	0.0000	0.00	0.0000	0.00
Uncontrolled Combustion Processes	25.6363	75.34	0.0000	0.00	42.1822	74.01
Production and Use of Chemical and Consumer Goods	0.0000	0.00	0.0000	0.00	0.9013	1.58
Miscellaneous	0.0015	0.00	0.0000	0.00	0.0047	0.01
Disposal/Landfill	0.0000	0.00	2.1762	99.84	4.1755*	7.33
TOTAL	**34.0273**	**100.00**	**2.1796**	**100.00**	**56.9953**	**100.00**

Note: Data reported in grammes, however estimated emissions from some sectors are small, hence the data are reported to 4 decimal places to allow inclusion of this data. This does not imply an accuracy in the best estimate emissions to four decimal places.

* This figure is principally composed of contributions from sewage sludge landspreading and disposal to landfill. In 2000, 40% of sewage sludge was landspread and 51% was disposed of in landfills.

Table II: Summary of Emissions to Air, Land and Water in Ireland for 2010

	AIR		WATER		LAND	
	Best estimate g/annum	**% Contribution to total air emissions**	**Best estimate g/annum**	**% Contribution to total water emissions**	**Best estimate g/annum**	**% Contribution to total land emissions**
Waste Incineration	0.5494	1.81	0.0060	1.83	18.0060*	22.82
Ferrous and Non-ferrous Metal Production	0.0509	0.17	0.0000	0.00	1.5705	1.99
Power Generation and Heating	2.4243	8.00	0.0000	0.00	3.9605	5.02
Mineral Products	0.6119	2.02	0.0000	0.00	0.0000	0.00
Transport	1.1697	3.86	0.0000	0.00	0.0000	0.00
Uncontrolled Combustion Processes	25.4898	84.13	0.0000	0.00	41.8518	53.05
Production and Use of Chemical and Consumer Goods	0.0000	0.00	0.0000	0.00	0.0000	0.00
Miscellaneous	0.0018	0.01	0.0000	0.00	0.0121	0.02
Disposal/Landfill	0.0000	0.00	0.3185	98.17	13.4883**	17.10
TOTAL	**30.2980**	**100**	**0.3245**	**100**	**78.8890**	**100**

Note: Data reported in grammes, however estimated emissions from some sectors are small, hence the data are reported to 4 decimal places to allow inclusion of this data. This does not imply an accuracy in the best estimate emissions to four decimal places.

* Incinerator bottom ash and flyash to be landfilled under controlled conditions at licensed facilities thereby limiting any potential release of dioxins to the environment. Land emissions in this case means the deposit of waste in landfills.

** This figure is principally composed of contributions from sewage sludge management, in 2010, assumed to be 100% landspreading.

Figure I: Best Estimate Emissions to air – 2000 (range also shown)

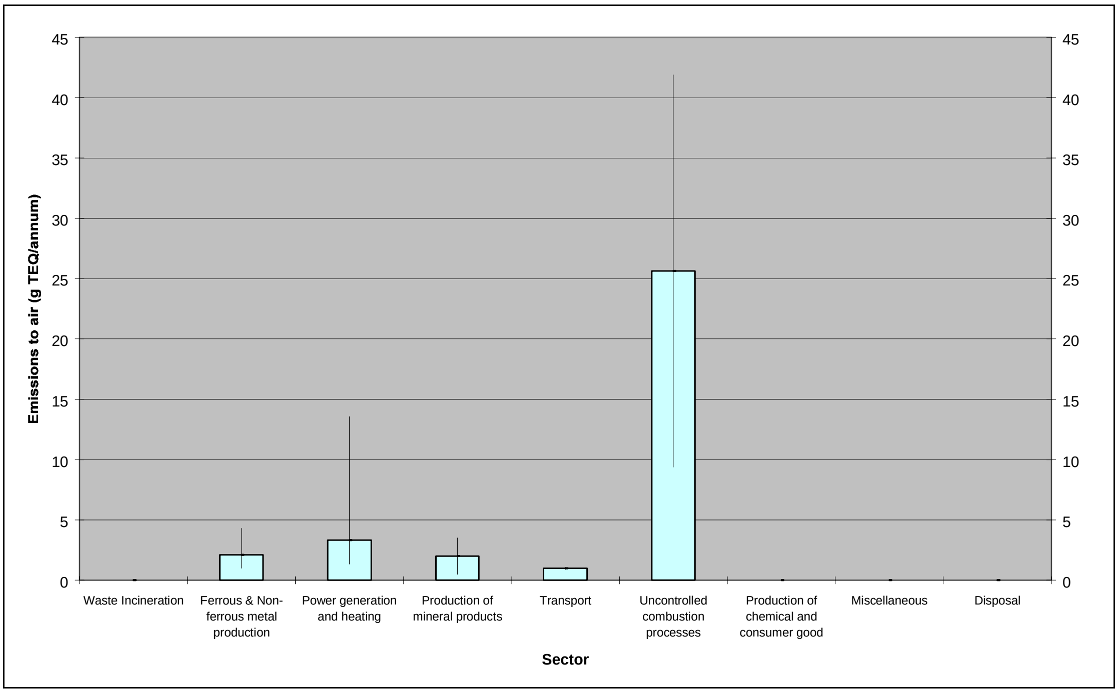
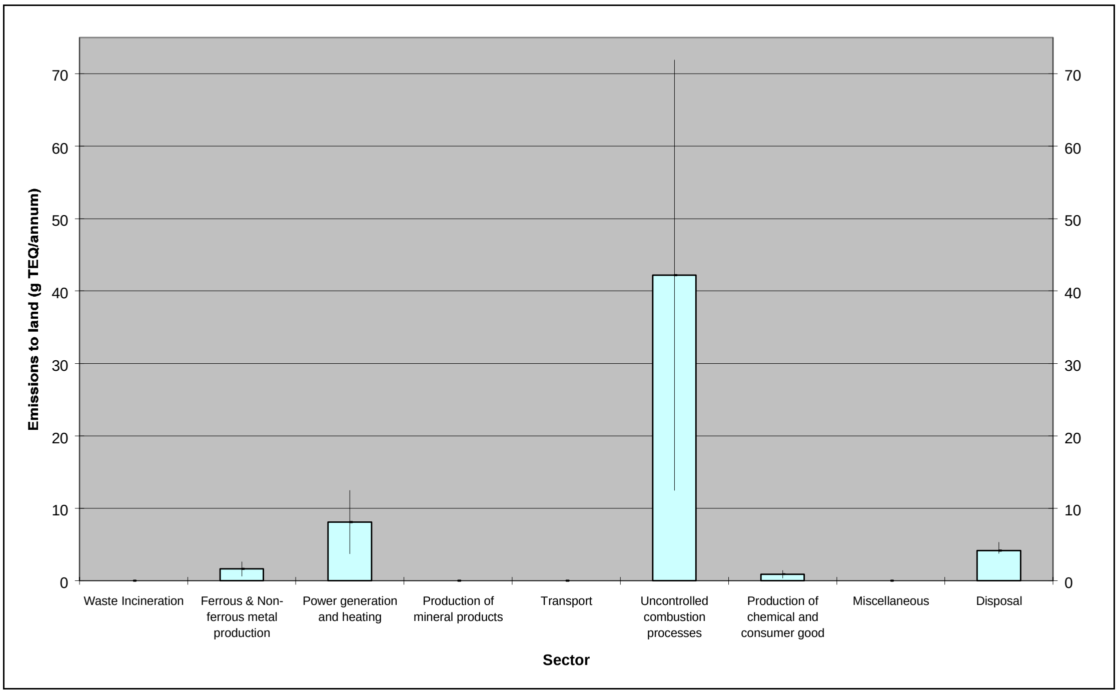


Figure II: Best Estimate Emissions to land – 2000 (range also shown)



Best estimate emissions to water for 2000 not plotted due to small quantity of data

Figure III: Best estimate emissions to air – 2010 (range also shown)

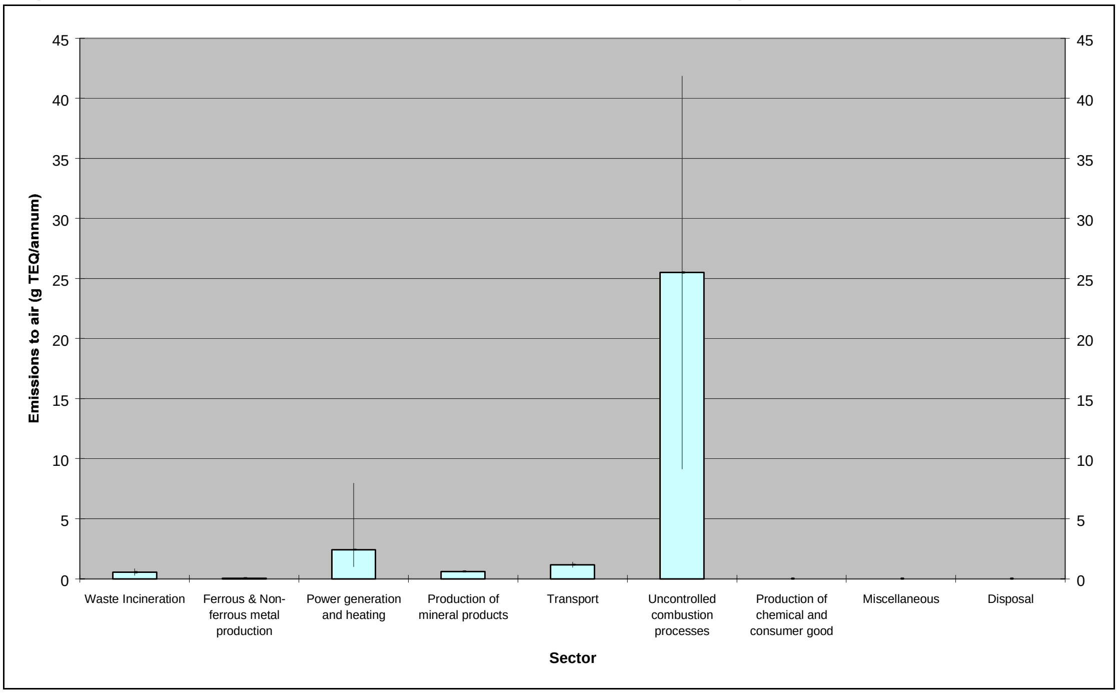
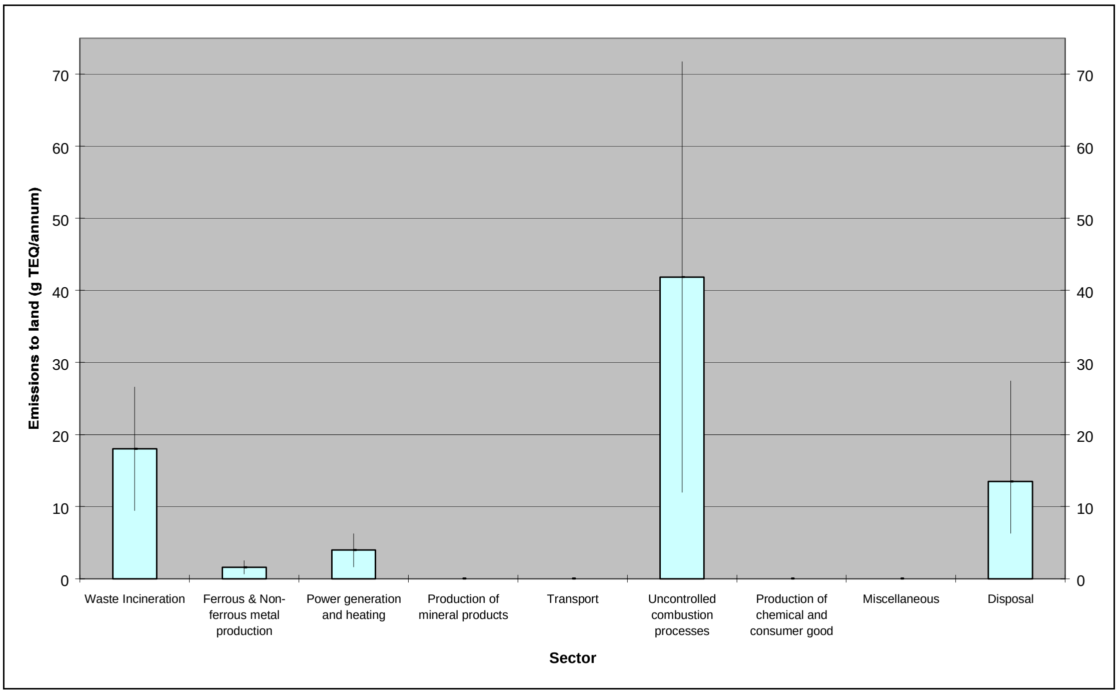


Figure IV: Best estimate emissions to land – 2010 (range also shown)



Best estimate emissions to water for 2010 not plotted due to small quantity of data

INVENTORY OF DIOXIN & FURAN EMISSIONS TO AIR, LAND AND WATER IN IRELAND FOR 2000 & 2010

1.0 INTRODUCTION

This project, Inventory for Dioxins and Furans (2000-DS-2-M1), was carried out by URS Dames & Moore, under the Environmental RTDI Programme 2000 – 2006. Funding for this project was provided by the Department of the Environment and Local Government, through the Environmental RTDI sub-measure of the Productive Sector Operational Programme of the National Development Plan.

Polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs), commonly referred to as 'dioxins' have received significant attention in the press in recent years, mainly due to public concern over potential dioxin emissions from municipal waste incineration as proposed by local and regional authorities in their Waste Management Plans. Several of these Waste Management Plans have recommended thermal treatment as a means of waste disposal, which may result in up to 1.5 million tonnes per annum being treated by this method within the next 10 –15 years, if the favoured scenario in each of the Waste Management Plans is adopted. There is currently no mass thermal treatment of municipal solid waste in Ireland.

No detailed dioxin emission inventory currently exists for Ireland, though estimates of dioxin emissions have been made in recent EU Inventories (LUA, 1997; Wenborn et al., 1999) as detailed in Section 1.2. This emission inventory is therefore the first carried out in Ireland.

It should be noted that PCDDs and PCDFs are referred to collectively throughout this report as "**dioxins**". The standard unit of measurement for dioxins is grams toxic equivalent (g TEQ). Toxicity equivalency factors have been developed for individual PCDD/PCDF congeners allowing the quantification of complex congener mixtures as a single numerical descriptor.

A number of polychlorinated biphenyls (PCBs) are also reported to exhibit dioxin like behaviour. There are 209 PCB congeners. However only 13 of these congeners are reported to have dioxin-like toxicity (USEPA, 1998), limited to those PCBs with four or more chlorines with a single or no substitution in the ortho position. Mixed brominated and chlorinated biphenyl congeners are also reported to have dioxin-like toxicity though very little is currently known about these compounds. It is reported that the toxicity of dioxin-like PCBs are generally lower than known toxic PCDDs and PCDFs although their environmental concentrations are usually higher.

Unlike dioxins, which are unwanted by-products and serve no useful purpose, PCBs were produced in large quantities for use in products such as dielectrics, hydraulic fluids, plastics and paints. PCBs may be released through use or disposal of PCB containing products and can also be formed as by-products during the manufacture of certain organic chemicals and as products of incomplete combustion of certain materials (USEPA, 1998).

Very little information is currently available on emission factors for sources of dioxin like PCBs, though the USEPA did attempt to include some detail on emissions of dioxin-like PCBs in their dioxin inventory (USEPA, 1998). The USEPA did not include emissions from reservoir source such as contaminated soil and sediments, though the USEPA consider that the quantities of dioxin-like PCBs available for release from reservoir sources are significantly larger than quantities of dioxin-like PCBs available for release from current use and disposal of PCB containing material. The USEPA also consider that insufficient information is currently available to enable a determination as to whether any significant release of newly formed dioxin-like PCBs is occurring in the United States, and that there is insufficient data upon which to estimate emission factors for any potential source category. Therefore, dioxin-like PCB emissions are not included in this inventory.

The USEPA does however consider some of these individual sources and present limited data on PCB measurements in identified sources (mainly combustion sources). However, in order to develop representative emission factors for newly formed and released dioxin-like PCB, congener specific measurements in discharges from these potential sources are required (USEPA, 1998).

1.1. SCOPE AND OBJECTIVES

The main objectives of the study can be summarised as follows:

- Identify the principal sources of dioxin emissions to air, land and water in Ireland;
- Quantify these emissions on the basis of reported information;
- Prepare an inventory of dioxin emissions for the calendar year 2000;
- Consider the likely future impact on the inventory resulting from the establishment of thermal treatment and other industrial plants;
- Comparison of the current (2000) and future (2010) dioxin emissions to permit the potential impact of new dioxin sources, in particular thermal waste treatment plants, to be estimated.

This report provides an estimate of dioxin emissions to air, land and water in the Republic of Ireland (hereafter referred to as Ireland) during the calendar year 2000, and also an estimate of emissions in 2010. A wide variety of sources of dioxin emissions have been identified, from heavy industry to domestic activity. It was considered that such a project could be carried out as a desk study; hence no dioxin monitoring was carried out, though some dioxin emissions data were available from IPC licensed facilities which are required by the EPA to monitor dioxin emissions on an annual or biannual basis. Dioxin information was also available from other facilities which have voluntarily carried out dioxin monitoring.

Over the last number of years several countries have published dioxin emission inventories, identifying possible sources of dioxin emissions and estimating emissions for each of these sources. These estimates have been used to derive 'emission factors' for dioxins, i.e. the expected mass emission of dioxins to the environment per unit of industrial activity – e.g. grams of dioxins per tonne of production. Emission factors developed by individual countries have been tentatively used to estimate emissions in other countries, where measured data may not be available. It was anticipated that such national emission factors would be used during this project to estimate dioxin emissions in Ireland where measured emissions data were not available.

However, in early 2001, the United Nations Environment Programme (UNEP) issued a draft "Standardized Toolkit for Identification and Quantification of Dioxin and Furan Releases" (UNEP Chemicals, 2001). The Toolkit has been developed by UNEP to address the lack of standardisation internationally with regard to the national and regional inventories and hence to facilitate the development of consistent and comparable data.

This inventory has been prepared with the aid of the methodology and suggested emission factors contained in the UNEP Toolkit. The approach and methodology adopted are described in Section 3.

Because dioxin emissions data were not available for the majority of the identified sources, a degree of uncertainty must be associated with the results. While the relative importance of the individual categories can be identified from the study, the actual emissions estimate from each category must be carefully interpreted.

This inventory addresses only direct releases and transfers of dioxins to air, water and land. Releases to products or in residues which are disposed of outside Ireland are not considered.

1.2 PREVIOUS DIOXIN EMISSION ESTIMATES FOR IRELAND

Previous estimates of dioxin emissions to air, land and water in Ireland have been made as part of EU projects.

Estimates of dioxin emissions to air in Ireland were made by German NRW State Environment Agency (LUA), 1997 as part of the European Dioxin Inventory – Stage I (LUA, 1997). A summary table of emissions from this study, and those of other European Countries are included in Table 1.1.

Estimates of dioxin emissions to land in European Countries are included in Table 1.2 (LUA, 1997), also developed as part of the European Dioxin Inventory.

The emission values presented in these two studies are not directly comparable with those used in this study, as the categorisation system used is different in each case; however the overall magnitude of the dioxin emissions may be comparable.

Stage II of the European Dioxin Inventory was completed in early 2000. This project aimed to revise the original emissions estimated for 1995, and also to extrapolate estimates of dioxin emissions to air for 2000 and 2005 based on activity trends, technological changes and upcoming legislation.

Stage II of the inventory includes estimates on a Europe-wide basis as well as on a regional basis. A summary table indicating estimated emissions to air in Ireland from the Stage II Inventory is included in Table 1.3. The Stage II results predict a decrease in dioxin emissions up to 2005.

Table 1.1: European Dioxin Emission Inventory Estimate of Emissions to Air 1995, g I-TEQ (LUA, 1997) (see Table 1.2 for legend)

	A	B	CH	D	DK	E	F	GR	I	IRL	L	N	NL	P	S	SF	UK
Residential Combustion – Wood	67.62	9.13	8.30	27.22	2.90	70.26	323.2	51.57	198.8	0.00	0.00	23.9	14.00	59.20	48.40	28.10	12.40
Residential Combustion – Coal	1.20	1.14	0.81	11.30	0.30	3.69	3.99	0.20	0.50	5.0	0.06	0.30	0.11	0.04	0.60	0.30	10.50
Combustion in Industry	0.43	0.55	0.39	4.45	0.29	2.17	3.16	0.56	3.11	0.19	0.02	0.24	0.84	0.54	0.48	0.28	3.18
Sinter Plants	27.20	98.28		254.5		62.00	183.9		128.0		46.00		41.40	4.00	9.60	19.20	136.0
Secondary Zinc Production	0.08	1.00		13.52		0.75	0.99		0.35	0.015		0.795	0.00	0.00	0.025	0.00	2.34
Secondary Copper Production	2.42	5.14	1.50	31.09	0.00	3.21	6.45	0.00	16.50	0.00	0.00	0.00	2.60	0.00	1.03	1.25	5.745
Secondary Aluminium Production	0.99	0.07	0.24	11.98	0.34	2.16	5.15	0.20	7.90	0.00	0.00	0.00	3.40	0.00	0.50	0.60	5.50
Cement Production	0.74	1.13	0.68	4.88	0.26	3.59	3.08	1.89	0.01	0.23	0.00	0.18	0.50	1.10	0.30	0.17	1.71
Lime Production																	
Metal Reclamation from Cables			0.00		0.13								1.52				
Electric Furnace Steel Plants	0.43	6.42	8.03	2.43	0.62	13.20	6.15	0.89	26.11	0.27	2.35	0.46	1.30	0.72	2.45	0.70	10.90
Non-Ferrous Metal Foundries	0.12	0.76	0.04	0.63	0.03	0.22	0.29	0.06	0.55	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.20
Sintering of Special Materials				115.0													
Preservation of Wood	7.92	10.08	7.13	81.34	5.28	39.57	57.75	10.28	56.76	3.5	0.40	4.3	15.40	9.90	8.70	5.10	58.00
Road Transport	0.36	2.56	3.31	9.14	1.16	11.27	18.41	4.46	29.86	1.2	0.40	1.3	2.20	3.00	0.50	0.50	21.50
Incineration of Domestic or Municipal Waste – Legal	0.06	187.0	123.1	157.3	25.00	0.60	161.4	0.00	252.0	0.00	0.10	2.6	6.20	0.00	3.00	3.00	515.7
Incineration of Domestic or Municipal Waste – Illegal	3.46	4.32	4.57	30.86	3.21	16.42	24.69	3.89	21.6	1.40	0.20	2.5	9.50	3.30	4.00	3.10	37.00
Incineration of Industrial Waste	0.017	20.9	7.00	1.3	0.23	ND	2.00	ND	ND	ND	ND	0.06	1.00	0.20	0.007	0.88	3.60
Incineration of Hospital Wastes	0.00	95.00	10.00	0.03	5.00	57.50	262.5	37.50	250.0	22.50	0.00	0.10	1.00	35.00	0.00	0.00	39.40
Cremation	0.10	0.19	0.42	2.10	0.16	1.39	2.17	0.40	2.22	0.10	0.00	0.10	0.20	0.40	0.50	0.20	6.10
Fires	7.89	10.04	7.10	81.00	5.26	39.40	57.51	10.24	56.52	3.50	0.40	4.30	15.30	9.80	8.70	5.10	57.80
Total	121.0	453.7	182.6	840.0	50.20	327.4	1,122	122.0	1,051	37.9	49.9	41.1	116.5	127.3	88.80	68.50	927.6

Table 1.2: European Dioxin Emission Estimates to Land, g I-TEQ (Wenborn *et al.*, 1999)

	A	B	CH	D	DK	E	F	GR	I	IRL	L	N	NL	P	S	SF	UK
Public Power, Cogeneration and District Heating	2	11	3	83	7	41	31	15	32	2	0	2	9	7	5	5	46
Commercial, institutional and Residential Combustion	26	8	7	59	2	55	233	37	142	10	1	17	10	42	34	20	24
Industrial Combustion	37	148	7	735	3	105	310	2	339	8	2	12	63	11	73	13	402
Industrial Processes	145	387	5	1,142	152	3,073	3,333	14	3,342	73	10	43	437	229	126	91	1,088
Extraction and Distribution of Fossil Fuels																	
Solvent Use																	
Road Transport																	
Other Mobile Sources and Machinery																	
Waste Treatment and Disposal Activities	98	601	399	1,821	160	544	1,282	121	2,614	45	82	362	475	120	228	125	2,482
Agricultural Activities	15	45	0	127	17	357	388	36	388	8	1	0	49	26	8	6	122
Nature																	
Fires and Other Sources	168	214	148	1,725	112	829	1,226	219	1,211	76	9	92	326	209	183	107	1,236
Total	490	1,410	570	5,700	450	5,000	6,800	440	8,070	220	110	530	1,370	640	660	370	5,400

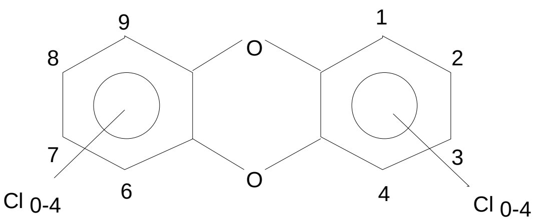
A: Austria
B: Belgium
CH: Switzerland
D: Germany
DK: Denmark
E: Spain
F: France
GR: Greece
I: Italy
IRL: Ireland
L: Luxembourg
N: Norway
NL: Netherlands
P: Portugal
S: Sweden
SF: Finland
UK: United Kingdom

Table 1.3: Stage II European Inventory Results for Ireland (dioxin emissions to air g TEQ / annum)

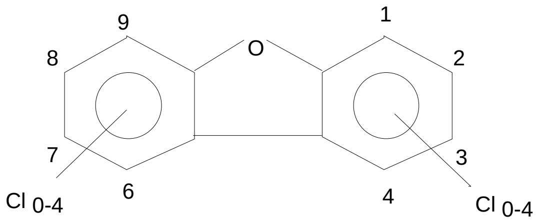
	1995			2000			2005			%
	Min	Prob	Max	Min	Prob	Max	Min	Prob	Max	Change 1995 – 2000
Fossil fuel power plants		0.7			0.7			0.7		0 %
Residential combustion boilers, stoves, fireplaces (wood)	8.3		20.7	7.1		17.6	6.0		15.0	- 14 %
Residential combustion: boilers, stoves, fireplaces (coal / lignite)		4.8			7.2			10.8		50 %
Combustion in industry: boilers, gas turbines, stationary engines	0.2		1.6	0.2		1.6	0.2		1.6	0 %
Sinter Plants		ne			ne			ne		0 %
Secondary zinc production		nd			nd			nd		0 %
Secondary copper production		nd			nd			nd		0 %
Secondary aluminium production		nd			nd			nd		0 %
Cement	0.2		0.2	0.2		0.2	0.2		0.2	0 %
Other: metal reclamation from cables		nd			nd			nd		0 %
Electric furnace steel plants	0.3		0.7	0.3		0.8	0.4		1.0	0 %
Other: non-ferrous metal foundries		nd			nd			nd		0 %
Other: sintering of special materials and drossing facilities		ne			ne			ne		0 %
Preservation of wood		3.5			3.1			2.8		- 11 %
Road transport	1.2		1.2	1.2		1.2	1.2		1.2	0 %
Incineration of domestic or municipal waste		ne			ne			ne		0 %
Illegal combustion of domestic waste	1.4		1.4	1.4		1.4	1.4		1.4	0 %
Incineration of industrial waste		ne			ne			ne		0 %
Incineration of hospital waste	0.0		2.0	0.0		2.0		0.0		0 %
Cremation	0.1		0.1	0.1		0.1	0.1		0.1	0 %
Fires	3.5		3.5	3.5		3.5	3.5		3.5	0 %
Total of Sources Considered		24 – 40			25 - 39			27 - 38		

2.0 BACKGROUND INFORMATION ON DIOXINS

Dioxins and furans have come to attention in recent years due to their highly toxic nature which can result in severe health effects. These compounds are more precisely known as polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs), respectively. An example of the molecular structures of dioxin and furan molecules are presented below.



