2014 Update of the New Zealand Inventory of Dioxin Emissions to Air, Land and Water, and Reservoir Sources

Report to the Ministry for the Environment

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Executive Summary

This report provides an update of the *New Zealand Inventory of Dioxin Emissions to Air, Land and Water, and Reservoir Sources 2011*, which provided release estimates for a reference year of 2008. It has been prepared under contract to the New Zealand Ministry for the Environment, and covers all of the 40 different sources covered in the 2008 Inventory, updated for a reference year of 2012, plus 9 additional sources.

The methodology was based on the use of the latest version (v3) of the *Standardised Toolkit for Identification and Quantification of Dioxin and Furan Releases* (the UNEP Toolkit). This uses an emission factor approach, in which the annual releases from each source are estimated by multiplying an activity statistic by an emission factor. Activity statistics are chosen on the basis of fuel consumption, production rates or some other similar measure, while the emission factors are based on data for the average emissions to air, land or water or release into products or as residues, per unit of activity.

The required activity data was obtained through published information sources and direct contact with government agencies, and specific industries. The emission factors were based on emissions data for the specific sources, where available, or the default factors given in the UNEP Toolkit.

The dioxin release estimates for 1998, 2008 and 2012 are summarised in the table below. This is based on nine of the Toolkit source categories, which is the summary level used for country reports under the Stockholm Convention. The estimates shown for 2008 are based on the revised estimates (ie. back-calculated) given throughout this report and are therefore directly comparable with the estimates for 2012. However, any comparisons with the 1998 estimates should be made with caution, because these pre-date the use of the UNEP Toolkit and were based on fewer source sub-categories than were used for the more recent estimates.

Source Categories		**Annual Releases (g TEQ/a)**										
		Air			Water			Land			Residue	
		1998	2008	2012	1998	2008	2012	1998	2008	2012	2008	2012
1	Waste Incineration	3.58	0.72	0.79	0.00	0.00	0.00	2.97	0.00	0.00	0.05	0.05
2	Ferrous and Non-Ferrous Metal Production	1.75	0.68	0.40	0.02	0.02	0.01	7.01	0.21	0.21	10.54	9.71
3	Heat and Power Generation	7.28	3.31	3.33	0.00	0.00	0.00	5.32	0.61	0.41	0.78	0.75
4	Production of Mineral Products	0.46	0.09	0.07	0.00	0.00	0.00	0.78	0.22	0.18	0.03	0.03
5	Transportation	0.64	0.71	0.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	Uncontrolled Combustion	18.30	4.78	2.44	0.00	0.00	0.00	5.7	1.04	0.78	0.00	0.00
7	Production of Chemicals and Consumer Goods	0.04	0.05	0.05	0.28	0.01	0.01	0.83	0.08	0.09	0.00	0.00
8	Miscellaneous	0.23	0.18	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	Waste Treatment	0.00	0.00	0.00	1.96	1.36	1.39	23.11	12.48	12.57	6.40	6.40
Totals*		**32.28**	**10.51**	**7.94**	**2.26**	**1.38**	**1.41**	**45.72**	**14.65**	**14.24**	**17.79**	**16.93**
Totals for all release vectors		**1998**			**2008 (revised)**				**2012**			
		80.26			**44.33**				**40.51**			

(* the sums of the figures in some columns may not agree exactly with the totals shown, due to rounding effects)

The estimates for releases in products have not been shown in the table because there are only two very minor sources: brick production and the use of the herbicide 2,4-D, with a total annual release of only 0.0003 g TEQ.

It should also be noted that the values shown for 1998 releases to land are effectively a combination of the estimates shown for releases to land and in residues, for both 2008 and 2012. This Toolkit distinction was not applied in the first New Zealand inventory and it was simply assumed that most residues would ultimately be disposed to land, usually via landfills. Another difference is that the 1998 estimates were originally reported as a range of values for each source. The 1998 data shown in the table is the mid-point for each of those ranges.

The figures shown at the bottom of the table for total dioxin releases to all vectors suggest that there were some very significant changes in the releases between 1998 and 2008, but that is not the case. Most of the changes are simply due to a lowering of the Toolkit release factors for some of the more significant sources. However, there have been a few notable changes, especially between 1998 and 2008. The reductions shown for the waste incineration category were due to the closure of most of these facilities, and those shown for ferrous and non-ferrous metal production reflect a marked fall-off in overall activity for this sector. The reductions for the transport category are primarily due to improvements in the New Zealand vehicle fleet, which have continued throughout the period covered by all 3 inventories.

Changes between 2008 and 2012

Appendix 1 includes charts that show the changes between 2008 and 2012 for each Toolkit sub-category. The most notable changes shown on these charts are as follows:

Releases to air

Secondary steel production – the release reduction here is due to a real reduction in plant emissions

Secondary lead production – releases ceased due to plant closure

Coal and gas-fired electricity generation – reductions due to reduced activity rates (fuel use)

Industrial/commercial coal use – increased releases due to increased fuel use

4-stroke engines – reduced releases due to improvements in the vehicle fleet

2-stroke engines – the reduction in releases is simply due to a more precise estimate of fuel use

Waste dumps, vehicles and structure fires – reduced releases due to reductions in fire numbers

Releases to land

Waste dumps, vehicle and structure fires – reduced releases due to reductions in fire numbers

Grassland and savannah fires – reduced releases due to reductions in the area burned

Lime kilns – the reduction in releases is simply due to a change in calculation method

Releases in residues

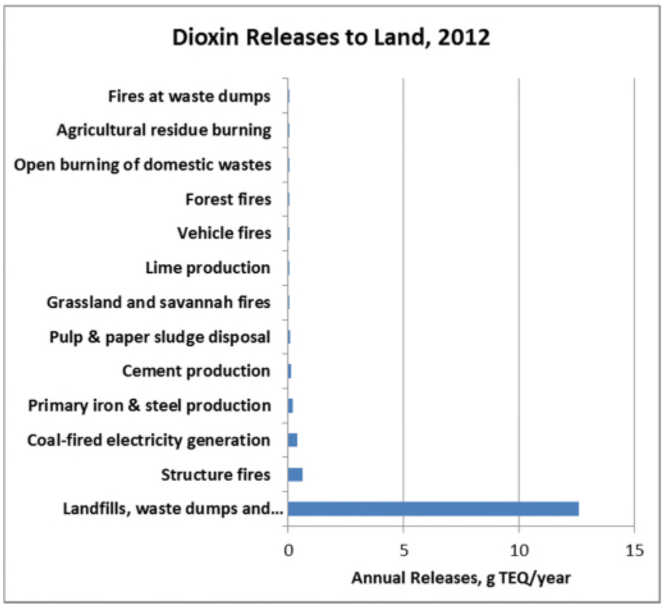
Secondary aluminium, brass and bronze – reduced releases due to reduced production rates

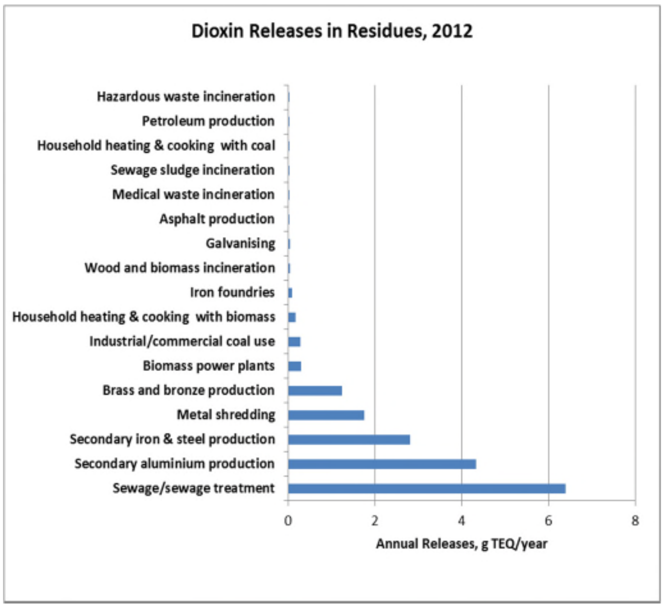
Metal shredding – increased releases due to the addition of a new plant

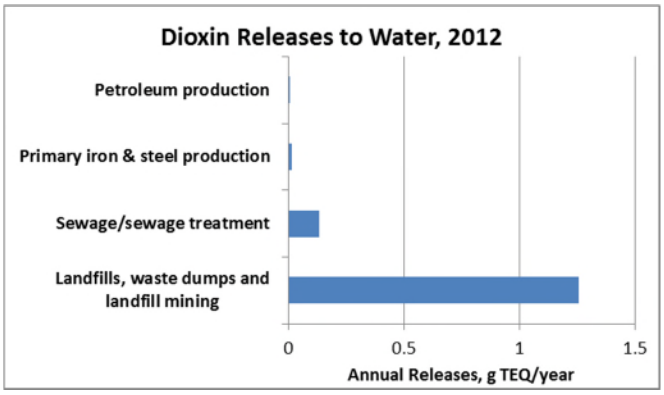
Releases by individual sub-categories

A summary of all of the release estimates for both 2008 and 2012 is given in Appendix 1, while the 2012 releases to each of the vectors are summarised in the figures below.


Dioxin Releases to Air, 2012
Hazardous waste incineration
Sewage sludge incineration
Tobacco smoking
Pottery and ceramics
Brick production
Galvanising
Household heating & cooking with oil
Glass production
Asphalt production
Heavy fuel oil-fired power plants
Lime production
Household heating & cooking with gas
2-stroke engines
Petroleum production
Wood and biomass incineration
Landfill gas/biogas combustion
Fuel oil and gas-fired power plants
Black liquor combustion
Fuel oil/gas-fired electricity generation
Secondary iron & steel production
4-stroke engines
Brass and bronze production
Cement production
Household heating & cooking with coal
Secondary aluminium production
Metal shredding
Primary iron & steel production
Destruction of animal carcasses
Iron foundries
Agricultural residue burning
Forest fires
Vehicle fires
Grassland and savannah fires
Crematoria
Diesel engines
Coal-fired electricity generation
Heavy oil-fired engines
Fires at waste dumps
Structure fires
Medical waste incineration
Open burning of domestic wastes
Household heating & cooking with biomass
Biomass power plants
Industrial/commercial coal use
0
0.2
0.4
0.6
0.8
1
1.2
Annual Releases, g TEQ/year


Dioxin Releases to Land, 2012
Fires at waste dumps
Agricultural residue burning
Open burning of domestic wastes
Forest fires
Vehicle fires
Lime production
Grassland and savannah fires
Pulp & paper sludge disposal
Cement production
Primary iron & steel production
Coal-fired electricity generation
Structure fires
Landfills, waste dumps and...
0
5
10
15
Annual Releases, g TEQ/year





The greatest releases of dioxins to air for 2012 are produced by several fuel use categories. This is primarily determined by the very large numbers of these sources; for example, there are about 500 coal-fired boilers in New Zealand and more than 175 power plants fired on biomass, while the releases from household heating and cooking come from over 540,000 homes. By comparison, the releases from medical waste incineration are produced by only 2 facilities. Releases from structure fires and fires at rubbish dumps are the two next most significant sources, but the numbers of incidents for both of these have been steadily decreasing over time. The next 10 sources are associated with industrial fuel use, transport, secondary metal production, waste disposal and uncontrolled burning.

Solid waste disposal is the most significant contributor to releases to land, but with other notable contributions coming from structure fires, coal-fired electricity generation and iron and steel production. The most significant sources of releases in residues are wastewater treatment plants, secondary metal production and industrial/commercial fuel use. In New Zealand, most of these residues are ultimately disposed to landfill. As a result, there may be an element of double accounting between these releases and the total estimated releases to landfills and waste dumps. However, there is unsufficient detail in the Toolkit release factors to allow the estimates to be adjusted for this effect.

There are only 4 source categories for releases to water, with the greatest contributions coming from solid and liquid waste disposal activities. The releases in products have not been shown in a chart because there are only two very minor sources: brick production and the use of the herbicide 2,4-D.

Global and national perspectives

An indication of the relative global significance of the New Zealand dioxin releases is presented in section 13.4 of this report. This presents the per-capita annual releases for 68 countries, with reference years ranging from 1999 to 2009 and New Zealand is ranked in the third lowest category of 21 to 29 grams TEQ per million people[1]. This ranking is based on the previous 2008 release estimates (as reported to the Stockholm Convention in 2010) but is unlikely to change significantly for inventories based on the latest edition of the UNEP Toolkit, because the changes in release factors will also apply to the inventories for other countries.

There are no official recommendations for 'acceptable' levels of national dioxin releases and it is also not possible to relate the release estimates directly to any potential health effects. The more relevant information is provided by national surveys of dioxin body burdens, for which there have been several New Zealand studies.

The levels of dioxins in mothers' milk have been measured on 3 occasions in New Zealand; 1988, 1998 and 2008. These studies showed that the dioxin concentrations in New Zealand mothers are relatively low by comparison with many other countries. Also, the levels have been steadily dropping, with a reduction of 70% observed from 1988 to 1998, and a further reduction of 40% from 1998 to 2008.

The levels of dioxins in blood serum have been monitored on two occasions in New Zealand, in 1997 and 2012. Once again, these studies showed the dioxin concentrations in New Zealanders are relatively low by comparison with many other countries, and the levels have dropped over time.

The improvements shown by these studies are much more marked than the reductions shown by the dioxin release inventories but this would be partly because they would also reflect any changes that had occurred prior to 1998. The half-life for dioxins in the environment is typically around 15 to 25 years and the half-life in humans is about 8 to 10 years. Hence there can be a significant lag between reductions in releases and the resulting changes in people.

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[1] The unadjusted New Zealand release estimate for 2008 was 89.4 g TEQ, which equates to a per capita release rate of just over 20 g TEQ per million people. With the revised estimate it will reduce to about 10 g TEQ per million people.

Contents

Units and abbreviations

Units

g	gram
kg	kilogram (10^3 grams)
tonne	10^3 kilograms or 10^6 grams
ktonne	kilotonne (10^3 tonnes or 10^6 kilograms)
µg	microgram (10^{-6} grams)
ng	nanogram (10^{-9} grams)
pg	picogram (10^{-12} grams)
MJ	megajoule (10^6 joules)
GJ	gigajoule (10^9 joules)
TJ	terajoule (10^{12} joules)
PJ	petajoule (10^{15} joules)
L	litre
m^3	cubic metre
Nm^3	normal cubic metre of dry gas at 0°C and 101.3 kilopascals
kW	kilowatt (10^3 watts)
kWh	kilowatt-hour
MW	megawatt (10^6 watts)
GWh	gigawatt-hour

Abbreviations

BAT/BEP	best available techniques / best environmental practices
BLS	black liquor solids
CKD	cement kiln dust
dioxins	generic name for the PCDDs and PCDFs
FAO	Food and Agriculture Organization
LPG	liquefied petroleum gas
MDF	medium density fibreboard
PCDD	polychlorinated dibenzo-*p*-dioxin
PCDF	polychlorinated dibenzofuran
TEQ	toxic equivalents
UNEP	United Nations Environment Programme
UORP	Used Oil Recovery Programme
USA	United States of America
US EPA	United States Environmental Protection Agency
WHO	World Health Organization

Update of the New Zealand Inventory of Dioxin Emissions to Air, Land and Water, and Reservoir Sources

1 Introduction

This report provides an update of the *New Zealand Inventory of Dioxin Emissions to Air, Land and Water, and Reservoir Sources 2011* (the 2008 Inventory). It has been prepared under contract to the New Zealand Ministry for the Environment, and covers all of the 40 different sources considered in the 2008 Inventory plus 9 additional sources.

1.1 Background

New Zealand has an obligation under the Stockholm Convention on Persistent Organic Pollutants to periodically prepare inventories of the unintentional releases of two specific groups of persistent organic pollutants: the polychlorinated dibenzo-p-dioxins (PCDDs) and the polychlorinated dibenzofurans (PCDFs). For convenience, these are generally referred to using the collective term 'dioxins', or the abbreviations PCDDs and PCDFs.

There have been two previous reports on dioxin releases to air, land and water, and reservoir sources in New Zealand. The first was published in 2000, based on 1998 data (Ministry for the Environment, 2000), and the second was published in 2011, based on 2008 data (Ministry for the Environment, 2011a). This report provides an update of the 2011 inventory report (herein referred to as the 2008 Inventory) for a reference year of 2012.

1.2 Methodology

The methodology used for the inventory update is summarised in Section 2 of this report. It has been based on the use of the latest version (v3) of the *Standardised Toolkit for Identification and Quantification of Dioxin and Furan Releases* (United Nations Environment Programme, 2013) (herein referred to as the UNEP Toolkit). The methodology involves an emission factor approach, in which the annual releases from each source are estimated by multiplying an activity statistic by an emission factor. Activity statistics are chosen on the basis of fuel consumption, production rates or some other similar measure, while the emission factors are based on data for the average emissions to air, land or water, per unit of activity.

The required activity data was obtained through published information sources and direct contact with government agencies, and specific industries. The emission factors were based on emissions data for the specific sources, where available, or the default factors given in the UNEP Toolkit.

1.3 Report layout and content

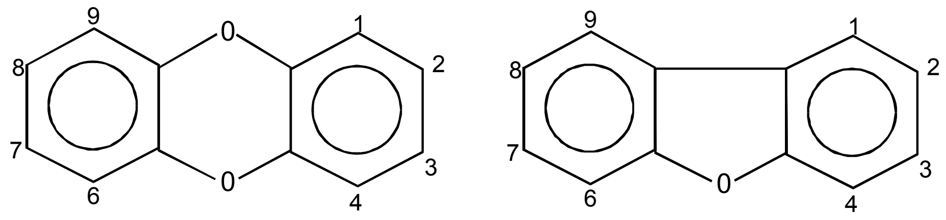
Details of the UNEP Toolkit methodology and related aspects are presented in section 2. This is followed by individual sections covering each of the 10 Toolkit source categories, and a summary and discussion section. It should be noted that the coverage of the different groups of sources is now spread across far fewer report sections than the 27 used in the report for the 2008 Inventory. This has been done to better align with the UNEP Toolkit layout. However, cross-referencing notes are provided in each section to assist the reader in identifying the corresponding sections in the 2008 Inventory.

2 Dioxin Formation and the UNEP Toolkit

2.1 Dioxin Formation

The basic structures of the polychlorinated dibenzodioxins and dibenzofurans are shown in Figure 2.1. Both groups of chemicals can have up to eight chlorine atoms attached at positions 1 to 4 and 6 to 9 of the ring structures. Each individual compound resulting from this arrangement is referred to as a congener, and specific congeners are distinguished by the number and position of chlorine atoms around the core structure. In total there are 75 possible PCDD congeners and 135 possible PCDF congeners.

Figure 2-1: Structures of dibenzo-p-dioxin and dibenzofuran



dibenzo-p-dioxin dibenzofuran

Dioxins are not produced intentionally, but are released to the environment from a variety of industrial discharges, combustion processes and as a result of their occurrence as unwanted by-products in various chemical products (United Nations Environment Programme, 2013).

Historically the manufacture and use of chlorinated aromatic chemicals has been a major source of dioxins. The most notable examples include the wood preservative and biocide, pentachlorophenol, the herbicide 2,4,5-T (2,4,5-trichlorophenoxy acetic acid), and the industrial chemicals known as PCBs (polychlorinated biphenyls).

Other chemical/industrial processes, such as the production of chlorine-bleached pulp, have led to environmental contamination by dioxins, as well as the trace contamination of pulp and paper products.

Combustion processes are another important source of dioxins. Dioxins have been detected in the emissions from waste incineration, particularly municipal, medical and hazardous wastes, from the production of iron and steel and other metals, including scrap metal reclamation, from fossil fuel plants, domestic coal and wood fires, rubbish burning, and motor vehicles (especially when using leaded fuels), as well as from accidental fires.

2.2 The UNEP Toolkit

The UNEP Toolkit was developed by UNEP Chemicals with the aim of achieving an effective and standardised approach to compiling PCDD/PCDF emission inventories (United Nations Environment Programme, 2005). This was intended to ensure a reasonable degree of consistency between the inventories reported by different countries, as part of their requirements under the Stockholm Convention, and should also help in comparing inventory results between countries or changes over time.

The 2008 Inventory was based on the second edition of the UNEP Toolkit (United Nations Environment Programme, 2005), while the 1998 Inventory (reported in 2000) predated the development of the UNEP Toolkit, but used much the same methodology. The 3rd edition of the UNEP Toolkit (2013) included changes to some of the release factors so the work presented here includes back-calculations for the 2008 Inventory data to assess the effects of those changes. This is discussed further in section 2.5.

The UNEP Toolkit methodology involves estimation of the annual releases from each source by multiplying an activity statistic by an emission factor:

annual release (g TEQ/year) = activity (tonnes/year) x emission factor (g TEQ/tonne)

Activity statistics are chosen on the basis of fuel consumption, production rates or some other similar measure, and are specific to each country. Emission factors can also be country specific, if sufficient emissions data is available for individual sources. However, the UNEP Toolkit provides default factors for use when this data is not available.

The UNEP Toolkit classifies all potential dioxin sources into the following 10 categories:

1. Waste incineration
2. Ferrous and non-ferrous metal production
3. Heat and power generation
4. Production of mineral products
5. Transportation
6. Open burning processes
7. Production of chemicals and consumer goods
8. Miscellaneous sources
9. Disposal
10. Contaminated sites and hotspots.

Within the Toolkit, each of the categories is divided into sub-categories on the basis of the different types of processes (eg, incineration of hazardous wastes, municipal wastes, medical wastes, etc), and each of the sub-categories is divided into several classes, depending on the degree of process and/or emission control. Typically, class 1 processes are those with basic equipment and minimal levels of control. As the class number increases (from class 2 through classes 4 or 5), the performance of the process or activity improves, resulting in lower dioxin releases. The highest Toolkit class in each subcategory is usually representative of the emission levels that can be achieved through the application of best available techniques and best environmental practices.

The default emission factors given for each class represent the best-estimate of average emission rates based on measured data at existing sources with similar technologies, process characteristics and operating practices. Most of the emission factors are based on published data found in peer-reviewed literature, or in government or institutional reports. In order to make the emission factors user-friendly, manageable and robust, this original data has been aggregated into order-of-magnitude estimates for the majority of the source sub-categories and classes.

Emission factors have been recommended for the following release vectors: to air, water, land, or in products or residues, although not all vectors are applicable to each subcategory. The UNEP Toolkit residues vector relates mainly to sources that result in a process by-product or waste (eg, the dusts collected in bag filters). These may be either processed (eg, for materials recovery) or disposed, usually to landfill. In New Zealand the latter option is the dominant route. However, for consistency with the UNEP Toolkit approach they have been recorded as releases via residues unless the wastes are known to be disposed at the company’s own (usually on-site) landfill.

2.3 Release estimates

The choice of emission factors for each source or group of sources is discussed within each of the inventory sections. The general approach taken has been to use New Zealand data, when available. In the absence of any local data, the factors given in the UNEP Toolkit have been used. In those cases where the amount of local data is limited, a judgement call has been made as to the most appropriate factor to use.

The estimates for the dioxin releases are expressed in terms of Toxic Equivalents. There are 210 different chlorinated dioxins, but only 17 have significant toxicity. When reporting the results of dioxin monitoring the quantities of all 210 congeners are converted to a single Toxic Equivalent (or TEQ) value, which reflects the overall toxicity of the mixture in terms of the most toxic congener; 2,3,7,8-tetrachlorodibenzo-p-dioxin (which, for simplicity is usually referred to as TCDD).

Historically, there have been several TEQ systems, but the most widely recognised are the “International” system, referred to as I-TEQs, and the World Health Organization (WHO) regime, referred to as WHO-TEQs. The most recent review of toxic equivalence was undertaken by WHO in 2005 and this is now the internationally preferred system (United Nations Environment Programme, 2013). Unlike the older I-TEQ system, the 2005 WHO TEQ system includes factors for 12 dioxin-like PCBs.

All of the dioxin release estimates presented in this inventory are reported as TEQ, with no distinction as to the TEQ system used. This is consistent with the approach taken in the UNEP Toolkit, which notes that, for the purposes of national inventories, the differences between TEQs and WHO-TEQs are relatively minor (United Nations Environment Programme, 2005). In addition, the primary focus of a national inventory should be on the relative (ie. order of magnitude) differences between different types of sources, and the broad-scale changes in releases over time.

The reference date for this inventory is taken as the 2012 calendar year, and 2012 activity data has been used whenever possible in deriving the estimates. The use of data from earlier years has been noted where relevant.

2.4 Certainty Estimates

No source considered in this inventory has been studied comprehensively (ie. had its emissions measured under all conditions over an extended period of time), and therefore all estimates made are subject to uncertainty. This uncertainty applies to both the activity data and the emission factors used to estimate the emissions. A qualitative indication of the certainty of each estimate has been provided using three ranking levels: high, medium and low. The certainty ranking was assigned on the basis of the available data, including a consideration of data quality, knowledge of each source sector, and a broad knowledge of emission factors. In addition, the following general principles were adopted.

Activity statistics

- A high certainty ranking was assigned if the statistics were based on specific industry data, or were derived from comprehensive survey data.
- A medium certainty ranking was applied if limited industry or survey data was available, or if the data was modified to account for confounding factors.
- A low certainty ranking was assigned if there was no data available and the level of activity was based on subjective assessment and/or modeled data.