Dioxin Molecule



Furan Molecule

Dioxins can have between one and eight chlorine atoms at eight different locations on the dioxin molecule. The combination of number and position of chlorine atom gives rise to 75 possible dioxins. Similarly, 135 furans can be identified based on position and number of chlorine atoms.

Each of the dioxin and furan congeners has different physical, chemical and toxicological properties. Of the 210 dioxins and furans, 17 have been identified as posing significant risk to human health, with 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) being identified as the most toxic compound.

Dioxins and furans are not formed intentionally outside of laboratories, but are rather by-products of other processes. Previously, dioxin emissions have been associated with production and use of chloro-organic chemicals. However, the main source of emissions identified in many industrialised countries in the past number of years is combustion processes, particularly poorly controlled or uncontrolled combustion sources. It is generally accepted that dioxins and furans can be formed in thermal processes where chlorine containing substances are burned together with carbon and a suitable catalyst in the presence of excess air or oxygen (UNEP, 1999 (Inventory)). Dioxin and furan formation also tends to occur in the zone when combustion gases cool from about 450 °C to 250 °C (de novo synthesis) and not in the combustion chamber (UNEP, 1999).

Significant uncertainty still remains with regard to the impact of exposure to dioxin concentrations on humans. Many studies have been conducted to assess the impact of high dioxin concentrations on animals, with intake almost exclusively enteral or dermal. The United Nations also points out that 90 % of the intake of dioxins and furans by humans is through food consumption, though it is thought that most of the dioxins and furans enter the food chain from the air (UNEP, 1999). The most frequent acute symptom of exposure to elevated dioxin concentrations is chloracne (skin lesions). Other acute symptoms of dioxin exposure include irritation of the eyes and mucous membranes, nausea and vomiting.

Long term effects are more difficult to quantify. Many studies have been carried out on animals to assess the effects of long term exposure to high concentrations of dioxins and furans, however the effects may not be directly comparable to those experienced by humans, particularly in terms of dose-response relationships (R & H Hall, 2000). This can be illustrated by the case of the Seveso accident, where an explosion at a chemical factory in Seveso (Italy) in 1976 resulted in the local population being exposed to high dioxin and furan concentrations, resulting in concentrations in body tissue 10,000 times higher than typical levels. Children were exposed to concentrations three times the relative amount which is reported to lead to death in guinea pigs. However, the main acute symptom was chloracne, with no increase in health problems being reported by the population of Seveso 15 years after the incident (Woodford and Gossman, 1994). Observations of health effects in humans after 22 industrial accidents involving dioxin and furan releases have been carried out, though exposure has generally been to a mixture of congeners, making the health impact of individual congeners difficult to quantify.

Laboratory exposure of animals to 2,3,7,8-TCDD identified this dioxin congener as a potential carcinogen. As no experiments have been carried out on humans the relationship between dioxins and furans and the development of tumours is more difficult to identify. The effect depends on the duration of exposure, dose and congener (USEPA, 1998), with 2,3,7,8-TCDD generally being identified as a carcinogenic compound, while the other congeners are currently classified as non-carcinogenic.

3.0 METHODOLOGY

3.1 INTRODUCTION

The preparation of this emission inventory was based on the United Nations Environment Programme (UNEP), Standardized Toolkit for Identification and Quantification of Dioxin and Furan Releases (UNEP Chemicals, 2001), which was released to the EPA in draft form in March 2001.

This toolkit was developed to assist countries in identifying sources and estimating releases of dioxins and furans. A further aim of the toolkit is to provide a common approach to the preparation of dioxin and furan emission inventories, allowing representative comparison of inventories prepared in different countries. Current inventories are generally not directly comparable, as there was previously no internationally established listing of dioxin emission sources.

The toolkit is not designed to provide an exact estimate of emissions for each country, as general emission factors are employed. The toolkit is particularly useful as a screening tool to make first estimates of dioxin and furan emissions where emissions data do not exist, or are limited.

In this inventory of Dioxin and Furan emissions, **where emissions data are available, these data have been used to improve the accuracy of the inventory**. The generic emission factors have been used for all other categories, particularly for estimating emissions to land and water, where information in Ireland is not available.

3.2 INVENTORY PREPARATION METHODOLOGY

There are five steps included in the application of the UNEP toolkit, namely:

1. Apply screening matrix to identify main source categories;
2. Check subcategories to identify existing activities and sources in the country *(note 1)*;
3. Gather detailed information on the processes and classify processes into similar groups by applying the standard questionnaire;
4. Quantify identified sources with default / measured emission factors;
5. Apply nation-wide to establish full inventory and report results using guidance given in the standard format.

Note 1: *Table 3.1 provides an overview of the UNEP main source and subcategories.*

The Toolkit methodology was not adhered to strictly during this project for a number of reasons. As the toolkit was received several months after the beginning of the project, much of the screening work had already been carried out to identify potential sources of dioxin emission in Ireland. Much work had also been carried out on gathering information on available dioxin and furan emissions data, and gathering activity statistics which can be used with default emission factors in the absence of measured data. Hence, the majority of steps 1, 2 and 3, as detailed above, had already been completed upon receipt of the toolkit.

As the toolkit categories were developed specifically for sources of dioxin emissions to air, land and water it was decided to use this categorisation scheme in the current inventory. Previous inventories had employed generic categorisation schemes related to categories of industrial emissions. The default emission factors included in the toolkit were also employed in the inventory. However, the toolkit emission factors were compared to other available emission factors to assess the applicability of the emission factors to Irish conditions – see Table 3.2.

Information was requested from selected industrial facilities on activity and emissions statistics for 2000. This required intensive and time consuming follow-up contact with many of the facilities to ensure a satisfactory response. As the information was requested on a voluntary basis, this relied heavily on the co-operation of the individual facilities. Complete data was not received from all of the facilities contacted, though responses were generally satisfactory. Where such information was made available, revised emission estimates were calculated based on these data to allow comparison with the toolkit based estimates. As these revised estimates based on measured data were considered more representative than the toolkit based estimates, these emissions were employed in the final total estimated dioxin emissions for 2000.

Prior to completion of the report, relevant excerpts from the report were sent to facilities in the following industrial sectors that had provided information for the purposes of the inventory (25 – 30 facilities were contacted):

- Waste incineration;
- Ferrous and non-ferrous metal production;
- Power generation;
- Mineral products;
- Wood processing.

The facilities were asked to respond with any specific comments on the inventory for their given industry sector. Less than ten responses were received mainly requesting some further information and clarification. No significant changes were requested by the facilities as a result of the consultation exercise.

UNEP recommend that the inventory should include the following information:

- A listing of all process subcategories that are carried out in the country;

- The activity statistic for each category and a short description of how this was found or estimated;
- The range of emission factors by process sub-category and the overall range of potential emissions (mass flow multiplied by low and high end emission factors);
- More precise country estimates, where available, shown separately from the potential range of releases made using the toolkit default emission factors, along with an explanation of how the result was achieved;
- Potential ranges shown as a bar chart for each source based on default emission factors;
- In country estimates shown as points or ranges overlaid on the potential range

In this report we have presented the following information for each subcategory which is applicable to Ireland:

- A brief description of the sub-category as it applies to Ireland;
- Available dioxin emission and subcategory activity data;
- An estimate of dioxin emissions in 2000 based on the Toolkit methodology and emission factors;
- A revised dioxin emission estimate based on dioxin measurement data where available.

For 2010, similar data are presented, with presentation of estimated activity data and an estimate of dioxin emissions in 2010 based on emission factors from the UNEP toolkit or on emission factors generated from Irish dioxin measurements as employed in the 2000 inventory.

Table 3.1: UNEP Main Source Categories and Subcategories.

No.	Description	No.	Description
1	**WASTE INCINERATION**	**4**	**PRODUCTION OF MINERAL PRODUCTS**
1a	Municipal solid waste	4a	Cement kilns
1b	Hazardous waste	4b	Lime
1c	Medical Waste	4c	Brick
1d	Light weight aggregate	4d	Glass
1e	Sewage sludge	4e	Ceramics
1f	Waste wood combustion	4f	Asphalt mixing
1g	Animal carcasses		
		5	**TRANSPORT**
2	**FERROUS & NON-FERROUS METALS**	5a	4-stroke engines
		5b	2-stroke engines
2a	Iron ore sintering	5c	Diesel engines
2b	Coke production	5d	Heavy fuel oil engines (ships, etc.)
2c	Steel production		
2d	Copper production	**6**	**UNCONTROLLED COMBUSTION PROCESSES**
2e	Aluminium production	6a	Fires/burning – biomass
2f	Lead production	6b	Fires - waste burning, landfill fires, accidental fires
2g	Zinc production		
2h	Brass production	**7**	**PRODUCTION OF CHEMICALS AND CONSUMER GOODS**
2I	Magnesium production	7a	Pulp mills
2j	Shredder (e.g. automobile)	7b	Paper mills
2k	Wire reclamation by combustion	7c	Chemical industry
		7d	Petroleum industry (refining)
3	**POWER GENERATION & HEATING**	7e	Textile plants
		7f	Leather plants
3a	Fossil fuel power plants (coal, oil, gas, peat, co-combustion)		
3b	Biomass power plants	**8**	**MISCELLANEOUS**
3c	Landfill, biogas combustion	8a	Drying of biomass
3d	Household heating and cooking (biomass)	8b	Crematoria
3e	Domestic heating (coal, oil, gas, peat)	8c	Smoke houses
		8d	Dry cleaning residues
4	**PRODUCTION OF MINERAL PRODUCTS**	8e	Tobacco smoking
4a	Cement kilns		
4b	Lime	**9**	**DISPOSAL**
4c	Brick	9a	Landfills and waste dumps
4d	Glass	9b	Sewage/sewage treatment
4e	Ceramics	9c	Composting
4f	Asphalt mixing	9d	Open water dumping
		9e	Waste oil disposal

Table 3.2: Ranges of emission factors employed in various inventories for a sample of different categories

Category	1*	2*	3*	4*	5*
Municipal waste incineration (µg TEQ/tonne)	0.5 – 3,500	0.8 – 231	NA	1.5 – 90.0	0.025 - 118
Iron and steel production (µg TEQ/tonne)	0.01 – 10.00	0.7 – 10	0.16	0.2 – 5.0	1.15
Coal fired boilers (power generation) (µg TEQ/tonne)	10.00	0.04 – 4.8	5.7 – 9.3	NA	0.087
Cement production (µg TEQ/tonne)	0.15 – 5.00	0.02 – 1.08	0.20 - 1.08	0.15 – 5.0	0.29
Crematoria (µg TEQ/cremation)	0.40 – 90.00	2.4 – 80.0	0.5 – 28.0	3.0 – 40.0	0.5
Uncontrolled domestic waste burning (µg TEQ/tonne)	300	NA	1 – 300	75.5 – 3,230	140

1: UNEP Toolkit Emission Factors (used in this study);
2: A Review of Dioxin Emissions in the UK (HMIP, 1995);
3: New Zealand Inventory (Buckland *et al*., 2000);
4: European Dioxin Inventory (LUA, 1997);
5: Draft Inventory of Sources of Dioxins in the United States (USEPA, 1998).

3.3 FORMAT OF EMISSION INVENTORY REPORT

The following sections detail estimated emissions for each of the categories as detailed in Table 3.1. If the sector is not relevant in an Irish context, this is stated and no further information on dioxin emissions from such sources is presented. Those interested in these sector should refer to the UNEP Toolkit. For all relevant sectors a brief description is presented of the category, and any other relevant information is also detailed.

Secondly, details are discussed of activity data available for the sector which can be used to generate dioxin emission estimates using available emission factors. In some sectors the available activity statistics must be manipulated to generate statistics compatible with the available emission factor units. For example, in assessing the mass of wood burned in forest fires, available Irish data on the area of forest affected was employed with internationally defined mass/hectare factors to generate the total mass of wood consumed in forest fires for 2000.

Thirdly, the activity statistics are employed with the UNEP toolkit emission factors to generate a dioxin emission estimate. A range of emission estimates are normally provided, with a low, high and best estimate (BE) emission presented. The range may be based on a range of emission factors given in the toolkit or on a margin of error based on estimated variances in approximate activity statistics which have been provided or calculated.

If dioxin monitoring data are available for a particular sector, these may be used to help generate a revised emission estimate. However, as only a small number of measurements are generally available for a given sector, the toolkit factors may still be used to aid in the generation of a potential emission range. Using the activity data and the dioxin emission data for a given sector allows calculation of a revised emission factor which can be compared to the toolkit factors. As little dioxin monitoring data are available for the identified sectors in Ireland, many of the sectors do not include a revised estimate. Where a revised estimate has been generated, this value, rather than the simple toolkit based emission estimate is used in the calculating total dioxin emissions to a given media as presented in the summary tables.

4.0 ESTIMATES OF DIOXIN AND FURAN EMISSIONS 2000

4.1 MAIN CATEGORY 1 – WASTE INCINERATION

4.1.1 Municipal Solid Waste Incineration

Large scale municipal solid waste incineration is not currently carried out in Ireland. Burning of refuse is carried out on a small scale (backyard refuse burning) and is reported in Section 4.6.2.

4.1.2 Hazardous Waste Incineration

4.1.2.1 Subcategory Description

Hazardous waste incineration is a scheduled process under the Waste Management (Amendment) Act, 2001 and is included under the IPC licensing system classification, Class 11.1.

During 2000 six sites, all in the chemicals/pharmaceuticals sector, operated licensed hazardous waste incineration facilities. There were nine individual incinerators, seven of which are licensed to incinerate liquid wastes only while two units are licensed to incinerate solid waste.

All of the incinerators are equipped with flue gas treatment systems and are regularly monitored for combustion performance and emissions to air.

At each of these facilities only waste generated on the site may be treated, hence no 'commercial' waste treatment is carried out.

Combustion conditions at these incinerator units are highly controlled, resulting in highly efficient destruction of any chlorinated solvents which may be introduced into the systems.

A number of other facilities operate thermal oxidation systems where vapour phase waste streams are treated. These are not classified as incinerators though dioxin emissions data are available for several of these facilities. Therefore, available information from such facilities has been included in the emissions estimate given in Section 4.1.2.4.

4.1.2.2 Available Activity Data

With regard to available activity data, i.e. the amount of hazardous waste incinerated in Ireland in the year 2000, the latest consolidated data available is from 1998, when a total of 17,880 tonnes of hazardous waste was incinerated on a national basis. Consolidated data for 2000 is not yet available. However as part of this study, estimates were obtained from several of the individual sites of tonnages incinerated. An estimate of the total quantity of hazardous waste incinerated in 2000 was made at 20,000 tonnes. Due to uncertainties in the quantity of waste treated, the following range of tonnes of waste treated is employed in the calculations:

Lower bound: 10,000 tonnes;
Upper bound: 30,000 tonnes.

4.1.2.3 Toolkit Estimate of Emissions

With regard to emissions to air the Toolkit describes four classes of systems ranging from Class 1 (low technology and no air pollution control systems) to Class 4 (high technology combustion, sophisticated air pollution control systems).

As all of the hazardous waste incinerators in Ireland are legally obliged to meet an emission limit of 0.1 ng/Nm^3 and are of relatively modern design with at least two stage air pollution control systems installed, we have assumed all hazardous waste incinerated in Ireland is carried out in Class 4 systems. The emission factor to be employed is 0.75µg TEQ/tonne of hazardous waste. This figure is based on a flue gas generation rate of 7,500 Nm^3/tonne of waste and a dioxin concentration of 0.1 ng/Nm^3. Therefore, using the average annual toolkit estimated emission to air can be calculated as follows:

UNEP recommended emission factor = 0.75 µg TEQ/tonne of waste treated; **A**
Total quantity of waste treated in Ireland in 2000 = 20,000 tonnes; **B**
Best estimate emission for 2000 = 0.015 g; **A x B**

The UNEP Toolkit provides a discussion on dioxin release to the environment via water and solid residues rather than a clearly defined set of emission factors based on sector activity. This is due to the fact that the air pollution control devices employed at hazardous waste incinerators vary considerably with many of the larger systems having separate fly-ash collection devices - bag-filters or electrostatic precipitators. Fly-ash is generally considered to be the most heavily contaminated residue. This is then followed by wet scrubbers and possible third stage polishing devices (catalyser beds or “policeman” filters).

In Ireland there is no consolidated data for contaminated fly ash or aqueous wastes (scrubber blow-down) from hazardous waste incinerators. However we understand that most systems in Ireland do not have separate collection of fly ash as wet scrubbing is the primary treatment method for flue gas. Any entrained fly ash is removed in the wet scrubber. In these cases the ultimate sink for dioxins will be aqueous discharges from the site and/or in surplus waste-water treatment plant sludge. (Note: We understand that in all cases, waste water from hazardous waste scrubbing systems is discharged to the chemical/pharmaceutical plants site waste water treatment plant for treatment prior to discharge to sewer or surface water). For those small number of systems in Ireland which have particulate filter technology employed, any potentially contaminated solid residue collected is exported from Ireland as a hazardous waste and hence is not released to the Irish environment.

The UNEP Toolkit concludes its discussion on releases to water and as solid residues stating that in order to produce an estimate in the absence of consolidated residue data, it is reasonable to assume that releases as residues (via disposal of residues to water bodies/landfills) are of the same order of magnitude as releases to air.

In the table below we have assumed this to be the case and we have evenly divided the estimated release between releases to water and releases to land (land-filled sludge from waste water treatment plant), i.e. 0.375 µg TEQ/tonne for releases to water and land respectively.

Note that the 50/50 split has been arbitrarily chosen in the absence of any reliable data on the ultimate fate of dioxin compounds in biological waste water treatment plants. Scrubbing liquor blow-down from the incinerators is mixed with considerably larger volumes of general site effluent and hence actual dioxin concentrations in the waste water treatment plant system are likely to be well below detection limits.

In the table below, we have calculated the Toolkit emission estimate for releases to air, water and land. The high and low estimates are based on the estimated range of material treated.

Table 4.1: Toolkit estimate of emissions – hazardous waste incineration

No.	Category	Air Emissions (g TEQ/a)			Water Emissions (g TEQ/a)			Land Emissions (g TEQ/a)		
		BE	L	H	BE	L	H	BE	L	H
1b	Hazardous Waste Incineration	0.015	0.0075	0.0225	0.0075	0.0038	0.0113	0.0075	0.0038	0.0113

4.1.2.4 Revised Estimate using Dioxin Measurement Data

Each of the sites operating hazardous waste incinerators holds a site IPC Licence that contains specific conditions for the incinerators regarding operations, emissions to air and monitoring.

Each incinerator must comply with a maximum dioxin concentration in the flue gas released to air of 0.1 ng/Nm^3 (dry gas corrected to 11% oxygen). Monitoring data for each of the operating incinerators for 2000 was obtained as part of this study. In most cases this consisted of 2 measurements during the year as well as operational hours and average flue gas generation rates.

A number of sites were also able to provide data on measured dioxin concentration in flue gas treatment system waste-water and bottom-ash sent to landfill in Ireland (no data on fly ash available).

Reported concentration data ranged from 0.0046ng/Nm^3 to 0.02 ng/Nm^3. All values were well below the licence limit values. These results were confirmed by independent EPA tests carried out at all six sites in 2000 with results obtained in the range 0.004 – 0.07 ng/Nm^3. All results were reported with congener non-detects reported at the detection limit.

It should be noted that emission data from licensed hazardous waste incinerators represents the most comprehensive data set of dioxin emissions measurements in Ireland. All sites have been monitoring dioxin emissions since at least the early 1990's or since commissioning. The 2000 monitoring results are similar to results obtained in earlier years.

Utilising the reported emissions data and the amount of hazardous waste incinerated at each site we have calculated emission factors for emissions to air in the range 0.06 to 1.1 µg TEQ/tonne for individual sites and an average factor for the subcategory of 0.34 µg TEQ/tonne of waste.

A sample calculation for generation of the above emission factors is given below, demonstrating the calculation of the lower emission factor based on data received from one of the incinerator operators:

Dioxin concentration measured in stack emissions = 0.019 ng TEQ/Nm^3; **A**
Average stack flow rate = 1,500 Nm^3/hour; **B**

Operational hours in 2000 = 5,815 hours; **C** ∴ Total dioxin emissions for 2000 = 165.73 μg; **A x B x C = D** Total quantity of waste treated in 2000 = 1,200 tonnes; **E** ∴ Emission factor = 0.138 μg / tonne of waste. **D/E**

Most of the emission factors derived from the measurement data are well below the UNEP Toolkit factor reflecting the fact that emission concentrations measured at the Irish sites are well below the statutory limit of 0.1 ng / Nm^3.

A number of sites produced emission factors higher than the toolkit factor despite the fact that these sites also reported dioxin concentrations in the flue gas well below the statutory limit. This may be explained by the simultaneous use of many of these hazardous waste incineration systems as thermal oxidisers for vapour phase VOCs arising from chemical production processes at the particular site. Therefore the incinerators must operate for longer hours than is necessary to incinerate the site-generated hazardous waste only. These systems will use fossil fuel to run the incinerators at high temperature in the absence of hazardous waste. Burning of support fuel (gas or diesel) is reflected in the fossil fuel combustion section (Section 4.3).

To derive a revised estimate for releases to air from this subcategory, we propose the use of the range of actual measured emissions factors for high and low estimates – this range comfortably includes the UNEP Toolkit factor. The best estimate is based on the average factor for the subcategory, also derived from the measurement data. For example, to calculate the maximum annual emission:

Measured maximum emission factor = 1.1 μg TEQ / tonne of waste; **A** Total quantity of waste treated in 2000 = 20,000 tonnes; **B** Maximum annual emission = 0.022 g; **B x C**

Data on dioxin concentrations in scrubber liquor was also available from several of the facilities. Information on dioxin emissions to water consisted of:

1. Dioxin concentration measured in scrubber water (prior to discharge to the sites waste water treatment plant;
2. Quantity of scrubber water emitted per annum;

However, dioxin concentrations in scrubber water are generally low (< 1 pg / litre) and the quantity of scrubber liquor emitted per annum is small. Typical dioxin emissions to water per annum for facilities which supplied information are between 2×10^{-5} and 4×10^{-4} g / annum. Many of the dioxin analyses on scrubber water indicate dioxin results below the detection limits of the analytical equipment. However the data set is incomplete and may not be as reliable as the data for emissions to air.

Therefore to develop a revised estimate for releases to water and land, we propose to adopt the approach recommended in the UNEP Toolkit and assume that releases to water via scrubber blow down is the same order of magnitude as releases to air. Again we propose to divide this mass flow of dioxin evenly between actual releases to water after treatment in the sites waste water treatment systems and releases to land as sludge.

Table 4.2: Revised estimate of emissions – hazardous waste incineration

No.	Category	Air Emissions (g TEQ/a)			Water Emissions (g TEQ/a)			Land Emissions (g TEQ/a)		
		BE	L	H	BE	L	H	BE	L	H
1b	Hazardous Waste Incineration	0.0068	0.0013	0.0220	0.0034	0.0006	0.0110	0.0034	0.0006	0.0110

4.1.3 Medical Waste Incineration

Medical waste incineration was not carried out in Ireland in 2000. This practice ceased in the late 1990s.

4.1.4 Light Fraction Shredder Waste Incineration

Incineration of light fraction shredder waste was not carried out in Ireland in 2000.

4.1.5 Sewage Sludge Incineration

Incineration of sewage sludge was not carried out in Ireland in 2000.

4.1.6 Waste Wood and Waste Biomass Incineration

This UNEP toolkit category refers to the combustion of contaminated waste wood. No information on combustion of contaminated wood is available, and it is understood that wood burned in large wood processing plants is uncontaminated wood. Wood consumption figures in the 2000 National Energy Balance also include wood combustion estimates for smaller wood processing facilities (furniture making, etc.) and dioxin emissions from this source are included in the ‘Power Generation and Heating’ Category.

4.1.7 Animal Carcass Burning

Incineration of animal carcasses was not carried out in Ireland in 2000.

4.2 MAIN CATEGORY 2 – FERROUS AND NON-FERROUS METAL PRODUCTION

4.2.1 Iron Ore Sintering

Iron ore sintering was not carried out in Ireland in 2000.

4.2.2 Coke Production

Coke production was not carried out in Ireland in 2000.

4.2.3 Iron and Steel Production Plants

4.2.3.1 Subcategory Description

This subcategory includes blast furnaces, basic oxygen furnaces, cupola furnaces, electric arc furnaces, rotary drum and induction furnaces.

The iron and steel industry in Ireland is small compared to other European countries. During 2000, production was dominated by one large facility (electric arc furnace) where scrap steel was reprocessed. Production figures of the order of 300,000 tonnes for this site dominated activity statistics in the sector. There are a small number of ferrous foundries using cupola-type and induction furnaces however annual production figures for the largest of these is believed to be less than 7,000 tonnes per year with the next largest having production figures of less than 4,000 tonnes per year.

Plants under this sub-category are subject to IPC licensing in Ireland under Class 3.

4.2.3.2 Available Activity Data

Data was obtained from the large electric arc furnace (EAF) facility with regard to production figures (320,000 tonnes, taken from IPC licence application). Production data was also estimated for the two largest foundries with an estimated combined production in 2000 of approximately 11,000 tonnes.

4.2.3.3 Toolkit Estimate of Emissions

With regard to Iron and Steel making in EAFs, the UNEP Toolkit provides a range of emission factors depending on the type of technology employed and the feedstock. For emission to air, the factor ranges from 10 µg/tonne steel for plants with limited controls using contaminated scrap to 0.1 µg/tonne steel for plants using clean scrap and operating with good environmental controls. A very low emission factor of 0.01 µg/tonne is given for blast furnaces with air pollution control.

No emission factor is given for emissions to water as this is not considered to be significant. The range for dioxin in solid residues ranges from 15 µg / tonne steel to 1.5 µg / tonne steel.

To arrive at a toolkit estimate for the Irish facility, we have assumed production in 2000 of 320,000 tonnes of steel and best estimate, low and high emission factors as follows:

Best estimate:	3 µg / tonne steel
Low:	0.1 µg / tonne steel
High:	10 µg / tonne steel.

No estimate is made of releases via solid residues as we understand that all solid residues were exported from Ireland for reprocessing.

The use of the 0.1 µg / tonne emission factor to generate a low estimate is likely to significantly underestimate actual emissions from the Irish facility considering the abatement technology employed and the potential for contaminated scrap to enter the furnace. However, as a revised emissions estimate based on dioxin monitoring data is presented in Section 4.2.3.4, the emissions estimate below should be considered as an indicator of the range of potential emissions from such a facility.

With regard to ferrous foundries, again the UNEP Toolkit provides a range of emission factors depending on the technology employed. Two large foundries were investigated for the purposes of the inventory. One was found to operate a cold air cupola furnace with fabric filters, while the other operates an induction furnace, again with fabric filters. The toolkit gives the following emission factors for these activities:

Cold air cupola:	1 µg / tonne of steel;
Induction furnace:	0.03 µg / tonne of steel;

These two sites process approximately 11,000 tonnes of steel per annum. To account for other smaller foundries an activity statistic of 15,000 tonnes is used in the inventory. The induction furnace and cold air cupola emission factors detailed above are used as the minimum and maximum emission factors to generate the emissions presented below.

No emission factor is given for releases to water while the following factors are given for solid residues:

Cold air cupola:	8 µg / tonne of steel;
Induction furnace:	0.5 µg / tonne of steel;

To arrive at a toolkit estimate of emissions to land from landfilled residues we have used the above factors and production figures of approximately 15,000 tonnes in 2000. It is understood that not all residues are landfilled with some furnace dust being pelletised and disposed through licensed contractors, however the range of emissions detailed below are considered representative of emissions to land from this sector.

Table 4.3: Toolkit estimate of emissions – iron and steel production

No.	Category	Air Emissions (g TEQ/a)			Water Emissions (g TEQ/a)			Land Emissions (g TEQ/a)		
		BE	**L**	**H**	**BE**	**L**	**H**	**BE**	**L**	**H**
2c	**Iron and Steel Production**	0.960	0.032	3.200	ND	ND	ND	NA	NA	NA
2d	**Ferrous foundries**	0.0077	0.0005	0.0150	NA	NA	NA	0.0638	0.0075	0.1200

4.2.3.4 Revised Emissions using Dioxin Measurement Data

Dioxin measurement data was provided for emissions to air for the EAF plant consisting of spot values measured in 1999 as well as average flue gas flow rates.

For the EAF, concentration data ranged from 0.328 ng/Nm^3 to 0.706 ng/Nm^3 with gas flow rates for two on-site sources of approximately 8 million Nm^3 per day each.

Assuming that 1999 dioxin concentrations in the flue gas can be considered representative of 2000 and annual steel production figures of approximately 320,000 tonnes of steel, a calculated emission factor in the range 6.1 – 18.6 µg/tonne steel can be derived.

The upper limit of this range may be overly conservative as it is based on a very limited data set with regard to dioxin concentration and assuming that the source operates at maximum flow for 365 days per year. However the lower limit of the range lies well within the range provided in the UNEP Toolkit, i.e. 3 – 10 µg/tonne steel (best/high estimate).

Therefore to produce a revised estimate we propose to use 6.1 µg/tonne steel as the best estimate factor with 3 – 10 representing the high and low boundary.

With regard to the ferrous foundries, dioxin measurement data were received from one facility which operates a cold air cupola furnace, consisting of volumetric flow rates and flue gas dioxin concentration. Information on the quantity of material processed allowed an emission factor of approximately 9.41 µg/tonne to be calculated. No dioxin emissions data were available for facilities operating induction furnaces. The toolkit suggests an emission factor for emissions to air from induction furnaces of 0.03 µg/tonne. This value is used as the minimum emission factor, while the calculated value of 9.41 µg/tonne is employed as the maximum emission factor, with the arithmetic mean employed as the best estimate emission. Applying the derived emission factor for a cupola furnace to all foundries may overestimate emissions from induction furnaces, however the best estimate emission is considered to be a representative emission estimate from this sector. No revised estimate of emissions to land is provided as no data were available on dioxin content in these materials. Therefore, the toolkit estimated emissions to land are employed in the inventory.

Table 4.4: Revised estimate of emissions – iron and steel production

No.	Category	Air Emissions (g TEQ/a)			Water Emissions (g TEQ/a)			Land Emissions (g TEQ/a)		
		BE	L	H	BE	L	H	BE	L	H

2c	**Iron and Steel Production**	1.9514	0.9600	3.2000	ND	ND	ND	NA	NA	NA
2d	**Ferrous foundries**	0.0708	0.0005	0.1412	NA	NA	NA	0.0638	0.0075	0.1200

4.2.4 Copper Production

No thermal recovery of copper was carried out in Ireland in 2000.

4.2.5 Aluminium Production

4.2.5.1 Subcategory Description

The Toolkit states that the main source of dioxin emissions in the aluminium industry is the thermal processing of scrap material. Refining of aluminium ore into alumina and subsequent electrolytic reduction into metallic aluminium is not thought to be a significant source of dioxin emissions.

Note that there is one large bauxite-to-alumina conversion facility in Ireland which is also a major user of heavy fuel oil. An estimate of dioxin emissions from this site is included in Section 4.3.1 - Fossil Fuel Power Generation.

Aluminium scrap is recycled (thermal reprocessing) on a small scale in Ireland, with just over 6,000 tonnes processed annually at one facility.

4.2.5.2 Available Activity Data

Activity statistics, in terms of tonnes of aluminium processed per year were received from one facility as well as outline details on the sources of the scrap aluminium and the processing methods.

4.2.5.3 Toolkit Estimate of Emissions

The toolkit gives a range of emission factors for emissions to air from the aluminium recycling industry. The emission factor range from 150 µg/tonne aluminium for plants with minimal pre-treatment of scrap and simple dust removal to 0.5 µg/tonne aluminium for modern plants optimised for dioxin control.

No emission factor is given for releases to water as this is not considered to be a significant release route.

Factors ranging from 100 to 400 µg/tonne aluminium produced are provided for solid residues.

The estimate provided below uses the range of emission factors provided coupled to the estimate of aluminium recycled at the one identified facility.

Table 4.5: Toolkit estimate of emissions – aluminium production

No.	Category	Air Emissions (g TEQ/a)			Water Emissions (g TEQ/a)			Land Emissions (g TEQ/a)		
		BE	L	H	BE	L	H	BE	L	H
2f	Aluminium Production	0.4690	0.0031	0.9348	ND	ND	ND	1.5580	0.6232	2.4928

4.2.5.4 Revised Emissions Using Dioxin Measurement Data

In September 2001, the EPA conducted dioxin monitoring at this site. One dioxin sample was collected at one of the two furnaces. The dioxin concentration measured in the flue gas of 0.666 ng/Nm^3 TEQ is equivalent to a dioxin mass emission of 5.693 μg/hour. Operational hours at the plant were provided by the facility. Assuming that both furnaces are operational throughout the year (and that both have similar emissions) allows an annual estimate of dioxin emissions to air of 0.05 g/annum, significantly lower than the toolkit estimate as detailed above.

Based on production figures received from this plant, an emission factor can be calculated of 8.3 μg/tonne of aluminium produced. This is towards the lower end of the emission factor range given in the toolkit, suggesting that minimal quantities of contaminated scrap enter the furnace. To generate a range of emissions to air, the lower and upper bound emission factors from the toolkit are used to calculate the low and high estimate, while the calculated emission based on the measured dioxin concentrations is used as the best estimate. No dioxin measurements were carried out on ash, hence no revised emissions to land are presented. Based on the results of the revised emissions estimate to air it may be expected that the emissions to land are also an overestimate.

Table 4.6: Revised estimate of emissions – aluminium production

No.	Category	Air Emissions (g TEQ/a)			Water Emissions (g TEQ/a)			Land Emissions (g TEQ/a)		
		BE	L	H	BE	L	H	BE	L	H
2f	Aluminium Production	0.0519	0.0031	0.9348	ND	ND	ND	1.5580	0.6232	2.4928

4.2.6 Lead Production

No significant thermal recovery of lead was carried out in Ireland in 2000.

4.2.7 Zinc Production

No significant thermal recovery of zinc was carried out in Ireland in 2000.

4.2.8 Brass Production

No significant thermal recovery of brass was carried out in Ireland in 2000.

4.2.9 Magnesium Production

No significant thermal recovery of magnesium was carried out in Ireland in 2000.

4.2.10 Other Non-Ferrous Metal Production

No significant thermal processing of other metals was carried out in Ireland in 2000.

4.2.11 Shredders

4.2.11.1 Subcategory Description

Shredding of metals is carried out at three facilities in Ireland; in Dublin, Limerick and Cork. No information on quantities of material processed were available from these sites, though estimated activity statistics are provided below. These facilities are licensed under local authority licences.

4.2.11.2 Available Activity Data

Typical materials processed in shredders are end of life vehicles and consumer goods (refrigerators, washing machines and cookers). An estimate of the quantity of ferrous material processed is generated based on vehicle statistics only as follows (Department of the Environment, 2000a & 2001):

- 1999 total private cars: 1,269,245
- 2000 new private cars: 225,269
- 2000 total private cars: 1,319,250
- ⇒ total cars taken off the road in 2000: 175,264

The following assumptions are made in estimating the mass of material processed:

- A typical private car has a mass of approximately 1,000 kg;
- 76 % of a vehicle is typically metal (assumed to be ferrous metal);

As not all vehicles taken off the road in 2000 would necessarily have been scrapped in 2000, it is assumed for the purposes of the inventory that between 50 % and 100 % of the vehicles taken off the road were scrapped in 2000, to give a low and high estimate of the activity statistic for this category. Based on these assumptions the following range of metal processed can be estimated:

- Low estimate: 66,601.5 tonnes
- High estimate: 133,201 tonnes

4.2.11.3 Toolkit Estimate of Emissions

The toolkit gives a single emission factor for this category of 0.2 µg TEQ/t of steel, also indicating that little emissions data are available from this sector. No data were available on other release routes such as in water releases to effluent or in residues.

The low and high estimate activity statistics are employed in generating the low and high estimate emissions, while the best estimate emission is taken as the arithmetic mean of the low and high estimates.

Table 4.7: Toolkit estimate of emissions - shredders

No.	Category	Air Emissions (g TEQ/a)			Water Emissions (g TEQ/a)			Land Emissions (g TEQ/a)		
		BE	L	H	BE	L	H	BE	L	H
2l	Shredders	0.0200	0.0133	0.0266	NA	NA	NA	NA	NA	NA

4.2.12 Thermal Wire Reclamation

No significant thermal wire reclamation was carried out in Ireland in 2000. While some illegal burning of cables for recovery of metals may be carried out in Ireland it is not possible to quantify the extent of this activity.

4.3 MAIN CATEGORY 3 – POWER GENERATION AND HEATING

4.3.1 Fossil Fuel Power Generation

4.3.1.1 Subcategory Description

This subcategory covers electricity generation for distribution through the national grid and also fuel usage in industry in boilers for heating and processing purposes. In the UNEP Toolkit peat is included as a biomass fuel, however it is considered that for the purposes of this inventory peat is more correctly classified as a fossil fuel.

In Ireland, this subcategory will include all the thermal power stations (coal/oil/gas/peat) as well as the range of industrial steam raising boilers used in industry.

4.3.1.2 Available Activity Data

Information on the quantity of fuel used in industrial combustion was sourced from the 2000 National Energy Balance published by the Department of Public Enterprise.

Information on fuel usage in electricity generation for 2000 was also received from the main electrical utility company.

Estimated 2000 activity statistics are as follows given in TJ/annum (converted from TOE as presented in the energy balance). Electricity generation fuel usage is based on supplied activity data, while industrial usage figures are taken from the 2000 energy balance:

Table 4.8: Fuel usage – power generation and heating (TJ/annum)

Fuel	Electricity Gen	Industrial	Total
Coal	65,206	8,332	73,538

Oil (HFO)	47,294	25,498	72,792
Gas	83,007	32,113	115,120
Gasoil & Kerosene	921	53,759	54,680
Peat	18,660	-	18,660

4.3.1.3 Toolkit Estimate of Emissions

The UNEP toolkit provides specific emission factors for releases to air based on the type of fuel used i.e.

Coal-fired boilers: 10 µg / TJ
Heavy Fuel Oil fired boilers: 2.5 µg / TJ
Gasoil / natural gas fired boilers: 0.5 µg / TJ

The emission factors are quoted as mass emission of dioxins per terajoule (TJ) of energy input.

Within the Toolkit there is a discussion on the derivation of the emission factors which are based on a relatively large data set of actual emissions data across Europe and North America. For coal fired power boilers the ranges reported are 0.09 – 7.1 µg / TJ (German data) and 0.06 – 0.32 µg / TJ (UK data). The UNEP factor for coal appears to be on the high side of the measurement data.

No factors are provided for emissions to water.

An emission factor of 14 µg / TJ is provided for solid residue from coal-fired boilers.

Dioxin emissions based on toolkit emission factors for the consumed quantity of each fuel are included in the table below. No estimated emission is included for peat combustion as no emission factor is available for this fuel. The toolkit does provide an emission factor for mixed biomass fuels, though investigation of this emission factor indicates a very large overestimate in emissions to air compared to revised emission estimate from dioxin monitoring data (see Section 4.3.1.4). Actual dioxin measurements for peat combustion are available and are used in the following section to generate estimates of dioxin emissions from peat fuelled power stations.

Table 4.9: Toolkit estimate of emissions – power and heat generation

No.	Category	Air Emissions (g TEQ/a)			Water Emissions (g TEQ/a)			Land Emissions (g TEQ/a)		
		BE	**L**	**H**	**BE**	**L**	**H**	**BE**	**L**	**H**
3a	**Coal**	0.7354	-	-	NA	NA	NA	1.0295	-	-
	Oil	0.1820	-	-	NA	NA	NA	NA	-	-
	Gas/Gasoil	0.0844	-	-	NA	NA	NA	NA	-	-

4.3.1.4 Revised Estimate using Dioxin Emissions Data

The only dioxin emission data available from this subcategory in Ireland was provided for a large coal-fired unit (300 MW), a heavy fuel-oil fired unit (256 MW) and a peat-fired station (40 – 45 MW).

Recorded flue gas concentrations were in the following ranges:

Coal: 0.0008 – 0.0123 ng TEQ / Nm^3 (7 tests, mean of 0.0036 TEQ ng / Nm^3)
Oil: 0.007 – 0.01 ng TEQ / Nm^3 (8 tests, mean of 0.008 ng TEQ / Nm^3)
Peat: 0.009 – 0.032 ng TEQ / Nm^3 (4 tests, mean of 0.023 ng TEQ / Nm^3)

It should be noted that the above figures include all congener non-detects at the analytical detection limit, hence emission estimates generated from these figures are likely to overestimate actual emissions. This factor particularly impacts the figures given for heavy fuel oil as most measurement results for this boiler (6 from 8 results) did not identify any dioxin above the detection limit.

Based on the measurement data provided, emission factors for releases to air can be calculated as follows:

Coal:	1 – 1.3	µg / TJ
Oil:	0.4 – 2.1	µg / TJ
Peat:	8.5 – 9.64	µg / TJ

No measurement data were available for gas-fired plants.

It will be noted that the emission factor based on the Irish dioxin monitoring data for coal is considerably lower than the UNEP recommended factor. However it is well within the range of factors developed in Germany and the UK. The factors for oil combustion are similar.

To develop a revised estimate for this subcategory for releases to air we propose to use the UNEP factor for coal and oil to produce the high estimate and the lower end of the dioxin measurement data derived factors as the low estimate. The best estimate is the simple arithmetic mean.

As the peat station dioxin monitoring data is the only data set available for peat combustion, we propose to use this data range and the high and low estimate with the best estimate being the average.

For gas-fired plant the UNEP factor is used and a factor of + / - 10% to produce a high and low estimate.

Analysis of bottom ash and fly ash samples from a coal fired boiler in Ireland (4 samples of each) was carried out in the 1990's. The range measured was 0.2 ng TEQ/kg to 0.5 ng/kg with no apparent difference between bottom ash and fly ash samples. The UNEP Toolkit factor of 14 µg/TJ is based on an ash concentration of 4 ng TEQ/ kg of ash which is one order of magnitude higher than the revised figure given above. However, the UNEP Toolkit reports a range of concentration data from the UK of 0.23 – 8.7 ng TEQ /kg for fly ash, taking 4 ng TEQ/kg as an approximate average. The revised factor based on measurements in Ireland is at the lower end of the range reported from the UK. Therefore to derive a revised estimate we propose to take the UNEP factor as the high estimate with the Irish calculated factor as the low estimate. The best estimate is the simple arithmetic average, i.e. factors as follows:

High:	14 µg/TJ
Low:	0.9 µg/TJ
Best estimate:	7.5 µg/TJ

It is noted that some of the ash produced from coal fired boilers is reused in the cement industry. In developing the revised estimate we have not taken this into account assuming all the ash is landfilled.

Available Irish data for dioxin concentrations in peat ash resulted in a dioxin concentration of 4.6 ng TEQ/kg for bottom ash and 7 ng TEQ per kg for fly ash (limited data set – one sample of each type of ash). These figures are an order of magnitude higher than the derived coal ash figures but within the range of concentrations used by UNEP to derive the Toolkit factor for coal. However peat has a much higher ash content compared to coal and consequently the emission factor per TJ of energy input will be higher.

Emission factors for peat ash in the range 14 – 20 µg/TJ can be calculated from the available measurement data and these have been used in the revised estimate given below. These factors should be treated with particular caution as they are based on a very limited data set and the absence of any guidance specific to peat ash in the UNEP toolkit.

The revised estimates are as follows:

Table 4.10: Revised estimate of emissions – power and heat generation

No.	Category	Air Emissions (g TEQ/a)			Water Emissions (g TEQ/a)			Land Emissions (g TEQ/a)		
		BE	**L**	**H**	**BE**	**L**	**H**	**BE**	**L**	**H**
3a	Coal	0.4045	0.0735	0.7354	NA	NA	NA	0.5515	0.0662	1.0295
	Oil	0.1055	0.0291	0.1820	NA	NA	NA	NA	NA	NA
	Peat	0.1693	0.1586	0.1799	NA	NA	NA	0.3172	0.2612	0.3732
	Gas	0.0844	0.0760	0.0929	NA	NA	NA	NA	NA	NA
	Total	0.7637	0.3373	1.1901				0.8688	0.3274	1.4027

4.3.2 Biomass Power Plants

4.3.2.1 Subcategory Description

Wood combustion for power/heat generation is employed on a relatively small scale in Ireland. The main user is the industrial timber processing sector, consuming waste wood generated on site.

There are four major wood processing plants in the country producing chipboard, MDF and other wood derivatives. These plants are all subject to IPC licensing.

Wood is also consumed in smaller wood processing facilities (such as furniture manufacturing).

The wood consumed in these facilities is generally residue from on-site processing. For the purposes of the toolkit it is assumed that all wood combusted is uncontaminated wood. As Ireland's forest cover is planned to increase from 8 % (at present) to 17 % in 2035, it is likely that power generation from biomass combustion will become a more significant energy source in the future.

4.3.2.2 Available Activity Data

Information is provided in the 2000 National Energy Balance on wood consumption for industrial power and heat generation. It is reported that wood is not used directly in electricity generation.

The amount of wood burnt is given as 0.088 MTOE (reported in energy balance) or approximately 3,700 TJ (340,000 tonnes at 11 MJ/kg). We have assumed ± 10 % margin of error on this activity statistic to generate a high and low activity statistic as follows:

- Low estimate: 3,330 TJ
- High estimate: 4,070 TJ

The four largest wood processing plants in Ireland which use wood as a fuel (bark, saw dust etc) also provided data on wood consumed in power generation.