Emission factor

- A high certainty ranking was assigned if a reasonable amount of recent emissions data was available for the specific New Zealand sources.
- A medium certainty ranking was assigned if the New Zealand emissions data was limited or dated, but the emission factors compared well with the UNEP Toolkit factors.

- A low certainty ranking was assigned if there was no New Zealand data available, and the estimate of PCDD/PCDF emissions was based solely on the UNEP Toolkit factors.

2.5 Back-calculations

The UNEP Toolkit provides emission factors for a total of about 400 different sub-categories and classes spread across the 10 source groupings. The accuracy and relevance of these factors is subject to periodic review by an Expert Group established under the auspices of the Stockholm Convention. The latest version (v3) of the UNEP Toolkit was produced by the Expert Group in January 2013 and included changes to about 150 of the sub-category and class descriptions and about 100 of the emission factors. Most of the changes were in categories 2 (metal production), 6 (open burning) and 7 (chemical products and processes). However, these changes are not as drastic as they may seem, because about two thirds of them relate to a major re-ordering of sections 7 and 10, and the addition of many new factors within section 7. The number of source sub-categories and classes affected by changes in other sections is relatively small.

One of the key functions of an emissions inventory is to allow changes in emissions to be tracked over time. Primarily, these changes should relate to changes in the mixture of different sources in the country, and the source activity rates. However, tracking these changes becomes more complicated if the emission factors are also changed. To address this, each section of this report includes a sub-section in which the previous 2008 estimates are reviewed and revised, when necessary, for changes in the emission factors, or in the methodology used for determining activity factors. This should assist in identifying those changes in emissions which are due to actual changes in activities and those that are simply due to changes in the inventory methodology.

2.6 Units

The use of different units within this report is potentially very confusing, because the data cover such a wide range of values. For example, the release factors for individual sources are usually measured in nanograms per gram (10^{-9} grams/gram), or micrograms per tonne (10^{-6} grams/tonne), while the annual activity rates for different sources may be measured in kilograms, tonnes or Megatonnes (10^{6} tonnes).

The complexity is further compounded by the use of different types of units. For example, most activity rates are measured in mass units (ie. tonnes/year) but those for fuels are measured in energy terms, such as Joules, and TeraJoules (10^{12} Joules). In addition, the activity rates for releases to water are measured on a volume basis (ie. litres or cubic metres (10^{3} litres)).

This issue has been partially addressed by standardising the release factors given in the report to units of micrograms (µg, or 10^{-6} grams) TEQ per tonne, for releases to air or land, and in residues or products, and picograms (pg, or 10^{-12} grams) TEQ per litre, for releases to water. In addition, all of the annual releases are given in standard units of g TEQ per year. Where necessary, the numbers may also be given in alternative units, in brackets, to assist with the overall understanding.

3 Waste incineration

This category covers the following dioxin sources (United Nations Environment Programme, 2013):

1a	Municipal solid waste incineration
1b	Hazardous waste incineration
1c	Medical waste incineration
1d	Light-fraction shredder waste incineration
1e	Sewage sludge incineration
1f	Waste wood and waste biomass incineration
1g	Destruction of animal carcasses

Waste incineration is well-recognised as a potential source of dioxins, with the dioxins being formed mainly as a result of incomplete combustion of the waste materials. The extent of dioxin formation is strongly influenced by the waste composition (eg. presence of chlorinated materials) and condition (eg. loose or compacted, wet or dry), the combustion conditions, the temperature and composition of the discharges, and the overall design and operation of the incinerator. The presence of metals such as copper in some of the wastes, can also have a catalytic effect on dioxin formation. In addition, the final emissions can be strongly influenced by the performance characteristics and efficiency of any pollution control equipment.

3.1 Municipal solid waste incineration

There are no large-scale facilities in New Zealand dedicated to the incineration of wastes, and most municipal solid wastes are disposed to landfill (Ministry for the Environment, 2005).

3.2 Hazardous waste incineration

This source was covered in section 5 of the report on the 2008 Inventory. There is one high-temperature hazardous waste incinerator in New Zealand, which is operated by Dow AgroSciences Ltd at their agrichemical formulation plant in New Plymouth.

The air emissions from the incinerator are usually tested twice a year for dioxins by an external contractor, and the results are reported to the Regional Council (Taranaki Regional Council, 2012). The results for 2012 indicate an average dioxin emission rate of 5.96 ng TEQ per hour (5.96×10^{-9} g TEQ/hr), which is similar to previous years. (T Gellen, Dow AgroSciences, pers comm, 2013). The incinerator is usually operated for about 8000 hours per year, which indicates a probable annual dioxin emission rate of 0.000048 grams TEQ/year. This result is 65% higher than the 0.000029 g TEQ/year reported for the 2008 Inventory, most likely due to longer operating hours. It should also be noted that the 2008 Inventory was based on a breakdown into separate activity rates for different types of wastes, but this detailed information is not readily available.

A very small proportion of the total waste burned is left as an ash residue, which is periodically removed from the unit and stored in drums, prior to disposal in an approved landfill. The current quantities of ash generated are about 2.1 tonnes per year, which is about 3 times higher than the total reported for the 2008 Inventory. The 2008 estimates for releases via these residues were based on a 2002 analysis which indicated a dioxin concentration of 25 µg TEQ per tonne (25×10^{-6} g TEQ/tonne). Applying this factor to the current waste quantities gives an annual release in residues of 0.000053 g TEQ per year.

The current release estimates for the hazardous waste incinerator are shown in Table 3-1, along with the estimates from the 2008 Inventory. There are no direct releases to water, land or in products.

Table 3-1: Dioxin releases from hazardous waste incineration

Year	Activity Rate	Release factors		Annual releases (g TEQ/yr)	
		Air	Residues	Air	Residues
2008	75 tonnes of waste/year	0.034 - 2.72 µg TEQ/tonne	-	0.000029	-
	0.75 tonnes of ash/year	-	25 µg TEQ/t	-	0.000019
2012	8000 hrs/year operation	5.96 ng TEQ/hr	-	0.000048	-
	2. 1 tonnes ash/year	-	25 µg TEQ/t	-	0.000053

Certainty assessment for 2012

Activity data:	Medium (because they are based on operator estimates)
Emission factors:	Air, High and residues, Low (because they are based on actual measurements, and historical analytical data, respectively)

Back-calculation for 2008

There have been no significant changes in the release factors so a back-calculation is not required.

3.3 Medical waste incineration

This source was covered in section 4 of the report on the 2008 Inventory, along with quarantine waste incineration, which is not covered in the UNEP Toolkit. Both of these sources will be covered here.

There is only one medical waste incinerator in New Zealand. This is a diesel-fired, dual-chamber unit, with no add-on emission controls, and has an annual waste throughput of about 200 tonnes/year (W Burnett, Grey Hospital, pers. comm., 2013). The emissions have not been tested for dioxins.

The only incinerator burning quarantine waste in New Zealand is a dual-chamber type which uses natural gas as the auxiliary fuel. Its primary function is the disposal of wastes collected from overseas aircraft. However, other waste types are also burned, including confiscated drugs, bio-hazardous materials and classified documents. The facility operates on approximately 50 occasions per year, with a total throughput of about 19 tonnes per annum (K Grey, Ohakea Air Base, pers. comm., 2013), and has never been tested for dioxin emissions.

The UNEP Toolkit recommends default factors of 3000 µg TEQ/tonne for releases to air and 20 µg TEQ/tonne for residues (ash), for batch-operated medical waste incinerators with minimal or no air pollution control systems (1 µg TEQ/tonne = 1 x 10^{-6} g TEQ/tonne). This is the appropriate sub-category for the two New Zealand incinerators, and the release estimates for 2012 based on these factors are shown in Table 3-2. The 2008 estimates have not been shown separately because there have been no changes in any of the data. There are no releases to water, land or in products.

Certainty assessment for 2012

Activity data:	Medium (because they are based on operator estimates)
Emission factors:	Low (because they are based on default factors given in the UNEP Toolkit)

Back-calculation for 2008

There have been no significant changes in the release factors so a back-calculation is not required.

Table 3-2: Dioxin releases from medical and quarantine waste incineration

Source	Activity Rate, tonnes of waste/year	Release factors, µg TEQ/t		Annual releases (g TEQ/yr)	
		Air	Residues	Air	Residues
Medical waste	200	3000	-	0.600	-
		-	20	-	0.0040
Quarantine waste	19	3000	-	0.057	-
		-	20	-	0.00038
Total for 2012 (& 2008)	**219**			**0.657**	**0.0044**

3.4 Light-fraction shredder waste incineration

Metal shredders are used for the processing of a range of scrap metals, including car bodies, whiteware and roofing iron. There are two outputs: a relatively clean ferrous metal stream and a 'fluff' or 'flock', which contains fragments of metals plus other waste materials from the input stream. This Toolkit category covers the disposal of the latter material by incineration, which is a potential source of dioxins. However, in New Zealand the material is disposed to a landfill (see section 4.3.2), so need not be considered here.

3.5 Sewage sludge incineration

This source was covered in section 6 (wastewater solids incineration) of the report on the 2008 Inventory.

There is one sewage sludge incinerator in New Zealand, operated by the Dunedin City Council at its wastewater treatment plant in Dunedin. The incinerator is a diesel-fired, fluidised bed unit, and the exhaust gases are treated in a high-efficiency venturi scrubber, followed by a packed-tower caustic scrubber. The gases are then passed through a bark biofilter which acts as a final scrubber, primarily for odour control.

The incinerator currently processes about 1700 tonnes of wastewater solids per year, on a dry basis, which is 15% higher than in 2008 (B Turner, Dunedin City Council, pers comm, 2013). The dioxin emissions to air are tested on an annual basis and the results were used to determine an average release factor for use in the 2008 Inventory. The test results obtained over the last 4 years show very similar dioxin concentrations to those reviewed in 2008, so the same factor will be used for the 2012 estimates for releases to air. The UNEP Toolkit default factors will be used for the releases in residues.

The release estimates for 2012 are shown in Table 3-3. There are no releases to water, land or in products.

Table 3-3: Dioxin releases from sewage sludge incineration

Year	Activity Rate, tonnes of waste/year	Release factors, µg TEQ/t		Annual releases (g TEQ/yr)	
		Air	Residues	Air	Residues
2008	1500	0.057	-	0.000086	-
		-	0.5	-	0.00075
2012	1700	0.057	-	0.000097	-
		-	0.5	-	0.00085

Certainty assessment for 2012

Activity data:	Medium (because they are based on operator estimates)
Emission factors:	High for air and Low for residues (because they are based on emission test data and the Toolkit default factors, respectively)

Back-calculation for 2008

There have been no significant changes in the release factors so a back-calculation is not required.

3.6 Waste wood and waste biomass incineration

Some timber mills and joinery factories burn their waste wood in simple incinerators (often known as Tepee burners) but there is no readily available national data that would allow this source to be distinguished from other industrial wood burning. Hence, the releases are included in the estimates reported in section 5.2.

Section 7 of the report for the 2008 Inventory covered two other related types; a document incinerator, and school incinerators. However, the document incinerator is now no longer operating, and document destruction is carried out by other means, such as shredding.

The school incinerators are not specifically covered in the UNEP Toolkit, but they fit reasonably well in this sub-category because at least some of the school wastes can be considered as biomass. In the 2008 Inventory the release estimates for the school incinerators were based on some default factors for domestic waste burning (sub-category 6b), which were given in the 2005 version of the UNEP Toolkit. These factors are identical to those given in sub-category 1f for biomass, so the latter will be just as appropriate.

For the 2008 Inventory it was established that there were 71 school incinerators operating in New Zealand, mainly in small rural schools without easy access to waste collection services or a local waste transfer station. The Ministry of Education does not have any more recent records on these incinerators but believes that the current number will either be the same as previously, or down by no more than10% (M Stallman, pers comm, 2013). The total waste quantity (70 tonnes per year) used for the 2008 Inventory was only a rough estimate, so will be retained for the current estimates, rather than making any adjustments for the minor change in incinerator numbers.

The release estimates for both 2008 and 2012, based on the default factors given in the UNEP Toolkit, are shown in Table 3-4. There are no releases to water, land or in products.

Table 3-4: Dioxin releases from waste wood and waste biomass incineration

Source	Activity Rate, tonnes/year	Release factors, µg TEQ/t		Annual releases (g TEQ/yr)	
		Air	Residues	Air	Residues
Document incinerators (2008)*	25	100	-	0.0025	-
School incinerators (2008 and 2012)	70	300	-	0.021	-
		-	600	-	0.042

(* The document incinerator is no longer operating)

Certainty assessment for 2012

Activity data:	Low (because it is based on a very rough estimate)
Emission factors:	Low (because they are based on default factors given in the UNEP Toolkit)

Back-calculation for 2008

There have been no significant changes in the release factors so a back-calculation is not required.

3.7 Destruction of animal carcasses

The disposal of animal carcasses in New Zealand using combustion falls into two categories depending on whether the animals are commercial livestock or domestic pets. On-farm disposal of dead livestock occurs by open burning and any releases should be captured under the general “Open Burning” sub-categories of section 8. On the other hand domestic pets and other small animals are disposed of by controlled incineration.

In New Zealand increasingly pet animals are disposed of by cremation rather than burial. In part this reflects the difficulties of burying animals in urban locations where the average plot size has diminished over the last twenty years. It also reflects changes in the care of animals, and current veterinary practice. Nowadays more animals are euthanised by vets in clinics at the end of their lives to alleviate suffering rather than dying at the family home, which was the case in the past (Radio New Zealand, 2013). Carcass disposal from clinics used to be predominantly to land, however pick-up services offered by animal cremators now make cremation a more straightforward option. The ability to return pet ashes to owners is another factor leading to the popularity of cremation.

A survey was conducted of regional councils and local authorities issuing consents for animal cremators and those disposing of animal pathological waste by combustion. In 2012 there were a total of 15 consented animal cremators spread throughout the country. A total cremator activity of 231 tonnes per annum was estimated from a combination of actual data and estimates based on consent conditions relating to loading rates and frequency of operation.

The UNEP Toolkit classifies animal cremators into 3 classes depending on whether the process is continuous or occurs in batches, and on the performance of air pollution control equipment installed, and the extent to which combustion gas monitoring occurs during operation.

Lower equipment cost and the expectation of many customers that they will receive the unique ashes of their pet are two strong factors that have led to batch cremators being exclusively installed in New Zealand. To date there have been no examples of discharge consents issued in New Zealand which make specific reference to the installation of air pollution control equipment. The emphasis in consent conditions is on maintaining elevated temperatures in the primary and secondary chambers thereby ameliorating the discharge of particulate matter and products of incomplete combustion to air.

Consequently currently all cremators in New Zealand are covered by the Toolkit’s class 1. This assigns an emission factor of 500 µg/tonne of carcasses (500 x 10^{-6} g TEQ/tonne) to emissions to air, with no releases to other compartments.

The release estimates for 2012 are shown in Table 3-5, along with the previous estimates for 2008. As shown, for 2008 the estimates were split across two equipment classes. However, after closer examination of the consent information, it has been decided that the higher class 1 factors should now be applied to all of the incinerators, because none of them has the necessary pollution control equipment that would allow them to be assigned to the better-performing Toolkit classes.

Certainty assessment for 2012

Activity data:	Medium (because it is based on a mixture of different source information)
Emission factor:	Low (because it is based on default factors given in the UNEP Toolkit)

Table 3-5: Dioxin releases from animal carcass disposal

	Source	Activity Rate, tonnes/year	Release factors, µg TEQ/t	Annual releases (g TEQ/yr)
			Air	Air
2008	**Class 1 cremators**	52	500	0.026
	Class 2 cremators	208	50	0.010
	Total for 2008			**0.036**
2008 (revised)	**Class 1 cremators**	260	500	**0.130**
2012	**Class 1 cremators**	231	500	**0.116**

Back-calculation for 2008

The 2013 Toolkit revision is more prescriptive than its predecessor in terms of assigning animal cremators to performance classes. If the 2008 activity rate had all been assigned to class 1 cremators the estimate for releases to air would have been 0.130 g TEQ, as shown against the 2008 (revised) entry in the table above.

3.8 Summary for this category

The 2012 release estimates for waste incineration are summarised in Table 3-6, along with the revised comparative totals for 2008.

Table 3-6: Summary of the release estimates for waste incineration

Category	2012 dioxin releases (g TEQ/yr)				
	Air	Water	Land	Product	Residue
Hazardous waste incineration	0.000048	-	-	-	0.000053
Medical waste incineration	0.657	-	-	-	0.0044
Sewage sludge incineration	0.000097	-	-	-	0.00085
Waste wood and biomass incineration	0.021	-	-	-	0.042
Destruction of animal carcasses	0.116	-	-	-	-
2012 totals	**0.794**	**-**	**-**	**-**	**0.047**
Revised 2008 totals	**0.717**	**-**	**-**	**-**	**0.047**

4 Ferrous and non-ferrous metal production

This category covers the following sub-categories (United Nations Environment Programme, 2013)

2a	Iron ore sintering
2b	Coke production
2c	Iron and steel production and foundries
2d	Copper production
2e	Aluminium production
2f	Lead production
2g	Zinc production
2h	Brass and bronze production
2i	Magnesium production
2j	Other non-ferrous metal production
2k	Shredders
2l	Thermal wire reclamation

The dioxin releases from metal production processes are nearly all combustion-related. They simply arise from the incomplete burning of small amounts of organic materials involved in the production processes. For primary metal production the organic material may be present as a contaminant in the metal ore, or may come from the carbon-based materials (eg. coke) used to promote ore reduction. In the case of secondary metal production, the most significant sources of organic matter are usually contaminants such as oil, grease, paint or plastic coatings that may be present on the surfaces of the input metals. In addition, metals such as copper are known to have a catalytic effect on the rate of dioxin formation.

4.1 Iron ore sintering

Iron ore sintering is a pre-treatment step in the production of iron. The sintering process involves heating of fine iron ore particles with flux and coke or coal fines, to produce a semi-molten mass that solidifies into porous pieces of sinter with the size and strength characteristics necessary for feeding into a blast furnace. This process is not used in the New Zealand steel-making process (see section 4.3.1).

4.2 Coke production (and charcoal)

Coke is produced by heating coal under vacuum in a process known as carbonisation. Along with iron ore and limestone it is an essential ingredient in the blast furnace method of steel production, and millions of tonnes of coke are produced globally for this purpose each year. However New Zealand uses a substantially different process to reduce iron sands to raw iron, which employs coal rather than coke (see s 4.3.1). Coke does find a use in the steel making plant (New Zealand Steel, 2010), but only as a relatively minor additive compared to the tonnages of steel produced – for 1 tonne of steel product only 14.6 kg of coke is used (Jaques, 2002). Total steel production at the plant in 2012 was 600,000 tonnes (see s 4.3) which would have required 8770 tonnes of coke. This coke is not produced in New Zealand, but is imported from China.

Small amounts of coke produced using an innovative microwave procedure known as Carbonscape have recently been trialled by New Zealand Steel. The Carbonscape process has been mooted as a technique for sequestering carbon in soils for long periods by producing 'biochar' from organic materials such as forestry and agricultural waste (see: www.carbonscape.com). Currently production is only at pilot plant stage but could become significant if the process was taken up in earnest.

Production of charcoal also involves heating under low oxygen conditions, except that wood rather than coal is used as the starting material. A survey of charcoal products available at a selection of New Zealand retail outlets showed that they were almost exclusively imported from South Africa, Namibia and Australia. This is supported by statistics published by the FAO (see: http://faostat.fao.org/) which show that in 2012, New Zealand imported 1187 tonnes of charcoal but exported only 2 tonnes.

The Toolkit emission factors for releases to air and water from coke and charcoal production are 3µg TEQ/tonne and 0.06 µg TEQ/tonne respectively (1 µg TEQ/tonne = 1 x 10^{-6} g TEQ/tonne). Consequently the potential contributions to dioxin burden from the small production quantities that may be occurring in New Zealand are likely to be significantly less than 0.001 grams TEQ/year. Given the lack of reliable production data and the likely low significance of any releases, no release estimates will be reported for this Toolkit sub-category.

4.3 Iron and steel production and foundries

This section of the UNEP Toolkit covers iron and steel plants, iron foundries, and galvanising.

4.3.1 Primary steel production

This source was covered in section 18 of the report on the 2008 Inventory.

The only primary iron and steel production in New Zealand is at the Glenbrook Mill south of Auckland, which is owned and operated by BlueScope Steel Ltd (and formerly New Zealand Steel Ltd). This plant is relatively unique in that the primary source of iron is obtained from nearby reserves of iron sand, which is a mixture of magnetite and titanomagnetite (NZ Institute of Chemistry, 1998). Most conventional steel mills use an iron ore, which is usually haematite. The total steel production in the year ended June 2012 was 609,000 tonnes and the mill also used 805,000 tonnes of coal, 80% of which was sourced from the Waikato region and 20% imported from Indonesia (C Jewel, BlueScope Steel, pers comm, 2013).

The dioxin release estimates for the 2008 Inventory were based on the emission factors used in the 2000 Inventory which, in turn, were based on emission test results from some unspecified time prior to 1998. The average air emission factor used for the 2008 Inventory was 0.134 µg TEQ per tonne of steel produced (0.134 x 10^{-6} g TEQ/tonne) and, in the absence of any more recent data, this factor will also be used for the 2012 estimates. The default factors given in the UNEP Toolkit are not relevant because they relate to conventional steel mills using iron ore.

The wastewater produced by the steel mill is passed through a treatment plant and then both this and the site stormwater are discharged to a waterway. The total discharge from the site is approximately 8400 m^3 per day (8,400,000 litres), and no dioxins have ever been detected in the (now historical tests) on the discharge. The previous inventories used a water concentration factor of 4.7 pg TEQ per litre (4.7 x 10^{-12} g TEQ/litre), based on a value of 50% of the limit of detection, and this will be used for the 2012 estimates in the absence of any more suitable factor.

The steel mill generated approximately 46,140 tonnes (dry weight) of solid wastes in 2012, which were disposed in a site landfill. There have been no recent tests for the dioxin content of these wastes, so the historical factors used in the 2008 Inventory will also be used here. It should be noted that for this source the waste residues are shown as a release to land, because they are disposed on-site. When wastes are disposed off-site they are recorded as a residue release, mainly because the actual disposal method is often not certain.

The current release estimates for primary steel production are shown in Table 4-1, along with the estimates from the 2008 Inventory. There are no releases in residues or in products.

Table 4-1: Dioxin releases from primary steel production

Year	Activity Rates	Release factors (µg TEQ/tonne or pg TEQ/litre (for water))			Annual releases (g TEQ/yr)		
		Air	Water	Land	Air	Water	Land
2008	620,000 tonnes of steel	0.134	-	-	0.083	-	-
	3.1 x 10^6 m^3 water	-	4.7	-	-	0.0146	-
	46,140 tonnes of waste	-	-	4.55	-	-	0.210
2012	609,000 tonnes of steel	0.134	-	-	0.082	-	-
	3.05 x 10^6 m^3 water	-	4.7	-	-	0.0143	-
	45,320 tonnes of waste	-	-	4.55	-	-	0.206

Certainty assessment for 2012

Activity data:	Medium (because they are based on company estimates)
Emission factors:	Medium (because they are based on historical site data)

Back-calculation for 2008

There have been no significant changes in the release factors so a back-calculation is not required.

4.3.2 Secondary steel production

This source sub-category was covered in section 18 of the report on the 2008 Inventory.

There is one secondary steel manufacturing plant in New Zealand, located in Otahuhu, South Auckland. This uses a single 48-tonne electric arc furnace, and produced 260,000 tonnes of steel in 2008 and 240,000 tonnes of steel in 2012 (J McLaren, Pacific Steel, pers comm, 2013). The plant uses scrap steel from a variety of sources, including industrial scrap and old motor vehicles. The melting of scrap metal contaminated with metal working fluids and materials containing chlorine provides conditions that are conducive to the formation of PCDDs and PCDFs. However, the contractual arrangements with the scrap provider are intended to ensure that these contamination levels are kept to a practical minimum.

The air emissions from the steel plant are captured and treated through a baghouse system, and the dioxin discharges from this are tested annually. The tests carried out in 2012 indicated an emission rate of 6.8 µg TEQ per hour (6.8 x 10^{-6} g TEQ/hour), or approximately 0.15 µg TEQ per tonne of steel (1 µg TEQ/tonne = 1 x 10^{-6} g TEQ/tonne). This is considerably lower than the factor used in the 2008 Inventory, but the bag house was given a major overhaul in 2009 and the dioxin emission rate was reduced significantly. Also, the most recent factor is still within the range of the UNEP Toolkit options of 0.1 µg TEQ per tonne (state of the art plant operation and emission controls) and 3 µg TEQ per tonne (clean scrap, plus air pollution controls).

The total quantity of dust collected in the baghouse is about 4000 tonnes per year, 11% higher than in 2008, and presumably a result of the bag house overhaul in 2009. The two previous inventories used a dioxin concentration factor of 700 µg TEQ per tonne of dust, which was based on a (now historical) analysis of a dust sample taken from the baghouse. This factor will be used for the current estimates, in the absence of any more recent data. The resulting release estimate of 2.8 g TEQ per year is 22% lower than the result that would be obtained using the default factor given in the UNEP Toolkit (3.6 g TEQ per year).