4.3.2.3 Toolkit Estimate of Emissions

The Toolkit provides emission factors for clean wood fired boiler of 50 µg/TJ for emissions to air and 15 µg/TJ for solid residues (ash). No factor is provided for releases to water as this is not considered a significant pathway. For emissions to air, the UNEP factor is employed to generate the emissions, using the low and high activity statistics to generate the low and high estimated emissions. The best estimate emission is taken as the arithmetic mean of the low and high estimates.

A number of national emission inventories have reported emission factors as a result of ash from wood combustion – although all comment that there is little reliable data available. As there is some Ireland-specific data generated as a result of this study no Toolkit based estimate is made for this release route.

Table 4.11: Toolkit estimate of emissions – biomass power plants

No.	Category	Air Emissions (g TEQ/a)			Water Emissions (g TEQ/a)			Land Emissions (g TEQ/a)		
		BE	L	H	BE	L	H	BE	L	H
3a	Wood	0.1842	0.1658	0.2026	NA	NA	NA	ND	ND	ND

4.3.2.4 Revised Estimate using Measurement Data

Data on dioxin emissions were received from the four largest users of wood as an industrial fuel. These facilities burn approximately 220,000 tonnes of wood per annum, which is approximately 65 % of the total industrial wood combustion reported in the 2000 Energy Balance. Data on the quantity of wood burned per annum allowed calculation of an emissions factor for waste wood burning in Ireland at such large wood processing facilities. The results suggest dioxin emissions to air in the range 0.025 µg TEQ/tonne to 0.7 µg TEQ/tonne of wood burned.

As the dioxin measurement data supplied by the Irish facilities is limited (small number of measurements) the range of emission factor employed for the revised estimate combines Irish derived and international factors. The lower estimate from Irish data of 0.025 µg/tonne is used as a lower bound, while the UNEP factor is employed as the upper bound emission factor. The best estimate emission is the average of the lower and upper bound estimates.

Employing these emission factors and the estimated annual wood combustion of 340,000 tonnes (see Section 4.3.2.2) results in the emissions as detailed below.

Limited data on dioxin content in wood ash were also provided by two facilities. As the ash is disposed to landfill, this allowed estimation of dioxin emissions to land per tonne of wood burned. The available figures suggest a range of 2.81 – 2,843 ng TEQ/tonne of wood burned, covering a range of three orders of magnitude. The total quantity of wood burned per annum is taken as 340,000 tonnes (see Section 4.3.2.2). As the dataset employed in generating these emission factors is limited, confidence in the emission data detailed below is low.

Table 4.12: Revised estimate of emissions – biomass power plants

No.	Category	Air Emissions (g TEQ/a)			Water Emissions (g TEQ/a)			Land Emissions (g TEQ/a)		
		BE	**L**	**H**	**BE**	**L**	**H**	**BE**	**L**	**H**
3a	**Wood**	0.0964	0.0085	0.1842	NA	NA	NA	0.4838	0.0010	0.9667

4.3.3 Landfill/Biogas Combustion

4.3.3.1 Subcategory Description

It is reported that there are currently six landfill sites in Ireland where electricity is generated from landfill gas. Landfill gas at each site is collected from wells drilled into the landfill. The pipes in the wells run back to collection points from where they are pumped to spark ignition engines which are coupled to generators. These generators feed directly into the national power distribution network. Five of these are located in Dublin, with one in Cork.

Biogas formed from anaerobic digestion can be employed for generation of electricity. Currently, biogas is employed for power and heat generation at a number of wastewater treatment facilities. As other wastewater treatment plants are upgraded it is anticipated that biogas usage in heat and power generation will increase. Currently all power generated from biogas combustion is employed on-site only, with no electricity being fed to the national grid. Gas from anaerobic digestion of wastewater at industrial facilities and on large farms is also reported to be used for on-site heat and power generation, though no information could be sourced on the quantities used at these facilities. Comprehensive information on gas consumption from anaerobic digestion was not available at the time of the study, hence dioxin emissions from combustion of landfill gas only is included below.

4.3.3.2 Available Activity Data

It is understood that the total installed capacity for electricity generation from landfill gas is 14.8 MW (e).

4.3.3.3 Toolkit Estimate of Emissions

Based on the following calculations, the quantity of landfill gas combusted (in TJ) can be estimated:

- Efficiency of engine: 25 % implies thermal input required = 59.2 MW;
- Assume load factors in the range 40 – 80 % giving a range of thermal input required over the year of:
    - Lower estimate: 746.7 TJ/annum;
    - Upper estimate: 1,493.4 TJ/annum.

Using the toolkit emission factor of 8 μg TEQ/TJ and the low and high activity statistics, a low and high estimated emissions can be calculated. The best estimate emission is taken as the arithmetic mean.

Table 4.13: Toolkit estimate of emissions – landfill gas combustion

No.	Category	Air Emissions (g TEQ/a)			Water Emissions (g TEQ/a)			Land Emissions (g TEQ/a)		
		BE	**L**	**H**	**BE**	**L**	**H**	**BE**	**L**	**H**
3c	**Landfill gas combust-ion**	0.0090	0.0060	0.0119	NA	NA	NA	NA	NA	NA

4.3.4 Household Heating and Cooking (Biomass)

4.3.4.1 Subcategory Description

This subcategory includes the use of biomass fuels for household heating and cooking. In Ireland, we have assumed that cooking is dominated by gas / electrical cookers.

Consequently this subcategory in Ireland will be dominated by wood burning for heating.

4.3.4.2 Available Activity Data

Information on consumption of biomass was taken from the 2000 Energy Balance and includes combustion of wood. Wood is not reported individually in the energy balance, but is included as a renewable energy source. Wood is the major renewable energy source employed in household heating, and the figure for renewable energy use in the residential sector is assumed to be representative of wood combustion in the residential sector.

Total renewable energy used in the residential sector amounts to 1,800 TJ. However, significant uncertainty must be associated with this activity statistic as wood grown, harvested and burned privately may not be reported. Therefore 1,800 TJ has been assumed as a lower bound activity statistic, with the higher bound activity statistic taken as 2,160 TJ (+ 20 % of lower bound).

4.3.4.3 Toolkit Estimate of Emissions

The Toolkit provides an emission factor of 100 µg/TJ for emissions to air from the burning of clean wood in residential stoves. This figure is based on a reported emissions factor of 1.5 µg/ tonne of wood and an assumed calorific value of 12 – 15 MJ/tonne.

The toolkit also reports a range of emission factors derived from a number of countries.

To calculate emissions to air the low and high activity statistics are employed to generate the low and high estimate emissions, with the arithmetic mean being used as the best estimate emission.

The emission factor specified for ash is 20 µg/TJ. To calculate emissions to land the low and high activity statistics are employed to generate the low and high estimate emissions, with the arithmetic mean being used as the best estimate emission.

Table 4.14: Toolkit estimate of emissions – household energy (biomass)

No.	Category	Air Emissions (g TEQ/a)			Water Emissions (g TEQ/a)			Land Emissions (g TEQ/a)		
		BE	**L**	**H**	**BE**	**L**	**H**	**BE**	**L**	**H**
3d	**Household heating and cooking with biomass**	0.1980	0.1800	0.2160	NA	NA	NA	0.0396	0.0360	0.0432

4.3.5 Household Heating and Cooking (Fossil Fuel)

4.3.5.1 Subcategory Description

The majority of household heating using coal and peat would be carried out in open fires rather than stoves. Oil would be employed in central heating boilers while gas is employed for both heating (boiler units) and cooking purposes.

4.3.5.2 Available Activity Data

Information on consumption of fossil fuels by residential users was taken from the 2000 Energy Balance, including use of coal, oil, peat and natural gas. The activity statistics for 2000 are indicated below (converted from TOE, as presented in the Energy Balance).

Table 4.15: Household fossil fuel usage

Fuel	**Official 2000 Energy Consumption (TJ)**
Coal	13,775
Oil	38,519
Natural Gas	18,380
Peat	12,518

4.3.5.3 Toolkit Estimate of Emissions

The UNEP Toolkit reports that emissions to air from coal burning are between 1 and 7 μg TEQ/tonne in most reported studies, and recommends an emission factor of 2 •g TEQ/tonne, which is equivalent to 70 •g TEQ/TJ assuming an average calorific value for coal of 28 MJ/kg. This emission factor is employed in generating the average emissions while the upper and lower bound emissions factors are based on the range of 1 – 7 •g TEQ/tonne as detailed above. This gives the following emission factors:

- Lower bound: 35 •g/tonne;
- Best estimate: 70 •g/tonne;
- Upper bound: 245 •g/tonne.

Similarly, emissions from oil burning are in the range 0.04 to 2 μg TEQ/tonne. The UNEP Toolkit chose an average value of 0.5 μg/tonne for oil combustion. Using this figure, and assuming an average calorific value of 44 MJ/kg, the UNEP toolkit calculated the following emission factor recommended for oil combustion of 10 μg TEQ/TJ. To generate a high and low emissions scenario the range of 0.04 to 2 •g TEQ/tonne is employed to generate the following emission factor range:

- Lower bound: 0.8 •g/tonne;
- Best estimate: 10 •g/tonne;
- Upper bound: 40 •g/tonne.

As expected, emissions from gas combustion are low, with reported figures ranging from 0.04 to 0.07 ng TEQ/m^3. The UNEP toolkit recommends an average value of 0.05 ng TEQ/m^3. Based on an average calorific value of 32 MJ/m^3, the following emission factor range can be employed to give a range of emission estimates:

- Lower bound: 1.2 •g/tonne;
- Best estimate: 1.5 •g/tonne;
- Upper bound: 2.1 •g/tonne.

Emissions to air from combustion of coal, oil and gas are presented below, employing the range of emission factors detailed above to generate a best estimate, low and high emission estimate.

The UNEP Toolkit also reports dioxin content in coal fly ash ranging from 4 – 42,000 ng TEQ/kg, recommending a value of 5,000 ng TEQ/kg for use in the toolkit. Fly ash emissions entrained in the flue gas emitted to air would be included in the toolkit emission factor for air emissions. Other fly ash emissions are difficult to quantify and would consist mainly of soot which may adhere to the inside of the chimney and be disposed to landfill after chimney cleaning.

This residue from chimney cleaning (entrained fly ash) is likely to have high dioxin content, though no information on the quantity of this material generated is available. If it is estimated that the ash content of coal burned domestically in Ireland is approximately 5 %, and that 97 - 99 % of this is collected as bottom ash (i.e. 1 – 3 % fly ash), then the annual generation of fly ash collected inside the chimney can be estimated at approximately 247 - 742 tonnes (based on 494,737 tonnes total residential coal consumption). If it is assumed that the fly ash residue is collected and disposed to landfill, then this figure can be used to estimate emissions to land from fly ash disposal.

The toolkit does not provide an emission factor for bottom ash, which is generally disposed to landfill in Ireland. The UK Environment Agency specifies a dioxin concentration in bottom ash of approximately 0.41 ng TEQ/kg. This emission factor is used in conjunction with the estimated range of bottom ash generation to estimate dioxin emissions to land from landfilling of bottom ash.

The toolkit specifies an emission factor for fossil fuel burning 'stoves'. It is possible that dioxin emissions from open fires (prevalent in Ireland) would be greater than emissions from closed stoves, due to poorer efficiency in open fires. For consistency, the toolkit-derived emission is included in the inventory.

No emission factor to air is specified in the UNEP toolkit for combustion of peat. Limited measurements at power generating stations indicate that dioxin emissions to air from peat burning may be up to 8 times greater than from coal burning. To generate an estimated emission to air from peat, the reported activity statistic for peat consumption (see Section 4.3.5.2) in 2000 is employed with the low and best estimate coal emission factor to air to generate the lower and best estimate emissions for peat. The high emission estimate for peat is calculated by multiplying the best estimate by a factor of 8, based on the limited monitoring data from generating stations. As this estimate is based on a very limited dataset, there is a high degree of uncertainty associated with this high estimate emissions figure.

No emission factors are available for dioxin content in fly and bottom ash from peat combustion in domestic fireplaces. Again, very limited monitoring data from monitoring carried out at power stations suggests that dioxin concentrations in bottom ash and fly ash may be up to 9 and 14 times greater, respectively, than dioxin concentrations in coal bottom and fly ash. However, the data for peat is based on a single sample of fly ash and bottom ash.

Therefore, for the purposes of the inventory, to generate a figure for dioxin emissions to land from disposal of bottom and fly ash from domestic peat combustion, the same methodology as that employed for coal ash disposal is used (including the same emission factors), giving the emission estimates detailed below. Again, a low degree of confidence is associated with this emission estimate.

Table 4.16: Toolkit estimate of emissions – household heating and cooking

No	**Category**	**Air Emissions (g TEQ/a)**			**Water Emissions (g TEQ/a)**			**Land Emissions (g TEQ/a)**		
		BE	**L**	**H**	**BE**	**L**	**H**	**BE**	**L**	**H**
3d	Coal	0.9642	0.4821	3.3748	NA	NA	NA	2.4836	1.2467	3.7206
	Oil	0.3852	0.0308	1.5407	NA	NA	NA	NA	NA	NA
	Gas	0.0276	0.0221	0.0386	NA	NA	NA	NA	NA	NA
	Peat	0.8763	0.4381	7.0104	NA	NA	NA	4.2308	2.1237	6.3378
	Total	2.2533	0.9731	11.9645				6.7144	3.3704	10.0584

4.4 MINERAL PRODUCTS

4.4.1 Cement Kilns

4.4.1.1 Subcategory Description

Cement production in Ireland was carried out at three locations during 2000. Cement production is an activity subject to IPC licensing and each of the three sites held current licences in 2000.

4.4.1.2 Available Activity Data

Approximate figures on cement production for 2000 were sourced directly from three cement manufacturing facilities based in Ireland, indicating that over 3 million tonnes of cement was produced in 2000. As exact figures were not provided the following range of production was assumed:

- Lower bound: 3,000,000 tonnes;
- Upper bound: 3,600,000 tonnes (estimated production capacity).

4.4.1.3 Toolkit Estimate of Emissions

The UNEP Toolkit provides a range of emission factors for emissions to air depending on the type of cement production facility involved (wet or dry kiln etc). For dry kiln production with air pollution control – this includes all plants in Ireland – the recommended factor is 0.15 µg TEQ / t cement.

No emission factor is given for releases to water.

A provisional emission factor is given for releases as solid residue, i.e. with cement kiln dust. However, we understand that all cement kiln dust at Irish facilities is recycled and not exported from the relevant sites for landfilling.

The table below provides an inventory estimate for releases to air using the UNEP emission factor. The high and low estimates are based on the upper and lower bound activity statistics provided above, while the best estimate emissions is the arithmetic mean of the low and high estimate.

Table 4.17: Toolkit estimate of emissions – cement production

No.	Category	Air Emissions (g TEQ/a)			Water Emissions (g TEQ/a)			Land Emissions (g TEQ/a)		
		BE	L	H	BE	L	H	BE	L	H
4a	**Cement Kilns**	0.495	0.450	0.540	ND	ND	ND	NA	NA	NA

4.4.2 Lime

4.4.2.1 Subcategory Description

Four manufacturers are licensed (IPC Licence) to produce lime in a kiln, and responses to enquiries were received from three of these operators.

4.4.2.2 Available Activity Data

Production figures for the majority of lime production in Ireland was sourced directly from the manufacturers. Estimates were made for one facility which did not provide information on production for 2000. The total production for 2000 is estimated at 281,000 tonnes.

4.4.2.3 Toolkit Estimate of Emissions

The UNEP toolkit suggests an emission factor of 0.07 µg TEQ/tonne lime for facilities with dust abatement, and 10 µg TEQ/tonne for facilities with little or no dust abatement equipment. Facilities operating in Ireland generally have basic or no dust abatement equipment fitted, with the exception of one facility which operates an electrostatic precipitator. The upper and lower bound emission factors detailed above are used to generate the upper and lower bound emissions based on the estimated production figures of approximately 281,000 tonnes/annum. The best estimate emission is simply the average of the upper and lower bound emission estimates.

No factor is given for releases to water as there are generally no significant aqueous effluents resulting from lime production.

No factor is provided for solid residues due to lack of data.

Table 4.18: Toolkit estimate of emissions – lime production

No.	Category	Air Emissions (g TEQ/a)			Water Emissions (g TEQ/a)			Land Emissions (g TEQ/a)		
		BE	L	H	BE	L	H	BE	L	H
4b	**Lime**	1.4143	0.0197	2.8090	NA	NA	NA	ND	ND	ND

4.4.3 Brick

4.4.3.1 Subcategory Description

Brick production in Ireland was identified at two facilities, which are licensed, or are applying for IPC licences. Both facilities produce red brick.

4.4.3.2 Available Activity Data

Information on brick production for 2000 was sourced directly from the manufacturers, with approximate production of 106,500 tonnes reported. These facilities do not operate dust abatement equipment.

4.4.3.3 Toolkit Estimate of Emissions

The UNEP toolkit provides an emission factor range emissions to air from 0.02 to 0.2 μg TEQ/tonne brick. These factors are based on emissions data sourced in Germany.

No factors are provided for emissions to water or as solid residue in the UNEP Toolkit due to lack of data.

To derive the toolkit estimate for releases to air we have used brick production figures and the upper and lower emission factor detailed in the UNEP Toolkit. The best estimate emission is simply the average of the upper and lower estimates. As the identified facilities do not operate dust abatement equipment, dioxin emissions are likely to be towards the upper end of the range estimated below.

Table 4.19: Toolkit estimate of emissions – brick production

No.	**Category**	**Air Emissions (g TEQ/a)**			**Water Emissions (g TEQ/a)**			**Land Emissions (g TEQ/a)**		
		BE	**L**	**H**	**BE**	**L**	**H**	**BE**	**L**	**H**
4c	**Brick**	0.0117	0.0021	0.0213	NA	NA	NA	ND	ND	ND

4.4.4 Glass

4.4.4.1 Subcategory Description

The glass production industry in Ireland was relatively small in 2000 with only two glass production facilities identified in Ireland during the preparation of the inventory. One glass wool insulation plant was also identified.

4.4.4.2 Available Activity Data

Information on approximate production statistics were received from both the glass producers. At one facility, a mixture of pelletised and broken glass are used as inputs to electric furnaces with resulting low dust emissions. As unabated emissions are compliant with their IPC licence limits, no particulate abatement is required. At the other facility (a glass recycling facility), particulate abatement equipment is fitted to one of the two furnaces. The other furnace is scheduled to be fitted with abatement equipment by 2005. Production figures received from these companies indicate annual glass production of up to 160,500 tonnes per annum.

Details of the production at a glass wool manufacturing plant, of 7,800 tonnes per annum, were provided by the EPA inspector for the site. It is reported that significant quantities of recycled glass are used at this plant, mainly flat glass (from windows).

4.4.4.3 Toolkit Estimate of Emissions

The toolkit provides an emission factor of 0.2 µg TEQ / tonne glass for sites with poor combustion control and limited abatement. A factor of 0.015 µg TEQ / Tonne glass is suggested for with modern abatement. These factors are based on a limited emission dataset from Germany.

No factors are provided in the UNEP Toolkit for emissions to water or for solid residues due to lack of data.

To derive the toolkit estimate for releases to air we have used glass production figure of 168,300 tonnes and the high and low estimate emission factor. The best estimate emissions is the arithmetic of the low and high estimate.

Table 4.20: Toolkit estimate of emissions – glass production

No.	Category	Air Emissions (g TEQ/a)			Water Emissions (g TEQ/a)			Land Emissions (g TEQ/a)		
		BE	L	H	BE	L	H	BE	L	H
4d	Glass	0.0181	0.0025	0.0337	NA	NA	NA	ND	ND	ND

4.4.5 Ceramics

Although ceramics production is tentatively considered as a source of dioxin emissions in the toolkit, no information is available on the scale of potential emissions from this category, particularly as figures on annual production are not easily available. As production of ceramics in Ireland is limited (small producers), it is likely that emissions from this category would not be significant. No emission factor is provided in the toolkit for emissions from ceramics production.

4.4.6 Asphalt Mixing

4.4.6.1 Subcategory Description

There are two major manufacturers of asphalt in Ireland, with another major supplier also located in Northern Ireland. Consultation with the National Roads Authority (NRA) indicated that asphalt mixing in Ireland is carried out at the suppliers central facility, and is then transferred to site. However, on future major projects, asphalt mixing may also be carried out on the construction site.

4.4.6.2 Available Activity Data

Information on asphalt production in Ireland was received from the two major manufacturers which constitute the majority of the asphalt mixing processes in Ireland. Total production is reported up to 1.5 million tonnes per annum at 16 sites. It is reported that bag filters are fitted at most of the production facilities, with the remainder scheduled to be fitted with bag filters by the end of 2001.

4.4.6.3 Toolkit Estimate of Emissions

The toolkit provides emission factors for emissions to air of 0.007 µg TEQ / tonne of asphalt for mixing plant with fabric filters or wet scrubbers and a factor of 0.07 µg TEQ / tonne for plants with no gas cleaning.

No factors are provided for releases to water.

An emission factor is provided for solid residues for those plants which collect dust in fabric filters. However we understand that in Ireland such dust is normally recovered and reused and hence no estimate is made on releases via this route.

To derive the toolkit estimate given below for releases to air we have used the emission factor range and the national production figures. The best estimate emission is the arithmetic mean of the low and high emission range. As not all mixing plants have fabric filters fitted the best estimate below is likely to be representative of the emissions from Irish plants in 2000.

Table 4.21: Toolkit estimate of emissions – asphalt mixing

No.	Category	Air Emissions (g TEQ/a)			Water Emissions (g TEQ/a)			Land Emissions (g TEQ/a)		
		BE	L	H	BE	L	H	BE	L	H
4f	Asphalt Mixing	0.0578	0.0105	0.1050	NA	NA	NA	NA	NA	NA

4.5 TRANSPORT

4.5.1 4-Stroke Engines

4.5.1.1 Subcategory Description

Four stroke engines are commonly used in passenger cars and in medium and large engine capacity motorcycles. Since 1993, all petrol vehicles sold in Ireland have been fitted with catalytic converters.

4.5.1.2 Available Activity Statistic

The total unleaded fuel consumption for 2000 was approximately 1,467,000 tonnes (data from Department of Public Enterprise), from which emissions due to 4-stroke engines can be estimated. It is estimated, based on vehicle numbers and statistics from the Irish Bulletin of Vehicle and Driver Statistics 1999 (Department of the Environment and Local Government, 2000) that 98 % of marketed petrol is consumed in 4-stroke engines.

An estimate of the proportion of the current vehicle fleet fitted with catalytic converters was estimated from the Irish Bulletin of Vehicle and Driver Statistics 1999 (Department of the Environment and Local Government, 2000), as all new vehicles since 1993 have had to comply with strict emissions standards, resulting in the installation of catalytic converters. Based on the age profile of the vehicle fleet at the end of 1999/beginning of 2000, the proportion of the vehicle fleet fitted with catalytic converters was estimated at between 57.4 % and 67.4 % (approximately 824,661 - 897,000 vehicles). This gives a range of petrol consumed in 4-stroke engines as follows:

- Consumption in vehicles with catalytic converters:
  - Lower estimate: 825,217 tonnes;

    - Upper estimate: 968,983 tonnes.

- Consumption in vehicles without catalytic converters:
    - Lower estimate: 468,677 tonnes;
    - Upper estimate: 612,443 tonnes.

4.5.1.3 Toolkit Estimate of Emissions

The UNEP emission factors for the transportation section are presented in terms of the dioxin emissions per tonne of fuel burned, with emissions from 4-stroke engines based on the total quantity of petrol fuel consumed.

The Toolkit emission factor for unleaded fuelled vehicles without catalysts is 0.1 μg TEQ/tonne of fuel burned. It is assumed in the UNEP toolkit that vehicles equipped with catalytic converters have zero dioxin emissions. Using the range of consumption given above, the emission estimates given below are calculated.

Table 4.22: Toolkit estimate of emissions – 4-stroke engines

No.	Category	Air Emissions (g TEQ/a)			Water Emissions (g TEQ/a)			Land Emissions (g TEQ/a)		
		BE	**L**	**H**	**BE**	**L**	**H**	**BE**	**L**	**H**
5a	**4-Stroke Engines**	0.0541	0.0469	0.0612	NA	NA	NA	NA	NA	NA

4.5.2 2-Stroke Engines

4.5.2.1 Subcategory Description

2-Stroke engines are employed mainly on small motorcycles, lawnmowers and other small capacity engines.