All of the steel mill wastewater and site stormwater is treated by passing through an artificial wetland prior to discharge to the Manukau Harbour. This treatment system should be highly effective in minimising any distribution of dioxins into the wider environment, and it has been assumed that the releases to water will be insignificant.

The current release estimates for secondary steel production are shown in Table 4-2, along with the estimates from the 2008 Inventory. It will be seen from the table that the releases to air have dropped significantly, but there has been a corresponding increase in the releases via residues (baghouse dust). There are no releases to water, land or in products.

Table 4-2: Dioxin releases from secondary steel production

Year	Activity Rate, tonnes/yr		Release factors (µg TEQ/tonne of steel or dust)		Annual releases (g TEQ/yr)	
	Steel	Dust	Air	Residue	Air	Residue
2008	260,000	-	0.92	-	0.24	-
	-	3,600	-	700	-	2.5
2012	240,000	-	0.15	-	0.036	-
	-	4,000	-	700	-	2.8

Certainty assessment for 2012

Activity data:	Medium (because they are based on company estimates)
Emission factors:	High (because they are based on annual test data)

Back-calculation for 2008

The release factor used for calculating air emissions has changed significantly since 2008. However, it is not appropriate to back-calculate the 2008 emissions because the reduction in release is due to a change in plant performance. Back-calculating using the new release factors would give falsely low releases for 2008.

4.3.3 Iron foundries

This source sub-category was covered in section 20 of the report on the 2008 Inventory.

Iron foundries manufacture cast-iron products from scrap iron, pig iron and internal plant returns (manufacturing rejects and wastes). Alloying materials such as silicon, magnesium, copper, nickel and carbon may also be added to the charge, along with fluxing materials, which often include chlorides or fluorides. The basic foundry operations are: raw material handling and preparation, mould and core production, metal melting and alloying, casting, and mould breakout, followed by finishing processes such as trimming, cleaning and polishing. A variety of furnaces can be used for metal melting, including electric arc and induction furnaces, cupolas and oil- or gas-fired crucibles. The melting operations have the greatest potential for dioxin releases to air, especially when processing contaminated scrap, and there can also be releases via furnace residues, such as slag and dross (United Nations Environment Programme, 2013).

The activity data for this sub-category was obtained through a survey of secondary metal production processes, which is described in Appendix 4. As indicated there, the total annual metal production by iron foundries was estimated to be 16,000 tonnes per year, which is only slightly lower than the production rate estimated for 2008 of 18,000 tonnes per year.

The current release estimates for iron foundries are shown in Table 4-3, along with the estimates from the 2008 Inventory. The estimates for releases to air for both years are based on a factor of 8.2 µg TEQ per tonne of metal (1 µg TEQ/tonne = 1 x 10^{-6} g TEQ/tonne), which was derived from a 2002 industry survey (Ministry for the Environment, 2004) and is marginally lower than the default factor of 10 µg TEQ per tonne given in the UNEP Toolkit. The releases in residues are based on the Toolkit factor of 8 µg TEQ per tonne of metal. In addition, the release estimates have been adjusted by a factor of 0.65 because the residues are only produced by plants fitted with bag filters (Ministry for the Environment, 2011a).

Table 4-3: Dioxin releases from iron foundries

Year	Activity Rate tonnes of iron per year	Release factors (µg TEQ/tonne of iron)		Annual releases (g TEQ/yr)	
		Air	Residue	Air	Residue
2008	18,000	8.2	-	0.148	-
		-	8	-	0.094
2012	16,000	8.2	-	0.131	-
		-	8	-	0.083

Certainty assessment for 2012

Activity data:	Medium (because they are based on survey data)
Emission factors:	Medium (because they are based on historical NZ emission data)

Back-calculation for 2008

There have been no significant changes in the release factors so a back-calculation is not required.

4.3.4 Hot-dip galvanising plants

This source sub-category was covered in section 18 of the report on the 2008 Inventory.

Galvanising refers to the process of coating iron or steel with a thin layer of zinc to provide long-term protection against corrosion. The hot-dip process involves pre-cleaning of the metal by immersion in acidic and/or alkaline cleaning baths, treatment with a fluxing agent (such as zinc ammonium chloride), and then immersion in a bath of molten zinc at a temperature of around 450°C. Hot-dip galvanising has been identified as a potential source of dioxins (United Nations Environment Programme, 2013).

The New Zealand galvanising industry is made up of two large coating plants for continuous steel sheet and a wire-galvanising operation (production rates of 5000 to 10,000 tonnes per year each), several mid-sized batch-processing plants (1000 − 2000 tonnes per year), and about 20 small batch operators (<500 tonnes per year). Data has been obtained from the Galvanising Association of New Zealand for the total annual production of galvanised iron and steel in New Zealand (J Notley, pers comm, 2014). However, this information is regarded as confidential and cannot be reported here. The data has been used to provide the 2012 release estimates shown in the table below.

Table 4-4: Dioxin releases from hot-dip galvanising

Year	Annual releases (g TEQ/yr)	
	Air	Residue
2008	0.00124	0.025
2012	0.00133	0.033

Certainty assessment for 2012

Activity data:	High (because they are based on industry data)
Emission factors:	Low (because they are based on the default factors given in the UNEP Toolkit)

Back-calculation for 2008

The Toolkit has made minor changes to the way in which releases in residues are calculated but these have not resulted in any changes to the release estimates. Hence no revised estimates have been shown in the table.

4.4 Copper production

This source sub-category was covered in section 20 of the report on the 2008 Inventory.

The UNEP Toolkit covers both primary and secondary copper production (United Nations Environment Programme, 2013). However there is no primary production in New Zealand; ie. metal production from the original copper ore (Crown Minerals, undated). Some of the secondary copper production in New Zealand involves the processing of copper on its own. However, most is done in conjunction with other metals such as tin, lead and zinc, for the manufacture of products made from brass and bronze.

The activity data for this sub-category was obtained through a survey of secondary metal production processes, which is described in Appendix 4. However, the information obtained through the survey does not allow the production rates for non-ferrous metals (except aluminium) to be sub-divided into the individual metals, so the dioxin releases have been accounted for under the brass and bronze sub-category which is reported in section 4.8 below.

4.5 Aluminium production

These source sub-categories were covered in sections 18 and 19 of the report on the 2008 Inventory.

4.5.1 Primary aluminium production

The only primary aluminium smelter in New Zealand is located at Tiwai Point in Southland. It produces approximately 350,000 tonnes of aluminium per year by the pre-bake Hall-Heroult process, with most production in the form of high-purity ingots.

Primary aluminium production was listed as a potential source of dioxins in the first edition of the UNEP Toolkit, although no data had been published to show that this was the case. However, more recent assessments indicate that it is no longer thought to be a significant source (United Nations Environment Programme, 2013).

4.5.2 Secondary aluminium production

The industries included in this subcategory are metal recyclers, who recover aluminium from mixed scrap, and manufacturers of cast aluminium products, such as alloy wheels and engine parts. Much of the manufacturing uses aluminium ingots and clean aluminium scrap, but may also include aluminium recovery from in-house metal wastes. Scrap metal and mixed metal wastes may contain organic impurities such as plastics, paints and solvents, and their presence can result in increased formation and release of dioxins.

The activity data for this sub-category was obtained through a survey of secondary metal production processes, which is described in Appendix 4. As indicated there, the total annual secondary aluminium production rate was estimated to be 15,000 tonnes per year, which is lower than the production rate estimated for 2008 of 20,000 tonnes per year.

The current release estimates for secondary aluminium production are shown in Table 4-5, along with the estimates from the 2008 Inventory. The estimates for releases to air for both years are based on a factor of 2.9 µg TEQ per tonne of metal (1 µg TEQ/tonne = 1 x 10^{-6} g TEQ/tonne), which was derived from a 2002 industry survey (Ministry for the Environment, 2004) and is within the range of the two default factors given in the UNEP Toolkit of 0.5 and 35 µg TEQ per tonne, depending on the condition of the input metals and the extent of control over the process emissions. The releases in residues are based on a factor of 200 µg TEQ per tonne of metal, which is the average of the two Toolkit factors of 100 and 300 µg TEQ per tonne of metal. In addition, the release estimates have been adjusted by a factor of 0.9 because the residues are only produced by plants fitted with bag filters (Ministry for the Environment, 2011a)

Table 4-5: Dioxin releases from secondary aluminium production

Year	Activity Rate tonnes of aluminium per year	Release factors (µg TEQ/tonne of aluminium)		Annual releases (g TEQ/yr)	
		Air	Residue	Air	Residue
2008	20,000	2.9	-	0.058	-
		-	300	-	5.40
2012	15,000	2.9	-	0.044	-
		-	300	-	4.05

Certainty assessment for 2012

Activity data:	Medium (because they are based on survey data)
Emission factors:	Medium (because they are based on historical NZ data)

Back-calculation for 2008

There have been no significant changes in the release factors so a back-calculation is not required.

4.6 Lead production

This source sub-category was covered in section 20 of the report on the 2008 Inventory. At that time, there was one secondary lead smelter in New Zealand, and no primary lead smelters. However, the secondary lead smelter was shut down at the start of 2012, so there are no longer any releases under this sub-category. This change is reflected in Table 4-6 below.

Certainty assessment for 2012

This is no longer relevant.

Back-calculation for 2008

The factor used for the 2008 release estimate was based on New Zealand emissions data, so a back-calculation is not required.

Table 4-6: Dioxin releases from secondary lead production

Year	Activity Rate tonnes of lead per year	Release factors (µg TEQ/tonne of Lead)	Annual releases (g TEQ/yr)
		Air	Air
2008	13,000	3.5	0.046
2012	0	3.5	-

4.7 Zinc production

This Toolkit sub-category covers the production of metallic zinc from ore and the recovery and refining of zinc from scrap metal (United Nations Environment Programme, 2013). There is no primary zinc production in New Zealand (Crown Minerals, undated) and the secondary metal survey reported in Appendix 4 did not identify any businesses specifically involved in zinc recovery.

4.8 Brass and bronze production

This source sub-category was covered in section 18 of the report on the 2008 Inventory.

The activity data for this sub-category was obtained through a survey of secondary metal production processes, which is described in Appendix 4. As indicated there, the total annual secondary metal production for copper and other non-ferrous metals was estimated to be 12,000 tonnes per year, which is well below the production rate estimated for 2008 of 23,200 tonnes per year. The information obtained through the survey does not allow these production rates to be sub-divided into the different types of metals, so the dioxin releases have been accounted for under the brass and bronze sub-category. The same approach was taken for the 2008 Inventory, but the estimates were given under a general heading of Other Non-Ferrous Metals[2]. The Toolkit release factors for brass and bronze production are similar to those for secondary copper production, so the grouping has no marked effect on the overall release estimates.

The current release estimates for this sub-category are shown in Table 4-7, along with the estimates from the 2008 Inventory. The estimates are based on the Toolkit default factors of 3.5 µg TEQ per tonne of metal for releases to air and 125 µg TEQ per tonne for releases to land, but the latter factor was adjusted to allow for only 66% of all plants using bag filters. The factor for releases to air is reasonably consistent with actual release data for New Zealand plants reported from a 2002 industry survey (Ministry for the Environment, 2004).

Certainty assessment for 2012

Activity data:	Medium (because they are based on survey data)
Emission factors:	Medium (because they are based on historical NZ emission data)

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[2] This is not the same as the heading used here for section 4.10. For the 2008 Inventory it referred to all non-ferrous metals apart from aluminium.

Back-calculation for 2008

There have been no significant changes in the release factors so a back-calculation is not required.

Table 4-7: Dioxin releases from brass, bronze and other non-ferrous metal production

Year	Activity Rate tonnes of metal per year	Release factors (µg TEQ/tonne of metal)		Annual releases (g TEQ/yr)	
		Air	Residue	Air	Residue
2008	23,200	3.5	-	0.081	-
		-	82.75	-	1.920
2012	12,000	3.5	-	0.042	-
		-	82.75	-	0.993

4.9 Magnesium production

This Toolkit sub-category covers the production of metallic magnesium, for which there is no such activity in New Zealand (Crown Minerals, undated).

4.10 Other non-ferrous metal production

This Toolkit sub-category covers the primary production of other non-ferrous metals, such as cadmium and nickel, for which there is no such activity in New Zealand (Crown Minerals, undated).

4.11 Metal shredding

This source sub-category was covered in section 18 of the report on the 2008 Inventory.

The operations at the Pacific Steel plant are carried out in conjunction with an adjoining scrap metal processing facility. This is run by Sims Pacific, who collect scrap metal from their branches throughout the country, and from numerous other scrap metal dealers. The heavier pieces of scrap are cut into smaller pieces using gas-cutting equipment, while the light-weight material (sheet steel) is passed through a mechanical shredder.

Metal shredders are used for the processing of a range of scrap metal, including car bodies, whiteware and roofing iron. There are two outputs: a relatively clean ferrous metal stream, made up of small (around 50 mm) pieces of steel, and a ‘fluff’ or ‘flock’, which contains fragments of other non-ferrous metals and other waste materials in the input stream. Dioxins have been detected in the air discharges from shredder plants, but there is no evidence to show that these are formed as a result of the shredding process. Instead, it is believed that the emissions arise from contaminants already present in the scrap metal (United Nations Environment Programme, 2013).

The Sims Pacific Auckland operation has an annual steel throughput of about 320,000 tonnes per year and about 60% of this is shredded (ie. 190,000 tonnes per year (Auckland Regional Council, 2010)). Most of the metal, both shredded and non-shredded, is transferred to the Pacific Steel operation, with any surplus production exported.

Sims Pacific also operate a shredder in Christchurch, which was assessed in the 2008 Inventory as having an annual throughput of around 60,000 tonnes per year. In addition, a second metal shredding operation was opened in Auckland in 2010, by CMA Recycling, with a capacity of around 100,000 tonnes per year (J Osman, Auckland Council, pers comm, 2013).

The amount of data available on dioxin releases to air from metal shredding is very limited, but the UNEP Toolkit recommends a single release factor of 0.2 µg TEQ per tonne of steel (0.2 x 10^{-6} g TEQ/tonne). This has been used for the current release estimates based on a total combined throughput for all 3 plants of 310,000 tonnes per year, which is a substantial increase on the 120,000 tonnes per year used for the 2008 Inventory.

The primary waste produced from metal shredding is a so-called fluff, which is stabilised prior to disposal to landfill. It was indicated in the 2008 Inventory Report that there was no data available on the likely dioxin concentrations in this waste. However, the updated UNEP Toolkit now provides a release factor of 5 µg TEQ per tonne of steel (5 x 10^{-6} g TEQ/tonne), and this has been used for the current estimates.

The 2012 release estimates for metal shredding are shown in Table 4-8, along with the estimates from the 2008 Inventory. As expected, the releases to air have increased significantly in accordance with the increased activity rate, and there is now also a residue release estimate. There are no releases to water, land or in products.

Table 4-8: Dioxin releases from metal shredding

Year	Activity Rate (tonnes of steel)	Release factors (µg TEQ/tonne of steel)		Annual releases (g TEQ/yr)	
		Air	Residue	Air	Residue
2008	120,000	0.2	-	0.024	-
2008 (revised)	120,000	0.2	-	0.024	-
		-	5	-	0.60
2012	350,000	0.2	-	0.070	
		-	5	-	1.75

Certainty assessment for 2012

Activity data:	Low (because they are based on indirect information on nominal plant capacities)
Emission factors:	Low (because they are based on the default factors given in the UNEP Toolkit)

Back-calculation for 2008

The releases via residues from this source were not covered in the 2008 Inventory Report because no default factor was available. The back-calculation using the new Toolkit factor is shown against the 2008 (revised) rows in the table.

4.12 Thermal wire reclamation and e-waste recycling

This Toolkit sub-category covers the burning of electrical cables for the purposes of copper recovery, and thermal processing of other electronic wastes to recover a variety of potentially valuable metals, including copper, silver and gold. Some of the secondary metal businesses covered under the industry survey reported in Appendix 4 process the copper in electrical cables as part of their feedstock. However, the releases from these operations have already been accounted for in section 4.8. Other than that, the open burning of plastic-coated wire is generally prohibited by most regional councils, so should not be occurring to any significant extent. The same restrictions would apply to the burning of other types of e-waste.

4.13 Summary for this category

The 2012 release estimates for metal production are summarised in Table 4-9, along with the revised comparative totals for 2008.

Table 4-9: Summary of the release estimates for metal production

Category	**2012 dioxin releases (g TEQ/yr)**				
	Air	**Water**	**Land**	**Product**	**Residue**
Primary steel production	0.082	0.0143	0.206	-	-
Secondary steel production	0.036	-	-	-	2.80
Iron Foundries	0.131	-	-	-	0.083
Hot dip galvanizing plants	0.0013	-	-	-	0.033
Secondary aluminium production	0.044	-	-	-	4.05
Lead production	-	-	-	-	-
Brass and bronze production	0.042	-	-	-	0.993
Metal shredding	0.070	-	-	-	1.75
2012 totals	**0.404**	**0.014**	**0.206**	**-**	**9.71**
Revised 2008 totals	**0.680**	**0.015**	**0.210**	**-**	**10.54**

5 Heat and power generation

This category covers the following dioxin sources (United Nations Environment Programme, 2013):

- 3a Fossil fuel power plants (coal, oil, gas, shale oil, and co-combustion of waste)
- 3b Biomass power plants (wood, straw, other biomass)
- 3c Landfill, biogas combustion
- 3d Household heating and cooking with biomass (wood, other biomass)
- 3e Household heating and cooking with fossil fuels (coal, oil, gas)

The dioxin releases from heat and power generation processes are all combustion-related, and they mainly arise from the incomplete combustion of the fuels being burned. For this reason, the dioxin release rates tend to be greatest for the more complex fuels (eg. coal and oil versus gas). They are also highly dependent on the types and design of the fuel-burning equipment (eg. industrial furnaces versus simple domestic ovens).

5.1 Fossil fuel power plants

It is important to note that the UNEP Toolkit uses the term power in its broadest technical sense, meaning energy produced by mechanical, thermal, electrical, or other means, whereas in New Zealand it is commonly used to refer specifically to electricity. The previous inventory reports avoided this potential confusion by having separate sections for electricity generation and other industrial/commercial fuel use, and this distinction will be maintained here through the use of sub-sections within each of the fuel-based sub-categories covered below.

The UNEP Toolkit lists 6 different classes within this sub-category, on the basis of fuel type. These are: fossil fuel/waste mixtures, coal, peat, heavy fuel oil, shale oil and light fuel oil/natural gas. The latter group may also be taken to include LPG. There is no co-firing of wastes or usage of peat or shale oil as fuels in New Zealand, but all other fuels have been considered below.

The fossil fuel power plants addressed under this section were those covered under sections 9 (power generation), and 10 (industrial/commercial coal, oil and gas) of the report on the 2008 Inventory.

5.1.1 Coal-fired power plants

Electricity Generation

The only coal-fired power station in New Zealand is the Huntly Power Station which, when first built, had a capacity of 1000 MW. This was based on four separate boiler/generation units of 250 MW each – known as Units 1 to 4 – which could be fired on natural gas or coal. More recently, additional generation units have been added to the power station (Units 5 and 6), giving it a nominal total capacity of 1435 MW. However, the newer units are gas-turbine systems, which use natural gas, and minor amounts of diesel.

Units 1 to 4 are over 30 years old and are now rarely utilised to their full capacity. One of the units was ‘retired’ in 2012 (Ministry of Business, Innovation and Employment, 2013) so that the total available capacity is now only 750 MW. This reduced utilisation is also reflected in the annual coal consumption statistics, which show a total coal energy usage of only 16,500 TJ in 2011[3] and 29,100 TJ in 2012, compared to 43,000 TJ in 2008, and a peak level of around 70,000 TJ/year in 2005 and 2006 (1 TJ = 10^{12} Joules). However, these data do not reflect the total plant utilisation, because there can be significant additional generation using natural gas.

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[3] Most of the energy data in this section is expressed on both an energy and mass basis. The latter will be more meaningful to the reader, but the energy-based values give a more precise measure of usage, and are required for the data inputs to the Toolkit.

The coal used at Huntly Power Station is a mixture of Waikato sub-bituminous coal, and coal imported from Indonesia. The total coal consumption by the power station in 2012 was 1,270,000 tonnes (T McKenzie, Genesis Energy, pers comm, 2013), which is equivalent to an energy consumption of 29,090 TJ.

The power station emissions to air have been tested for dioxins on several occasions, and most recently in 2010 (Sinclair Knight Merz, 2011). However, the results from this and the other previous tests noted in the report on the 2008 Inventory are quite comparable to the factor of 10 µg TEQ per TJ given in the UNEP Toolkit (10×10^{-6} g TEQ per TJ). Therefore, the toolkit default has been used for the current estimates.

The Huntly Power Station units are fitted with electrostatic precipitators for the control of particulate emissions to air. The fly ash collected by the precipitators is disposed to land in a specially designed ash disposal facility. No information has been obtained on the exact quantities of ash collected by the precipitators, nor the dioxin content. However, the releases to land can be calculated from the fuel consumption rate using the default factors given in the UNEP Toolkit.

The 2012 release estimates for coal-fired electricity generation are shown in Table 5-1, along with the estimates from the 2008 Inventory. As shown, the releases have dropped since 2008 because of the reduced coal consumption. There are no direct releases to water or in products, and the residue (ash) is disposed to land.

Table 5-1: Dioxin releases from coal-fired electricity generation

Year	Activity Rate (TJ of coal/year)	Release factors (µg TEQ/TJ of coal)		Annual releases (g TEQ/yr)	
		Air	Land	Air	Land
2008	43,400	10	-	0.434	-
		-	14	-	0.608
2012	29,090	10	-	0.291	-
		-	14	-	0.407

Certainty assessment for 2012

Activity data:	High (because it is based on actual fuel consumption data)
Emission factors:	High for air and low for residues (because they are both based on the Toolkit default factors, but the factor for air has been validated by testing at the power station)

Back-calculation for 2008

There have been no significant changes in the release factors so a back-calculation is not required.

Coal-fired industrial manufacturing and commercial appliances

The total New Zealand coal consumption for consumer energy uses in 2012 was 24,390 TJ (1 TJ = 10^{12} Joules), or about 1,185,000 tonnes (Ministry of Business, Innovation and Employment, 2013). Consumer energy uses include agricultural, industrial, commercial, residential and transport. The figures for coal consumption include two sources that are covered under other sections of the inventory: cement manufacture and domestic heating[4]. The 2012 consumption data for these two sources is not yet available, but in 2011 they accounted for 17.7% of

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[4] Coal use in steel production is also not included here, but this is counted in an Energy Transformation heading in the MBIE energy data summaries, rather than as Consumer Energy.

the total consumer energy use. Subtracting this fraction from the consumer energy total gives a total annual energy consumption associated with the remaining coal combustion sources of 20,070 TJ (1 TJ = 10^{12} Joules).

The estimates for the releases to air from these sources have been based on the same approach as adopted for the 2008 Inventory. For plant greater than 10 MW, the UNEP Toolkit emission factor of 10 µg TEQ per TJ has been applied (10 x 10^{-6} g per TJ), while a factor of 100 µg TEQ per TJ has been used for plants less than 10 MW (100 x 10^{-6} g per TJ). The 20,070 TJ of total coal consumption in this source category has been assigned to the two size ranges in accordance with the proportion of the total boiler capacity they comprise in the national Heat Plant Database (CRL Energy, 2011). The total capacity of boilers of 10 MW or greater is 662 MW (52.3% of the total), while those less than 10 MW have a total capacity of 603 MW (47.7%). Accordingly the energy distribution used was 10,500 TJ and 9570 TJ, respectively.

The default release factor of 14 µg TEQ per TJ (14 x 10^{-6} g TEQ per TJ) given in the UNEP Toolkit has been used for estimating the annual releases in residues from these coal fired sources.

The 2012 release estimates for industrial and commercial coal use are shown in Table 5-2, along with the estimates from the 2008 Inventory. As shown, the releases in residues have dropped slightly, due to a reduction in coal consumption, but the releases to air have gone up because of a redistribution of coal use between small and large plant. There are no direct releases to water or in products. The ash production is assigned to the residues Toolkit vector, because the final place of disposal is not known with any certainty.

Table 5-2: Dioxin releases from industrial and commercial coal use

Year	Plant size	Activity Rate (TJ of coal/year)	Release factors (µg TEQ/TJ of coal)		Annual releases (g TEQ/yr)	
			Air	Residue	Air	Residue
2008	> 10 MW	13,900	10	-	0.139	-
			-	14	-	0.195
	< 10 MW	6,900	100	-	0.690	-
			-	14	-	0.097
	Totals	**20,800**			**0.829**	**0.291**
2012	> 10 MW	10,500	10	-	0.105	-
			-	14	-	0.147
	< 10 MW	9,570	100	-	0.957	-
			-	14	-	0.134
	Totals	**20,070**			**1.062**	**0.281**

Certainty assessment for 2012

Activity data: High (because it is based on national fuel consumption data)
Emission factors: Low (because they are both based on the Toolkit default factors)

Back-calculation for 2008

There have been no significant changes in the release factors so a back-calculation is not required.

5.1.2 Heavy fuel oil-fired power plants

This source category was not included in the 2008 Inventory, apart from a very minor use of oil for electricity generation at the Whirinaki Power Station. The industrial uses of heavy fuel oil were considered to be also very minor, so were not assessed. A review of the national fuel consumption data given in the Energy Data File confirms that this is still the case. However, they have been included in this inventory for the sake of completeness.

Heavy fuel oil is sometimes used as a supplementary or stand-by fuel in some of the larger New Zealand industries, such as the pulp and paper mills. It is also known to be used in a plant that processes waste oil. However, there is no significant use in industrial or commercial boilers, as indicated by the absence of any such listings in the Heat Plant Database (CRL Energy, 2011).

The total heavy fuel oil used in industrial applications in 2012 was 3310 TJ (1 TJ - 10^{12} Joules), or about 76,000 tonnes (Ministry of Business, Innovation and Employment, 2013). There was a further 4000 TJ (92,000 tonnes) used in coastal shipping, but this should be accounted for under the Transport category. The UNEP Toolkit provides a default factor for releases to air and indicates there are no data available on the releases via other pathways, such as in residues (ash).

The 2012 release estimates for heavy fuel oil-fired power plant are shown in Table 5-3. There were no corresponding estimates made in the 2008 Inventory.

Table 5-3: Dioxin releases from heavy fuel oil-fired power plant

Year	Activity Rate (TJ of fuel oil/year)	Release factors (µg TEQ/TJ of oil)	Annual releases (g TEQ/yr)
		Air	Air
2008	not assessed	-	-
2008 (revised)	3,070	2.5	0.0077
2012	3,310	2.5	0.0083

Certainty assessment for 2012

Activity data:	High (because it is based on actual fuel consumption data)
Emission factor:	Low (because it is based on the Toolkit default factors)

Back-calculation for 2008

The release factors given in the UNEP Toolkit have not changed. However, a back-calculation is appropriate because this source was not included in the 2008 Inventory. The amount of heavy fuel oil used in 2008 was 3070 TJ (70,500 tonnes), and the release estimate is shown in the 2008 (revised) row in the table above.

5.1.3 Fuel oil and natural gas-fired power plants

This category was considered in two parts in the 2008 Inventory – electricity generation (section 10) and industrial/commercial use (section 9). The same approach will be adopted here.

Fuel oil and natural gas-fired electricity generation

There are 10 gas-fired power stations in New Zealand with individual electricity generation capacities of 10 MW or greater, and a combined capacity of 1556 MW (Ministry of Business, Innovation and Employment, 2013). Five of these are combined-cycle or open-cycle gas turbines, and the other 5 are cogeneration plants. There are 5 other cogeneration plants fired predominantly on biomass (3) or coal (2), which may also burn gas.

In 2012 the total consumption of natural gas for electricity generation was 72,150 TJ (1 TJ = 10^{12} Joules), including that used in cogeneration plants. The total consumption of diesel in 2012 was only 40 TJ, which suggests it was simply being used when running standby plants for annual maintenance purposes.

There are no dioxin emission data available for gas-fired electricity plants in New Zealand, so the UNEP Toolkit default factors have been used. These make no distinction between the use of gas or oil, and indicate that the only relevant release route is to air.

The 2012 release estimates for fuel oil (diesel) and natural gas-fired electricity generation are shown in Table 5-4, along with the corresponding estimates made in the 2008 Inventory.

Table 5-4: Dioxin releases from fuel oil and natural gas-fired electricity generation

Year	Activity Rate (TJ of fuel/year)	Release factors (µg TEQ/TJ of fuel)	Annual releases (g TEQ/yr)
		Air	Air
2008	85,400	0.5	0.043
2012	72,190	0.5	0.036

Certainty assessment for 2012

Activity data:	High (because it is based on actual fuel consumption data)
Emission factor:	Low (because it is based on the Toolkit default factors)

Back-calculation for 2008

There have been no significant changes in the release factors so a back-calculation is not required.

Industrial/commercial fuel oil and gas-fired power plants

The major industrial uses of fuel oil (diesel), LPG and natural gas are in dairy factories, meat processing plants, pulp and paper and other wood processing industries, and steel manufacture. However, there are also numerous small boilers found in industrial/commercial businesses, and institutions, such as schools and hospitals.

The industrial and commercial consumption of natural gas (excluding electricity generation) accounted for 47,710 TJ of energy in 2012 (Ministry of Business, Innovation and Employment, 2013). In addition, the industrial and commercial uses of LPG were 3840 TJ, half of which has been assumed to be used in heat-raising appliances.

The industrial and commercial combustion of diesel in boilers is not easily distinguished from that used in stationary combustion engines[5] on the basis of the available statistical information. An estimate of the heat produced by diesel-fired boilers has been made using the plant capacities recorded in the Heat Plant Database (CRL Energy, 2011). The total installed capacity is 189 MW. If it is assumed these boilers operate 24 hours a day for 320 days a year, at 75% efficiency, the total energy consumed would be about 3900 JT per year.

The UNEP Toolkit provides an emission factor of 0.5 μg TEQ per TJ (0.5 x 10^{-6} g TEQ per TJ), for the discharges to air from power plants fired with natural gas and light fuel oil. There are no factors for releases to any of the other release routes. The UNEP Toolkit factor has been used in the absence of any relevant New Zealand data.

The 2012 release estimates for industrial/commercial fuel oil and gas-fired power plant are shown in Table 5-5, along with the corresponding estimates made in the 2008 Inventory.

Table 5-5: Dioxin releases from fuel oil and gas-fired power plant

Year	Activity Rate (TJ of fuel/year)	Release factors (μg TEQ/TJ of fuel)	Annual releases (g TEQ/yr)
		Air	Air
2008	38,300	0.5	0.019
2012	53,530	0.5	0.027

Certainty assessment for 2012

Activity data:	High (because it is based on actual fuel consumption data)
Emission factor:	Low (because it is based on the Toolkit default factors)

Back-calculation for 2008

There have been no significant changes in the release factors so a back-calculation is not required.

5.2 Biomass power plants

There are 3 large biomass-fired cogeneration plants in New Zealand, with a total installed capacity of 72 MW (Ministry of Business, Innovation and Employment, 2013). These are the power boilers at the two pulp and paper mills in Kawerau and Kinleith, and the thermo-mechanical pulp plant in Napier. Biomass is also burned in the recovery boilers at the pulp and paper mills, and in numerous other power boilers in board mills, fibreboard plants, and sawmills. The Heat Plant Database lists about 175 industrial wood-fired installations rated at greater than 1 MW capacity, with a total combined capacity of more than 1035 MW (CRL Energy, 2011). Altogether, these account for about 80% of New Zealand wood combustion.

This section addresses the industrial biomass power plants, and any incidental incineration of wood waste. These sources were covered in section 12 of the report on the 2008 Inventory. Combustion processes in the pulp and paper industry are split into two, with wood and biomass combustion included here and the combustion of black liquor solids covered in section 8.

The dioxin releases from this source category were assessed by the same procedure as used in the 2008 Inventory. The gross heat energy ratings for relevant plant listed in the Heat Plant Database (CRL Energy, 2011) were summed and an estimate of the annual energy consumption was made based on the assumption that the

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[5] In the UNEP Toolkit, stationary combustion engines are considered under the Transport category (see section 7).

facilities operated 24 hours a day, at 70% capacity, for 320 days per year. The total energy consumption was estimated at 20,000 TJ (1 TJ – 10^{12} Joules), not including the contribution from black liquor combustion in the pulp and paper industry. If black liquor is taken into account, the total energy consumption is 29,440 TJ.

The latter figure (black liquor included) compares very well with the results of a manufacturing energy use survey conducted by Statistics New Zealand, which determined a total annual energy usage in 2008, for wood and wood waste production, of 29,250 TJ (Statistics New Zealand, 2009).

The report on the first dioxin inventory included the results from dioxin emissions tests on 2 New Zealand wood-fired boilers and used these to determine local emission factors. However, these data are very limited and now also quite dated. The 2008 Inventory estimates were based on the default factors given in the UNEP Toolkit, of 50 µg TEQ per TJ for releases to air, and 15 µg TEQ per TJ for releases in residues (1 µg TEQ/TJ = 1 x 10^{-6} g TEQ/TJ). These factors have also been used for the current estimates.

The 2012 release estimates for biomass-fired power plant are shown in Table 5-6, along with the corresponding estimates made in the 2008 Inventory. There are no direct releases to water or in products. The ash production is assigned to the residues Toolkit vector, because the final place of disposal is not known with any certainty.

Table 5-6: Dioxin releases from biomass-fired power plant

Year	Activity Rate (TJ of biomass/year)	Release factors (µg TEQ/TJ of biomass)		Annual releases (g TEQ/yr)	
		Air	Residues	Air	Residues
2008	21,350	50	-	1.068	-
		-	15	-	0.320
2012	20,000	50	-	1.000	-
		-	15	-	0.300

Certainty assessment for 2012

Activity data:	High (because it is based on actual fuel consumption data)
Emission factor:	Low (because it is based on the Toolkit default factors)

Back-calculation for 2008

There have been no significant changes in the release factors so a back-calculation is not required.

5.3 Landfill, biogas combustion

Landfill gas from solid waste disposal and biogas from domestic wastewater treatment are both generated from anaerobic digestion of organic matter. The resulting gas is predominantly methane but may also contain carbon monoxide, carbon dioxide, ammonia and smaller fractions of volatile organic compounds (United Nations Environment Programme, 2013). Dioxins can be produced when the gases are burned, either in a flare or a gas engine (eg. for electricity generation).

The potential dioxin releases from landfill gas utilisation were addressed in section 26 of the 2008 Inventory report but releases from other biogas utilisation were not considered.

The New Zealand Greenhouse Gas Inventory publishes data on the amount of methane that is recovered and flared or utilised from both of these sources (Ministry for the Environment, 2014). In 2011, 22 landfills from a total of about 60 were actively capturing the landfill gas produced. Similarly 8 wastewater treatment plants were capturing biogas for further utilisation. The information given in the 2014 greenhouse gas inventory report (for 2012 emissions) shows that 48,510 tonnes of pure methane were recovered from managed waste disposal on land with a further 13,450 tonnes recovered from wastewater operations; giving a total methane recovery of 61,960 tonnes. Applying a heating value of 50.1 MJ/kg for pure methane (50.1 x 10^6 Joules/kg), the energy associated either with its flaring or combustion for power generation is 3104 TJ (1 TJ = 10^{12} Joules).

It should be noted that a new methodology was introduced in the 2011 greenhouse gas inventory report for assessing the gas emissions for these two sources, and this was applied retrospectively to the inventories for previous years (ie. as a back-calculation). This has resulted in significant changes to the release estimates for previous years, which will also need to be reflected in corresponding changes in the dioxin release estimates for these sources. For example in the 2010 greenhouse gas inventory report (which was used for the 2008 dioxin inventory estimates), the quantity of methane recovered from waste disposal to land in 2008 was reported to be 66,000 tonnes and there was no estimate for the quantity recovered from wastewater operations. In the 2014 greenhouse gas inventory report, the revised estimates for 2008 are given as 36,060 tonnes for waste disposal on land and 12,850 tonnes for wastewater operations.

The Toolkit emission factor for landfill and biogas utilisation is 8 μg TEQ/TJ gas burned (8 x 10^{-6} g TEQ/TJ), and the estimated releases to air are shown in the table below. There are no releases to any other environmental compartments.

The 2008 Inventory report included an additional release to air of 0.061 g TEQ/yr for fugitive emissions of landfill gas. However, this has not been included in the revised estimates because the UNEP Toolkit indicates that no measureable dioxin emissions are expected from this source (United Nations Environment Programme, 2013). The estimates in the two previous dioxin inventories were based on very limited data published in the mid-1990s, which has not been borne out by any more recent studies.

Table 5-7: Dioxin releases from landfill gas and biogas combustion

Year	Activity Rate (TJ of gas/year)	Release factors (µg TEQ/TJ of gas)	Annual releases (g TEQ/yr)
		Air	Air
2008	3,300	8	0.026
2008 (revised)	2,450	8	0.020
2012	3,104	8	0.025

Certainty assessment for 2012

Activity data:	Medium (because it is based on a national data source)
Emission factor:	Low (because it is based on the Toolkit default factor)

Back-calculation for 2008

As indicated above, the gas quantities reported in the annual greenhouse gas inventory reports have been changed as a result of changes in the assessment method. The revised total gas utilisation for 2008 was 48,910 tonnes of methane, which is equivalent to 2450 TJ. The Toolkit emission factor is unchanged, at 8 μg TEQ/TJ, and the resulting back-calculation is shown in the 2008 (revised) row of the table above.

5.4 Household heating and cooking with biomass

The use of different types of energy for home heating is surveyed every five or so years in New Zealand through the national Census of Populations and Dwellings. The results for the last four surveys are shown in Table 5-8 (Statistics New Zealand, 2013), from which it can be seen that electricity is the dominant form of energy used, followed by wood burning (Note that the figures in the table add up to more than 100% because many homes use more than one type of heating). This sub-section addresses the emissions from domestic wood burning while those from the burning of oil, coal and gas are covered in section 5.5 below.

Table 5-8: Energy use for home heating in New Zealand

	Percentage of dwellings using each fuel type			
Fuel type	**1996**	**2001**	**2006**	**2013**
Electricity	77.2	72.0	74.8	79.2
Mains gas	11.6	13.5	13.2	12.0
Bottled gas (LPG)	22.3	28.3	27.7	15.4
Wood	48.7	44.7	40.9	36.8
Coal	13.0	9.3	7.0	4.1
Solar energy	0.7	0.9	1.1	1.6
None	0.9	2.8	2.4	3.0
Other fuels	1.9	1.1	2.1	1.6

The dioxin releases from domestic cooking and heating using biomass are calculated using the census data for the number of households that use wood for home heating multiplied by the average wood energy use per household. The energy factors are taken from the results of the Household Energy End-use Project (HEEP) (Camilleri, et al., 2006), which found that the average energy consumption of houses that use an enclosed solid-fuel burner was 4480 kWh per year, and those with an open fire used 995 kWh.

The 2013 Census found that wood was used for heating in 542,283 dwellings nationwide, which is a significant reduction in the figure of 574,485 reported in the 2006 Census. For the previous dioxin inventory it was assumed that about 12% of these dwellings would be using open fires. However, that assumption was based on a survey published in 2004, and the use of open fires has since been banned or restricted in some urban areas. This is illustrated by the results of several recent home heating surveys that report the following percentages of homes still using open fires:

Napier, 6%, Hastings, 5% and Havelock North, 5% (Wilton & Baynes, 2010)

Taumaranui, 3% and Taihape, 2% (Wilton & Baynes, 2010a)

Invercargill, 3% and Gore 4% (Wilton, 2011)

Hamilton, 2% and Tokoroa, 2% (Wilton, 2012)

Rotorua, 4.4% (APR Consultants, 2012)

Reefton 5% (Wilton, 2013)

The restrictions on open fires have not been applied in all urban areas, or in most rural areas, for which it might be expected that the 12% figure would still apply. Therefore, for the purposes of this inventory it will be assumed that the current nationwide average usage of open fires is 8%. Applying this factor plus the HEEP energy consumption rates to the census data gives a total national energy consumption of 2235 GWh per year (1

GWh = 10^6 kWh) from the burning of wood in enclosed appliances and a further 43 GWh per year from the use of open fires. This is equivalent to a total energy consumption of 8200 TJ per year (TJ = 10^{12} Joules), or approximately 650,000 tonnes of wood.

The 2012 release estimates for domestic wood combustion are shown in Table 5-9 along with the corresponding estimates made in the 2008 Inventory. There are no direct releases to water or in products. The ash production is assigned to the residues Toolkit vector, because the final place of disposal is not known with any certainty.

Table 5-9: Dioxin releases from household heating & cooking with biomass

Year	Activity Rates (TJ wood/year)	Release factors (µg TEQ/TJ wood)		Annual releases (g TEQ/yr)	
		Air	Residues	Air	Residues
2008	8,400	100	-	0.84	-
		-	20	-	0.168
2012	8,200	100	-	0.82	-
		-	20	-	0.164

Certainty assessment for 2012

Activity data: High (because it is based on a national survey of energy use coupled with census data)

Emission factors: Low (because they are based on the Toolkit default factors)

Back-calculation for 2008

There have been no changes in the release factors so a back-calculation is not required.

5.5 Household heating and cooking with fossil fuels

This sub-section addresses the dioxin emissions from the domestic burning of oil, coal and gas. The oil category covers both fuel oil and diesel, while gas consumption includes both natural gas and LPG.

5.5.1 Coal

The total amount of coal burned in domestic appliances in 2012 was 440 TJ (Ministry of Business, Innovation and Employment, 2013), which is slightly higher than the 380 TJ reported for 2008 (1 TJ = 10^{12} Joules). Domestic coal consumption declined steadily through the 1990s but now appears to have stabilised at a rate of about 400 to 800 TJ/year.

In the 2008 dioxin inventory the Toolkit factor of 100 µg TEQ/TJ of coal was used for estimating the releases to air (1 µg TEQ/TJ = 1 x 10^{-6} g TEQ/TJ). However, the releases via ash were determined using a factor of 0.41 µg TEQ/tonne of ash, which was originally used in the 2000 Inventory report. This was derived from a UK study, but it was considered more appropriate than the Toolkit factor of 5 µg TEQ/tonne of ash, which relates to the dioxin concentrations in soot rather than ash. The ash quantities were calculated using a factor of 1265 tonnes/TJ, which was derived from an assumed average ash content of 3.15% for New Zealand coal and a calorific value of 25 MJ/kg (25 x 10^6 J/kg) .

The 2012 release estimates for domestic coal combustion are shown in Table 5-10, along with the corresponding estimates made in the 2008 Inventory. There are no direct releases to water or in products. The ash production is assigned to the residues Toolkit vector, because the final place of disposal is not known with any certainty.

Table 5-10: Dioxin releases from household heating & cooking with coal

Year	Activity Rates		Release factors		Annual releases (g TEQ/yr)	
	(TJ coal/year)	(tonnes ash/year)	Air (µg TEQ/TJ coal)	Residues (µg TEQ/tonne ash)	Air	Residues
2008	380	-	100	-	0.038	-
	-	481	-	0.41	-	0.00020
2012	440	-	100	-	0.044	-
	-	557	-	0.41	-	0.00023

Certainty assessment for 2012

Activity data: High for coal, medium for ash (because the coal quantities are based on national fuel data but the ash quantities are derived using an assumed average ash content)

Emission factors: Low (because the air release is based on the Toolkit default factor, and the ash release factor is taken from a now relatively dated UK publication)

Back-calculation for 2008

There have been no changes in the release factors so a back-calculation is not required.

5.5.2 Oil

The 2008 Inventory indicated that the amount of oil used in residential applications was very low (Ministry for the Environment, 2011a), with the national energy statistics reporting figures of 10 TJ for diesel and none at all for fuel oil, in 2008 (1 TJ = 10^{12} Joules). It was concluded that dioxin releases from this source would be negligible. The national energy data for 2012 indicates that there was no fuel oil consumed in the residential sector in 2012, but the residential diesel consumption was 290 TJ, and the diesel consumption in 2008 was actually 280 TJ (Ministry of Business, Innovation and Employment, 2013). These increased figures for residential diesel consumption were introduced in 2009 as a result of new information being obtained from independent fuel distribution companies. The previous estimates were only based on annual sales reports provided by the major oil distributors.

The 2012 release estimates for domestic oil combustion are shown in Table 5-11, along with the corresponding estimates made in the 2008 Inventory. The Toolkit factor shown is the same as that used for the 2008 inventory and there are no releases to land, water, or in products or residues.

Certainty assessment for 2012

Activity data: High (because it is based on national fuel consumption data)

Emission factor: Low (because it is based on the Toolkit default factors)

Table 5-11: Dioxin releases from household heating & cooking with oil

Year	Activity Rate (TJ of oil/year)	Release factors (µg TEQ/TJ of oil)	Annual releases (g TEQ/yr)
		Air	Air
2008	10	10	0.0001
2008 (revised)	280	10	0.0028
2012	290	10	0.0029

Back-calculation for 2008

There has been no change in the release factor but a back-calculation is still required to recognise the change in activity data. The new estimate is shown in the 2008 (revised) row of the above table.

5.5.3 Gas

The domestic use of gas in New Zealand includes both natural gas and LPG. Natural gas is used mainly in fixed installations for heating, cooking and water heating, while LPG is more commonly used in portable equipment such as barbeques and patio heaters. The total residential usage of natural gas in 2012 was reported to be 6120 TJ, and LPG usage was 2900 TJ (Ministry of Business, Innovation and Employment, 2013) (1 TJ = 10^{12} Joules). The corresponding figures for 2008 are now reported to be 5380 TJ of natural gas and 3630 TJ of LPG, whereas previously they were reported as 4270 TJ and 2560 TJ, respectively (Ministry of Economic Development, 2009). These changes are due to the use of revised industry sales data.

The 2012 release estimates for domestic gas combustion are shown in Table 5-12, along with the corresponding estimates made in the 2008 Inventory. The Toolkit factor shown is the same as that used for the 2008 inventory and there are no releases to land, water, or in products or residues.

Table 5-12: Dioxin releases from household heating & cooking with gas

Year	Activity Rate (TJ of gas/year)	Release factors (µg TEQ/TJ of gas)	Annual releases (g TEQ/yr)
		Air	Air
2008	6830	1.5	0.010
2008 (revised)	9010	1.5	0.014
2012	9020	1.5	0.0135

Certainty assessment for 2012

Activity data: High (because it is based on national fuel consumption data)

Emission factor: Low (because it is based on the Toolkit default factors)

Back-calculation for 2008

There has been no change in the release factor but a back-calculation is still required to recognise the change in activity data. The new estimate is shown in the 2008 (revised) row of the above table.

5.6 Summary for this category

The 2012 release estimates for heat and power generation are summarised in Table 5-13, along with the revised comparative totals for 2008.

Table 5-13: Summary of the release estimates for heat and power generation

Category	2012 dioxin releases (g TEQ/yr)				
	Air	Water	Land	Product	Residue
Coal-fired power plants: electricity generation	0.291	-	0.407	-	-
Coal-fired power plants: Industrial and commercial	1.062	-	-	-	0.281
Heavy fuel oil-fired power plants	0.0083	-	-	-	-
Fuel oil and gas-fired power plants: electricity generation	0.036	-	-	-	-
Fuel oil and gas-fired power plants: industrial and commercial	0.027	-	-	-	-
Biomass power plants	1.000	-	-	-	0.300
Landfill gas/biogas combustion	0.025	-	-	-	-
Household heating & cooking with biomass	0.82	-	-	-	0.164
Household heating & cooking with coal	0.044	-	-	-	0.00023
Household heating & cooking with oil	0.0029	-	-	-	-
Household heating & cooking with gas	0.0135	-	-	-	-
2012 totals	**3.329**	**-**	**0.407**	**-**	**0.745**
Revised 2008 totals	**3.305**	**-**	**0.608**	**-**	**0.780**

6 Production of mineral products

This category covers the following dioxin sources (United Nations Environment Programme, 2013):

4a	Cement production
4b	Lime production
4c	Brick production
4d	Glass production
4e	Ceramics production
4f	Asphalt mixing
4g	Oil shale pyrolysis

The dioxin releases from the production of mineral products are all basically combustion-related. However, the alkaline nature of many of the materials being processed may help to reduce dioxin formation, either by neutralising some of the active chlorine species or by surface absorption of the dioxins after they are formed.

6.1 Cement production

This source was covered in section 17 of the report on the 2008 Inventory.

There are two cement plants in New Zealand; Golden Bay Cement in Northland, and the Holcim plant in the West Coast region. Both plants use coal as the primary fuel, but in Northland this is supplemented with wood waste, while the West Coast plant is co-fired with waste lubricating oil. The combined capacity of the two plants is 1,350,000 tonnes of clinker per year, and the annual production in 2012 was 1,057,000 tonnes of clinker, or about 1,110,000 tonnes of cement (A Krishna, Holcim Ltd, and O Khanal, Northland Regional Council, pers comm, 2013).

The Golden Bay plant uses a 'dry' process in which the raw materials are fed into the system in a dry state, while the Holcim plant uses a wet process, in which the raw materials are fed in as a slurry.

The dioxin emissions to air are tested annually at the Holcim plant. The stack concentrations recorded in 2012 were 0.002 to 0.004 ng TEQ per Nm^3, which is slightly below the range of 0.005–0.015 ng TEQ per Nm^3 noted for the 2008 Inventory (1 ng TEQ per Nm^3 = 1×10^{-9} g TEQ per Nm^3). These emissions correspond to an average release rate of less than 0.02 µg TEQ per tonne of cement (1 µg TEQ/tonne = 1×10^{-6} g TEQ/tonne), and this factor has been used for estimating the releases to air from the Holcim plant. There is no emission data for the Northland plant so the default factor given in the UNEP Toolkit for dry process kilns (0.05 µg TEQ per tonne) will be used.