4.5.2.2 Available Activity Data

In estimating the quantity of unleaded fuel consumed in 2-stroke engines, it was assumed that all petrol not consumed in 4-stroke engines was consumed in 2-stroke engines. However, as some uncertainty exists in this statistic, a margin of error of ± 10 % is applied to this statistics to give the following range of emissions:

- Lower estimate: 26,406 tonnes;
- Upper estimate: 32,274 tonnes.

4.5.2.3 Toolkit Estimate of Emissions

The UNEP quoted emission factor for 2 stroke engines is 2.5 μg TEQ / tonne of fuel burned, derived from various European studies.

The default UNEP emission factor is employed to calculate the emissions detailed below using the range of activity statistics presented above. The best estimate emission is the arithmetic mean of the low and high estimate.

Table 4.23: Toolkit estimate of emissions – 2-stroke engines

No.	Category	Air Emissions (g TEQ/a)			Water Emissions (g TEQ/a)			Land Emissions (g TEQ/a)		
		BE	L	H	BE	L	H	BE	L	H
5b	2-Stroke Engines	0.0734	0.0660	0.0807	NA	NA	NA	NA	NA	NA

4.5.3 Diesel Engines

4.5.3.1 Subcategory Description

Diesel engines are commonly employed in most vans, trucks and buses, and a smaller proportion of passenger cars.

4.5.3.2 Available Activity Data

Estimates of consumption of diesel in transportation were taken from the 2000 Energy Balance. The 2000 diesel consumption (for transportation) is reported at approximately 1,687,935 tonnes per annum. To account for variations in actual consumption a margin of error of ± 10 % is applied to generate a range of activity statistics as follows:

- Lower estimate: 1,519,142 tonnes;
- Upper estimate: 1,856,729 tonnes.

The UNEP Toolkit includes only one emission factor for diesel engines of 0.5 μg TEQ / tonne of fuel burned. The toolkit also indicates that no information is available on dioxin concentrations in diesel soot which may result in emissions to land via residues. These residues refer to particulate build-up in the exhaust system or in other parts of engines rather than particulates released to air from the exhaust.

4.5.3.3 Toolkit Estimate of Emissions

The recommended UNEP emission factor for diesel is 0.5 μg TEQ / tonne of fuel burned. This factor is employed with the above activity statistics to generate the low and high emission estimate, while the best estimate is the arithmetic mean of the low and high estimate.

Table 4.24: Toolkit estimate of emissions – diesel engines

No.	Category	Air Emissions (g TEQ/a)			Water Emissions (g TEQ/a)			Land Emissions (g TEQ/a)		
		BE	L	H	BE	L	H	BE	L	H
5c	Diesel Engines	0.8440	0.7596	0.9284	NA	NA	NA	NA	NA	NA

4.5.4 Heavy Oil Fired Engines

Heavy fuel oil in transportation is commonly employed in ships. Statistics on consumption of heavy fuel oil in transportation are available in the 2000 National Oil Balance. The 2000 consumption is reported at approximately 20,456 tonnes. However, as much of the consumption of the heavy fuel oil used in transportation is likely to take place outside of Ireland (i.e. en route to destination) this source is not considered significant.

Dioxin emission estimates for heavy fuel oil used in other sectors (e.g. electricity generation) is reported elsewhere.

4.6 UNCONTROLLED COMBUSTION PROCESSES

4.6.1 Biomass Burning

4.6.1.1 Subcategory Description

This category covers burning of biomass (both deliberate and accidental) occurring in the open. This includes forest fires, grassland and moor fires, and agricultural residue burning in the field. In an Irish context, bog fires may also be relevant to this category.

4.6.1.2 Available Activity Data

Forest Fires

Data on the area of forest affected by fire was sourced from the Irish Forestry Board (Coillte), however the data covers only fires affecting Coillte lands. There are wide variations in the area of Coillte forest affected annually by fire ranging from 32 to 660 hectares over the last five years, with 230 hectares affected in 2000. Data from the European Forest Institute indicates a total area of forest and other wooded land at approximately 591,000 hectares. Coillte report a total forested area (Coillte land only) of 378, 349 hectares. Assuming a pro rata number of forest fires for all forested land in Ireland provides an estimate of the total land affected by forest fires in 2000 at 359.3 hectares.

Varying statistics are available on the quantity of material consumed per hectare of forest fire, ranging from 10 tonnes/hectare in New Zealand to 23 tonnes/hectare in the United States. This range of consumable material was used to estimate dioxin emissions for Ireland in 2000 as follows:

- Lower estimate: 3,592.7 tonnes;
- Upper estimate: 8,371.0 tonnes.

Bog Fires

Little data is available on the area of grassland/bog affected by fires in Ireland. Fires on bogland can be started deliberately to clear heather, and are unlikely to be reported. 1998 Fire Statistics (Department of the Environment and Local Government, 2000) report fire service attendance at 1,783 forest, bog or grass fires. A rough estimate of the area of grassland/bog affected by fire can be calculated from this figure. Assuming that 2/3 of these fires are grassland/bog fires, and that between 0.5 – 1.5 hectares is affected in each fire, with the UNEP Toolkit estimating that 8 tonnes of material are consumed per hectare, giving an estimated range of material burned as follows:

- Lower estimate: 4,756 tonnes;
- Upper estimate: 14,268 tonnes.

Agricultural Residue Burning

No data is available on the area of land affected by agricultural residue burning in Ireland. Information from Teagasc (Irish Agriculture and Food Development Authority) indicated that the practice of 'stubble burning' is not widely carried out. Also, tillage farming is not widely carried out in Ireland with only approximately 15,000 farms, compared to 130,000 farms in total. Many farmers are now also members of the Rural Environmental Protection Scheme (REPS), which requires that environmentally harmful practices such as stubble burning are not employed. As more and more farms join the REPs scheme the practice of stubble burning will further reduce. No information is available on the area of land affected annually by stubble burning, hence no estimate of dioxin emissions from this source is included in the inventory.

4.6.1.3 Toolkit Estimate of Emissions

The estimate below includes emissions from forest and bog fires only, as no data were available on agricultural residue burning. The UNEP default emission factors for forest fires, grassland fires and moor fires is 5 µg TEQ/tonne of material burned for emissions to air, and 4 µg TEQ/tonne of material burned for emissions to land. These factors are applied to the range of activity statistics estimated above to generate the low and high emission estimates. The best estimate emission is taken as the arithmetic mean of the low and high emission estimate.

Table 4.25: Toolkit estimate of emissions – biomass burning

No	Category	Air Emissions (g TEQ/a)			Water Emissions (g TEQ/a)			Land Emissions (g TEQ/a)		
		BE	**L**	**H**	**BE**	**L**	**H**	**BE**	**L**	**H**
6a	**Biomass Burning**	0.0776	0.0417	0.1132	ND	ND	ND	0.0620	0.0334	0.0906

4.6.2 Waste Burning and Accidental Fires

4.6.2.1 Subcategory Description

This category includes landfill fires, accidental fires in houses and factories, uncontrolled domestic waste burning, accidental fires in vehicles, and open burning of wood (construction / demolition).

4.6.2.2 Available Activity Data

Landfill Fires

The very high emission factor associated with landfill fires in the UNEP Toolkit (1000 µg TEQ / t of material burned), indicates this is a potentially significant source of dioxin emissions.

Studies in both New Zealand and the United States have based their emission estimates on data from landfill fire experiments carried out in Sweden. Comparing the population and mass of landfilled waste in each country allowed a pro-rata estimate of dioxin emissions to air due to landfill fires. Applying this methodology to calculate dioxin emissions from landfill fires in Ireland would lead to significant estimated emissions.

However, the number of reported landfill fires in Ireland is low, suggesting that the above emission may be an overestimate. Consultation with EPA waste licensing inspectors indicated only two reported landfill fires in 2000. Both the duration and extent of these fires was short. These reports suggest minimal dioxin emissions to atmosphere from landfill fires, therefore emissions from this sub-category are assumed to be negligible.

Accidental Building Fires

Statistics on accidental fires in domestic, commercial and industrial buildings were sourced from the 1998 (most recent available year) Fire Statistics (Department of the Environment and Local Government, 2000b), with 12,773 such fires being attended in 1998. A large number of domestic fires were reported as chimney fires.

The mass of combustible material consumed in fires can be estimated based on the size of the fire. The New Zealand Emission Inventory (Buckland *et al.*, 2000) classifies fires in the following manner, based on the total number of reported domestic, commercial and industrial building fires:

- 90 % of fires are small, consuming 100 – 250 kg of material per fire;
- 90 % of the remaining fires are moderate consuming 1 – 2.5 tonnes of material per fire;

- 90 % of the remaining fires are large, consuming 10 – 25 tonnes of material per fire;
- The remaining fires are very large, consuming 250 – 1,000 tonnes of material per fire.

This methodology was applied to fire statistics for Ireland, with one minor difference. Of the 90 % of fires in Ireland classified as small under the above methodology, approximately 8,000 are reported by the Fire Service as being chimney fires. These fires are assumed to consume between 5 – 15 kg of material per fire, based on estimates provided by Hansen (2000), rather than the 100 – 250 kg per fire as detailed above. The range of material consumed in each fire allows a range of activity statistics for this sub-category as follows:

- Lower estimate: 5,945 tonnes;
- Upper estimate: 19,758 tonnes;

Domestic Waste Burning

The quantity of material consumed through uncontrolled burning of domestic waste was estimated from the 1998 National Waste Database Report (Crowe *et al.*, 2000) and through consultation with EPA inspectors. Based on population in each local authority area, the population served by a refuse collection, and the quantity of waste arising in each area an estimate of uncollected waste of 166,196 tonnes was calculated. The 1998 National Waste Database also includes an estimate of uncollected waste of 123,203 tonnes. The National Waste Database includes details on the breakdown of domestic waste, suggesting that approximately 10 % of the landfilled waste is non-combustible (glass and metal). Therefore, the figure detailed above (166,196 tonnes) is reduced to 149,576 tonnes of combustible material. Assuming a maximum, minimum and average of 70 %, 10 % and 40 %, respectively of this material is combusted in open fires gives a range of activity statistics as follows:

- 10 % of material combusted: 14,958 tonnes;
- 40 % of material combusted: 59,831 tonnes;
- 70 % of material combusted: 104,703 tonnes.

Accidental Vehicle Fires

The most recent Fire Statistics for Ireland, 1998 (Department of the Environment and Local Government, 2000b), indicate that 4,130 vehicle fires were attended by the fire services.

Open Burning of Construction Wood

No direct data is available on the quantity of construction/demolition wood consumed in open burning. However, the 1998 National Waste Database Report reports that 2,704,958 tonnes of construction/demolition waste is disposed of to landfill each year. Assuming that 10 % (by mass) of this waste is wood, and 5 % of this wood waste is consumed in open burning, an estimate of the dioxin emissions from open burning of construction/demolition waste can be calculated at approximately 13,525 tonnes. There is high uncertainty associated with this estimate.

Bonfires

A conservative estimate of dioxin emissions from bonfires is also included in this category, based on a methodology used in a dioxin inventory produced in Denmark (Hansen, 2000). No information is available on the number of bonfires built at Halloween. However, based on an estimate of one bonfire for each 1,000 of the population, an estimate of 3,788 bonfires at Halloween (based on 2000 population estimates) can be made. Assuming that wood only is burned, and that the volume of each bonfire is 100 m^3, 5 % of which is wood (with a density of 800 kg/m^3) an estimate of approximately 15,152 tonnes of wood consumed in bonfires can be generated.

Farm Plastics

An estimate is also included for uncontrolled burning of farm plastic sheeting. Information on the quantity of farm plastic sold in 2000, and the quantity recovered were received from the Irish Farm Film Producers Group (IFFPG). Based on the quantity of unrecovered material (assuming 15 % of this material is burned), an estimate of dioxin emissions was made, employing the emission factors for uncontrolled burning of domestic waste.

4.6.2.3 Toolkit Estimate of Emissions

The UNEP toolkit assigns a default emission factor for accidental fires in houses and factories of 400 μg TEQ/tonne of material burned.

The default UNEP emission factor for uncontrolled domestic waste burning is 300 μg TEQ/tonne of material burned.

The UNEP Toolkit provides an emission factor per vehicle fire of 94 μg TEQ per event; hence the mass of material consumed is not required.

The default UNEP emission factor for open burning of waste construction/demolition wood is 60 μg TEQ/tonne of material consumed. This emission factor is also employed in estimating emissions from bonfires. The figure presented below for emissions from bonfires is likely to be a significant underestimate of actual dioxin emissions from bonfires, as other materials such as plastics and rubber are also likely to be burned on bonfires. Confidence in the calculated dioxin emissions from bonfires is also low due to uncertainty in the number of bonfires held annually and the quantity of material consumed in each bonfire.

The UNEP emission factor for uncontrolled burning of domestic waste is also employed for estimating emissions from burning of farm plastics.

A breakdown of the emissions from each subcategory in this sector is presented below. All estimates are based on the UNEP toolkit default emission factors.

Table 4.26: Toolkit estimate of emissions – waste burning and accidental fires

No	Category	Air Emissions (g TEQ/a)			Water Emissions (g TEQ/a)			Land Emissions (g TEQ/a)		
		BE	L	H	BE	L	H	BE	L	H
6b	Landfill fires	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Accidental building fires	5.1407	2.3782	7.9033	ND	ND	ND	5.1407	2.3782	7.9033
	Domestic waste burning	17.9492	4.4873	31.411	ND	ND	ND	35.8983	8.9746	62.8221
	Accidental vehicle fires	0.3882	0.3882	0.3882	ND	ND	ND	0.0743	0.0743	0.0743
	Open burning of construction wood	0.8115	0.8115	0.8115	ND	ND	ND	0.1352	0.1352	0.1352
	Bonfires	0.9091	0.9091	0.9091	ND	ND	ND	0.1515	0.1515	0.1515
	Farm plastics	0.3600	0.3600	0.3600	ND	ND	ND	0.7200	0.7200	0.7200
	TOTAL	25.5587	9.3343	41.7832	0.0	0.00	0.00	42.1202	12.4338	71.8065

4.7 PRODUCTION AND USE OF CHEMICAL AND CONSUMER GOODS

4.7.1 Pulp and Paper Mills

The main source of dioxins from the pulp and paper industry is expected from de-inking and bleaching involving chlorinated agents. There is one facility in Ireland that recycles paper and cardboard. No de-inking is carried out at the site and the paper is not bleached at any point during production, hence little chlorinated residues would be expected from the production process. Therefore, dioxin emissions from pulp and paper industry are expected to be insignificant in Ireland.

4.7.2 Chemical Industry

Historically, the main source of dioxins from the chemical industry has been from the manufacture of chlorinated phenols and their derivatives, in particular pesticides. High dioxin concentrations are also found in polychlorinated biphenyls some of which have dioxin-like properties. PCBs along with some of the more toxic “POPS” (persistent organic pollutants) pesticides are now effectively banned, although their presence is likely to be detected in the environment for many years due to their persistence.

No default emission factors for the chemical industry are given in the UNEP toolkit, as processes at individual chemical facilities can potentially result in significantly different dioxin emissions, depending on the design of the processes. In Ireland, there are no major producers of industrial bulk chemicals involving chlorine chemistry. Chlorinated solvents may be used in the pharmaceutical industry, and waste chlorinated solvent liquids and vapours are treated on site in a number of plants using thermal oxidation and incineration systems. Emissions from these facilities are included in Section 4.1.

4.7.3 Petroleum Industry

Only one source of dioxin emissions has been identified in the petroleum production industry, during regeneration of the catalyst used during catalytic cracking of the larger hydrocarbon molecules into smaller, lighter molecules. There is one petroleum refinery in Ireland, which supplies approximately 20 % of the petrol sold in the country. However, consultation with the EPA inspector for this site indicated that this type of catalytic cracking is not carried out at the refinery and thus there is no potential for dioxin emissions from this source.

4.7.4 Textile Plants

The UNEP Toolkit indicates that little data are available on dioxin emissions to air, land and water from the textile industry, but indicates that measurable dioxin concentrations are likely to be found in the product. No significant dioxin deposition to air is expected. Dioxin emissions to water in effluent may be measurable, though no data exists at present on the likely concentrations. There are approximately 20 IPC licensed textile plants in Ireland. The reason for measurable dioxin concentrations are reported to be due to:

- Use of chlorinated chemicals to protect raw materials (e.g. cotton);
- Use of dioxin contaminated dyes (e.g. chloranil based dyes);
- Finishing processes may utilise chlorinated chemicals.

Emissions from the textile industry are not included in the inventory.

4.7.5 Leather Plants

It is reported in the UNEP Toolkit that high dioxin concentrations in the leather industry are likely to be found in the product. As in the textile industry, this is likely to be due to use of chlorinated compounds in the production process. Dioxins may be present in effluent water and in other production residues, though no emission factors for these sources are currently available. There are a small number of IPC licensed leather plants in Ireland.

Emissions from the leather industry are not included in the inventory.

4.7.6 Application of Pesticides to Land

4.7.6.1 Subcategory Description

Certain pesticides (chlorine containing) are reported to contain measurable quantities of dioxins. The dioxins are unintentionally produced residues of the pesticide production process. Application of pesticides to crops leads to dioxin deposition to land.

4.7.6.2 Available Activity Data

No emission factors are given for this potential source of dioxins in the UNEP toolkit, though data are available from other inventories, such as the New Zealand Inventory, which includes emissions of dioxins due to application of 2,4-dichlorophenoxyacetic acid to land. The USEPA (1998) has also carried out significant work in the area of identification of pesticides with the potential to contain dioxins and furans as by-products of the pesticide production process. Many of the pesticides which may be placed on the market in Ireland and used in accordance with the European Communities (Authorisation , placing on the market, use and control of plant protection products) Regulations, 1994 – 2000 have been identified by the USEPA as potential dioxin containing products. Details of pesticides which can be marketed in Ireland are published annually by the Department of Agriculture, Food and Rural Development, Pesticide Control Services.

Some of the active ingredient identified by the USEPA include:

- 4-chlorophenoxyacetic acid;
- Dichlobenil;
- Chlorothalonil (tetrachloroisophthalonitrile);
- Oxadiazon;
- Dicamba (3,6-dichloro-o-anisic acid);
- 2,4-dichlorophenoxyacetic acid;
- Isooctyl(2-ethylhexyl)2,4-dichlorophenoxyacetate;
- 4-(2,4-dichlorophenoxy)butyric acid;
- MCPP acid (2-(2-mehtyl-4-chlorophenoxy)propionic acid);
- Irgasan (5-chloro-2-(2,4-dichlorophenoxy)phenol);
- Dimethyl tetrachloroterephthalate;

Plant protection products imported in Ireland in 1998 are detailed below. These are the most recent available data.

Table 4.27: Plant protection products import figures

Product Type	**1998 Imports (tonnes)**
Herbicides	1,413
Fungicides	566
Insecticides/acaricides	80
Growth regulators	165
Seed treatments	35
Molluscicides	20
Adjuvants, wetters, etc.	146
Miscellaneous	44
TOTAL	**2,469**

The product types of most concern with regard to dioxin content are herbicides, fungicides and insecticides. Figures are available on the dioxin content of 2,4-dichlorophenoxyacetic acid (2,4-D), and are reported by the USEPA to average 0.7 µg/kg of pesticide. 2,4-D is part of the phenoxy class of chemicals. The Irish Pesticide Control Service (PCS) data for 1998 indicate that 516 tonnes of phenoxy based herbicide products were imported. If it is assumed that all of this material is 2,4-D, applying the USEPA emission factor suggests an emission due to application of 2,4-D of approximately 0.36 g/annum. No dioxin content data was found for other pesticides, though applying the 2,4-D emission factor to total herbicide, fungicide and insecticide imports suggests a (highly uncertain) worst case total dioxin emission to land of 1.4413 g/annum.

A detailed analysis of the types of pesticides used in Ireland is outside the scope of this study, however, the above exercise has been completed in order to provide an order of magnitude estimate of emissions from this category. Therefore, a high degree of uncertainty must be associated with the figures given below.

Table 4.28: Toolkit estimate of emissions – application of pesticides to land

Category	Air Emissions (g TEQ/a)			Water Emissions (g TEQ/a)			Land Emissions (g TEQ/a)		
	BE	L	H	BE	L	H	BE	L	H
Application of pesticides to land	NA	NA	NA	ND	ND	ND	0.9013	0.3612	1.4413

4.8 MISCELLANEOUS

4.8.1 Drying of Biomass

The UNEP toolkit indicates that dioxin emissions during drying of biomass can occur if contaminated wood is used as a fuel, resulting in significant dioxin concentrations in the product, and dioxin emissions to air. Such drying of biomass is not widely carried out in Ireland, and would not be expected to result in significant dioxin emissions to air, however, no specific data is available on the quantity of green fodder and wood chips dried on an annual basis in Ireland. Several large wood processing companies burn uncontaminated wood in boilers, these facilities are detailed in Section 4.3.2.

4.8.2 Crematoria

4.8.2.1 Subcategory Description

There were two crematoria operational in Ireland during 2000, both located in Dublin.

4.8.2.2 Available Activity Data

Data on the number of cremations carried out in Ireland was sourced from the two facilities currently operating crematoria in Ireland, who hold records of total cremations for 2000 (1,860 in 2000). It is understood that both of the cremators in operation in Dublin during 2000 are compliant with the UK Local Air Pollution Prevention and Control (LAPPC) Guidance Note on the environmental performance of crematoria (PG 5/2), in the absence of applicable Irish standards. This guidance note specifies a dioxin emission limit of 1 ng/m^3 for emissions to air. A minimum temperature of 850 ^{o}C in the secondary combustion chamber is also required, as well as a minimum residence time of 2 seconds.

Dioxin measurements were carried out in the UK on a number of PG 5/2 compliant cremators (AEA Technology, 2001). Average dioxin concentrations of 0.03 ng I-TEQ/Nm^3 were measured. Assuming (as detailed in the UNEP Toolkit) a cremation time of 70 minutes, and a measured flue gas flow of approximately 950 Nm^3/hour during these tests, dioxin emissions per cremation can be estimated at approximately 0.033 μg/cremation. This is significantly lower than even the optimal control emission factor detailed in the toolkit.

4.8.2.3 Toolkit Emission Estimate

No data on dioxin emissions from crematoria in Ireland were available. However, based on the technology of the cremators operated in 2000 and the emission factor generated from monitoring of similar cremators in the UK, the emission factor generated above, of 0.033 μg/cremation is used to generate the lower bound emissions estimate. The default toolkit emission factors of 0.4 (optimal control) and 10 (medium control) μg TEQ/cremation are employed to generate the best estimate and high estimate range of emissions, respectively.

A single emission factor is given in the UNEP Toolkit for dioxin in residue from the combustion process. The disposal route for this material is uncertain, though for the purposes of the inventory disposal to land is assumed.

Table 4.29: Toolkit estimate of emissions - crematoria

No.	Category	Air Emissions (g TEQ/a)			Water Emissions (g TEQ/a)			Land Emissions (g TEQ/a)		
		BE	L	H	BE	L	H	BE	L	H
8b	**Cremato-ria**	0.0007	0.0001	0.0186	NA	NA	NA	0.0047	0.0047	0.0047

4.8.3 Smoke Houses

As wood is a commonly used fuel in smoke houses, there is potential for dioxin emissions to air, and to land in the form of ash disposal. No data is available on smoke houses in Ireland, though it is considered that the majority of operations are very small. Consultation with BIM (Irish Sea Fisheries Board) indicated that fish smoking is not a large scale practice in Ireland and emissions are likely to be small. Emissions will vary depending on the quality of the fuel used in each smoke house, though no data are available on the types of fuels used in these facilities. Therefore, no estimate of emissions from these facilities can be formulated, though it is considered that emissions would be minimal.

4.8.4 Dry Cleaning Residues

The main source of dioxins from the dry cleaning process is from the actual textiles being cleaned, which may have dioxin contamination due to manufacturing methods. No dioxins are generated during the actual cleaning process, however dioxins from the textiles may be concentrated in the cleaning solvents. As the solvents are distilled for recovery and reuse, dioxins may be concentrated in the distillation residues, though these residues would not be disposed of directly to water or land.

4.8.5 Tobacco Smoking

4.8.5.1 Subcategory Description

Tobacco smoking is regarded as a minor source of dioxin emission to air, with the smoker normally regarded as the most exposed individual due to inhalation of tobacco smoke.

4.8.5.2 Available Activity Data

Official tobacco sales for 1998 indicate a total consumption of approximately 6,400,000,000 cigarettes per annum. However, it must be considered that significant quantities of cigarettes are consumed through illegal imports and legal personal imports. The Tobacco Manufacturers Association suggest that 1 in 3 cigarettes consumed in Ireland are illegal imports. Legal personal imports must also be considered, giving a range of emission factors for this category. A relatively small number of cigars are also consumed in Ireland, resulting in insignificant dioxin emissions.