As indicated in the report on the 2008 Inventory, there are no releases of cement kiln dust (CKD) to land from the Golden Bay plant. The CKD produced at the Holcim plant is now being used as a void filling and waste capping material at the Stockton coal mine, which should still be counted as a release to land (Tyler & Anderson, 2011). The UNEP Toolkit does not give a specific factor for releases to land from CKD disposal. However, a release factor of 6.7 µg TEQ per tonne of CKD was used in the 2008 Inventory, based on other published information. This factor has also been used here and applied to an annual CKD production of 20,000 tonnes.

The 2012 release estimates for cement production are shown in Table 6-1, along with the corresponding estimates made in the 2008 Inventory.

Table 6-1: Dioxin releases from cement production

Year	Plant	Activity Rate (tonnes/year)		Release factors (µg TEQ/tonne of cement or CKD)		Annual releases (g TEQ/yr)	
		Cement	CKD	Air	Land	Air	Land
2008	Golden Bay	850,000	-	0.05	-	0.043	-
	Holcim	450,000	-	0.02	-	0.009	-
		-	20,000	-	6.7	-	0.134
2012	Golden Bay	690,000	-	0.05	-	0.035	-
	Holcim	420,000	-	0.02	-	0.008	-
		-	20,000	-	6.7	-	0.134

Certainty assessment for 2012

Activity data:	High (because it is based on actual cement production data)
Emission factor:	High for Holcim and Low for Golden Bay (because they are based on plant test data and the Toolkit default factor, respectively)

Back-calculation for 2008

There have been no significant changes in the release factors so a back-calculation is not required.

6.2 Lime production

This source sub-category was covered in section 17 of the report on the 2008 Inventory.

There are 5 lime kilns in New Zealand, which produce burnt lime from limestone. The two North Island pulp and paper mills also operate lime kilns but these do not process limestone[6]. The other 5 kilns are located in Te Kuiti, Otorohanga (2), and Te Kumi, all in the Waikato region, and Dunback, in Otago.

The total burnt lime production in New Zealand in 2008 was estimated to be about 360,000 tonnes, with half of that being produced at the pulp and paper mills. The production by the non-pulp & paper kilns was based on installed capacity rather than actual production because detailed current production data could not be obtained. The same situation applies for this inventory, but the annual data given in the New Zealand Greenhouse Gas Inventory reports indicates that in previous years the actual production has been consistently in the range of 165,000 to 175,000 tonnes per year (Ministry for the Environment, 2011). Hence the current release estimates have been based on an activity rate of 170,000 tonnes per year.

The 2008 Inventory estimates for releases to air were based on the default UNEP Toolkit factor of 0.07 µg TEQ per tonne of lime (1 µg TEQ/tonne = 1 x 10^{-6} g TEQ/tonne). For releases to land it was assumed that there would be about 6000 tonnes of dust collected from the air pollution control equipment on the kilns, with a dioxin content of 6.7 µg TEQ per tonne, and 36,000 tonnes of product (lime) applied to land, with a dioxin content of 1.24 µg TEQ per tonne. The same factors and assumptions have been applied to the current estimates, but the calculations have only been applied to the annual burnt lime production at the 5 lime kilns (ie excluding the pulp mill kilns).

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[6] The pulp mill kilns form part of an internal chemical recycling process for the 'lime mud' produced in the pulp making process.

The lime kilns used at the pulp and paper mills do produce some dioxin emissions to air. These emissions were tested on the 2 kilns at the Bay of Plenty mill in 2002, and showed dioxin concentrations of 23 and 14 pg TEQ/Nm^3 (1 pg TEQ/Nm^3 = 1 x 10^{-12} g TEQ/Nm^3) (Beca Amec, 2006). On the basis of the gas flow data provided in a more recent report (Beca Amec, 2009), and assuming the same release rate for the Waikato mill, the total annual dioxin release is estimated at 0.0006 g TEQ per year. There would be no releases to land or water from these kilns.

The release estimates for both 2008 and 2012 for lime production are shown in Table 6-2.

Table 6-2: Dioxin releases from lime production

Year	**Activity Rate (tonnes of lime/year)**		**Release factors (µg TEQ/tonne of lime)**		**Annual releases (g TEQ/yr)**	
			Air	**Land**	**Air**	**Land**
2008	Lime production	360,000	0.07	-	0.0252	-
	Lime application to land	36,000	-	1.24	-	0.044
	APC equipment dust	6,000	-	6.7	-	0.040
Total					**0.0252**	**0.084**
2012	Lime production	170,000	0.07	-	0.0119	-
	Lime application to land	17,000	-	1.24	-	0.022
	APC equipment dust	3,000	-	6.7	-	0.020
	Pulp mill lime kilns	-	-	-	0.0006	-
Total					**0.0125**	**0.042**

Certainty assessment for 2012

Activity data:	Medium (because it is based on estimated production data)
Emission factor:	Low (because it is based on the Toolkit default factors and other published information)

Back-calculation for 2008

There have been no significant changes in the release factors so a back-calculation is not required.

6.3 Brick production

This source was covered in section 17 of the report on the 2008 Inventory.

Currently there are three significant manufacturers of bricks in New Zealand located in Auckland, Huntly and Christchurch. The Auckland plant is fired by natural gas and produced 32,806 tonnes in 2012 (A Draisey, Monier Bricks, pers comm, 2014). The Huntly plant is also fired by gas and produced 4,740 tonnes, and the Christchurch plant produced 7,000 tonnes and is fired with oil (R Thomas, Canterbury Clay Bricks, pers comm, 2014). Consequently total brick production for 2012 was 44,546 tonnes.

The UNEP Toolkit differentiates between small, poorly controlled kilns (which it assigns as Class1) and larger better-controlled kilns (Class 2). Kilns can qualify for the class 2 category if they have either emission control technology in place or state of the art process control, in which case they can burn fuels of any type including those which the Toolkit refers to as "contaminated". Alternatively larger kilns with no emission control technology, but which use uncontaminated fuels, also qualify as class 2. On this basis the three New Zealand brick-making facilities should be assigned to Class 2.

The Toolkit provides emission factors for releases to air, in products and in residues. The residues produced in brick making are the ash products resulting from the combustion of solid fuels. Where the fuel is natural gas or a liquid fuel such as oil or diesel, virtually no ash is produced. Consequently there are no significant releases via residues for the 3 New Zealand plants.

The 2012 release estimates for brick production are shown in Table 6-3, along with the corresponding estimates reported for the 2008 Inventory. The 2008 estimates only covered releases to air because the factors for releases via residues and in products were only added in the latest version of the Toolkit.

Table 6-3: Dioxin releases from brick production

Year	Activity Rate (tonnes/year)	Release factors (µg TEQ/tonne)		Annual releases (g TEQ/yr)	
		Air	Products	Air	Products
2008	54,000	0.02	-	0.00108	-
2008 (revised)	54,000	0.02	-	0.00108	-
		-	0.006	-	0.00032
2012	44,546	0.02	-	0.00089	-
		-	0.006	-	0.00027

Certainty assessment for 2012

Activity data:	High (because it is based on industry production data)
Emission factor:	Low (because it is based on the Toolkit default factors)

Back-calculation for 2008

As indicated above, the 2013 Toolkit has introduced additional factors for releases in products and residues. However, the only relevant factor here is for the releases in products. For the 2008 production rate of 54,000 tonnes/year, the release in products would be 0.00032 g TEQ, as indicated in the 2008 (revised) row of the table above.

6.4 Glass production

This source was covered in section 21 of the report on the 2008 Inventory.

There are three industrial glass manufacturers in New Zealand. The largest of these is based in Auckland and produces glass bottles and jars, while the other two, located in Auckland and Christchurch, produce fibreglass insulation. The annual combined production figure for 2012 was 230,511 tonnes per year of glass product (M Coster, O-I Glass Limited, Auckland, and M Burgess, Tasman Insulation New Zealand Ltd, Auckland, pers comm, 2013).

The emission estimates in the 2008 Inventory were based on the UNEP Toolkit default factor of 0.15 µg TEQ per tonne of glass (0.15×10^{-6} g TEQ/tonne) for releases to air, and there were no significance releases via any other media. The same approach has been adopted here. The 2012 release estimates for glass production are shown in Table 6-4, along with the corresponding estimates made in the 2008 Inventory.

Table 6-4: Dioxin releases from glass production

Year	Activity Rate (tonnes of glass/year)	Release factors (µg TEQ/tonne of glass)	Annual releases (g TEQ/yr)
		Air	Air
2008	149,200	0.15	0.0022
2012	230,511	0.15	0.0035

Certainty assessment for 2012

Activity data:	High (because it is based on actual production data)
Emission factor:	Low (because it is based on the Toolkit default factor)

Back-calculation for 2008

There have been no significant changes in the release factors so a back-calculation is not required.

6.5 Pottery and ceramics production

This source was covered in section 17.1.3 of the report on the 2008 Inventory.

The annual production of clay for pottery and ceramics in New Zealand, in 2012, was 11,578 tonnes (NZ Petroleum and Minerals, 2014) and a further 6649 tonnes were imported for this purpose (data obtained from the Statistics NZ InfoShare website). However, these imports were partially offset by exports of 2172 tonnes, which gives an overall figure for total in-country use of 16,055 tonnes. This is only slightly below the figure of 18,000 tonnes used for the 2008 estimates.

The UNEP Toolkit notes that dioxins will most likely be released to air during ceramics production, as a result of the thermal processes involved. However, no specific emission data has been reported, and it recommends using the emission factors developed for brick making to give an indication of the likely releases (United Nations Environment Programme, 2013). The Toolkit differentiates between small, poorly controlled kilns (which it assigns as Class 1) and other types of kilns (Class 2). The Class 2 category covers a variety of situations, including kilns with no emission control technology, but which use uncontaminated fuels. It has been assumed that all New Zealand kilns should be assigned to Class 2. The 2012 release estimates for pottery and ceramics production are shown in Table 6-5, along with the corresponding estimates reported for the 2008 Inventory.

Table 6-5: Dioxin releases from pottery and ceramics production

Year	Activity Rate (tonnes/year)	Release factors (µg TEQ/tonne)	Annual releases (g TEQ/yr)
		Air	Air
2008	18,000	0.02	0.00036
2012	16,055	0.02	0.00032

Certainty assessment for 2012

Activity data:	High (because it is based on national clay production data and import statistics)
Emission factor:	Low (because it is based on the Toolkit default factor)

Back-calculation for 2008

There have been no significant changes in the release factors so a back-calculation is not required.

6.6 Asphalt mixing

This source sub-category was covered in section 18 of the report on the 2008 Inventory, which indicated that there were 39 stationary asphalt plants in New Zealand and several mobile units, and the annual asphalt production was about 850,000 tonnes per year. This information was provided by Roading New Zealand, and they have confirmed that the data is still appropriate for 2012 (A Stevens, pers comm, 2013). Major projects in some parts of the country have boosted production in those areas, but these have been offset by reduced activity in other areas, with the result that overall production rates are unchanged. In addition, there has been no change in the number of asphalt plants accredited by Roading New Zealand, although some plants are currently inactive.

The 2008 Inventory estimates for this source category were based on the UNEP Toolkit default factors of 0.007 µg TEQ per tonne of asphalt for emissions to air, and 0.06 µg TEQ per tonne of asphalt for releases in residues (1 µg TEQ/tonne = 1 x 10^{-6} g TEQ/tonne). However, the latter factor was only applied to 50% of the total production, because in about half of the plants the dust collected in the air pollution control equipment is recycled back to the process. The same factors have been applied to the current estimates.

The 2012 release estimates for asphalt production are shown in Table 6-6. The estimates for 2008 have not been shown separately because they are identical to 2012.

Table 6-6: Dioxin releases from asphalt production

Year	Activity	Activity Rate (tonnes of asphalt)	Release factors (µg TEQ/tonne of asphalt)		Annual releases (g TEQ/yr)	
			Air	Residues	Air	Residues
2008 & 2012	Asphalt production	850,000	0.007	-	0.006	-
	Plant residues (dust)	50% of the above	-	0.06	-	0.026

Certainty assessment for 2012

Activity data:	Medium (because it is based on estimated production data)
Emission factor:	Low (because it is based on the Toolkit default factors and other published information)

Back-calculation for 2008

There have been no significant changes in the release factors so a back-calculation is not required.

6.7 Oil shale pyrolysis

Oil shale is a general term applied to a group of hard rocks (only some of which are described geologically as shales) rich enough in bituminous material to yield petroleum upon pyrolysis and distillation (Ministry of Economic Development, 2008). Some of New Zealand’s oil reserves occur in soft clay-based rocks that are also described as shales. However, the oil is extracted from these *in situ* rather than by pyrolysis. Hence this is not a potential source for New Zealand.

6.8 Summary for this category

The 2012 release estimates for mineral production are summarised in Table 6-7, along with the revised comparative totals for 2008.

Table 6-7: Summary of the release estimates for mineral production

Category	**2012 dioxin releases (g TEQ/yr)**				
	Air	**Water**	**Land**	**Product**	**Residue**
Cement production	0.043	-	0.134	-	-
Lime production	0.0125	-	0.042	-	-
Brick production	0.00089	-	-	0.00027	-
Glass production	0.0035	-	-	-	-
Pottery and ceramics	0.00032	-	-	-	-
Asphalt production	0.006	-	-	-	0.026
2012 totals	**0.066**	**-**	**0.176**	**0.00027**	**0.026**
Revised 2008 totals	**0.086**	**-**	**0.218**	**0.00032**	**0.026**

7 Transport

This source category covers emissions to air from the combustion of petroleum-based fuels in transportation. It was previously covered in section 15 of the report on the 2008 Inventory. The primary focus is on fuel use in motor vehicles, but the methodology also captures fuel consumption by other forms of transport, such as trains, boats and off-road vehicles, and also fuel use in stationary engines, such as generators (United Nations Environment Programme, 2013). Aircraft are not included because the combustion of aviation fuel is believed to not result in any significant releases of dioxins. The category is broken down into the following sub-groups:

5a	4-Stroke engines
5b	2-Stroke engines
5c	Diesel engines
5d	Heavy oil-fired engines

The dioxin releases from transport are all combustion-related, and they mainly arise from the incomplete combustion of the fuels being burned. For this reason, the dioxin release rates tend to be greatest for the more complex fuels (eg. oil versus petrol versus LPG). They are also affected by the different engine designs and the use of catalytic converters on the engine exhausts. An additional factor specific to leaded petrol is noted below.

7.1 4-Stroke engines

The use of leaded petrol was the major cause of dioxin emissions from motor vehicles, due to the presence of chemicals such as dichloroethane that were used as scavengers for the lead (United Nations Environment Programme, 2013). Dioxins have also been detected in the emissions from vehicles burning unleaded petrol and diesel, but in much lower amounts. The use of modern emission control technologies, especially catalytic converters, has been shown to reduce the emissions to almost negligible levels.

The engines of most petrol-fuelled vehicles operate on a 4-stroke cycle and, in New Zealand, all petrol has been unleaded since the late 1990s. The total petrol consumption in 2012 was 106,420 TJ, or about 2,263,000 tonnes (1 TJ = 10^{12} Joules) (Ministry of Business, Innovation and Employment, 2013).

The Ministry of Transport estimates that 83% of the on-road use of petrol in 2012 was in vehicles fitted with catalytic converters (I McGlinchy, Ministry of Transport, pers comm, 2014). This estimate was obtained by combining the Ministry's estimates of national fuel consumption (Ministry of Transport, 2013) with information and assumptions as to which vehicles are currently fitted with working exhaust catalysts. Generally, most pre-2004 vehicles were assumed to not have working catalysts.

The UNEP Toolkit provides different emission factors for 4-stroke vehicles with or without catalysts, and also for vehicles operated on petrol/ethanol blends containing 50% or more ethanol. Petrol/ethanol blends are available in New Zealand but the proportion of ethanol is limited under the *Engine Fuel Specifications Regulations 2011* to no more than 10%. The total amount of bioethanol produced in New Zealand 2012 was only 220 TJ, and the consumption for transport has already been included in the total petrol figure given above.

The use of LPG in vehicles is also included in this category, and the emissions are expected to be similar to those from 4-stroke engines fitted with exhaust catalysts. The total LPG consumption for transport in 2012 was only 390 TJ or 7,800 tonnes,

The 2012 release estimates for 4-stroke engines are shown in Table 7-1, along with the corresponding estimates made in the 2008 Inventory. The activity rates were obtained by subtracting the petrol used in 2-stroke engines (see section 7.2 below) and then distributing 17% of the remainder to non-catalyst vehicles and 83% to those fitted with catalysts. The annual LPG consumption has been added to the latter figure.

It can be seen from the table that the total dioxin releases have dropped significantly since 2008. This is primarily due to the reduction in fuel use in non-catalyst engines, as older vehicles are removed from the national fleet. In the previous inventory it was estimated that only 60% of vehicles were fitted with exhaust catalysts.

Table 7-1: Dioxin releases from 4-stroke petrol engines

Year	Type of 4-stroke engine	Activity Rate (tonnes of fuel/year)	Release factors (µg TEQ/tonne of fuel)	Annual releases (g TEQ/yr)
			Air	Air
2008	no catalyst	944,000	0.1	0.094
	catalyst	1,416,000	0.001	0.001
	Totals			**0.096**
2012	no catalyst	383,758	0.1	0.038
	catalyst	1,881,442	0.001	0.002
	Totals			**0.040**

Certainty assessment for 2012

Activity data:	High (because it is based on national fuel data)
Emission factor:	Low (because it is based on the Toolkit default factor)

Back-calculation for 2008

There have been no significant changes in the release factors so a back-calculation is not required. LPG consumption was not included in the previous estimates. However, this is not significant, as the 0.93 PJ (18,600 tonnes) used in 2008 would add only 0.00002 g TEQ to the total estimated releases.

7.2 2-Stroke engines

Petrol engines operating on a 2-stroke cycle were commonly used in the past in applications that required relatively small light-weight power units, such as chain saws, lawn mowers, outboard motors, and motor bikes. However, the 2-stroke engines were generally less fuel-efficient than 4-stroke engines and also produced proportionately higher quantities of exhaust pollutants, including dioxins (eg. see (Maritime New Zealand, undated-2). As a result the engines used in many of these applications are now 4-stroke.

Much of the fuel used in 2-stroke engines will be in off-road or non-road applications. The Ministry of Transport has estimated that the total annual off-road and non-road fuel use in New Zealand would account for about 4 to 5% of total fuel consumption in transport applications (Ministry of Transport, 2013). However, much of this would still be in 4-stroke engines rather than 2-stroke.

For the 2008 inventory, it was assumed that the fuel used in 2-stroke engines would account for no more than 1% of total national petrol use (ie. 23,600 tonnes per year). However, the information on 2-stroke oil consumption given in Section A3.3 of Appendix 3, suggests an annual fuel consumption in 2-stroke motor bikes of only 2,800 tonnes per year. There is no information available on the fuel consumption in other types of 2-stroke engines, but it is unlikely to be more than that that used in motor bikes. Therefore, the total fuel consumption for 2012 has been assumed to be 5,600 tonnes per year. The release estimates based on this figure are shown in Table 7-2, along with the corresponding estimates for 2008.

Table 7-2: Dioxin releases from 2-stroke petrol engines

Year	Activity Rate (tonnes of fuel/year)	Release factors (µg TEQ/tonne of fuel)	Annual releases (g TEQ/yr)
		Air	Air
2008	23,600	2.5	0.059
2012	5,600	2.5	0.014

Certainty assessment for 2012

Activity data:	Low (because it is based on assumed annual fuel consumption)
Emission factor:	Low (because it is based on the Toolkit default factor)

Back-calculation for 2008

There has been no change in the release factor so a back-calculation is not required. Also, it is not possible to revise the 2008 activity data because the Ministry of Transport estimates for 2-stroke fuel consumption (as discussed in Appendix 3) are only available for the current vehicle fleet.

7.3 Diesel engines

The total consumption of diesel in transport, industrial and commercial applications, agriculture and residential uses in 2012 was 112,900 TJ (1 TJ = 10^{12} Joules) (Ministry of Business, Innovation and Employment, 2013). However, some of this usage has already been accounted for under sections 5.1.3 (industrial/commercial heat and power, 3900 TJ) and 5.5.2 (domestic heating and cooking, 290 TJ). Subtracting these figures from the total gives an annual diesel usage in transportation and stationary engines of 108,710 TJ or 2,380,000 tonnes.

The UNEP Toolkit includes a separate release factor for biodiesel, although it is only marginally lower than that for normal diesel (0.07 vs 0.1 µg TEQ/tonne) (1 µg TEQ/tonne = 1 x 10^{-6} g TEQ/tonne). However, the total biodiesel produced in New Zealand in 2012 was only 50 TJ (1,100 tonnes) so this has not been considered separately under this category. The variation introduced by using the lower biodiesel factor would only change the total release estimate by 0.00003g TEQ.

The 2012 release estimates for diesel consumption in transport and stationary engines are shown in Table 7-3, along with the corresponding estimates from the 2008 Inventory.

Table 7-3: Dioxin releases from diesel engines

Year	Activity Rate (tonnes of fuel/year)	Release factors (µg TEQ/tonne of fuel)	Annual releases (g TEQ/yr)
		Air	Air
2008	2,390,000	0.1	0.239
2012	2,380,000	0.1	0.238

Certainty assessment for 2012

Activity data:	High (because it is based on national fuel data)
Emission factor:	Low (because it is based on the Toolkit default factor)

Back-calculation for 2008

There has been no significant change in the release factor so a back-calculation is not required.

7.4 Heavy oil-fired engines

The consumption of heavy fuel oil for transportation is primarily confined to its use in coastal shipping, for which the total fuel consumption in 2012 was 4000 TJ, or about 92,000 tonnes (Ministry of Business, Innovation and Employment, 2013). This total includes both ‘new’ fuel oil and some of the recycled waste oil discussed in Appendix 3.

The 2012 release estimates are shown in Table 7-4, along with the corresponding estimates made in the 2008 Inventory. The 2008 estimate is much lower than that for 2012 because it only covered the use of recycled waste oil. A revised estimate for all heavy fuel oil consumption in 2008 is also shown in the table.

Table 7-4: Dioxin releases from heavy fuel oil-fired engines

Year	Activity Rate (tonnes of fuel/year)	Release factors (µg TEQ/tonne of fuel)	Annual releases (g TEQ/yr)
		Air	Air
2008	5,600	4	0.022
2008 (revised)	77,400	4	0.311
2012	92,000	4	0.368

Certainty assessment for 2012

Activity data:	High (because it is based on national fuel data)
Emission factor:	Low (because it is based on the Toolkit default factor)

Back-calculation for 2008

The release factors given in the UNEP Toolkit have not changed. However, a back-calculation is appropriate because only a portion of the total fuel oil was included in the 2008 Inventory estimates. The total amount of heavy fuel oil used for coastal shipping in 2008 was 3380 TJ, or 77,740 tonnes, which gives an annual release to air of 0.311 g TEQ, as indicated in the table above.

7.5 Summary for this category

The 2012 release estimates for fuel use in transportation and stationary engines are summarised in Table 7-5, along with the revised comparative totals for 2008.

Table 7-5: Summary of the release estimates for transport

Category	**2012 dioxin releases (g TEQ/yr)**				
	Air	**Water**	**Land**	**Product**	**Residue**
4-stroke engines	0.040	-	-	-	-
2-stroke engines	0.014	-	-	-	-
Diesel engines	0.238	-	-	-	
Heavy oil-fired engines	0.368	-	-	-	-
2012 totals	**0.660**	**-**	**-**	**-**	**-**
Revised 2008 totals*	**0.705**	**-**	**-**	**-**	**-**

(* The 2008 estimates included an allowance for dioxin releases from the disposal of used engine oil to land. This activity is now discussed in section 11.5 and the 2008 estimate has been reassigned to the waste disposal category – see Table 11-3.)

8 Open burning processes

This category covers the following dioxin sources (United Nations Environment Programme, 2013):

6a Biomass burning

6b Waste burning and accidental fires

Open burning processes are usually characterised by the presence of mixtures of waste materials, with little or no control over the condition of these (ie wet or dry), and little or no control over the burning processes. As a result, there is often a high potential for dioxins to be formed as a result of incomplete combustion processes. Despite this, the potential for dioxin formation from the burning of clean biomass is relatively low, unless the material is contaminated with specific dioxin precursors, such as chlorinated phenoxy herbicides (see section 9). Also, it is much higher for waste burning and accidental fires because of the potential presence of chlorinated materials (eg some plastics, such as PVC) and catalytic metals, such as copper.

8.1 Biomass burning

These sources were covered in section 16 of the report on the 2008 Inventory. The category is divided into the following sub-categories:

i. Agricultural residue burning

ii. Sugarcane burning

iii. Forest fires

iv. Grassland and savannah fires

The activity data for all of these sources is taken from the annual greenhouse gas inventory reports produced by the Ministry for the Environment, with the most recent report covering data up to the end of 2012 (Ministry for the Environment, 2014). The activity rates for biomass burning show a significant amount of variation from year to year so, as was done in the previous dioxin inventory, the activity rates for 2012 will be based on the average data from the previous 3 years; ie 2010 to 2012.

8.1.1 Agricultural residue burning

This source category covers the burning of crop residues in the fields where the crops were originally grown, usually as a land clearance activity prior to the planting of the next crop. This practice is used in New Zealand for barley, wheat and oats, but not for maize or legumes (Ministry for the Environment, 2014). The total area of crop land burned is obtained through annual surveys carried out by Statistics New Zealand, and then converted to a mass basis using biomass density factors.