The estimated range of tobacco consumption is as follows:

- Lower estimate: 6,400,000,000 cigarettes;
- Upper estimate: 9,500,000,000 cigarettes.

4.8.5.3 Toolkit Estimate of Emissions

The default UNEP toolkit emission factor of 0.1 pg TEQ/cigarette is used to calculate the data presented in the table below using the upper and lower bound activity statistics to generate the high and low emission estimates, respectively. The best estimate is taken as the arithmetic mean.

Table 4.30: Toolkit estimate of emissions – tobacco smoking

No.	Category	Air Emissions (g TEQ/a)			Water Emissions (g TEQ/a)			Land Emissions (g TEQ/a)		
		BE	L	H	BE	L	H	BE	L	H
8e	Tobacco Smoking	0.0008	0.0006	0.0010	NA	NA	NA	NA	NA	NA

4.9 WOOD PRESERVATION

Historical use of PCP (pentachlorophenol) in preserving of wood at timber manufacture and treatment sites is associated with dioxin emissions, as commercial preparations of PCP tend to contain varying percentages of chlorinated compounds including dioxins and furans. The Department of Agriculture, Food and Rural Development Pesticide Control Service provides authorisation, clearance, notification or permission to market pesticides on the Irish market. The term pesticide includes those products intended to protect plants from harmful organisms and those products intended to protect processed crops, sawn timber, masonry, and other materials, industrial products, processes and materials from harmful organisms.

Consultation with the pesticide control service indicated that PCP containing wood preservatives have not been used in Ireland for at least five years, and thus no direct emissions will have occurred in 2000, though reservoirs of PCP may be present on sites where PCP was formerly employed as a preservative. Wooden electricity transmission and phone telegraph poles are commonplace in Ireland, however these poles are treated with creosote, rather than PCP, hence dioxin emissions are not expected from this source.

There is potential for dioxin emissions from wood previously treated with PCP through slow evaporation, though emissions from this source are difficult to quantify as no information was available on the quantity of wood in Ireland which may have been treated with PCP preservatives. For this reason no estimate is presented in the current inventory.

4.10 DISPOSAL/LANDFILL

4.10.1 Landfills and Waste Dumps

4.10.1.1 Subcategory Description

Dioxins contained in landfill sites can enter the local groundwater when rainfall infiltration into the landfill results in dioxin contaminated leachate entering the groundwater. In lined landfill sites, leachate will not enter directly into the groundwater. However, any leachate treatment carried out either on or off-site may still result in dioxin emissions to water in effluent emissions. As the majority of landfills in Ireland are unlined it is assumed that 80 - 100 % of leachate enters the groundwater. This allows a range of emission estimates to be generated.

4.10.1.2 Available Activity Data

No estimate of leachate emissions to groundwater in Ireland was identified for the purposes of the dioxin emission calculations. The New Zealand Dioxin Emission Inventory (Buckland *et al.*, 2000) uses a methodology to estimate leachate production based on rainfall, mass of material landfilled, and the size of the landfill. This methodology can be applied roughly to the Irish situation to give an estimate of water contamination due to leachate from landfill sites.

Firstly, landfills are categorised according to their size as:

- Small (< 500 tonnes/annum);
- Medium (500 – 5,000 tonnes per annum);
- Large (> 5000 tonnes/annum).

Assuming that 0.5 tonnes equals 1 m^3, the volume of the landfilled waste in each category can be estimated. Then, taking the average landfill depth as 10 m for small and medium sites, and 20 m for large sites, the surface area of the sites can be calculated. Using rainfall data, the volume of water falling on the landfill for a given year can be estimated.

If the degree of infiltration of the rainwater is taken as 20 % for the small and medium sites, and 10 % for the large sites, then the quantity of leachate generated for the waste dumped per annum can be estimated. The UNEP toolkit provides an emission factor for dioxin content in leachate from landfills, hence the emissions to water from landfills can be estimated.

For Ireland, the 1998 National Waste Database Report (Crowe *et al.*, 2000) provides an estimate of the quantity of material landfilled at each of the local authority, private and industrial landfills in the country for that year (over 8 million tonnes in total). Based on this information each of the landfills can be classified by size, and the volume of landfilled waste can be estimated. Rainfall data for 2000 was provided by Met Eireann for each of their synoptic meteorological monitoring stations, allowing the volume of rainfall to be estimated based on the surface area of the landfilled waste.

To estimate the leachate generated from waste already in place an estimate of the total landfilled waste must be made. The quantity of waste landfilled is assumed to have grown by approximately 5 % per annum. Based on this, a rough estimate of the quantity of waste landfilled over the past fifty years can be approximated at 325,535,531 m^3. Assuming an average depth of 15 m, and an infiltration of 15 % for all of the waste, an approximation can be made of the volume of leachate produced annually from landfilled waste already in place. Assuming 80 – 100 % infiltration to water results in the following range of activity statistics (total leachate emissions to water in 2000):

- Lower estimate: 3,073,055 m^3;
- Upper estimate: 3,841,319 m^3.

4.10.1.3 Toolkit Estimate of Emissions

There is significant uncertainty associated with this estimate, though this calculation estimates that the annual dioxin emissions to water in landfill leachate can be expected to be relatively low. The default UNEP emission factor for dioxin emissions in leachate from non-hazardous landfilled waste is used to generate the figures below, using the range of leachate emissions detailed above to generate the low and high emission estimates. The best estimate emission is the arithmetic mean of the low and high emission estimates.

Table 4.31: Toolkit estimate of emissions – landfill leachate

No.	Category	Air Emissions (g TEQ/a)			Water Emissions (g TEQ/a)			Land Emissions (g TEQ/a)		
		BE	L	H	BE	L	H	BE	L	H
9a	Landfill Leachate	NA	NA	NA	0.1037	0.0922	0.1152	NA	NA	NA

4.10.2 Sewage and Sewage Treatment

4.10.2.1 Subcategory Description

The EPA report, Urban Waste Water Discharges in Ireland, A Report for the Years 1998 and 1999, provides details on the level of treatment applied to waste water discharges in Ireland. This 1998/1999 report indicates the following levels of treatment:

- 29 % of waste water arising did not receive any form of treatment;
- 7 % of waste water arising received preliminary treatment only;
- 38 % of waste water arising received primary treatment only;
- 21 % of waste water arising received secondary treatment only; and

- 5 % of waste water arising received phosphorus reduction in addition to secondary treatment.

The national population equivalent figure reported for 1998/1999 period is 5,101,115.

The main source of dioxins and furans from sewage and sewage treatment is in the dry sewage sludge, with an emission factor estimated at 100 µg TEQ/tonne of dry matter, compared to an emission factor of 5 pg TEQ/litre in sewage water effluent. It should be noted that dioxins are not formed during the treatment process, but are already present in the raw sewage.

4.10.2.2 Available Activity Data

1999 figures on sewage disposal pathways are available for Ireland (O'Leary *et al.*, 2000) indicating municipal sludge treatment as follows:

Table 4.32: Sewage sludge disposal routes, 1999

Disposal/Recovery Route	Total Quantity of Sludge (tonnes of dry matter/year)	% of Total
Agriculture	8,734	23.2
Landfill	16,753	44.6
Marine	11,763	31.3
Forestry	0.0	0.0
Other or unspecified	345	0.9
Total	37,595	100

For 2000, dumping at sea (i.e. marine in the above table) was not permitted. Consultation with the EPA indicated that the majority of this material was employed in agriculture in 2000. Therefore, the total sludge disposed to land in 2000 can be estimated at 37,250 tonnes (landfill + agriculture + marine). However, this figure is for 1998/1999, with the generation of sewage sludge likely to have increased for 2000. Reported dry sludge values for previous years indicate the following quantities of dry solids produced:

- 1994/1995: 28,541 tonnes;
- 1996/1997: 34,484 tonnes, increase of 5,943 tonnes;

The increase in dry solids generated between 1996/1997 to 1998/1999 is 3,111 tonnes. Therefore, the increase for 2000/2001 can be roughly estimated from these figures to be in the range 3,000 – 6,000 tonnes of dry solids. For the purposes of the inventory the following range of dry solids generation for 2000 is assumed:

- Lower estimate: 37,250 tonnes;
- Upper estimate: 43,250 tonnes.

To generate an activity statistic for emissions to water a per capita usage of 160 - 200 litres/day of water is assumed. However the 1998/1999 Urban Waste Water Discharges Report indicates that only 71 % of waste arising receives some form of treatment. Assuming that this percentage can be applied directly to population statistics, and based on a population of 3,786,900 in 2000 (CSO, 2001), it can be calculated that 2,688,699 persons are served by some form of treatment. Employing this figure in conjunction with the per capita daily water usage figures gives the following range of estimated waste water emissions:

- Lower estimate: 1.570×10^{11} litres/annum;
- Upper estimate: 1.963×10^{11} litres/annum.

4.10.2.3 Toolkit Estimate of Emissions

The UNEP emission factor for sewage sludge from urban environments (100 μg TEQ/tonne) is employed in generating the emission estimate to land given below. The range of activity statistics are used to generate the low and high emission estimate, while the best estimate emission is taken as the arithmetic mean.

The UNEP emission factors recommended for urban wastewater is applied to emissions to water (0.5 pg TEQ/litre of effluent), using the range of activity statistics above to generate the low and high emission estimate, with the best estimate taken as the arithmetic mean.

Table 4.33: Toolkit estimate of emissions- sewage/sewage treatment

No.	Category	Air Emissions (g TEQ/a)			Water Emissions (g TEQ/a)			Land Emissions (g TEQ/a)		
		BE	L	H	BE	L	H	BE	L	H
9b	Sewage/ Sewage Treatment	NA	NA	NA	0.0883	0.0785	0.0981	4.025	3.725	4.325

4.10.3 Composting

4.10.3.1 Subcategory Description

Composting is employed for disposal of organic waste from kitchens and gardens, parks and any other suitable material. The practice is not currently widespread in Irish homes. There is significant chicken litter composting being carried out in Ireland and seven Waste Licence Applications are currently lodged with the EPA for composting activities. No decision has yet been reached by the EPA on the issuing of these licences.

4.10.3.2 Available Activity Data

The UNEP Toolkit indicate that fractions can enter the compost which have high concentrations of dioxin, such as the content of vacuum cleaner bags or other fine particulates such as house dust, soil from contaminated land entering with vegetable and other plant leftovers, leaves from alleys impacted by traffic using leaded gasoline, greens from cemeteries or pesticide treated organic wastes. Concentrations above 100 ng I-TEQ/kg have been detected in these composts. The typical dioxin content of the final product when composting garden/kitchen waste is given as 15 µg TEQ/t of dry matter. In 1998 it is estimated that 1,003,053 tonnes of biodegradable waste, consisting of paper waste and kitchen and garden waste, were consigned to landfill (Crowe *et al.*, 2000). The development of composting has been slow in Ireland. Assuming that an equivalent of 1 % of the above landfilled biodegradable waste (1998 figure) was composted in Ireland in 2000, a conservative estimate of the likely dioxin emissions to land due to the application of the compost can be generated.

4.10.3.3 Toolkit Estimate of Emissions

The default UNEP toolkit emission factors for composted organic waste (100 µg TEQ/tonne of dry matter), composted garden/kitchen waste (15 µg TEQ/tonne of dry matter) and composted green material from unimpacted environments (5 µg TEQ/tonne of dry matter) were employed in calculating the high, medium and low estimates, respectively of dioxin emissions detailed below.

Table 4.34: Toolkit estimate of emissions - composting

No.	Category	Air Emissions (g TEQ/a)			Water Emissions (g TEQ/a)			Land Emissions (g TEQ/a)		
		BE	L	H	BE	L	H	BE	L	H
9d	Compost	NA	NA	NA	NA	NA	NA	0.1505	0.0502	1.003

4.10.4 Open Water Dumping

4.10.4.1 Subcategory Description

This sector relates to discharges from households, offices and other small businesses as well as run-off from contaminated land.

4.10.4.2 Available Activity Data

The 1998/1999 Urban Wastewater Discharges in Ireland Report (O'Leary *et al.*, 2000) indicates that 29 % of waste water receives no treatment. Assuming this can be related directly to population statistics, and based on an estimated population in 2000 of 3,786,900 it can be calculated that 1,098,201 persons are not served by any type of wastewater treatment facility. Based on an average daily consumption of water of 180 litres/day, direct emissions of untreated effluent can be estimated at 7.215×10^{10} litres/annum.

4.10.4.3 Toolkit Estimate of Emissions

The toolkit provides an emission factor to water for contaminated waste water (50 pg/litre) and mixed urban waste water (5 pg/litre). Using these low and high toolkit emission factors a low and high emission estimate can be calculated based on the estimated untreated waste water emissions. It is assumed that all untreated waste water is disposed to water. The best estimate emission is taken as the arithmetic mean.

Table 4.35: Toolkit estimate of emissions – open water dumping

No.	Category	Air Emissions (g TEQ/a)			Water Emissions (g TEQ/a)			Land Emissions (g TEQ/a)		
		BE	L	H	BE	L	H	BE	L	H
9e	Open	NA	NA	NA	1.9842	0.3608	3.6076	NA	NA	NA

	water dumping									

4.10.5 Waste Oil Disposal

This section relates to waste oils from canteens, restaurants, businesses, and also waste oils from cars and other motors. It is considered that a significant proportion of the waste mineral oils generated in Ireland may be combusted illegally, without treatment, however no activity statistics are available for this sector. Treatment of waste oil is carried out in Ireland. The main users of this recycled oil would be industrial sources, such as power generation and large industrial boilers/kilns.

DIOXIN AND FURAN INVENTORY FOR IRELAND

PART II: 2010 INVENTORY

5.0 ESTIMATE OF DIOXIN AND FURAN EMISSIONS 2010

5.1 MAIN CATEGORY 1 – WASTE INCINERATION

5.1.1 Municipal Solid Waste Incineration

5.1.1.1 Projected Activity Statistics

For the 2000 inventory, no municipal waste incineration activity was identified for Ireland.

The future management of solid municipal waste in Ireland is currently subject to significant uncertainty. A number of local authorities and groups of local authorities in Ireland have published or adopted waste management plans which include thermal treatment of waste as a potential disposal option. In early 2001, seven such plans were identified which include the incineration option, i.e. Dublin Region, North-east, Midlands, South-east, Connaught, Donegal and Wicklow. Based on these plans and draft plans the total potential amount of municipal waste for incineration by 2010 amounts to approximately 1,300,000 tonnes. All draft waste management plans were required to be adopted by 14 September 2001.

At the present time, only one large-scale municipal waste incineration project has reached the planning permission stage, i.e. the Carranstown proposal in Co. Meath.

Although several of the waste management plans include incineration as an option there is still some uncertainty as to whether such options will be fully implemented by 2010. Therefore, to develop a projected inventory for 2010 we have assumed high, medium and low activity statistics as follows:

Low: 500,000 tonnes / annum;
Medium: 1,000,000 tonnes per annum;
High: 1,500,000 tonnes per annum.

5.1.1.2 2010 Estimate of Emissions

The toolkit describes 4 classes of municipal waste incineration facilities, with Class 4 described as – *High technology combustion, sophisticated air pollution control.*

It is anticipated that all new municipal waste incineration facilities to be constructed in Ireland will be Class 4.

With regard to emissions to air, the toolkit specified an emission factor of 0.5 µg per tonne of MSW incinerated. This figure is based on a flue gas generation rate of 5,000 Nm^3 / tonne of MSW and a dioxin concentration of 0.1 ng / Nm^3.

Releases to water are not considered to be a significant release route and no factor is provided.

For solid residues, the toolkit provides a factor for both fly-ash and bottom ash of 15 and 1.5 µg per tonne of MSW incinerated, respectively. It is assumed that both bottom and fly ash are landfilled under controlled conditions at licensed facilities thereby limiting any potential release of dioxins to the environment. Land emissions in this case means the deposit of waste in landfills.

The 2010 estimate of emissions from this sector is as follows:

Table 5.1: Municipal waste incineration, estimated 2010 emissions

No.	Category	Air Emissions (g TEQ/a)			Water Emissions (g TEQ/a)			Land Emissions (g TEQ/a)		
		BE	L	H	BE	L	H	BE	L	H
1a	Municipal Waste Incineration	0.500	0.250	0.750	NA	NA	NA	16.500	8.250	24.750

It should be noted that this estimate does not take into account any advances in incineration or flue gas treatment systems to the year 2010. For example, the Carranstown proposal for municipal waste incineration states that emissions to air from the incineration facilities will be limited to 0.01 ng/Nm^3 TEQ, i.e. 1/10^{th} of the assumed emission limit in the UNEP Toolkit. There are also a number of technologies at the development stage for flyash treatment to reduce dioxin levels.

5.2.1 Hazardous Waste Incineration

5.2.1.1 Projected Activity Statistics

For the year 2000, an estimated 20,000 tonnes of hazardous wastes were incinerated in on-site dedicated incinerators in the pharmaceutical and chemical industries.

During the same year it is estimated that 40,000 – 50,000 tonnes of waste was exported from Ireland for incineration elsewhere in Europe.

In deriving an estimate of the amount of hazardous waste likely to be incinerated in Ireland in the year 2010, the following has been taken into consideration.

In early 2001 one additional on-site hazardous waste incinerator was commissioned. There is also one additional on-site hazardous waste incinerator currently under construction in Ireland which is expected to treat up to approximately 10,000 tonnes of on-site generated hazardous waste per annum. It is understood that no other major on-site hazardous waste incinerators are currently planned. The additional plant commissioned in 2001 and the new plant currently under construction may raise the total on-site incineration for the year 2010 to 30,000 – 40,000 tonnes. One commercial hazardous waste treatment plant is currently being planned for Ireland, with an expected annual capacity of approximately 40,000 – 60,000 tonnes.

5.2.1.2 2010 Estimate of Emissions

For the on-site hazardous waste incineration figure of 30,000 – 40,000 tonnes/annum, the range of emission factors derived for the 2000 inventory are applied to these data as these are based on actual measurements at such facilities.

For the commercial hazardous waste facility capacity of 40,000 – 60,000 tonnes/annum the default toolkit emission factors for emissions to air (0.75 μg/tonne) and in fly ash (30 μg/tonne) are employed while the range of treated material is used to generate the low and high emissions scenarios with the arithmetic mean used as the best estimate emission.

Table 5.2: Hazardous waste incineration, estimated 2010 emissions

No.	Category	Air Emissions (g TEQ/a)			Water Emissions (g TEQ/a)			Land Emissions (g TEQ/a)		
		BE	L	H	BE	L	H	BE	L	H
1b	Hazardous Waste Incineration	0.0494	0.0318	0.0890	0.0060	0.0009	0.0220	1.5060	1.2009	1.8220

5.2.2 Medical Waste Incineration

It is not anticipated that medical waste will be incinerated in Ireland in the future but rather will be sterilised prior to landfill disposal (Humphreys and Murphy, 2000). Three such sterilisation facilities are currently licensed by the EPA under the Waste Management licensing system and it is understood that the Department of Health hold contracts with these facilities up to the year 2010.

5.2.3 Light Fraction Shredder Waste Incineration

It is not anticipated that incineration of light fraction shredder waste will be carried out in Ireland in 2010.

5.2.4 Sewage Sludge Incineration

It is not considered that sewage sludge incineration will be carried out in Ireland in 2010. Other disposal routes such as use on agricultural land are expected to be a major disposal route, while landfilling of sludge is also likely to be carried out. In 2005, it is estimated that 74 % of the treated sludge in Ireland will be recycled, with the remainder disposed to landfill (European Environment Agency, 2001). The most recent report on Urban Waste Water Discharges in Ireland (O'Leary *et al.*, 2000) recommends investigation of disposal routes such as in forestry and bog restoration. In the UK disposal routes including land reclamation and the production of light-weight aggregates for use in construction are currently employed (ENDS Report, 2001). In Scotland, dried sludge is used in Scottish Power's coal fired power stations to generate electricity (ENDS Report, 2001).

5.2.5 Waste Wood and Waste Biomass Incineration

Dioxin emissions from this source are included in the 'Power Generation and Heating' Category.

5.2.6 Animal Carcass Burning

It is not anticipated that animal carcass burning will be carried out in 2010. However, the possibility cannot be ruled out in the event of a catastrophic animal disease breakout.

5.3 MAIN CATEGORY 2 – FERROUS AND NON-FERROUS METAL PRODUCTION

5.3.1 Iron Ore Sintering

It is not anticipated that Iron ore sintering will be carried out in Ireland in 2010.

5.3.2 Coke Production

It is not anticipated that coke production will be carried out in Ireland in 2010.

5.3.3 Iron and Steel Production Plants

5.3.3.1 Projected Activity Statistics

The 2000 emissions estimate from this category was dominated by one large facility (electric arc furnace) where scrap steel was reprocessed. During 2001 this facility was closed and is not expected to reopen.

It is considered that the small number of ferrous foundries currently in the country will be operational in 2010. One of these facilities is currently investigating increasing production capacity from 7,000 to 30,000 tonnes per annum (figures taken from EIS for upgraded plant). The 2000 estimate of foundry activity employed a production figure of 15,000 tonnes per annum. Allowing for potential expansions, 2010 production has been estimated at 35,000 tonnes/annum. It is considered likely that foundries in 2010 will be required to employ advanced gas cleaning systems resulting in lower emissions. Therefore, the following emission factor as specified in the toolkit, has been employed to generate the best estimate emission.

- Hot air cupola/induction furnace with fabric filter: 0.03 µg/tonne to air; 0.5 µg/tonne to land;

As there is significant uncertainty in the activity data employed in generating this estimate, a range of activity statistics is employed as follows:

- Lower bound: 15,000 tonnes:
- Upper bound: 35,000 tonnes.

5.3.3.2 2010 Emission Estimates

The low and high emission estimates are based on the range of production figures and the emission factor of 0.03 µg/tonne for emissions to air and 0.5 µg/tonne or emissions to land. The best estimate emission is taken as the arithmetic mean.

Table 5.3: Ferrous foundries, estimated 2010 emissions

No.	Category	Air Emissions (g TEQ/a)			Water Emissions (g TEQ/a)			Land Emissions (g TEQ/a)		
		BE	L	H	BE	L	H	BE	L	H
2d	Ferrous foundries	0.0008	0.0005	0.0011	NA	NA	NA	0.0125	0.0075	0.0175

5.3.4 Copper Production

It is considered that production of copper is unlikely to be carried out in 2010.

5.3.5 Aluminium Production

5.3.5.1 Projected Activity Statistics

It is considered that significant increases in quantities of processed aluminium will not occur within the next ten years.

5.3.5.2 2010 Emission Estimates

It is envisaged that waste gas treatment technology will improve by 2010, hence the UNEP reported emission factors associated with advanced abatement technology (0.5 µg/tonne) is employed in estimating the low emissions estimate for 2010, assuming the same production figures as were employed in the 2000 inventory. The emission factor generated from measurements carried out in 2001 (see Section 4.2.5.4) of 8.3 µg/tonne is employed to generate the high emission estimate. The best estimate emission is taken as the arithmetic mean.

For emissions to land, there is no difference in the toolkit emission factors as employed in the 2000 inventory as follows:

- Minimum: 100 µg/tonne;
- Maximum: 400 µg/tonne;

Using the above emission factors and the 2000 activity statistics, emission estimates are presented below. Air emissions are reduced compared to the 2000 inventory, while emissions to land remain unchanged.

Table 5.4: Aluminium production, estimated 2010 emissions

No.	Category	Air Emissions (g TEQ/a)			Water Emissions (g TEQ/a)			Land Emissions (g TEQ/a)		
		BE	L	H	BE	L	H	BE	L	H
2f	Aluminium Production	0.0274	0.0031	0.0517	NA	NA	NA	1.5580	0.6232	2.4928

5.3.6 Lead Production

It is considered that lead production is unlikely to be carried out in Ireland in 2010.

5.3.7 Zinc Production

It is considered that zinc production is unlikely to be carried out in Ireland in 2010.

5.3.8 Brass Production

It is considered that brass production is unlikely to be carried out in Ireland in 2010.

5.3.9 Magnesium Production

It is considered that magnesium production is unlikely to be carried out in Ireland in 2010.

5.3.10 Other Non-Ferrous Metal Production

It is considered that processing of other non-ferrous metals is unlikely to be carried out in Ireland in 2010.