The total mass of crop residues burned in New Zealand in 2010, 2011 and 2012 was 353,180, 260,039 and 252,204 tonnes/year, respectively, which gives an annual average rate of 288,474 tonnes/year. This average activity rate has been used for the 2012 release estimates, coupled with the UNEP Toolkit factors for burning under relatively favourable combustion conditions. The alternative Toolkit factors for burning under poor combustion conditions and in the presence of dioxin precursors, such as chlorinated pesticides, are not relevant to the New Zealand practices. The release estimates are shown in the table below, along with the corresponding estimates from the report on the 2008 inventory.

Table 8-1: Dioxin releases from agricultural residue burning

Year	Activity Rate (tonnes biomass burned/year)	Release factors (µg TEQ/tonne)		Annual releases (g TEQ/yr)	
		Air	Land	Air	Land
2008	173,770	0.5	-	0.087	-
		-	10	-	1.738
2008 (revised)	318,728	0.5	-	0.159	-
		-	0.05	-	0.016
2012	288,474	0.5	-	0.144	-
		-	0.05	-	0.014

Certainty assessment for 2012

Activity data:	High (because they are based on the national greenhouse gas inventory data)
Emission factor:	Low (because they based on the Toolkit default factors)

Back-calculation for 2008

There have been significant changes in the activity data and also in one of the release factors since the 2008 estimates were reported. The methodology used in the greenhouse gas inventories for determining the mass of agricultural residue burned was changed in 2011, with the release data for previous years being adjusted accordingly (Ministry for the Environment, 2011). As a result the biomass burn rate used for the 2008 dioxin estimates should be changed from 173,770 tonnes of dry matter per year, to 318,728 tonnes of dry matter per year (based on the 3-year average for 2005 to 2007). In addition, there has been a major reduction in the UNEP Toolkit factors for releases to land; from 10 to 0.05 µg TEQ/tonne (1 µg TEQ/tonne = 1 x 10^{-6} g TEQ/tonne).

Applying these changes to the 2008 estimates gives the results shown in the 2008 (revised) rows in the table above.

8.1.2 Sugarcane burning

This source has not been assessed because there are no sugarcane plantations in New Zealand. All local sugar production at New Zealand's only sugar refinery is based on imported sugarcane (NZ Sugar Company, 2010).

8.1.3 Forest fires

This source category covers wildfires and controlled burn-offs in forests. Both of these activities are addressed in the greenhouse gas inventory reports, and estimates for the total area of forest land burned are obtained through surveys of forestry owners and data available from the National Rural Fire Authority. These are converted to a mass basis using a single biomass density factor for all forest types (Ministry for the Environment, 2014).

The total mass of forest biomass burned in New Zealand in 2010, 2011 and 2012 was 186,675, 149,311 and 117,400 tonnes/year, respectively, which gives an average rate of 151,129 tonnes/year. This activity rate has been used for the 2012 release estimates, coupled with the UNEP Toolkit factors. The release estimates are shown in the table below, along with the corresponding estimates from the report on the 2008 inventory.

Table 8-2: Dioxin releases from forest fires

Year	Activity Rate (tonnes biomass burned/year)	Release factors (µg TEQ/tonne)		Annual releases (g TEQ/yr)	
		Air	Land	Air	Land
2008	320,346	5	-	1.602	-
		-	4	-	1.282
2008 (revised)	166,079	1	-	0.166	-
		-	0.15	-	0.025
2012	151,129	1	-	0.151	-
		-	0.15	-	0.023

Certainty assessment for 2012

Activity data:	Medium (because they are based on the national greenhouse gas inventory data)
Emission factor:	Low (because they based on the Toolkit default factors)

Back-calculation for 2008

There have been significant changes in the activity data and also in both of the release factors since the 2008 estimates were reported. The methodology used in the greenhouse gas inventories for determining the mass of forest biomass burned was changed in 2011, with the release data for previous years being adjusted accordingly (Ministry for the Environment, 2011). As a result the biomass burn rate used for the 2008 dioxin estimates should be changed from 320,346 tonnes of dry matter per year, to 166,079 tonnes of dry matter per year (based on the 3-year average for 2005 to 2007). In addition, there has been a major reduction in the UNEP Toolkit factors; from 5 to 1 µg TEQ/tonne for releases to air, and from 4 to 0.15 µg TEQ/tonne for releases to land (1 µg TEQ/tonne = 1 x 10^{-6} g TEQ/tonne).

Applying these changes to the 2008 estimates gives the results shown in the 2008 (revised) rows in the table above.

8.1.4 Grassland and savannah fires

This source category covers both controlled and accidental burning of grassland and savannah. In New Zealand, the savannah category is used for land covered in tussock. The total area of grassland and savannah burned is obtained through national information on changes in land-use and data from the National Rural Fire Authority. These are converted to a mass basis using biomass density factors (Ministry for the Environment, 2014).

The total mass of grassland and savannah material burned in New Zealand in 2010, 2011 and 2012 was 418,194, 323,478 and 394,618 tonnes/year, respectively, which gives an average rate of 378,763 tonnes/year. This activity rate has been used for the 2012 release estimates, coupled with the UNEP Toolkit factors. The release estimates are shown in the table below, along with the corresponding estimates from the report on the 2008 inventory.

Certainty assessment for 2012

Activity data:	Medium (because they are based on the national greenhouse gas inventory data)
Emission factor:	Low (because they based on the Toolkit default factors)

Table 8-3: Dioxin releases from grassland and savannah fires

Year	Activity Rate (tonnes biomass burned/year)	Release factors (µg TEQ/tonne)		Annual releases (g TEQ/yr)	
		Air	Land	Air	Land
2008	279,604	5	-	1.398	-
		-	4	-	1.118
2008 (revised)	503,820	0.5	-	0.252	-
		-	0.15	-	0.076
2012	378,763	0.5	-	0.189	-
		-	0.15	-	0.057

Back-calculation for 2008

There have been significant changes in the activity data and also in both of the release factors since the 2008 estimates were reported. The methodology used in the greenhouse gas inventories for determining the mass of grassland and savannah burned was changed in 2011, with the release data for previous years being adjusted accordingly (Ministry for the Environment, 2011). As a result the biomass burn rate used for the 2008 dioxin estimates should be changed from 279,604 tonnes of dry matter per year, to 503,820 tonnes of dry matter per year (based on the 3-year average for 2005 to 2007). In addition, there has been a major reduction in the UNEP Toolkit factors for releases to air, from 5 to 0.5 µg TEQ/tonne, and for releases to land, from 4 to 0.15 µg TEQ/tonne (1 µg TEQ/tonne = 1 x 10^{-6} g TEQ/tonne).

Applying these changes to the 2008 estimates gives the results shown in the 2008 (revised) rows in the table above.

8.2 Waste burning and accidental fires

These sources were covered in section 16 of the report on the 2008 Inventory. The category is divided into the following sub-categories:

v. Fires at waste dumps
vi. Accidental fires in houses, factories
vii. Open burning of domestic waste
viii. Accidental fires in vehicles
ix. Open burning of wood (construction/ demolition)

8.2.1 Fires at waste dumps

Landfill fires were identified in the first dioxin inventory as New Zealand's most significant source of dioxin releases to air (Ministry for the Environment, 2000). In response to this, the deliberate lighting of fires and burning of wastes at landfills was banned under the *Resource Management (National Environmental Standards Relating to Certain Air Pollutants, Dioxins and Other Toxics) Regulations 2004*.

The second dioxin inventory report showed that the numbers of fires at landfills and rubbish dumps had dropped significantly over time; from an estimated 274 fires in 1998, to 50 fires in 2008 (Ministry for the Environment, 2011a). These estimates were based on 3-yearly averages of fire incident data published by the NZ Fire Services, and the most recent data shows even further reductions, with 28 fires recorded in the 2011/12 financial year, 36 fires in 2012/13, and only 18 fires over 11 months of 2013/14 (S Quirke, pers comm, 2013). This indicates a 3-yearly average rate of about 28 fires per year, and this value has been used for the 2012 release estimates.

Most landfills in New Zealand that receive municipal solid wastes are included in the national Waste Disposal Levy scheme (see: www.mfe.govt.nz/issues/waste/waste-disposal-levy/index), and the operators of all of these sites were contacted for additional information on landfill fires. Responses were received in relation to 60% of the total operational landfills, and only 3 fires were reported for the period 2011 to 2013. This suggests that most of the fires recorded by NZ Fire Services were at cleanfill sites, closed landfills, or private rubbish dumps.

The previous dioxin inventories used a factor of 1000 µg TEQ per tonnes of waste (1 mg TEQ per tonne) for estimating the releases to air from landfill fires. However, no information was available on the actual quantities of wastes involved in New Zealand fires, and the estimates were based on a 1991 Swedish study which indicated an average waste quantity of 45 tonnes of waste per fire (Ministry for the Environment, 2000). This would be equivalent to about 4 to 5 truckloads of compressed waste. In the absence of any more recent information, the same waste quantity factor has been used here. However, the latest version of the Toolkit recommends a lower factor of only 300 µg TEQ per tonne for releases to air, and a new factor of 10 µg TEQ per tonne for releases to land (1 µg TEQ/tonne = 1 x 10^{-6} g TEQ/tonne)(United Nations Environment Programme, 2013). These new factors have been used for the 2012 release estimates shown in the table below, and they have also been used to produce revised estimates for 2008.

Table 8-4: Dioxin releases from waste dump fires

Year	Activity Rate (tonnes of waste burned/year)	Release factors (µg TEQ/tonne)		Annual releases (g TEQ/yr)	
		Air	Land	Air	Land
2008	2250	1000	-	2.25	-
2008 (revised)	2250	300	-	0.675	-
		-	10	-	0.0225
2012	1260	300	-	0.378	-
		-	10	-	0.0126

Certainty assessment for 2012

Activity data:	Low (because it based on national fire statistics but coupled with a highly uncertain conversion factor for the mass of material burned)
Emission factors:	Low (because they are based on the Toolkit default factors)

Back-calculation for 2008

A number of recent studies were taken into account in the latest version of the UNEP Toolkit, and this has resulted in a significant lowering of the air release factor for this source and the addition of a new factor for releases to land. Use of the new factors gives the results shown in the 2008 (revised) rows in the table above.

8.2.2 Accidental fires in houses, factories

The release estimates for the previous dioxin inventories were based on New Zealand Fire Service statistics for the numbers of structure fires attended each year. The quantities of materials involved in the fires were estimated using an approximate size distribution, which was first presented in the 2000 Inventory Report, and subsequently modified for the 2008 Inventory. The approach used in 2008 has also been applied to the current estimates.

Annual fire incident data has been obtained directly from the New Zealand Fire Service, for the 2012 calendar year (S Quirke and A Hong, pers comm, 2013). The total number of structure fires recorded in 2012 was 4754, which is significantly lower than the 6467 fires used for the 2008 estimates. However, the longer term data confirm that here has been a steady downward trend in fire numbers over the last 5 years or so, apart from a significant increase in 2010, which was most likely associated with the Christchurch earthquake.

Applying the mass calculation methodology used for the 2008 Inventory gives a total quantity of 1562 tonnes for material consumed by fire in 2012. The UNEP Toolkit gives default factors of 400 µg TEQ per tonne for dioxin releases to both air and land (400 x 10^{-6} g TEQ/tonne). These factors have been used for the current release estimates, which are shown in Table 8-5, along with the corresponding estimates made in the 2008 Inventory.

Table 8-5: Dioxin releases from structure fires

Year	Activity Rate (tonnes burned/year)	Release factors (µg TEQ/tonne)		Annual releases (g TEQ/yr)	
		Air	Land	Air	Land
2008	2125	400	-	0.85	-
		-	400	-	0.85
2012	1562	400	-	0.625	-
		-	400	-	0.625

Certainty assessment for 2012

Activity data:	Medium (because it is based on national fire statistics coupled with an approximate conversion factor for the mass of material burned)
Emission factor:	Low (because it is based on the Toolkit default factors)

Back-calculation for 2008

There have been no significant changes in the release factors so a back-calculation is not required.

8.2.3 Open burning of domestic waste

This section covers the emissions from the burning of domestic wastes in open fires or crude incinerators, where combustion conditions are poor and no controls are applied. Most of the waste disposed of in this way comprises wood, paper, leaves and vegetation, together with a range of other possible materials, including kitchen wastes and plastics. Information on domestic waste burning in New Zealand is summarised in Appendix 2 of this report. It includes a review of the current controls on domestic waste burning in regional plans, national and regional incident data for waste burning, and a summary of recent regional surveys. The latter have provided the key information required for determining the dioxin releases from waste burning, which is an estimate of the number of households that burn rubbish and the average quantities burned per household.

For the 2008 dioxin inventory it was assumed that waste burning was practiced by 5% of all households on 5 to 10 occasions per year, and the average quantity of material burned was 250 kg per household, per year (ie 25 to 50 kg per burn). The results from the more recent surveys summarised in Appendix 2 suggest that these assumptions should also be applicable for the current inventory. The total number of occupied dwellings in New

Zealand in 2012 was about 1,560,000 (based on the average annual increase between the census figures for 2006 and 2013). If 5% of these households (ie. 78,000) burn waste, the total quantity of waste burned would be 19,500 tonnes per year.

The UNEP Toolkit gives default factors of 40 µg TEQ per tonne of waste, for dioxin releases to air, and 1 µg TEQ per tonne of waste, for releases to land (1 µg TEQ/tonne = 1 x 10^{-6} g TEQ/tonne). These factors have been used for the current release estimates, which are shown in Table 8-6, along with the corresponding estimates made in the 2008 Inventory.

Table 8-6: Dioxin releases from open domestic waste burning

Year	Activity Rate (tonnes/year)	Release factors (µg TEQ/tonne)		Annual releases (g TEQ/yr)	
		Air	Land	Air	Land
2008	18,000	300	-	5.4	-
		-	600	-	10.8
2008 (revised)	18,000	40	-	0.720	-
		-	1	-	0.018
2012	19,500	40	-	0.780	-
		-	1	-	0.020

Certainty assessment for 2012

Activity data:	Low (because it is based on limited survey data)
Emission factor:	Low (because it is based on the Toolkit default factors)

Back-calculation for 2008

A number of recent and more relevant studies were taken into account in the latest version of the UNEP Toolkit, and this has resulted in a drastic lowering of the Toolkit release factors for this source (United Nations Environment Programme, 2013). Use of the new factors for the 2008 estimates gives the results shown in the 2008 (revised) rows in the table above.

8.2.4 Accidental fires in vehicles

The release estimates for the previous dioxin inventories were based on New Zealand Fire Service statistics for the numbers of mobile property fires attended each year, and the same approach has been taken here. Annual fire incident data has been obtained directly from the New Zealand Fire Service, for the 2012 calendar year (S Quirke and A Hong, pers comm, 2013). Once again this shows a significant reduction in the annual numbers of fires, with only 1712 being recorded in 2012, compared to the figure of 3329 used for the 2008 Inventory.

The UNEP Toolkit gives default factors of 100 µg TEQ per fire, for dioxin releases to air, and 18 µg TEQ per fire, for releases to land (1 µg TEQ/tonne = 1 x 10^{-6} g TEQ/tonne). These factors have been used for the current release estimates, which are shown in Table 8-7, along with the corresponding estimates made in the 2008 Inventory.

Certainty assessment for 2012

Activity data:	High (because it is based on national fire statistics)

Emission factor: Low (because it is based on the Toolkit default factors)

Table 8-7: Dioxin releases from vehicle fires

Year	Activity Rate (vehicle fires/year)	Release factors (µg TEQ/fire)		Annual releases (g TEQ/yr)	
		Air	Land	Air	Land
2008	3329	94	-	0.313	-
		-	18	-	0.060
2008 (revised)	3329	100	-	0.333	-
		-	18	-	0.060
2012	1712	100	-	0.171	-
		-	18	-	0.031

Back-calculation for 2008

The UNEP Toolkit factor for releases to air has been changed slightly, as indicated in the table above. Use of the new factor gives the results shown in the 2008 (revised) rows in the table above.

8.2.5 Open burning of wood (construction/demolition)

The on-site burning of waste timber produced during construction or demolition works is either prohibited or restricted in most urban areas (see Appendix 1), but is still likely to occur on rural properties and in urban areas where restrictions have not been applied. There may also be some illegal burning in the controlled areas.

In 2006 it was estimated that construction and demolition (C&D) wastes made up about 14% of the total wastes disposed in landfills; ie, about 440,000 tonnes per year (Ministry for the Environment, 2007). An additional 300,000 tonnes per year was disposed at cleanfill sites. There is no more recent data available on C&D waste quantities, and nor is there any information on the quantities of C&D wastes disposed by burning. As a result, it is not possible to provide any reliable estimates of the dioxin releases associated with this activity.

Some indication of the potential releases can be obtained by assuming that the quantities of C&D wastes disposed by burning are equivalent to no more than l % of the total disposed of at landfills and cleanfill sites; ie. 7,400 tonnes per year. If the amount of material burned in each fire was 1 tonne (ie. a small rubbish skip full), the total annual quantity would equate to 7,400 fires per year[7], or just over 20 fires per day. The UNEP Toolkit recommends an emission factor of 60 µg TEQ per tonne (60 x 10^{-6} g TEQ/tonne), for dioxin releases to air. Applying this factor to 1% of the total C&D waste quantities indicates possible annual releases to air of 0.2 g TEQ per year. If correct, this would make C&D waste burning a small, but not insignificant, contributor to the total dioxin releases to air. It therefore suggests the need for continuing support for, and enforcement of, the regional controls on open burning summarised in Appendix 1.

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[7] As indicated in section A2.2 of Appendix 2, the NZ Fire Services attends about 4000 to 5000 fires per year that are specifically identified as involving some form of ‘rubbish’.

8.3 Summary for this category

The 2012 release estimates for accidental fires are summarised in Table 8-8, along with the revised comparative totals for 2008.

Table 8-8: Summary of the release estimates for open burning processes

Category	**2012 dioxin releases (g TEQ/yr)**				
	Air	**Water**	**Land**	**Product**	**Residue**
Agricultural residue burning	0.144	-	0.014	-	-
Forest fires	0.151	-	0.023	-	-
Grassland and savannah fires	0.189	-	0.057	-	-
Fires at waste dumps	0.378	-	0.0126	-	-
Structure fires	0.625	-	0.625	-	-
Open burning of domestic wastes	0.780	-	0.020	-	-
Vehicle fires	0.171	-	0.031	-	-
2012 totals	**2.439**	**-**	**0.782**	**-**	**-**
Revised 2008 totals	**4.780**	**-**	**1.044**	**-**	**-**

9 Production of chemicals and consumer goods

This category covers dioxin releases from the following sub-categories (United Nations Environment Programme, 2013):

7a	Pulp and Paper Production
7b	Chlorinated Inorganic Chemicals
7c	Chlorinated Aliphatic Chemicals
7d	Chlorinated Aromatic Chemicals
7e	Other Chlorinated and Non-Chlorinated Chemicals
7f	Petroleum Production
7g	Textile Production
7h	Leather Refining

The dioxin releases from these sources are not combustion-related, apart from black-liquor combustion in the pulp and paper mills, and the various releases from petroleum production. Historically, pulp and paper mills were a significant source of dioxin releases due to the use of elemental chlorine as a bleaching agent, which reacted with phenolic species in the pulp to form dioxins. The dioxins associated with most of the other chemical products are also similar, in that they are formed as reaction by-products of the chemical processes used in manufacturing. Generally, the dioxins are accounted for as releases into products, and these then lead on to the last two sub-categories in this group, where the dioxins are transferred to textile and leather products through the use of treatment chemicals contaminated with dioxins.

9.1 Pulp and paper production

This source was covered in section 22 of the report on the 2008 Inventory.

The total wood pulp production in New Zealand for 2012 was about 1.51 million tonnes (air dry basis), of which 47% was produced by thermo-mechanical or chemi-thermo-mechanical pulping, and 53% by chemical pulping (Ministry for Primary Industries, 2013). Mechanical pulp is produced at four plants in the Bay of Plenty, Hawke’s Bay and Manawatu−Wanganui regions. There are also two other mills in Auckland and the Bay of Plenty that produce paper and paperboard products from mixtures of wood pulp and waste paper. Chemical (kraft) pulp is produced at two pulp and paper mills in Kawerau and Tokoroa. The bleached kraft pulp mills are the source of primary interest for dioxin releases, and are the only ones considered below.

Black liquor combustion

There are two primary sources of dioxin releases to air from bleached kraft mills: the combustion of wood and other biomass in the power boilers, and the combustion of black liquor in the chemical recovery boilers. The contributions from the power boilers have already been addressed under section 5.2, so only the recovery boilers are covered here.

Black liquor is the liquid residue that is left after the cellulose fibre has been extracted from wood chips with pulping liquor in the kraft process. Releases from black liquor combustion are directly related to pulp production figures, and the total annual production of kraft pulp at the two mills in 2012 was about 800,000 tonnes on an air-dry basis [8]. In the previous dioxin inventories it was estimated that approximately 1.8 tonnes of black liquor solids were produced per tonne of pulp, and this indicates a current annual production rate of about 1.44 million tonnes of black liquor solids.

The release estimates for the two previous inventories were based on the results of emission testing on the two recovery boilers at the Waikato mill. There have been no more recent tests, but the emissions are unlikely to have changed significantly over the 5 years since the last test was done. Hence the previously estimated release factor of 0.025 µg TEQ per tonne of black liquor solids has been used for the current estimates (0.025×10^{-6} g TEQ/tonne).

The 2012 estimates for releases to air from black liquor combustion are shown in Table 9-1, along with the corresponding estimates made in the 2008 Inventory. There are no releases to water, land, or in products or residues from this source.

Table 9-1: Dioxin releases from black liquor combustion

Year	Activity Rate (tonnes of black liquor solids/year)	Release factors (µg TEQ/tonne of BLS)	Annual releases (g TEQ/yr)
		Air	Air
2008	1,300,000	0.025	0.0325
2012	1,440,000	0.025	0.0360

Certainty assessment for 2012

Activity data:	High (because it is based on actual production data)
Emission factor:	Medium (because it is based on historical emission data)

Back-calculation for 2008

There have been no significant changes in the release factors so a back-calculation is not required.

Releases to land

The wastewater treatment systems used at both mills result in the production of both primary and secondary sludge, and these are the only solid waste streams expected to contain dioxin residues. The release estimates given in the report on the 2008 Inventory were based on the UNEP Toolkit default factor of 0.2 µg TEQ per tonne of air-dry pulp, and this has been used in the release estimates given below (0.2×10^{-6} g TEQ/tonne). As was done in 2008, the calculations have been based on an annual production rate for bleached pulp only. In the absence of production figures for 2012, an estimate has been made based on the proportion of bleached pulp to total pulp production given in the 2008 inventory (58%), which gives a bleached pulp figure of 464,000 tonnes for 2012.

The 2012 estimates for releases to land from bleached pulp production are shown in Table 9-2, along with the corresponding estimates made in the 2008 Inventory.

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[8] Using the annual pulp production data published by the Ministry for Primary Industries. See: http://www.mpi.govt.nz/news-resources/statistics-forecasting/forestry.aspx.

Table 9-2: Dioxin releases to land from bleached pulp production

Year	Activity Rate (tonnes of air dried pulp/year)	Release factors (µg TEQ/tonne of pulp)	Annual releases (g TEQ/yr)
		Land	Land
2008	415,000	0.2	0.083
2012	464,000	0.2	0.093

Certainty assessment for 2012

Activity data:	Medium (because it is based on production data coupled with an approximate sludge production factor)
Emission factor:	Low (because it is based on the Toolkit default factors)

Back-calculation for 2008

There have been no significant changes in the release factors so a back-calculation is not required.

Releases to water

The dioxins in the pulp mill wastewaters are absorbed onto suspended solids and are therefore removed with the sludge. As such, they have already been accounted for in the estimates given above for releases to land, and the releases to water should be taken as zero.

Additions to existing land reservoir

The disposal of primary and secondary sludge produced in the pulp mills contributes to existing reservoirs of dioxins which have been created at the company's various waste disposal sites (landfills). The overall size of the reservoir was estimated in the 2008 Inventory at 24.8 g TEQ on the basis of historical sludge production. This figure can now be updated for an additional 5 years' input, based on the 2012 release rate shown in Table 9-2. If this rate is assumed to apply for all of the last 5 years, the additional inputs to the reservoir would be 0.465 g TEQ, and the total current reservoir would be 25.27 g TEQ.

9.2 Chlorinated inorganic chemicals

This sub-category covers dioxin releases from the manufacture of chlorine gas by electrolysis of solutions of sodium chloride. Prior to the 1980s most chlorine plants used either mercury cells or a diaphragm system, and both of these processes were shown to be significant sources of dioxins (United Nations Environment Programme, 2013). Nowadays, most plants use an alternative membrane cell process which, until recently, had not been shown to produce any dioxins. However, the latest version of the Toolkit indicates that dioxins have also been detected in the releases from these plants, albeit at very low levels.