5.3.11 Shredders

5.3.11.1 Projected Activity Statistics

It is estimated that there will be approximately 1.5 million private cars on the road in 2010 (Department of Public Enterprise, 1999). In 2000, the ratio of total vehicles taken off the road to vehicles on the road is estimated at 13.3 %. Applying this to the estimated 2010 vehicle number provides an estimate of 199,500 vehicles taken off the road in 2010. Again, assuming that these vehicles are all scrapped, the mass of ferrous metal produced can be estimated at 151,620 tonnes. Using the same methodology as the 2000 estimate, the following range of activity statistics can be generated:

- Lower estimate: 75,810 tonnes;
- Upper estimate: 151,620 tonnes.

5.3.11.2 2010 Estimate of Emissions

In the absence of detailed emission factors for shredding processes it is difficult to estimate reductions in emissions between 2000 and 2010. In 2010 scrap will require significant preparation before shredding to remove contaminants (plastics/oils). As these contaminants would contribute to dioxin generation, there is potential for reduced dioxin emissions in 2010.

However, as little data are available regarding future dioxin emissions from shredding, the data presented below use the emission factor employed for estimating 2000 emissions (the UNEP Toolkit emission factor). The range of activity statistics presented above are used to generate the low and high emission estimates, while the arithmetic mean is taken as the best estimate.

Table 5.5: Shredders, estimated 2010 emissions

No.	Category	Air Emissions (g TEQ/a)			Water Emissions (g TEQ/a)			Land Emissions (g TEQ/a)		
		BE	L	H	BE	L	H	BE	L	H
2l	Shredders	0.0227	0.0152	0.0303	NA	NA	NA	NA	NA	NA

5.3.12 Thermal Wire Reclamation

It is considered that thermal wire reclamation will not be carried out in Ireland in 2010.

5.4 MAIN CATEGORY 3 – POWER GENERATION AND HEATING

5.4.1 Fossil Fuel Power Generation

5.4.1.1 Projected Activity Statistics

A projected 2010 National Energy Balance was prepared as part of the Green Paper on Sustainable Energy (Department of Public Enterprise, 1999) and is also included in the EPA publication Emissions to Air 1990 – 1998 (McGettigan and Duffy, 2000). No distinction is made between gasoil and oil in the projected 2010 Energy Balance, which are given different emission factors in the UNEP toolkit. The oil/gasoil ratio employed in the 2000 Oil Balance is applied to the 2010 estimates to give the following results:

Table 5.6: Estimated 2010 fuel usage, fossil fuel power generation

Fuel	Electricity Gen	Industrial	Total
Coal	60,834	10,634	71,468
Oil	16,580	36,739	53,319
Gas/gasoil	142,100	106,701	248,801
Peat	20,725	-	20,725

5.4.1.2 2010 Estimate of Emissions

The emission factors used in revising the 2000 emissions from this category are employed in the 2010 emission estimate calculations.

The 2010 emission estimates are as follows:

Table 5.7: Fossil fuel power generation, estimated 2010 emissions

No.	Category	Air Emissions (g TEQ/a)			Water Emissions (g TEQ/a)			Land Emissions (g TEQ/a)		
		BE	L	H	BE	L	H	BE	L	H
3a	**Coal**	0.3931	0.0715	0.7147	NA	NA	NA	0.5360	0.0643	1.0006
	Oil	0.0773	0.0213	0.1333	NA	NA	NA	NA	NA	NA
	Peat	0.1880	0.1762	0.1998	NA	NA	NA	0.3523	0.2901	0.4145
	Gas	0.1244	0.1120	0.1368	NA	NA	NA	NA	NA	NA
	Total	0.7828	0.3809	1.1846				0.8883	0.3545	1.4151

5.4.2 Biomass Power Plants

5.4.2.1 Projected Activity Statistics

A projected 2010 National Energy Balance was prepared as part of the Green Paper on Sustainable Energy (Department of Public Enterprise, 1999) and is also included in the EPA publication Emissions to Air 1990 – 1998 (McGettigan and Duffy, 2000).

The amount of wood burnt is given as 0.095 MTOE or approximately 3,977 TJ (367,000 tonnes at 11 MJ/kg).

5.4.2.2 2010 Estimate of Emissions

The emission factors employed for estimating emissions in the 2000 inventory are employed for the 2010 inventory. The total quantity of wood burned per annum is taken as 367,000 tonnes. As the dataset employed in generating these emission factors is limited, confidence in the emission data detailed below is low.

Table 5.8: Biomass power plants, estimated 2010 emissions

No.	**Category**	**Air Emissions (g TEQ/a)**			**Water Emissions (g TEQ/a)**			**Land Emissions (g TEQ/a)**		
		BE	**L**	**H**	**BE**	**L**	**H**	**BE**	**L**	**H**
3a	**Wood**	0.1040	0.0092	0.1989	NA	NA	NA	0.5223	0.0010	1.0436

5.4.3 Landfill/Biogas Combustion

5.4.3.1 Projected 2010 Activity Statistics

It is reported that up to 39.8 MWe of electrical power could be generated from landfill gas by 2020 (Altener, 1997), i.e. a 25 MW increase over 2000 capacity. No estimates are available for 2010. However, assuming that 50 % of this capacity is installed by 2010, a figure of 27.3 MWe can be used to estimate emissions in 2010.

5.4.3.2 2010 Estimate of Emissions

Employing the same methodology as was used to estimate landfill gas consumption for the 2000 emissions estimate (with the exception that the efficiency of the engines is assumed at 35 %), the following emissions were calculated for 2010.

Table 5.9: Landfill gas combustion, estimated 2010 emissions

No.	Category	Air Emissions (g TEQ/a)			Water Emissions (g TEQ/a)			Land Emissions (g TEQ/a)		
		BE	L	H	BE	L	H	BE	L	H
3c	**Landfill gas combust-ion**	0.0118	0.0079	0.0157	NA	NA	NA	NA	NA	NA

5.4.4 Household Heating and Cooking (Biomass)

5.4.4.1 Projected Activity Statistics

Information on consumption of biomass was derived from the projected 2010 Energy Balance (McGettigan and Duffy, 2000) and includes combustion of wood. Wood is not reported individually in the energy balance, but is included as a renewable energy source. This figure is assumed to be representative of wood combustion in the residential sector.

Total renewable energy used in the residential sector amounts to 1,717 TJ (this is understood to relate to wood burning only). As there is some uncertainty in this statistic, this values is taken as the lower bound activity statistic, with 2060 TJ (+ 20 % of lower bound) taken as the upper bound activity statistic.

5.4.4.2 2010 Estimate of Emissions

The UNEP Toolkit factors for emissions to air and land (as ash) and the range of activity statistics given above are used to generate the low and high emission estimate. The arithmetic mean is taken as the best estimate emission.

Table 5.10: Heating and cooking with biomass, estimated 2010 emissions

No	Category	Air Emissions (g TEQ/a)			Water Emissions (g TEQ/a)			Land Emissions (g TEQ/a)		
		BE	L	H	BE	L	H	BE	L	H
3d	**Household heating and cooking with biomass**	0.1888	0.1717	0.2060	NA	NA	NA	0.0378	0.0343	0.0412

5.4.5 Household Heating and Cooking (Fossil Fuel)

5.4.5.1 Projected Activity Statistics

Information on consumption of fossil fuels by residential users was taken from the projected 2010 Energy Balance, including use of coal, oil, peat and natural gas.

The energy consumption in the residential sector is reported below.

Table 5.11: Household heating and cooking fossil fuel usage (TJ/annum)

Fuel	Official estimate (TJ)
Coal	5,191
Oil	60,960
Gas	27,675
Peat	4,605

5.4.5.2 2010 Estimate of Emissions

The methodologies used to generate the 2000 emissions are also employed for the 2010 emission estimates.

Table 5.12: Fossil fuel heating and cooking, estimated 2010 emissions

No	Category	Air Emissions (g TEQ/a)			Water Emissions (g TEQ/a)			Land Emissions (g TEQ/a)		
		BE	L	H	BE	L	H	BE	L	H
3d	Coal	0.3634	0.1817	1.2719	NA	NA	NA	0.9361	0.4699	1.4023
	Oil	0.6096	0.0488	2.4384	NA	NA	NA	NA	NA	NA
	Gas	0.0415	0.0332	0.0581	NA	NA	NA	NA	NA	NA
	Peat	0.3224	0.1612	2.5791	NA	NA	NA	1.5760	0.7911	2.3609
	TOTAL	1.3369	0.4249	6.3475				2.5121	1.2610	3.7632

5.5 MINERAL PRODUCTS

5.5.1 Cement Kilns

5.5.1.1 Projected Activity Statistics

Cement production in Ireland was carried out at three locations during 2000. Another facility is scheduled to begin production in 2002, which will increase cement production capacity by up to 450,000 tonnes per annum. Total capacity will then be in the region of 4 million tonnes/annum. The following range of activity statistics are employed (the upper estimate is based on estimated production capacity):

- Lower estimate: 3,645,000 tonnes;
- Upper estimate: 4,050,000 tonnes.

5.5.1.2 2010 Estimate of Emissions

The emission factors employed for the 2000 inventory are used to generate the figures detailed below. The low and high estimates use the range of activity statistics detailed above, while the arithmetic mean is taken as the best estimate emission.

Table 5.13: Cement production, estimated 2010 emissions

No.	Category	Air Emissions (g TEQ/a)			Water Emissions (g TEQ/a)			Land Emissions (g TEQ/a)		
		BE	L	H	BE	L	H	BE	L	H
4a	**Cement Kilns**	0.5771	0.5468	0.6075	ND	ND	ND	NA	NA	NA

5.5.2 Lime

5.5.2.1 Projected Activity Statistics

There are no indications at present of any significant variations in lime production in the coming years. The 2000 estimated production was estimated at approximately 281,000 tonnes. To account for slight variations in production in 2010, the following range of production is employed in estimating 2010 emissions:

- Lower estimate: 250,000 tonnes;
- Upper estimate: 310,000 tonnes.

5.5.2.2 2010 Estimate of Emissions

Assuming improved flue gas cleaning technology in 2010, the UNEP Toolkit emission factor for lime production with dust abatement (0.07 μg/tonne) is employed. The range of activity statistics above are used to generate the low and high emission estimate, while the arithmetic mean is taken as the best estimate emission.

Table 5.14: Lime production, estimated 2010 emissions

No.	Category	Air Emissions (g TEQ/a)			Water Emissions (g TEQ/a)			Land Emissions (g TEQ/a)		
		BE	L	H	BE	L	H	BE	L	H
4b	**Lime**	0.0196	0.0175	0.0217	NA	NA	NA	ND	ND	ND

5.5.3 Brick

5.5.3.1 Projected Activity Statistics

Brick production for 2000 was estimated at 105,000 tonnes. In the absence of 2010 estimates of brick production, the following production range is employed:

- Lower estimate: 80,000 tonnes;
- Upper estimate: 130,000 tonnes.

5.5.3.2 Toolkit Estimate of Emissions

The UNEP toolkit provides an emission factor range emissions to air from 0.02 (with abatement) to 0.2 (minimal abatement) µg TEQ / tonne brick. These factors are based on emissions data sourced in Germany.

While the 2000 high scenario emission estimate assumed minimal dust abatement, the UNEP emission factor for production with dust abatement has been employed for the 2010 estimate. The low and high emission estimates employ the range of activity statistics detailed above, while the arithmetic mean is taken as the best estimate.

Table 5.15: Brick production, estimated 2010 emissions

No.	Category	Air Emissions (g TEQ/a)			Water Emissions (g TEQ/a)			Land Emissions (g TEQ/a)		
		BE	L	H	BE	L	H	BE	L	H
4c	Brick	0.0021	0.0016	0.0026	NA	NA	NA	NA	NA	NA

5.5.4 Glass

5.5.4.1 Projected Activity Statistics

In the absence of 2010 estimated production figures the following range of production is assumed, based on the 2000 figures:

- Lower estimate: 140,000 tonnes;
- Upper estimate: 200,000 tonnes.

5.5.4.2 Toolkit Estimate of Emissions

The toolkit provides an emission factor of 0.2 µg TEQ / tonne for sites with poor combustion control and limited abatement. A factor of 0.015 µg TEQ / tonne glass is suggested with modern abatement. These factors are based on a limited emission dataset from Germany. For the 2010 inventory it is assumed that dust abatement is used at all production facilities, hence the factor of 0.015 µg TEQ / tonne is used.

The low and high estimates given below are based on the range of activity statistics given in Section 5.5.4.1, while the arithmetic mean is taken as the best estimate emission.

Table 5.16: Glass production, estimated 2010 emissions

No.	Category	Air Emissions (g TEQ/a)			Water Emissions (g TEQ/a)			Land Emissions (g TEQ/a)		
		BE	**L**	**H**	**BE**	**L**	**H**	**BE**	**L**	**H**
4d	**Glass**	0.0026	0.0021	0.0030	NA	NA	NA	ND	ND	ND

5.5.5 Ceramics

No emission factor is provided in the toolkit for emissions from ceramics production, and consolidated production figures are not available. This sector is not considered a significant source of dioxin emissions.

5.5.6 Asphalt Mixing

5.5.6.1 Projected Activity Statistics

Total production in 2000 is reported at approximately 1.5 million tonnes. In the absence of production estimates for 2010, the following range of production is assumed:

- Lower estimate: 1,250,000 tonnes;
- Upper estimate: 1,750,000 tonnes.

5.5.6.2 2010 Estimate of Emissions

The toolkit provides emission factors for emissions to air of 0.007 µg TEQ / tonne of asphalt for mixing plant with fabric filters or wet scrubbers and a factor of 0.07 for plants with no gas cleaning. For the 2010 inventory it is assumed that all production facilities will use fabric filters or wet scrubbers.

The range of production figures detailed in Section 5.5.6.1 is employed in generating the low and high emission estimates for 2010, while the arithmetic mean is taken as the best estimate emission.

Table 5.17: Asphalt mixing, estimated 2010 emissions

No.	Category	Air Emissions (g TEQ/a)			Water Emissions (g TEQ/a)			Land Emissions (g TEQ/a)		
		BE	L	H	BE	L	H	BE	L	H
4f	Asphalt Mixing	0.0105	0.0088	0.0123	NA	NA	NA	NA	NA	NA

5.6 TRANSPORT

5.6.1 4-Stroke Engines

5.6.1.1 Projected Activity Statistics

The total unleaded fuel consumption for 2000 was 1,467,000 tonnes. Total transportation fuel usage in 1999 is given at 3,745,000 tonnes of oil equivalent. The projected 2010 national energy balance estimates transportation fuel usage of 4,863,000 tonnes of oil equivalent. This implies a 30 % increase from 1999. Assuming a pro rata increase for all transportation fuel, an approximate unleaded fuel usage for 2010 of 1,907,100 tonnes can be estimated. For the 2000 inventory it was estimated that 98 % of unleaded petrol is used in 4-stroke engines. Applying the same statistics to the 2010 inventory suggests a total fuel usage of 1,868,958 tonnes of unleaded fuel in 4-stroke engines.

It has been estimated that the number of passenger vehicles on the road in 2010 will increase to between 1.5 and 1.6 million passenger cars (Department of Public Enterprise, 1999). As the toolkit indicates that there are no significant dioxin emissions from catalyst equipped vehicles it is important to estimate the number of such vehicles.

The most recent bulletin of vehicle and driver statistics (Department of the Environment, 2000), indicates that 99 % of road vehicles are less than 17 years old. As all vehicles after 1993 are fitted with catalysts, all vehicles in 2010 less than 17 years old should be catalyst equipped, assuming a similar trend in vehicle purchasing. Therefore, it can be assumed that 1 % of vehicles in 2010 will not be catalyst equipped. Hence, it can be estimated that a range of 0.5 %

- 1.5 % of unleaded fuel sales will be used in non-catalyst vehicles, giving a range of activity statistics as follows:

- Lower estimate: 9,345 tonnes;
- Upper estimate: 28,034 tonnes.

5.6.1.2 2010 Estimate of Emissions

The Toolkit emission factor for unleaded fuelled vehicles without catalysts is 0.1 µg TEQ/tonne of fuel burned. Using the range of fuel usage (in non-catalyst equipped vehicles) as given in Section 5.6.1.1 the low and high emission estimate can be calculated. The arithmetic mean is taken as the best estimate emission.

Emissions from catalyst equipped vehicles are reported as zero.

Table 5.18: 4-Stroke engines, estimated 2010 emissions

No.	Category	Air Emissions (g TEQ/a)			Water Emissions (g TEQ/a)			Land Emissions (g TEQ/a)		
		BE	L	H	BE	L	H	BE	L	H
5a	4-Stroke Engines	0.0019	0.0009	0.0028	NA	NA	NA	NA	NA	NA

5.6.2 2-Stroke Engines

5.6.2.1 Projected Activity Statistics

Fuel usage in 4-stroke petrol engines was assumed to be 98 % of total sales. Due to uncertainty in the use of petrol in unregistered vehicles (such as outboard engines on boats and other non-road 2-stroke engines such as lawnmowers) a range of dioxin emissions from 2-stroke engines was estimated assuming petrol consumption between 1 % and 3 % of total fuel sales.

The EU have proposed a new directive relating to measures against the emissions of gaseous and particulate pollutants from internal combustion engines to be installed in non-road mobile machinery (COM(2000) 840). This relates to emissions from lawn mowers, chain saws, strimmers and other small petrol engined equipment. It is suggested that emissions from small handheld engines will be reduced by 80-85 % from 2010, with some reductions also occurring from 2004 as the first set of limit values come into force at this stage. However, as the impact of this directive in 2010 is difficult to quantify. the UNEP default emission factors are employed in calculating 2010 emissions.

5.6.2.2 2010 Estimate of Emissions

The UNEP quoted emission factor for 2 stroke engines is 2.5 µg TEQ/tonne of fuel burned, derived from various European studies.

The default UNEP emission factor is employed to calculate the emissions detailed below.

Table 5.19: 2-Stroke engines, estimated 2010 emissions

No.	Category	Air Emissions (g TEQ/a)			Water Emissions (g TEQ/a)			Land Emissions (g TEQ/a)		
		BE	**L**	**H**	**BE**	**L**	**H**	**BE**	**L**	**H**
5b	**2-Stroke Engines**	0.0954	0.0477	0.1430	NA	NA	NA	NA	NA	NA

5.6.3 Diesel Engines

5.6.3.1 Projected Activity Statistics

Assuming an approximate 25 – 35 % growth in diesel fuel sales, 2010 diesel consumption can be estimated in the following range:

- Lower estimate: 1,787,500 tonnes;
- Upper estimate: 2,502,500 tonnes.

5.6.3.2 2010 Estimate of Emissions

Dioxin emissions from diesel consumption account for a significantly higher level of dioxin emissions compared to other categories in the transportation sector. The recommended UNEP emission factor for diesel is 0.5 µg TEQ/tonne of fuel burned. It is likely that diesel engines will operate more efficiently in 2010 and be less polluting. As no emission factor is available for such a scenario the lower emission scenario is taken as 75 % of the estimated emissions employing the toolkit emission factor. The emission calculated using the toolkit factor is used for the maximum emission scenario while the best estimate uses the arithmetic mean of the low and high emissions scenarios.

Table 5.20: Diesel engines, estimated 2010 emissions

No.	Category	Air Emissions (g TEQ/a)			Water Emissions (g TEQ/a)			Land Emissions (g TEQ/a)		
		BE	**L**	**H**	**BE**	**L**	**H**	**BE**	**L**	**H**
5c	**Diesel Engines**	1.0725	0.8938	1.2513	NA	NA	NA	NA	NA	NA

5.6.4 Heavy Oil Fired Engines

As much of the combustion of heavy fuel oil on ships is likely to occur outside Ireland, this source is not considered significant.

5.7 UNCONTROLLED COMBUSTION PROCESSES

5.7.1 Biomass Burning

5.7.1.1 Projected Activity Statistics

In order to estimate emissions from forest fires, data received from Coillte detailing the area of forest fires over the period 1995 – 2000 (32 – 660 ha/annum) was employed to generate the range of potential material consumed in 2010. As these figures are for Coillte forests only, the 1995 – 2000 figures can be extrapolated to between 50 and 1031 hectares, based on total forested area in Ireland (see Section 4.6.1.2).

In order to estimate the mass of this material a range of 10 – 23.3 tonnes/hectare as employed in estimating 2000 emissions was again used. Combining these above datasets provided a potential range of material consumed in 2010 as follows:

- Lower estimate: 500 tonnes;
- Upper estimate: 24,021 tonnes;

The range of emissions estimated for bog fires in the 2000 inventory is also employed for the 2010 estimate.

No information is available on the area of land affected annually by stubble burning; hence no estimate of dioxin emissions from this source is included in the inventory for 2010.

5.7.1.2 2010 Estimate of Emissions

The estimate below includes emissions from forest and bog fires only, as no data were available on agricultural residue burning.

Table 5.21: Biomass burning, estimated 2010 emissions

No	Category	Air Emissions (g TEQ/a)			Water Emissions (g TEQ/a)			Land Emissions (g TEQ/a)		
		BE	L	H	BE	L	H	BE	L	H
6a	Biomass Burning	0.1089	0.0263	0.1914	ND	ND	ND	0.0871	0.0210	0.1532

5.7.2 Waste Burning and Accidental Fires

5.7.2.1 Projected Activity Statistics

The number of reported landfill fires in Ireland is low. Consultation with EPA waste licensing inspectors indicated that only two reported landfill fires in 2000. Both the duration and extent of these fires was short. These reports suggest minimal dioxin emissions to atmosphere from landfill fires, therefore emissions from this sub-category are considered negligible, assuming a similar or smaller number of fires in 2010.

Estimates of emissions from accidental fires in houses/factories in 2010 are difficult to predict, as the number of fires occurring can not easily be predicted. It is likely that the number of fires occurring in 2010 will be lower than that in 2000 due to improved fire safety and also improved fire fighting techniques which may reduce the duration and extent of a fire. However, as no estimates of the potential reduction in the extent of fires are available the 2000 emissions data are used in the 2010 inventory.

In 2010 it is considered that significant quantities of material will be still be consumed through uncontrolled burning of domestic waste, though it is likely that a reduction in the quantity of material may result from improved waste collection, increased public awareness coupled with greater anticipated legislative enforcement and implementation of waste minimisation methods. The extent of any reduction in the quantity of material burned is difficult to predict, hence the 2000 estimates are employed for 2010.

Emissions from vehicle fires in 2010 have been assumed to be the same as emissions calculated in 2000, as no estimate of the future number of vehicle fires is available.

No direct data are available on the quantity of construction/demolition wood consumed in open burning. The emission estimate generated for 2000 is employed in the 2010 inventory.

Dioxin emissions from bonfires in 2010 are assumed to be the same as estimated for 2000.

It is considered that burning of farm plastics will reduce as the REPS (Rural Environmental Protection Scheme) scheme continues to grow. Currently 40 % of farm plastics are collected for recycling. It is considered that this figure will increase and a figure of 60 – 80 % has been employed in the 2010 inventory to generate the low and high emission scenarios. 70 % collection is assumed for the best estimate scenario. The upper and lower bound activity statistics are as follows, based on 15 % of uncollected plastics being burned:

- Lower estimate: 405 tonnes;
- Upper estimate: 810 tonnes.

5.7.2.2 Toolkit Estimate of Emissions

A breakdown of the emissions from each subcategory in this sector is presented below. All estimates are based on the UNEP toolkit default emission factors.

Table 5.22: Waste burning and accidental fires, estimated 2010 emissions

No	Category	Air Emissions (g TEQ/a)			Water Emissions (g TEQ/a)			Land Emissions (g TEQ/a)		
		BE	L	H	BE	L	H	BE	L	H
6b	Landfill fires	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Accidental building fires	5.1407	2.3782	7.9033	ND	ND	ND	5.1407	2.3782	7.9033
	Domestic waste burning	17.9492	4.4873	31.4110	ND	ND	ND	35.8983	8.9746	62.8221
	Accidental vehicle fires	0.3882	0.3882	0.3882	ND	ND	ND	0.0743	0.0743	0.0743
	Open burning of construction wood	0.8115	0.8115	0.8115	ND	ND	ND	0.1352	0.1352	0.1352
	Bonfires	0.9091	0.9091	0.9091	ND	ND	ND	0.1515	0.1515	0.1515
	Farm plastics	0.1823	0.1215	0.2430	ND	ND	ND	0.3645	0.2430	0.4860
	TOTAL	25.3810	9.0958	41.6662	0.00	0.00	0.00	41.7647	11.9568	71.5725

5.8 PRODUCTION AND USE OF CHEMICAL AND CONSUMER GOODS

5.8.1 Pulp and Paper Mills

No information is available on the potential for pulp production in Ireland in the future, though it is considered unlikely.

5.8.2 Chemical Industry

In Ireland, there are no major producers of chemicals. This situation is unlikely to change by 2010.