There are two chlorine plants in New Zealand and these use the modern membrane cell process, and have a total capacity of about 20,000 tonnes per year of chlorine. However, these are associated with the two pulp and paper mills discussed in section 9.1 and their dioxin releases have already been accounted for under the mill-wide release estimates given in that section. However, for the sake of completeness, it can be noted that the releases from the chlorine plants would be in the order of about 0.00004 g TEQ to water, and 0.006 g TEQ to land, if considered separately from the rest of the mill.

9.3 Chlorinated aliphatic chemicals

This sub-section covers dioxin releases from the manufacture of polyvinyl chloride (PVC) resin, which usually starts with the manufacture of ethylene dichloride (EDC), followed by conversion to vinyl chloride monomer (VCM), and then a final polymerisation process to form PVC. Almost without exception, the first two of these steps are carried out in petrochemical manufacturing complexes, while the third may be done in a separate manufacturing plant, using imported VCM. However, there are no such facilities in New Zealand and the manufacture of PVC products is carried out using imported resin (Plastics New Zealand, 2011). Hence this source category is not relevant to New Zealand.

9.4 Chlorinated aromatic chemicals

This sub-section covers a range of different chemicals, only some of which are relevant to New Zealand. Each of the chemicals is discussed under separate sub-headings below.

9.4.1 1,4-dichlorobenzene

Dichlorobenzene may be contaminated with dioxins during manufacturing, and can therefore represent a potential source of releases via products, in subsequent uses. The chemical is not manufactured in New Zealand but it is listed in the New Zealand Inventory of Chemicals maintained by the Environmental Protection Authority (see www.epa.govt.nz). The UNEP Toolkit indicates that 1.4-dichlorobenzene has been used as an insecticide and fungicide, but the chemical is not registered for any such uses under the *Agricultural Compounds and Veterinary Medicines Act* (ACVM) *1997* (see www.foodsafety.govt.nz/industry/acvm/registers-lists.htm). Other possible uses are as a disinfectant and odour control agent in waste containers and restrooms, but products such as these are not subject to any specific controls in New Zealand that would allow these uses to be readily identified. Hence it is not possible to provide a quantitative assessment for this chemical.

9.4.2 Polychlorinated biphenyls (PCBs)

PCBs were used in the past as transformer oils and in other related applications (United Nations Environment Programme, 2013). In New Zealand the import, manufacture, and use of PCBs is prohibited under the *Hazardous Substances and New Organisms Act* (HSNO) *1996* without an exemption, and any stocks of old PCBs must be safely stored, managed and disposed in accordance with the *Hazardous Substances (Storage and Disposal of Polychlorinated Biphenyls) Notice 2007*. There are no facilities in New Zealand for the destruction of PCB-containing wastes, so disposal is by export to a suitable facility overseas (Ministry of Health, 2008).

The UNEP Toolkit provides no specific factors for estimating the possible dioxin releases from the storage of PCBs. However, if the storage is being carried out properly in accordance with the HSNO requirements, the releases due to leakages should be minimal.

9.4.3 Pentachlorophenol and sodium pentachlorophenate

The primary use of pentachlorophenol (PCP) in New Zealand was in the timber industry, either as sodium pentachlorophenate, for use as an antisapstain treatment, or as a preservative in diesel oil (Ministry for the Environment, 2011a). PCP was also used to a relatively minor extent as a slimicide in the pulp and paper industry, as a soil and timber steriliser in mushroom production, and in a variety of other applications for the control of moss and algae. The use of PCP in the timber industry voluntarily ceased in 1988, and PCP was deregistered for all uses by the Pesticides Board in 1991.

Past releases of dioxins from the use of PCP have resulted in a number of contaminated sites throughout New Zealand, and these are discussed further in Section 12 of this report.

9.4.4 2,4,5-Trichlorophenoxyacetic acid (2,4,5-T) and 2,4,6-trichlorophenol

The herbicide 2,4,5-T was manufactured in New Zealand from 1948 to 1987 and was widely used for the control of gorse, blackberry and other woody weeds (Ministry for the Environment, 2011a). The manufacturing process involved the initial formation of 2,4,5-trichlorophenol from 1,2,4,5-tetrachlorobenzene, and PCDDs and PCDFs (primarily 2,3,7,8-TCDD) were formed as a by-product of this reaction.

The residual soil contamination resulting from the past uses of 2,4,5-T is discussed in section 12 of this report.

9.4.5 Chloronitrofen, chlornitrofen, or 2,4,6 trichlorophenyl-4-nitrophenylether (CNP)

This chemical is not listed in the New Zealand Inventory of Chemicals or in any of the other registers of approved substances maintained by the Environmental Protection Authority (see www.epa.govt.nz). Hence it should not be found in New Zealand.

9.4.6 Pentachloronitrobenzene (PCNB - Quintozene)

Quintozene is a broad-spectrum, contact fungicide which was approved in New Zealand for the control of soil fungi in vegetable and ornamental seedlings, and non-grazed turf. However, this approval was revoked in January 2011 because of concerns about the presence of dioxin impurities (ERMA New Zealand, 2011). The presence of these impurities had only come to the attention of regulatory agencies, both here and overseas, in the preceding 2 years.

It is not known what quantities of Quintozene were previously used in New Zealand, but the Environmental Risk Management Authority (now EPA) determined that the uses were mainly limited to bowling greens and golf courses, and the quantities were "not large". For the purposes of this inventory, it can be assumed that the usage in 2012 was nil, and hence there were no associated dioxin releases.

9.4.7 2,4-Dichlorophenoxyacetic acid (2,4-D) and derivatives

The phenoxy herbicide 2,4-D is used in New Zealand, mainly on hill country farms, to control thistles and other broadleaf weeds. This agrichemical has been shown in the past to contain dioxin residues as production by-products, although with current manufacturing technologies the contamination levels are very low (United Nations Environment Programme, 2013). The annual usage in New Zealand was estimated in the 2008 Inventory at about 335 tonnes per year, and the current usage is believed to be still at about that level (A Cliffe, Nufarm NZ, Auckland, pers comm, 2014).

The release estimate for the 2008 Inventory was based on a measured dioxin contamination level of <10 µg TEQ/tonne of product (1 µg TEQ/tonne = 1 x 10^{-6} g TEQ/tonne). However, the latest edition of the UNEP Toolkit puts the level at 0.1 µg TEQ/tonne, based on more precise analytical data. Hence the Toolkit factor has been used for the 2012 release estimate, which is shown in Table 9-3 below.

Table 9-3: Dioxin releases via products from the use of 2,4-D

Year	Activity Rate (tonnes of 2,4-D used/year)	Release factors (µg TEQ/tonne of product)	Annual releases (g TEQ/yr)
		Product	Product
2008	335	<10	<0.003
2008 (revised)	335	0.1	0.000034
2012	335	0.1	0.000034

Certainty assessment for 2012

Activity data:	High (because it is based on an industry estimate of national production)
Emission factor:	Medium (because it is based on the Toolkit default factor supported by analytical data obtained previously from one of the manufacturers)

Back-calculation for 2008

As indicated above, the release factor has been changed. The back-calculation based on the much lower factor is shown in the 2008 (revised) row of the table above.

9.4.8 Chlorinated Paraffins

Chlorinated paraffins (CPs) are produced by chlorination of straight-chain hydrocarbons, with chain lengths generally ranging from C_{10} to C_{30}. The largest use of CPs is in industrial cutting fluids, but they may also be present in paints, adhesives, sealants and caulks, as well as plasticizers for PVC and flame retardants in other plastics and rubber.

Given the nature of their uses, most chlorinated paraffins are likely to be imported as minor constituents of a wide range of manufactured products. As such, it would be virtually impossible to determine the total quantities of CPs entering the country, or the dioxin contamination levels.

9.4.9 p-Chloranil

Chloranil (2,3,5,6-tetrachloro-2,5-cyclohexadiene-1,4-dione) was used in the past as a fungicide and seed dressing, although these uses were discontinued in most countries by the early 1980s. It is still used in the manufacture of dioxazine dyes and as a laboratory reagent (e.g., for the detection of primary and secondary amines). Chloranil has been shown to be contaminated with dioxins, but the level of contamination is highly dependent on the method of manufacture (United Nations Environment Programme, 2013).

Chloranil is listed in the New Zealand Inventory of Chemicals maintained by the Environmental Protection Authority (see www.epa.govt.nz). The HSNO approval for chloranil lists it as a pesticide, veterinary medicine or pharmaceutical active ingredient. However, the substance is not currently registered under the Agricultural Chemicals and Veterinary Medicines Act 1997 (see www.foodsafety.govt.nz/-industry/acvm/registers-lists.htm), and therefore cannot be used in New Zealand for any of these applications.

No current uses of chloranil have been specifically identified for New Zealand, although there may be some minor uses as a laboratory reagent.

9.4.10 Phthalocyanine dyes and pigments

Phthalocyanine dyes are artificial organic pigments which can be used in a wide range of dye applications. However, the UNEP Toolkit is primarily concerned with two specific substances; phthalocyanine copper (blue) and phthalocyanine green. The first of these can have minor levels of dioxin contamination (70 µg TEQ/tonne, i.e. 70×10^{-6} g TEQ/tonne) while the contamination levels in the latter can be 200 times greater. These substances are mainly used on textiles.

Phthalocyanine copper is listed in the New Zealand Inventory of Chemicals but phthalocyanine green is not. There is no readily available information on the quantities of phthalocyanine copper imported into New Zealand. However, the total value of all synthetic organic dye imports for New Zealand in 2012 was about $12 million (data obtained from the Statistics New Zealand InfoSearch database). A search of the websites of international chemical suppliers indicates that the cost of these dyes is typically in the range of $1,000 to $20,000 per tonne. This suggests that the total quantity of synthetic organic dyes brought into New Zealand would be around 2000 tonnes per year. There are literally hundreds of different dyes in this group, so the average import quantity for any individual dye is likely to be no more than about 10 tonnes per year.

If the quantity of phthalocyanine copper used annually in New Zealand is assumed to be 10 tonnes per year, it would contribute 0.0007 g TEQ per year. This would make only a very minor contribution to the total dioxin releases in New Zealand so, given the lack of any specific import data, no releases will be reported for this Toolkit sub-category.

9.4.11 Tetrachlorophthalic acid (TCPA) and related pigments

TCPA is listed in the Toolkit as a potential source of dioxins but there are no data available on the possible contamination levels. There is no readily available information on the quantities of TCPA-based pigments imported into New Zealand.

9.4.12 Dioxazine dyes and pigments

The dioxazine pigments with the potential for dioxin contamination are CI Pigment Violet 23, and CI Direct Blue 106 and 108. However, the contamination has only been reported for dyes made by a specific chemical process, which was replaced by a ‘cleaner’ method in the 1990s (United Nations Environment Programme, 2013).

These pigments can be used in a wide range of materials, including plastics, paints and printing inks, and they are also used in the production of dyes for use on textiles and leather. Only the first of these pigments is listed in the New Zealand Inventory of Chemicals. It is also listed in Schedule 7 to the ACVM Act as being acceptable for use as a seed treatment, provided the total levels of dioxins are no more than 20 µg/kg (note: this refers to total dioxins rather than TEQ). This indicates that the pigment should be essentially dioxin-free, and is therefore not one of the highly contaminated forms of the product that are considered in the Toolkit.

9.4.13 Triclosan

Triclosan (5chloro2(2,4dichlorophenoxy)phenol) is used throughout the world as an antibacterial and antifungal agent in consumer products, including soaps, deodorants, toothpastes, shaving creams, mouth wash, and cleaning supplies. In New Zealand, its use in cosmetics is limited to a concentration of no more than 0.3%, under the *Cosmetics Products Group Standard*, issued under the HSNO Act.

There is no readily available information on the extent of triclosan usage in New Zealand. However, a recent assessment for Australia indicated total annual imports there of between 21 and 31 tonnes per year (NICNAS, 2009). On a simple pro rata basis this would suggest annual imports for New Zealand of between 3.8 and 5.7 tonnes per year (based on 2013 population figures of 23,235,800 and 4,242,048, respectively).

The UNEP Toolkit indicates that triclosan can have dioxin contamination levels of 3 to 60 µg TEQ/tonne (i.e. 3 to 60 x 10^{-6} g TEQ/tonne) when made using current manufacturing technologies. This suggests that the overall contribution to New Zealand releases would be in the range of 0.000011 and 0.000342 g TEQ/year. This would make only a very minor contribution to the total dioxin releases in New Zealand so, given the lack of any specific import data, no releases will be reported for this Toolkit sub-category.

9.5 Other chlorinated and non-chlorinated chemicals

This section of the Toolkit covers dioxin releases from the manufacturing of titanium dioxide (via titanium tetrachloride) and caprolactam, which is a starting material for the manufacture of nylon (United Nations Environment Programme, 2013). Neither of these substances is produced in New Zealand.

9.6 Petroleum production

New Zealand's petroleum refining needs are served by a single refining plant in Northland. In 2012 the refinery processed 42.1 million barrels of crude oil and supplied 50 – 80 % of New Zealand's distilled transport fuel requirements (Refining NZ, 2013). The refining process involves a catalytic reforming unit where naphtha is turned into high octane petrol products, but there is no coking unit at the plant (Luke Gillingham, NZ Refining, pers comm, 2014).

Dioxin production during petroleum refining results from the combustion of volatile process gases in flares and complex reactions of hydrocarbons at elevated temperatures on catalytically active surfaces (United Nations Environment Programme, 2013). There can also be releases via wastewater and solid wastes.

For the emissions to air, the UNEP Toolkit assigns an emission factor for flares of 0.25 µg TEQ per TJ of fuel burnt and for the catalytic refining unit an air emission factor of 0.017 µg TEQ per tonne of fuel processed is applicable (1 µg = 10^{-6} g, and 1 TJ = 10^{-12} Joules). In 2012 37.5 TJ of gas were combusted in the flares (Luke Gillingham, NZ Refining, pers comm, 2014) corresponding to a release to air of 0.0000094 g TEQ per annum. Also 1,065,914 tonnes of oil were passed through the catalytic converter unit, resulting in a release to air of 0.0181 g TEQ/annum.

Refinery-wide wastewater treatment is assigned an emission factor of 5pg TEQ per litre by the Toolkit (1 pg = 10^{-12} grams). In 2012 a total of 1.55 million cubic metres of wastewater was processed through the plant's wastewater treatment system (Refining NZ, 2013). This gives a release of 0.00775 g TEQ/annum.

For releases in residues, the Toolkit assigns a factor of 14 µg TEQ per tonne of waste generated from the catalytic refining unit. A total of 5 tonnes of waste was produced by this unit in 2012 (Luke Gillingham, NZ Refining, pers. comm., 2014) giving a release to residues of 0.00007g TEQ/annum.

The 2012 estimates for releases from petroleum production are shown in Table 9-4. In the interests of clarity, the entries in the table have been limited to only the release estimates, rather than showing all of the different types of activity data and related releases factors noted above. This source sub-category was a new addition to the UNEP Toolkit in 2013 so no release estimates were reported for the 2008 Inventory. However, the back-calculated values are also shown in the table.

Table 9-4: Dioxin releases from petroleum production

Year	Annual releases (g TEQ/yr)		
	Air	Water	Residues
2012 and 2008 (revised)	0.018	0.00775	0.00007

Certainty assessment for 2012

Activity data: High (because they are based on actual production data)
Emission factor: Low (because they are based on the Toolkit default factors)

Back-calculation for 2008

Petroleum refining emission factors were developed in the latest Toolkit revision so were not available for the previous inventory calculations. In 2008 there were 39.14 million barrels of oil processed at the refinery (NZ Refining Company, 2009) which is only slightly less than the 42.1 million barrels handled in 2012. The specific throughput data required for each of the plant processes is not available. However, given the similarity in production figures it is a reasonable assumption that dioxin releases from the refinery in 2008 would have been similar to those calculated for 2012.

9.7 Textile (and leather) production

The UNEP Toolkit indicates that dioxins may be found in textile and leather products and production wastes as a result of a number of factors, including:

- the treatment of raw materials with agrichemicals, especially pentachlorophenol,
- the use of dioxin-contaminated dyestuffs (e.g., dioxazine dyes)
- the formation of dioxins as unintentional by-products in the production processes.

Pentachlorophenol and the sodium salt of pentachlorophenol were mainly used in New Zealand for timber treatment (see section 9.4.3), but they may have also been used in the textiles and leather industries, mainly as a fungicide or preservative. All uses of pentachlorophenol were deregistered by the Pesticides Board in 1989, and the substance approval under the HSNO Act was formally withdrawn in 2008 (Environmental Risk Management Authority, 2008). In the 2008 Inventory it was noted that the testing of New Zealand pelts and hides intended for export had not shown any detectable levels of pentachlorophenol.

The uses of pentachlorophenol have been either banned or severely restricted in many other countries. For example, the register maintained by the Secretariat of the Rotterdam Convention indicates that the substance has been banned or is no longer approved for use in at least 45 countries and is prohibited from import in a further 42 (Secretariat of the Rotterdam Convention, 2013). Imports and/or uses may still be permitted in other countries, including Australia, and Canada, but with conditions; for example, a residue limit in finished products.

The potential for dioxin contamination from dioxazine dyes was discussed in section 9.4.12. In the previous inventory report it was noted that some of these dyes have been used in the past in the New Zealand leather and textiles industries, but there were no current known uses.

Dioxins are expected to occur in the wastes from textile and leather-processing plants, especially wastewater discharges, but mainly as a result of contaminated inputs from the chemicals noted above (United Nations Environment Programme, 2013). There is also the potential for dioxin production as unintentional by-products when incineration processes are used for waste disposal. However, incineration is not used in New Zealand.

On the basis of the above information, there is no reason to expect any significant dioxin releases from the processing and manufacture of textiles and leather products within New Zealand. However, there is some potential for them to be present in imported products, especially those sourced from countries where pentachlorophenol or dioxazine dyes are still in use.

In the previous inventory report it was estimated that the total annual releases from dioxins present in imported textiles and leather goods would be no more than about 0.036 g TEQ. There is no new information available to suggest that this estimate will have changed significantly since 2008. The 2008 estimate was not included in the inventory results because of the associated very high uncertainties, and the same approach will be adopted here.

9.8 Leather refining

See section 9.7 above.

9.9 Summary for this category

The 2012 release estimates for the production of chemicals and consumer goods are summarised in Table 9-5, along with the revised comparative totals for 2008.

Table 9-5: Summary of the release estimates for the production of chemicals and consumer goods

Category	**2012 dioxin releases (g TEQ/yr)**				
	Air	**Water**	**Land**	**Product**	**Residue**
Black liquor combustion	0.036	-	-	-	-
Pulp & paper sludge disposal	-	-	0.093	-	-
Use of 2,4-D	-	-	-	0.000034	-
Petroleum production	0.018	0.00775	-	-	0.00007
2012 totals	**0.054**	**0.00775**	**0.093**	**0.000034**	**0.00007**
Revised 2008 totals	**0.051**	**0.00775**	**0.083**	**0.000034**	**0.00007**

10 Miscellaneous sources

This category covers dioxin releases from the following sub-categories (United Nations Environment Programme, 2013):

8a	Drying of Biomass
8b	Crematoria
8c	Smoke houses
8d	Dry cleaning
8e	Tobacco smoking

The dioxin releases from most of these sources are combustion-related, and they mainly arise from the incomplete combustion of the fuels and/or materials being burned. The only exception is drycleaning, where the dioxins arise as a result of incoming contamination on the materials being cleaned.

10.1 Drying of Biomass

This Toolkit category refers to the drying of biomass such as wood chips or animal fodder using direct heating methods, in which the material to be dried is exposed directly to combustion off-gases. The biomass can become contaminated with dioxins if the fuel being used is contaminated with dioxin precursor materials, such as pentachlorophenol. Thus, the category mainly applies to biomass drying using other biomass as the fuel.

The most significant biomass drying operations in New Zealand, by size, take place in the board and fibreboard mills already considered in section 5.2, and the potential releases have already been accounted for under the heat and power generation source category. Other biomass drying in New Zealand (eg, grain drying) is carried out using dryers fired by fossil fuels, especially natural gas, LPG or diesel. The dioxin releases from these activities have already been accounted for under section 5.

10.2 Crematoria

This source was covered in section 8 of the report on the 2008 Inventory. In 2012, there were 50 crematoria in New Zealand, of which 33 were privately owned and the remainder were operated by territorial local authorities (R Grooby, Funeral Directors Association of New Zealand, pers comm, 2013).

The release estimates for the 2008 Inventory were based on the annual numbers of cremations multiplied by the default factor given in the UNEP Toolkit for releases to air. There were no significant releases to land, water, or in products or residues. Information obtained from the Department of Internal Affairs indicates that in 2012 the total number of deaths in New Zealand was 30,099, and approximately 63% of bodies (19,053) were cremated (J Arnold, pers comm, 2013)[9]. Applying the UNEP Toolkit factor of 10 µg TEQ per cremation (10×10^{-6} g TEQ/cremation) gives the release estimates shown in Table 10-1, along with the corresponding estimates from the 2008 Inventory.

Certainty assessment for 2012

Activity data:	Medium (because it is based on national death registration data)
Emission factor:	Low (because it is based on the default factor given in the UNEP Toolkit)

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[9] The cremation/burial split is a little uncertain because the records note the place of disposal rather than the method of disposal.

Table 10-1: Dioxin releases from crematoria

Year	Activity Rate (no of cremations/year)	Release factors (µg TEQ/cremation)	Annual releases (g TEQ/yr)
		Air	Air
2008	18,289	10	0.1829
2012	19,053	10	0.1905

Back-calculation for 2008

There has been no change in the release factor so a back-calculation is not required.

10.3 Smokehouses

This source sub-category was covered in section 30.1 of the report on the 2008 Inventory.

Smoking is used to add flavour, colour and aroma to various meats, including pork, beef, poultry and fish. Several methods are used to produce the smoke, but the most common approach is based on the pyrolysis of wood chips or sawdust. In a typical smoke generator, the wood is placed on a heated metal surface at 350° to 400°C. Another method involves use of the heat generated by constantly rubbing blocks of wood against a blunt metal blade, or vice versa. Liquid smoke, which is a washed and concentrated natural smoke, is also used.

The release factors given in the UNEP Toolkit relate to smoking processes based on wood pyrolysis. No data is available on the amount of fuel used in New Zealand for this purpose and there is also no information on the proportion of smoked meats that are produced in this way. Hence, there is insufficient information to allow any reliable estimates of the releases for this source. However, it can be noted that the report on the previous inventory produced a worst-case estimate, based on total smoked food production, of no more than 0.15 g TEQ per year (Ministry for the Environment, 2011a). This estimate was not included in the inventory totals because of the associated very high uncertainties.

10.4 Dry cleaning

Dioxins have been detected in the distillation residues from drycleaning, but this is believed to originate from contaminants already present on the textiles from the use of chemicals such as pentachlorophenol and dioxazine dyes (United Nations Environment Programme, 2013). The drycleaning process itself does not generate any dioxins. The UNEP Toolkit recommends release factors of 3000 µg TEQ per tonne of residue for cleaning of textiles with high levels of PCDD/PCDF contamination, and 50 µg TEQ per tonne of residue for ‘normal’ textiles (1 µg = 10^{-6} g). These factors are based on European work published in 1992 and 1993, and it is likely that the current contamination levels in New Zealand will be much lower than those reported, simply because there is now little or no use of the contaminated chemicals.

There is no accurate data available on the quantities of drycleaning distillation residues produced in New Zealand. In the previous inventory report it was estimated that the potential releases could be in the order of only 0.007 grams TEQ per year, but this figure was not included in the inventory totals because it was highly uncertain (Ministry for the Environment, 2011a). There is no reason to believe that the current releases would be substantially different from the 2008 estimate.

10.5 Tobacco smoking

This source sub-category was covered in section 23 of the report on the 2008 Inventory.

The release estimates for the 2008 Inventory were based on total tobacco consumption in 2007 of 2445 million cigarettes and 904 tonnes of tobacco, or 3349 million cigarette equivalents (based on a factor of 1 million cigarettes per tonne of loose tobacco). This indicated an overall drop in tobacco consumption of about 17% over the previous 10 years, and further reductions are expected to have occurred since then.

National statistics on tobacco consumption are only available up to the end of 2009[10]. However, in that year the total consumption figures were 2436 million cigarettes and 856 tonnes of tobacco, which indicates further reductions of 0.99% and 5.4% in cigarette and tobacco consumption respectively, from 2007. More limited data covering tobacco sales by the 3 major distributors has been obtained from the Ministry of Health, and this indicates that since 2009 the cigarette sales by these companies have fallen by a further 10.06%, and tobacco sales by 23.3% (J Stribling, pers comm, 2013). If the same reductions are assumed to apply to all cigarette and tobacco sales then the 2012 tobacco consumption rates can be estimated at 2112 million cigarettes and 657 tonnes of tobacco, or 2769 million cigarette equivalents.

The UNEP Toolkit default factor of 0.1 pg TEQ per cigarette for releases to air (0.1×10^{-12} g TEQ/cigarette), has been applied to this total to give the 2012 estimates shown in Table 10-2, along with the corresponding estimates from 2008.

Table 10-2: Dioxin releases from tobacco smoking

Year	Activity Rate (million cigarettes/year)	Release factors (pg TEQ/cigarette)	Annual releases (g TEQ/yr)
		Air	Air
2008	3349	0.1	0.00033
2012	2769	0.1	0.00028

Certainty assessment for 2012

Activity data:	Medium (because it is based on national statistics)
Emission factor:	Low (because it is based on the default factor given in the UNEP Toolkit)

Back-calculation for 2008

There has been no change in the release factor so a back-calculation is not required.