5.8.3 Petroleum Industry

There are currently no potential sources of dioxin emissions from this category in Ireland. The same situation is assumed for 2010.

5.8.4 Textile Plants

Dioxin emissions from the textile industry are poorly characterised, with the UNEP Toolkit only providing emissions factor for dioxin in the product, thus no estimate can be made for 2010.

5.8.5 Leather Plants

Dioxin emissions from the leather industry are poorly characterised, hence no emission estimate is made for 2010.

5.8.6 Application of Pesticides to Land

5.8.6.1 Projected Activity Statistics

No future activity statistics in terms of the usage of pesticides/herbicides were identified. Several existing active substances used in pesticides are known to be contaminated with dioxins as by-products of the production process.

At present the European Union is carrying out a review of xenobiotics (industrial chemicals, plant protection products and biocidal active substances). Separate reviews are being carried out for existing chemical substances and new chemical substances.

The European Union Plant Protection Products Directive (91/414/EEC) detail the criteria for evaluating plant protection products and the data required for this evaluation. Subsequent to the review process, those products authorised for continued marketing and use will be included in Annex I of the directive (the positive list).

The review is divided into three stages, stage 1 comprises a list of 90 priority active substances which are currently under review. Final decisions on a few of the stage I compounds have been made though most are still undergoing review. Stage 2 review includes 148 active substances, mostly organophosphorus compounds and carbamates. This review is scheduled to begin in late 2002. Stage 3 deals with any remaining substances. The review period for all three stages was initially estimated at 12 years (i.e. 2003). Increased resources are being directed to the review process, which is now scheduled for completion in 2008. It is not until this time that Annex I of 91/414/EEC will be complete, and estimates can be made of dioxin deposition to land due to continued use of dioxin contaminated pesticides.

As many of the dioxin containing pesticides may be considered to present a risk to health and the environment they may not be included in Annex I after the review process has concluded. Until this review is complete, estimation of 2010 emissions is difficult. However, it is considered that usage of pesticides/herbicides with known dioxin contamination will be phased out prior to 2010. Under these circumstances, the emissions from this category in 2010 are considered insignificant.

5.9 MISCELLANEOUS

5.9.1 Drying of Biomass

This is not considered to be a significant source of emissions for 2010.

5.9.2 Crematoria

5.9.2.1 Projected Activity Statistics

It is likely that the annual number of cremations will increase over the next ten years. For the purposes of the 2010 inventory an increase in cremation of 10 % per annum over the next ten years has been employed (based on recent trends) to generate an activity statistic for 2010 of 4,824 cremations.

5.9.2.2 2010 Emission Estimate

The emission factor generated in Section 4.8.2.2, of 0.033 µg/cremation, is used to generate the lower bound emissions estimate while the default toolkit emission factor of 0.4 (optimal control) µg TEQ/cremation is employed to generate the high emission estimate. The use of this range of factors assume improved abatement between 2000 and 2010. The best estimate emissions is taken as the arithmetic mean of the low and high estimate emissions.

A single emission factor is given for dioxin in residue from the combustion process, disposal to land is assumed for this material.

Table 5.23: Crematoria, estimated 2010 emissions

No.	Category	Air Emissions (g TEQ/a)			Water Emissions (g TEQ/a)			Land Emissions (g TEQ/a)		
		BE	L	H	BE	L	H	BE	L	H
8b	Cremato-ria	0.0010	0.0002	0.0019	NA	NA	NA	0.0121	0.0121	0.0121

5.9.3 Smoke Houses

This category is not considered to be a significant source of dioxin emissions for 2010.

5.9.4 Dry Cleaning Residues

Emissions from this category are not expected to be a significant source of emissions for 2010.

5.9.5 Tobacco Smoking

5.9.5.1 Projected Activity Statistics

Official tobacco sales for 1998 indicate a total consumption of approximately 6,400,000,000 cigarettes per annum. In the absence of predictions for 2010 the same figures are employed in the 2010 inventory resulting in the same emissions as calculated for the 2000 inventory. The lower and upper bound activity statistics employed are as follows:

- Lower estimate: 6,400,000,000 cigarettes;
- Upper estimate: 9,500,000,000 cigarettes.

5.9.5.2 Toolkit Estimate of Emissions

The default UNEP toolkit emission factor of 0.1 pg TEQ/cigarette is used to calculate the data presented in the table below.

Table 5.24: Tobacco smoking, estimated 2010 emissions

No.	Category	Air Emissions (g TEQ/a)			Water Emissions (g TEQ/a)			Land Emissions (g TEQ/a)		
		M	L	H	M	L	H	M	L	H
8e	Tobacco Smoking	0.0008	0.0006	0.0010	NA	NA	NA	NA	NA	NA

5.10 DISPOSAL/LANDFILL

5.10.1 Landfills and Waste Dumps

5.10.1.1 Projected Activity Statistics

The same methodology employed in generating the 2000 statistics is employed in the 2010 inventory. The quantity of waste landfilled in 2010 is estimated assuming a 5 % increase in landfilled waste until 2010, based on 1998 figures. An estimate of total waste in place can be made at approximately 560,000,000 m^3 including disposal over the previous 50 years. This takes into account material which may have been incinerated in proposed thermal treatment plants, assuming that on average 500,000 tonnes/annum of municipal waste in incinerated between 2002 and 2010.

Assuming 80 – 100 % infiltration to water results in the following range of activity statistics (total leachate emissions to water in 2000):

- Lower estimate: 5,349,291 m^3
- Upper estimate: 6,686,614 m^3

5.10.1.2 2010 Estimate of Emissions

The default UNEP emission factor for dioxin emissions in leachate from non-hazardous landfilled waste is used to generate the figures below. The range of estimated leachate infiltration to the water table is used to generate the low and high emission estimate, while the arithmetic mean is taken as the best estimate emission.

Table 5.25: Landfill leachate, estimated 2010 emissions

No.	Category	Air Emissions (g TEQ/a)			Water Emissions (g TEQ/a)			Land Emissions (g TEQ/a)		
		BE	**L**	**H**	**BE**	**L**	**H**	**BE**	**L**	**H**
9a	**Landfill Leachate**	NA	NA	NA	0.1805	0.1605	0.2006	NA	NA	NA

5.10.2 Sewage and Sewage Treatment

5.10.2.1 Projected Activity Statistics

Currently, significant quantities of waste water receive no treatment prior to emissions to receiving waters. Under the Urban Waste Water Treatment Regulations (1994) waste water from all agglomerations will require some degree of treatment prior to 2010. In 1998/1999 (the most recently reported period), a population equivalent of 1,464,298 received no treatment of waste water, from a total population equivalent of 5,101,116 (3,636,818 population equivalents receiving treatment). The total quantity of dry sludge generated from treatment in 1998/1999 was 37,595 tonnes/annum from a population equivalent of 3,636,818. This implies that if all wastewater had undergone some form of treatment, an estimated total of 52,732 tonnes/annum of dry sludge would have been generated in 1998/1999.

The population in 1998/1999 can be estimated at approximately 3.755 million, assuming equal annual increases from 1996 (3.6261 million) to an estimated 2001 population of 3.8339 million (CSO, 2001). The population in 2011 has been estimated at 4.2018 million, which is taken as the 2010 population for the purposes of the inventory. This implies an approximate 12 % increase in population from 1998/1999 to 2010. Assuming that all waste water receives some treatment in 2010, and assuming that the quantity of dry sludge generated increases pro-rata with the increases in population, the quantity of sludge generated in 2010 can be estimated at 58,416 tonnes.

However, the increase in secondary treatment of waste water under the waste water treatment regulations will result in increased sludge generation, likely to be greater than the 58,416 tonnes calculated. Sludge generation from primary waste water treatment is likely to result in 0.05 kg/population equivalent.day. Sludge generation from secondary treatment is likely to result in approximately 0.05 kg/population equivalent.day. Therefore, a total sludge generation (assuming all waste water undergoes secondary treatment in 2010) can be estimated based on a population equivalent of 5,101,116 (1998/1999 population equivalent used in absence of estimate for 2010) giving a total dry sludge generation of 184,329 tonnes/annum in 2010. Thus, the following range of activity statistics can be employed (tonnes of dry solids):

- Lower estimate: 58,416 tonnes;
- Upper estimate: 184,329 tonnes.

The 2010 population figure of 4.2018 million is also used to generate estimated total emissions to water assuming a range of usage of 160 - 200 litres of water is used per person per day. This gives the following range:

- Lower estimate: 2.454 x 10^{11} litres;
- Upper estimate: 3.067 x 10^{11} litres.

5.10.2.2 2010 Emission Estimate

The UNEP Toolkit emission factors for emissions to water (0.5 pg TEQ/litre of effluent) and emissions to land (100 μg TEQ/tonne of dry matter are employed to generate the emission estimates detailed below.

For the purposes of the inventory it is assumed that all dry sludge will be spread on land in 2010. Using the range of dry solids generation estimated above, the low and high emission estimates can be calculated. The arithmetic mean is taken as the best estimate emission.

The low and high estimate emissions to water are generated using the range of waste water generation estimated above. The arithmetic mean is taken as the best estimate emission.

Table 5.26: Sewage/sewage treatment, estimated 2010 emissions

No.	Category	Air Emissions (g TEQ/a)			Water Emissions (g TEQ/a)			Land Emissions (g TEQ/a)		
		M	L	H	M	L	H	M	L	H
9b	**Sewage/ Sewage Treatment**	NA	NA	NA	0.1380	0.1227	0.1534	12.1373	5.8416	18.4329

5.10.3 Composting

5.10.3.1 Projected Activity Statistics

In 1998 it is estimated that 1,003,053 tonnes of biodegradable waste, consisting of paper waste and kitchen and garden waste, were consigned to landfill (Crowe *et al.*, 2000). Assuming a growth in the quantity of biodegradable waste generated of approximately 5 % per annum to 2010, the total quantity of biodegradable waste generated in 2010 will be approximately 1,801,000 tonnes. Then, assuming increased domestic composting in 2010, resulting in 5 % of this material being composted, an estimate of approximately 90,000 tonnes of composted material can be calculated.

5.10.3.2 2010 Estimate of Emissions

The default UNEP toolkit emission factors for composted organic waste (100 µg TEQ/tonne of dry matter), composted garden/kitchen waste (15 µg TEQ/tonne of dry matter) and composted green material from unimpacted environments (5 µg TEQ/tonne of dry matter) were employed in calculating the high, medium and low estimates, respectively of dioxin emissions detailed below.

Table 5.27: Composting, estimated 2010 emissions

No.	Category	Air Emissions (g TEQ/a)			Water Emissions (g TEQ/a)			Land Emissions (g TEQ/a)		
		M	L	H	M	L	H	M	L	H
9d	**Compost**	NA	NA	NA	NA	NA	NA	1.3510	0.4503	9.0067

5.10.4 Open Water Dumping

5.10.4.1 Projected Activity Statistics

The 1998/1999 Urban Wastewater Discharges in Ireland Report (O'Leary *et al.*, 2000) indicates that a total population equivalent of 1,464,298 is not served by any type of wastewater treatment facility. No Irish data on the dioxin content of such untreated effluent was identified.

The Urban Waste Water Treatment Regulations (1994) details the required waste water treatment based on the population equivalent served and the nature of the receiving waters.

For agglomerations discharging to freshwater or estuaries with population equivalent above 2000, secondary treatment is required at all sites by 2006, with nutrient reduction required in sensitive areas with a population equivalent above 10,000. For agglomerations with a population equivalent less than 2,000 'appropriate treatment' is required by 2006. The level of appropriate treatment will depend on local circumstances but must allow the receiving waters to comply with relevant quality objectives.

For agglomerations discharging to coastal waters, all population equivalents above 10,000 will require secondary treatment by 2006. For population equivalents < 10,000 appropriate treatment will be required by 2006.

The regulations suggest that waste water from all agglomerations will have some form of treatment by 2010, hence open waste dumping of untreated waste will have ceased. Estimated emissions for 2010 are therefore considered to be insignificant.

5.10.5 Waste Oil Disposal

No details are available on the quantity of waste oil combusted illegally in 2000, hence no estimate can be made for 2010.

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Appendix A

Detailed Summary Tables

Table A.1: Summary of Emissions to Air, Land and Water in Ireland for 2000 (Sub-categories)

	AIR			WATER			LAND		
	Best estimate g/annum	Low g/annum	High G/annum	Best estimate g/annum	Low g/annum	High G/annum	Best estimate g/annum	Low g/annum	High G/annum
Waste Incineration									
Municipal Solid Waste Incineration	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Hazardous Waste Incineration	0.0068	0.0013	0.0220	0.0034	0.0006	0.0110	0.0034	0.0006	0.0110
Medical Waste Incineration	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Light Fraction Shredder Waste Incineration	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Sewage Sludge Incineration	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Waste Wood and Waste Biomass Incineration	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Animal Carcass Burning	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
CATEGORY TOTAL	**0.0068**	**0.0013**	**0.0220**	**0.0034**	**0.0006**	**0.0110**	**0.0034**	**0.0006**	**0.0110**
Ferrous and Non-Ferrous Metal Production									
Iron Ore Sintering	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Coke Production	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Iron and Steel Production	2.0223	0.9605	3.3412	0.0000	0.0000	0.0000	0.0638	0.0075	0.1200
Copper Production	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Aluminium Production	0.0519	0.0031	0.9348	0.0000	0.0000	0.0000	1.5580	0.6232	2.4928
Lead Production	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Zinc Production	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Brass Production	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Magnesium Production	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Thermal Non-Ferrous Metal Production	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Shredders	0.0200	0.0133	0.0266	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Thermal Wire Reclamation									
CATEGORY TOTAL	**2.0942**	**0.9769**	**4.3026**	**0.0000**	**0.0000**	**0.0000**	**1.6218**	**0.6307**	**2.6128**

Summary of Emissions to Air, Land and Water in Ireland for 2000 continued

	AIR			WATER			LAND		
	Best estimate g/annum	Low g/annum	High G/annum	Best estimate g/annum	Low g/annum	High G/annum	Best estimate g/annum	Low g/annum	High G/annum
Power Generation and Heating									
Fossil Fuel Power Plants	0.7637	0.3373	1.1901	0.0000	0.0000	0.0000	0.8688	0.3274	1.4027
Biomass Power Plants	0.0964	0.0085	0.1842	0.0000	0.0000	0.0000	0.4838	0.0010	0.9667
Landfill and Biogas Production	0.0090	0.0060	0.0119	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Household Heating & Cooking (Biomass)	0.1980	0.1800	0.2160	0.0000	0.0000	0.0000	0.0396	0.0360	0.0432
Household Heating & Cooking (Fossil Fuel)	2.2533	0.9731	11.9645	0.0000	0.0000	0.0000	6.7144	3.3704	10.0584
CATEGORY TOTAL	**3.3203**	**1.5049**	**13.5668**	**0.0000**	**0.0000**	**0.0000**	**8.1066**	**3.7347**	**12.4710**
Mineral Products									
Cement Kilns	0.4950	0.4500	0.5400	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Lime	1.4143	0.0197	2.8090	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Brick	0.0117	0.0021	0.0213	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Glass	0.0181	0.0025	0.0337	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Ceramics	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Asphalt Mixing	0.0578	0.0105	0.1050	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
CATEGORY TOTAL	**1.9969**	**0.4848**	**3.5090**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**
Transport									
4-Stroke Engines	0.0541	0.0469	0.0612	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2-Stroke Engines	0.0734	0.0660	0.0807	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Diesel Engines	0.8440	0.7596	0.9284	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Heavy Oil Fired Engines	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
CATEGORY TOTAL	**0.9714**	**0.8725**	**1.0703**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**

Summary of Emissions to Air, Land and Water In Ireland for 2000 continued

	AIR			WATER			LAND		
	Best estimate g/annum	Low g/annum	High G/annum	Best estimate g/annum	Low g/annum	High G/annum	Best estimate g/annum	Low g/annum	High G/annum
Uncontrolled Combustion Processes									
Fires/Burnings – Biomass	0.0776	0.0417	0.1132	0.0000	0.0000	0.0000	0.0620	0.0334	0.0906
Waste Burning and Accidental Fires	25.5587	9.3343	41.7832	0.0000	0.0000	0.0000	42.1202	12.4338	71.8065
CATEGORY TOTAL	**25.6363**	**9.3760**	**41.8964**	**0.0000**	**0.0000**	**0.0000**	**42.1822**	**12.4672**	**71.8971**
Production of Chemicals, Consumer Goods									
Pulp and Paper Mills	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Chemical Industry	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Petroleum Refineries	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Textile Plants	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Leather Plants	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Application of Pesticides to Land	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.9013	0.3612	1.4413
CATEGORY TOTAL	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.9013**	**0.3612**	**1.4413**
Miscellaneous									
Drying of Biomass	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Crematoria	0.0007	0.0001	0.0186	0.0000	0.0000	0.0000	0.0047	0.0047	0.0047
Smoke Houses	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Dry Cleaning Residues	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Tobacco Smoking	0.0008	0.0006	0.0010	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
CATEGORY TOTAL	**0.0015**	**0.0007**	**0.0196**	**0.0000**	**0.0000**	**0.0000**	**0.0047**	**0.0047**	**0.0047**

Summary of Emissions to Air, Land and Water In Ireland for 2000 continued

	AIR			WATER			LAND		
	Best estimate g/annum	Low g/annum	High G/annum	Best estimate g/annum	Low g/annum	High G/annum	Best estimate g/annum	Low g/annum	High G/annum
Disposal/Landfill									
Landfill Leachate	0.0000	0.0000	0.0000	0.1037	0.0922	0.1152	0.0000	0.0000	0.0000
Sewage/Sewage Treatment	0.0000	0.0000	0.0000	0.0883	0.0785	0.0981	4.0250*	3.7250	4.3250
Open Water Dumping	0.0000	0.0000	0.0000	1.9842	0.3608	3.6076	0.0000	0.0000	0.0000
Composting	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1505	0.0502	1.0030
Waste Oil Disposal (combustion)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
CATEGORY TOTAL	**0.0000**	**0.0000**	**0.0000**	**2.1762**	**0.5315**	**3.8209**	**4.1755**	**3.7752**	**5.3280**
TOTAL EMISSIONS	**34.0273**	**13.2170**	**64.3866**	**2.1796**	**0.5321**	**3.8319**	**56.9953**	**20.9743**	**93.7659**

* Sewage sludge landspreading and disposal to landfill. In 2000, 40% of sewage sludge was landspread and 51% was disposed of in landfills.

Table A.2: Summary of Emissions to Air, Land and Water In Ireland for 2010

	AIR			WATER			LAND		
	Median g/annum	Low g/annum	High G/annum	Median g/annum	Low g/annum	High g/annum	Median g/annum	Low g/annum	High g/annum
Waste Incineration									
Municipal Solid Waste Incineration	0.5000	0.2500	0.7500	0.0000	0.0000	0.0000	16.500*	8.2500	24.7500
Hazardous Waste Incineration	0.0494	0.0318	0.0890	0.0060	0.0009	0.0220	1.5060*	1.2009	1.8220
Medical Waste Incineration	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Light Fraction Shredder Waste Incineration	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Sewage Sludge Incineration	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Waste Wood and Waste Biomass Incineration	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Animal Carcass Burning	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
CATEGORY TOTAL	**0.5494**	**0.2818**	**0.8390**	**0.0060**	**0.0009**	**0.0220**	**18.0060**	**9.4509**	**26.5720**
Ferrous and Non-Ferrous Metal Production									
Iron Ore Sintering	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Coke Production	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Iron and Steel Plants (incl. foundries)	0.0008	0.0005	0.0011	0.0000	0.0000	0.0000	0.0125	0.0075	0.0175
Copper Production	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Aluminium Production	0.0274	0.0031	0.0517	0.0000	0.0000	0.0000	1.5580	0.6232	2.4928
Lead Production	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Zinc Production	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Brass Production	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Magnesium Production	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Thermal Non-Ferrous Metal Production	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Shredders	0.0227	0.0152	0.0303	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Thermal Wire Reclamation	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
CATEGORY TOTAL	**0.0509**	**0.0187**	**0.0831**	**0.0000**	**0.0000**	**0.0000**	**1.5705**	**0.6307**	**2.5103**

Summary of Emissions to Air, Land and Water In Ireland for 2010 continued

	AIR			WATER			LAND		
	Median g/annum	Low g/annum	High G/annum	Median g/annum	Low g/annum	High g/annum	Median g/annum	Low g/annum	High g/annum
Power Generation and Heating									
Fossil Fuel Power Plants	0.7828	0.3809	1.1846	0.0000	0.0000	0.0000	0.8883	0.3545	1.4151
Biomass Power Plants	0.1040	0.0092	0.1989	0.0000	0.0000	0.0000	0.5223	0.0010	1.0436
Landfill and Biogas Production	0.0118	0.0079	0.0157	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Household Heating & Cooking (Biomass)	0.1888	0.1717	0.2060	0.0000	0.0000	0.0000	0.0378	0.0343	0.0412
Household Heating & Cooking (Fossil Fuel)	1.3369	0.4249	6.3475	0.0000	0.0000	0.0000	2.5121	1.2610	3.7632
CATEGORY TOTAL	**2.4243**	**0.9945**	**7.9527**	**0.0000**	**0.0000**	**0.0000**	**3.9605**	**1.6508**	**6.2630**
Mineral Products									
Cement Kilns	0.5771	0.5468	0.6075	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Lime	0.0196	0.0175	0.0217	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Brick	0.0021	0.0016	0.0026	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Glass	0.0026	0.0021	0.0030	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Ceramics	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Asphalt Mixing	0.0105	0.0088	0.0123	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
CATEGORY TOTAL	**0.6119**	**0.5767**	**0.6471**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**
Transport									
4-Stroke Engines	0.0019	0.0009	0.0028	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2-Stroke Engines	0.0954	0.0477	0.1430	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Diesel Engines	1.0725	0.8938	1.2513	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Heavy Oil Fired Engines	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
CATEGORY TOTAL	**1.1697**	**0.9424**	**1.3971**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**

Summary of Emissions to Air, Land and Water In Ireland for 2010 continued

	AIR			WATER			LAND		
	Median g/annum	Low g/annum	High G/annum	Median g/annum	Low g/annum	High g/annum	Median g/annum	Low g/annum	High g/annum
Uncontrolled Combustion Processes									
Fires/Burnings – Biomass	0.1089	0.0263	0.1914	0.0000	0.0000	0.0000	0.0871	0.0210	0.1532
Waste Burning and Accidental Fires	25.3810	9.0958	41.6662	0.0000	0.0000	0.0000	41.7647	11.9568	71.5725
CATEGORY TOTAL	**25.4898**	**9.1220**	**41.8576**	**0.0000**	**0.0000**	**0.0000**	**41.8518**	**11.9779**	**71.7257**
Production of Chemicals, Consumer Goods									
Pulp and Paper Mills	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Chemical Industry	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Petroleum Refineries	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Textile Plants	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Leather Plants	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Application of Pesticides to Land	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
CATEGORY TOTAL	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**
Miscellaneous									
Drying of Biomass	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Crematoria	0.0010	0.0002	0.0019	0.0000	0.0000	0.0000	0.0121	0.0121	0.0121
Smoke Houses	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Dry Cleaning Residues	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Tobacco Smoking	0.0008	0.0006	0.0010	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
CATEGORY TOTAL	**0.0018**	**0.0008**	**0.0029**	**0.0000**	**0.0000**	**0.0000**	**0.0121**	**0.0121**	**0.0121**

Summary of Emissions to Air, Land and Water In Ireland for 2010 continued

	AIR			WATER			LAND		
	Median g/annum	Low g/annum	High G/annum	Median g/annum	Low g/annum	High g/annum	Median g/annum	Low g/annum	High g/annum
Disposal/Landfill									
Landfill Leachate	0.0000	0.0000	0.0000	0.1805	0.1605	0.2006	0.0000	0.0000	0.0000
Sewage/Sewage Treatment	0.0000	0.0000	0.0000	0.1380	0.1227	0.1534	12.1373**	5.8416	18.4329
Open Water Dumping	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Composting	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.3510	0.4503	9.0067
Waste Oil Disposal (combustion)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
CATEGORY TOTAL	**0.0000**	**0.0000**	**0.0000**	**0.3185**	**0.2832**	**0.3540**	**13.4883**	**6.2920**	**27.4396**
TOTAL EMISSIONS	**30.2980**	**11.9384**	**52.7785**	**0.3245**	**0.2841**	**0.3760**	**78.8890**	**30.0143**	**134.5226**

* Incinerator bottom ash and flyash to be landfilled under controlled conditions at licensed facilities thereby limiting any potential release of dioxins to the environment. Land emissions in this case means the deposit of waste in landfills.

** Sewage sludge landspreading.