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[10] Statistics New Zealand stopped publishing these on the basis that the data was commercially sensitive.

10.6 Summary for this category

The 2012 release estimates for miscellaneous sources are summarised in Table 10-3.

Table 10-3: Summary of the release estimates for miscellaneous sources

Category	2012 dioxin releases (g TEQ/yr)				
	Air	Water	Land	Product	Residue
Crematoria	0.1905	-	-	-	-
Tobacco smoking	0.00028	-	-	-	-
2012 totals	**0.191**	**-**	**-**	**-**	**-**
Revised 2008 totals	**0.183**	**-**	**-**	**-**	**-**

11 Disposal and landfill

This category covers dioxin releases from the following sub-categories (United Nations Environment Programme, 2013):

9a	Landfills, waste dumps and landfill mining
9b	Sewage/sewage treatment
9c	Open water dumping
9d	Composting
9e	Waste oil disposal

All of the sources in this category should be considered as secondary dioxin sources, in that there are no new dioxins being produced. The dioxins are simply associated with the incoming and outgoing wastes.

11.1 Landfills, waste dumps and landfill mining

According to the UNEP Toolkit this category covers wastes generated at a national level which are landfilled. In 2011 there were 51 landfill facilities in New Zealand receiving municipal solid waste (Ministry for the Environment, 2011b). In addition to these there were a number of cleanfills or construction and demolition fills. The latter are not adjudged to be significant sources of dioxins and their activity has not been included in this dioxin release assessment. There is one example of a dedicated hazardous waste landfill in New Zealand which no longer receives wastes (Bell & Wilson, 1988). There are also a small number of private industrial landfills. Industrial wastes containing dioxins have already been accounted for in the other sections of this report dealing with individual processes, and there is no landfill mining done in New Zealand. Consequently municipal solid waste is the sole focus for this waste category.

New Zealand's waste disposal levy scheme is currently the best means of estimating domestic waste activity The Waste Minimisation Act 2008 introduced a levy of $10 for every tonne of waste arriving at domestic waste landfills. This has resulted in more accurate monitoring of waste quantities disposed. The levy has applied since August 2009 and its effectiveness was reviewed by the Ministry for the Environment in 2011. Another 3-yearly review is in preparation for 2014.

For the 2010 calendar year the scheme reported that a total of 2,525,977 tonnes of waste went to landfill which equated to an average of 575 kg for each New Zealander (Ministry for the Environment, 2011b). More recent data is available on the Waste Levy web site (www.mfe.govt.nz/issues/waste/progress-and-outcomes/waste-disposal-levy) and this shows that in 2012 the total quantity of waste disposed was 2,514,182 tonnes. The 2011 waste levy review stated that the quality of available waste data before the introduction of reporting under the levy was varied, and that the levy now provides a consistent data set which will provide a baseline for comparison over time.

The UNEP Toolkit gives three classifications for landfills:

> Class 1 applies to landfills where wastes from (Toolkit) source groups 1 to 8 are deposited.
>
> Class 2 applies to landfilling of waste which may contain some hazardous components. A typical situation is where a country has no organised waste management systems.
>
> Class 3 applies to landfilling of non-hazardous wastes.

The greenhouse gas inventory report commented that New Zealand has insufficient data to categorise solid waste as either municipal solid waste or industrial solid waste, because many municipal landfills accept industrial waste (Ministry for the Environment, 2014). However current New Zealand landfill practice does involve waste assessment and would reject for disposal any industrial wastes which were known to contain significant quantities of dioxins. Landfills in New Zealand are engineered facilities where the wastes deposited are contained by impermeable liners and water ingress prevented by capping materials. Consequently the Toolkit class 3 category is considered appropriate for all waste currently being deposited in landfills.

With regard to releases to water the situation is more complicated. The leachate produced by a landfill is not solely associated with the waste currently being deposited. It may originate, or come in contact with waste from earlier periods, which may have had higher concentrations of dioxins. Class 2 emission factors are seen as more appropriate for New Zealand landfill leachate.

The estimates for dioxin releases from landfilling for 2012 are shown in Table 11-1, along with the corresponding estimates made in the 2008 Inventory.

Table 11-1: Dioxin releases from landfills, waste dumps and landfill mining

Year	Activity Rate	Release factors		Annual releases (g TEQ/yr)	
		Water (µg TEQ/m^3)	Land (µg TEQ/tonne)	Water	Land
2008	3,180,000 tonnes of waste/year	-	6	-	19.080
	3,700,000 m^3 leachate/year	0.2	-	0.740	-
2008 (revised)	2,455,250	0.5	-	1.228	-
		-	5	-	12.276
2012	2,514,182	0.5	-	1.257	-
		-	5	-	12.571

Certainty assessment for 2012

Activity data:	High (because it is based on the national waste levy data)
Emission factors:	Low (because they are based on the Toolkit default factors)

Back-calculation for 2008

A different procedure was used to estimate releases to water resulting from landfill leachate for 2008. This involved estimating the total production of landfill leachate and applying an emission factor derived from the results of leachate dioxin analysis. It is difficult to know exactly what volumes of solid waste were being produced in New Zealand in 2008. However, using the per capita deposition rate of 575 kg per annum for a 2008 population of 4.27 million (Statistics New Zealand, 2008) would give a revised annual waste quantity of 2,455,250 tonnes and a dioxin release to water of 1.228 g TEQ/annum for 2008, as indicated in the table above.

The UNEP Toolkit factor for releases to land has also been changed slightly, as indicated in the table above.

11.2 Sewage/sewage treatment

This source was covered in section 27 of the report on the 2008 Inventory.

About 320 wastewater treatment plants (WWTPs) treat the domestic sewage produced by 80% of New Zealand’s 4.43 million population. Approximately 70% of the population are connected to 25 high rate WWTPs, many of which have full secondary treatment and produce digested dewatered sludge. The majority of the remaining WWTPs use small waste stabilisation ponds which accumulate sludge for infrequent removal (New Zealand

Water and Wastes Assn, 2003). Both large and small WWTPs discharge treated water on a continuous basis producing about 1.8 billion litres of treated wastewater per day (ie. 657 billion litres/year). Total dewatered sludge production for all WWTPs in 2012 was estimated at 320,000 tonnes per annum (Walmsley, 2012). This figure was derived from the assumption of a per capita biological oxygen demand (BOD) of between 70 and 90 g per person per day. Independently the greenhouse gas inventory for 2012 (Ministry for the Environment, 2014) assumed a BOD loading of 26 kg per person per year, which equates to 71 g per person per day.

The remaining 20% of the population (880,000 people) not connected to a WWTP rely on domestic on-site systems (septic tanks) to treat their wastewater. In 2008 there were about 270,000 dwellings with such facilities (Ministry for the Environment, 2008). The septic tank design manuals published by several regional councils indicate typical wastewater flows ranging from 120 to 220 litres per person per day (eg. see Auckland Regional Council, 2004). Taking the average of these two figures (170 litres/day) indicates a total wastewater flow of 149.6 million litres per day (ie. 54.6 billion litres/year). The frequency at which sludge is removed from septic tanks varies throughout New Zealand. However, a commonly applied rule of thumb is that older style septic tanks servicing an average–sized family household should be pumped out every three years and this is reflected in the proposed national environmental standard which promotes a septic tank warrant of fitness issued at three-yearly intervals (Ministry for the Environment, 2009). Most sludge removed from septic tanks, which is referred to as septage, is taken to WWTPs for disposal and is accounted for in their sludge output.

The latest Toolkit revision (United Nations Environment Programme, 2013) has maintained the previous three classifications for wastewater sources but has clarified the class descriptions and also the associated emission factors. Class 2 – "urban and industrial inputs" and class 3 – "domestic inputs" are appropriate for New Zealand. Based on the new class descriptions in the Toolkit it has been decided that the distinction between the two classes should be on the basis of whether or not the wastewater is reticulated and that Class 2 should be used for all WWTP releases and Class 3 for septic tank releases. This differs from the previous inventory in that all wastewater releases in New Zealand were assigned to Class 2 ("urban environments"). It has also been decided that all WWTP releases to water be classified as "sludge removed", rather than this classification applying only to the high rate WWTPs, as was the case for the previous inventory. This change is consistent with the published information on local WWTPs (New Zealand Water and Wastes Assn, 2003).

In line with observations of an international decreasing trend in dioxin concentrations in sewage (United Nations Environment Programme, 2013), the Toolkit factors for releases to both water and residues (the sludge itself) have decreased. For instance for Class 2 discharges of treated wastewater from a WWTP to water involving sludge removal, the emission factor has decreased from 0.5 to 0.2 pg TEQ/litre (0.2×10^{-12} g TEQ/litre) . Similarly for Class 2 releases of sludge, the emission factor has dropped from 100 to 20µg TEQ/tonne dried sludge (20×10^{-6} g TEQ/tonne of sludge).

The UNEP Toolkit factors have been used for the current release estimates, which are shown in Table 11-2, along with the corresponding estimates made in the 2008 Inventory. It can be seen that the release estimates have reduced significantly, mainly due to the lowering of the Toolkit release factors.

Certainty assessment for 2012

Activity data:	Medium (because they are based on national estimates, rather than complete data)
Emission factor:	Low (because they are based on the Toolkit default factors).

Table 11-2: Dioxin releases from sewage/sewage treatment

Year	Class	Activity Rates		Release factors		Annual releases	
		Water (10^9 litres/yr)	Residue (tonnes/yr)	Water (pg TEQ/litre)	Residue (µg TEQ/tonne)	Water (g TEQ/yr)	Residue (g TEQ/yr)
2008	sludge removal*	328.5	-	0.5	-	0.165	-
		-	234,112	-	100	-	23.411
	no sludge removal*	328.5	-	2	-	0.658	-
	Total releases					**0.823**	**23.411**
2012 and 2008 (revised)	Class 2*	657	-	0.2	-	0.1314	-
		-	320,000	-	20	-	6.400
	Class 3*	54.6	-	0.04	-	0.0022	-
	Total releases					**0.1336**	**6.400**

(* For 2008 the New Zealand sources were assigned to Toolkit Class 2, urban environments, with or without sludge removal. For 2012, most sources have been assigned to the revised Toolkit Class 2: urban and industrial inputs, with sludge removal, while septic tanks have been assigned to Toolkit Class 3: domestic inputs)

Back-calculation for 2008

The wastewater volume used for estimating WWTP discharges to water in 2012 is the same as that reported previously for 2008 (ie 1.8 billion litres/day). There is no more recent discharge data available. The wastewater discharges from septic tanks were not included in the previous inventory. The main change in the release calculations is the lower Toolkit release factors, and if these were applied to the 2008 activity rates, the estimated releases to water would be the same as those shown for 2012.

11.3 Open water dumping

This Toolkit source category refers to the practice of discharging untreated wastewater or other liquid wastes directly into surface waters, such as streams, rivers, lakes or the sea. It was not considered for inclusion in the report on the 2008 Inventory, mainly because of the unavailability of any relevant data.

New Zealand has 425,000 kilometres of rivers and streams, almost 4,000 lakes that are larger than 1 hectare, and about 200 aquifers (Ministry for the Environment, 2008a). Water quality is generally poorest in rivers and streams in urban and farmed catchments and in coastal areas adjacent to urban centres. This reflects the impact of non-point-sources of pollution, such as urban stormwater, animal effluent, or fertiliser run-off. Urban stormwater is the most likely of these to be contaminated with dioxins. However, it would be almost impossible to determine stormwater volumes on a national basis, or their likely contamination levels, with any reasonable degree of accuracy. In addition, the most significant dioxin contributions should have already been accounted for under other environmental compartments, especially air and land. Similarly, the most significant point source discharges should have already been accounted for under other source sub-categories (eg WWTP effluents).

Waste discharges within New Zealand's EEZ are controlled by Maritime New Zealand, in accordance with standards derived from the 1996 Protocol to the International Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter 1972 (Maritime New Zealand, 2001). Permits may be issued for the disposal at sea of a variety of solid and liquid wastes, provided it can be shown that any adverse effects will be avoided, remedied or mitigated. There is some national data available on the quantities of these wastes but the dioxin contamination levels are unknown. This therefore precludes any estimates of the likely dioxin discharges.

11.4 Composting

This source was not considered in the 2008 Inventory and will similarly not be included here. The Toolkit category mainly relates to compost made from the organic fraction of municipal solid wastes, whereas most New Zealand compost is made from green waste which should have little or no dioxin contamination.

11.5 Waste oil disposal

This sub-category was covered in section 24 of the 2008 Inventory, which addressed the disposal of used oil by land application or dumping. It was assumed for that inventory that 2,400 tonnes (3 million litres) of oil were used for dust suppression and 3,200 tonnes (4 million litres) were dumped, and the total dioxin releases to land were estimated to be 0.207 g TEQ[11]. However, the information sources used for these estimates are now very dated and there is no more recent data available. Hence no release estimates can be provided for 2012.

The UNEP Toolkit refers to this source sub-category as Waste Oil Treatment (non-thermal), but provides no release factors because of the highly variable nature of the possible treatment processes and the lack of any reliable release data. It also notes that no new dioxins are created in the treatment processes. The dioxins are simply present as contaminants introduced via previous uses of the oil (United Nations Environment Programme, 2013). There are several waste oil processors in New Zealand, and any potential discharges from their operations are subject to controls in resource consents issued under the *Resource Management Act 1991*. The consents are mainly targeted at minimising oil releases, rather than dioxins. However, it would be reasonable to assume that any dioxin releases will also be minimised if the oil discharges are properly controlled. No data has been found that would allow for any specific estimates of the releases from this source.

11.6 Summary for this category

The 2012 release estimates for the waste disposal and landfill sources are summarised in Table 11-3, along with the revised comparative totals for 2008.

Table 11-3: Summary of the release estimates for the disposal and landfill category

Category	2012 dioxin releases (g TEQ/yr)				
	Air	Water	Land	Product	Residue
Landfills, waste dumps and landfill mining	-	1.257	12.571	-	-
Sewage/sewage treatment	-	0.1336	-	-	6.400
2012 totals	**-**	**1.391**	**12.571**	**-**	**6.400**
Revised 2008 totals	**-**	**1.361**	**12.483**	**-**	**6.400**

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[11] For 2008 the estimates for the land application and dumping of used engine oil were arbitrarily assigned to the Transport category because the source was not specifically covered in the Toolkit, at that time. Land disposal of used oil was added to the Disposal category in the 3rd edition, and the 2008 releases have now been reassigned to this category. The estimated release to land (0.207 g TEQ) is included in the 2008 totals shown in Table 11-3.

12 Contaminated sites and hotspots

This section of the UNEP Toolkit does not generate any data for inclusion in the national inventory. Rather, it is simply intended to provide ‘an indicative list of activities that might have resulted in the contamination of soils and sediments with PCDD/PCDF and other unintentional POPs, including related deposits’ (United Nations Environment Programme, 2013). No significant new work has been undertaken in the preparation of this section, which simply provides an update of the information given in section 28 of the previous inventory report for the following sources:

- the manufacture of phenoxy herbicides
- the use of the herbicide 2,4,5-T
- timber treatment using pentachlorophenol
- gasworks
- landfills.

12.1 Pesticide manufacture

This sub-section is concerned with the dioxins present in a reservoir associated with the historical manufacture of phenoxy herbicides. The Waireka Secure Containment Facility, in the Taranaki region, was constructed in 1985 and contains waste from earlier manufacturing of phenoxy herbicides, including 2,4-D and 2,4,5-T. The accumulated wastes were deposited in 1985 and the landfill was closed. The facility is a secure landfill, fully lined and capped, with leak detection wells that are routinely monitored. Any leachate collected from within the landfill is disposed of in the incinerator described in section 3.2 of this report.

Although dioxins are known to be present in the Waireka facility, insufficient data is available to enable an accurate estimate of the quantity present.

12.2 Historical use of 2,4,5-T

The herbicide 2,4,5-T was manufactured in New Zealand from 1948 to 1987 and was widely used for the control of gorse, blackberry and other woody weeds. The manufacturing process involved the initial formation of 2,4,5-trichlorophenol from 1,2,4,5-tetrachlorobenzene, and dioxins, primarily 2,3,7,8-TCDD (TCDD), were formed as a by-product of this reaction.

The total quantity of 2,4,5-T manufactured was estimated in the 2000 Inventory at 11,640 tonnes, with about 15% of this being exported (Ministry for the Environment, 2000). The levels of TCDD in the final product varied greatly, depending on the manufacturing conditions and purification efficiency. From 1973 the level of TCDD was restricted by requirements imposed by the Agricultural Chemicals Board. On the basis of the total production figures and the known residue concentrations, it was estimated that the total quantity of TCDD distributed over the land surface of New Zealand, throughout the entire period of manufacture and use, was between 2.71 and 3.38 kg TEQ.

The size of the reservoir from 2,4,5-T usage was estimated in the previous inventory reports by making an allowance for TCDD degradation over time, using a half-life of 15 years. Thus, for 1998 the residual amount of TCDD was estimated to have dropped to a level of 620 to 860 g TEQ, and by 2008 it was down to 390 to 540 g TEQ (calculated using a factor of $1/2^n$, where n = number of half-lives). Using the same methodology, the 2012 quantity of TCDD remaining in soil as a result of the past use of 2,4,5-T is estimated to be 324 to 437 g TEQ.

12.3 Historical use of pentachlorophenol for timber treatment

The primary use of pentachlorophenol (PCP) in New Zealand was in the timber industry, either as the sodium salt (NaPCP), for use as an antisapstain treatment, or as a preservative mixed with diesel oil. The use of PCP in the timber industry commenced in the mid- to late-1950s and voluntarily ceased in 1988, and the chemical was deregistered for all uses by the Pesticides Board in 1991. The total amount of PCP imported into New Zealand for use in the timber industry is believed to be about 6000 tonnes (Ministry for the Environment, 2011a), and the total input of dioxins into the New Zealand environment was estimated to be 9.9 kg TEQ.

The concentrations of dioxins in the antisapstain formulations marketed in New Zealand were believed to be in the range 0.2 –1.85 g TEQ per tonne, with a mean of 0.9 g TEQ per tonne. Investigations at some of the timber treatment sites have been used to produce an estimate of the total dioxin contamination resulting from antisapstain use (Ministry for the Environment, 2011a), and in 2008 the residual amount remaining was estimated to be 0.81 kg TEQ. This estimate was based on site assessments completed in 2002, and some of the sites have since been remediated. However, there have been no specific treatments aimed at removing the dioxin contaminants. In addition, much of the remediation work is based simply on soil removal and replacement. Hence, the quantities of dioxins in the reservoirs are unlikely to have changed, but they may have been moved to other locations.

The use of PCP as a preservative in diesel oil was only undertaken at four sites in New Zealand, although only two of these are believed to be of any significance: the Waipa Mill near Rotorua and a plant at Hanmer Springs in Canterbury. The total usage of PCP was estimated to be approximately 2700 tonnes and the average contamination level of the PCP was believed to be 1.65 g TEQ per tonne, which gives a total dioxin input of 4.5 kg TEQ. As reported in the 2008 Inventory, it was estimated that 0.23 kg TEQ of this total would have contributed to soil contamination at the sawmill sites, and the remaining 4.27 kg TEQ was absorbed in the treated products and distributed more widely. It is not expected that these reservoirs will substantially change over time, unless specific action is taken to destroy the dioxin contamination prior to the disposal of waste materials.

12.4 Gasworks sites

Prior to the introduction of natural gas in New Zealand, ‘town gas’ was produced by coal gasification plants at gasworks sites throughout the country. There were approximately 54 gasworks sites, which operated for varying periods from the mid-1800s through to 1988. Internationally, dioxins have not been recognised as a priority contaminant of gasworks waste. However, New Zealand studies have found that some dioxins may be present in the wastes produced from coal gasification and can be found at some of the sites where gasworks were previously located (Ministry for the Environment, 2011a).

In the 1998 Inventory it was noted that at least five of the 54 gasworks sites had been remediated, and the reservoir estimates for the remaining 49 sites were reported to be between 0.028 and 6.4 g TEQ (Ministry for the Environment, 2000). The 2008 Inventory reported that a further 10 sites had been remediated and the 2008 dioxin reservoir was estimated at 0.022 to 5.2 g TEQ. No reports have been found of any more recent remediation work, so the 2008 estimate should still apply for 2012.

12.5 Landfills

Solid waste landfills also represent a reservoir of dioxins. In the 2008 Inventory it was estimated that the total mass of waste stored in landfills in 2008 was 110 million tonnes, and the associated dioxin reservoir would be 0.66 kg TEQ (based on a Toolkit factor of 6×10^{-6} g TEQ per tonne). In the following 4 years, the quantity of waste will have increased by about 10 million tonnes (see section 11.1). Thus the existing reservoir in 2012 will be 0.72 kg TEQ.

13 Summary and discussion

The key points arising from the 2012 inventory are summarised and discussed below, along with some comparative data from the previous inventories for 1998 and 2008. A table showing the revised release estimates for 2008 and the current estimates for 2012 is given in Appendix 1.

13.1 Changes in the dioxin release estimates over time

The dioxin release estimates for 1998, 2008 and 2012 are summarised in Table 13-1 below. This summary is based on nine of the Toolkit source categories, which is the summary level used for country reports under the Stockholm Convention. The estimates shown for 2008 are based on the revised estimates (i.e. back-calculated) given throughout this report and are therefore, directly comparable with the estimates for 2012. However, any comparisons with the 1998 estimates should be made with caution, because these pre-date the use of the UNEP Toolkit and were based on fewer source sub-categories than were used for the more recent estimates.

It should also be noted that the values shown for 1998 releases to land are effectively a combination of the estimates shown for releases to land and in residues, for both 2008 and 2012. This Toolkit distinction was not applied in the first New Zealand inventory and it was simply assumed that most residues would ultimately be disposed to land, usually via landfill. Another difference is that the 1998 estimates were originally reported as a range of values for each source. The 1998 data shown in the table is the mid-point for each of those ranges.

Table 13-1: Summary of the release estimates for 1998, 2008 and 2012

	Source Categories	Annual Releases (g TEQ/a)										
		Air			Water			Land			Residue	
		1998	2008	2012	1998	2008	2012	1998[a]	2008	2012	2008	2012
1	Waste Incineration	3.58	0.72	0.79	0.00	0.00	0.00	2.97	0.00	0.00	0.05	0.05
2	Ferrous and Non-Ferrous Metal Production	1.75	0.68	0.40	0.02	0.02	0.01	7.01	0.21	0.21	10.54	9.71
3	Heat and Power Generation	7.28	3.31	3.33	0.00	0.00	0.00	5.32	0.61	0.41	0.78	0.75
4	Production of Mineral Products	0.46	0.09	0.07	0.00	0.00	0.00	0.78	0.22	0.18	0.03	0.03
5	Transportation	0.64	0.71	0.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	Uncontrolled Combustion	18.30	4.78	2.44	0.00	0.00	0.00	5.7	1.04	0.78	0.00	0.00
7	Production of Chemicals and Consumer Goods	0.04	0.05	0.05	0.28	0.01	0.01	0.83	0.08	0.09	0.00	0.00
8	Miscellaneous	0.23	0.18	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	Waste Treatment	0.00	0.00	0.00	1.96	1.36	1.39	23.11	12.48	12.57	6.40	6.40
	Total[b]	**32.28**	**10.51**	**7.94**	**2.26**	**1.38**	**1.41**	**45.72**	**14.65**	**14.24**	**17.79**	**16.93**
Totals for all release vectors		**1998**				**2008 (revised)**				**2012**		
		80.26				**44.33**				**40.51**		

(a The 1998 releases to land represent releases to both land and in residues)

(b The sums of the figures in some columns may not agree exactly with the totals shown, due to rounding effects)

The estimates for releases in products have not been shown in the table because there are only two very minor sources: brick production and the use of the herbicide 2,4-D, with a total annual release of only 0.0003 g TEQ.

The figures shown at the bottom of the table for total dioxin releases to all vectors suggest that there were some very significant changes in the releases between 1998 and 2008, but that is not the case. The total release estimate originally reported for 2008 using the previous Toolkit factors was 89.4 g TEQ/year (Ministry for the Environment, 2011a), but the revised estimate now puts that figure at only 44.33 g TEQ/year. Most of this reduction is simply due to a lowering of the Toolkit release factors for some of the more significant sources, and in particular those in the uncontrolled combustion source category, as noted in section 8 of this report.

Notwithstanding the above, there have been some notable changes in the release estimates, especially between 1998 and 2008. The reductions shown for the waste incineration category were due to the closure of most of these facilities, and those shown for ferrous and non-ferrous metal production reflect a marked fall-off in overall activity for this sector. The reductions for the transport category are primarily due to improvements in the New Zealand vehicle fleet, which have continued throughout the period covered by all 3 inventories.

Some graphical summaries of the relative source distributions and the changes in these between 2008 and 2012 are given in Figures 13-1 to 13-3. These are shown separately for releases to air, land and in residues. A distribution chart has not been shown for releases to water or in products because there are only 4 and 2 source categories, respectively, for these vectors.

Figure 13-1: Releases to air by source category for 2008 and 2012

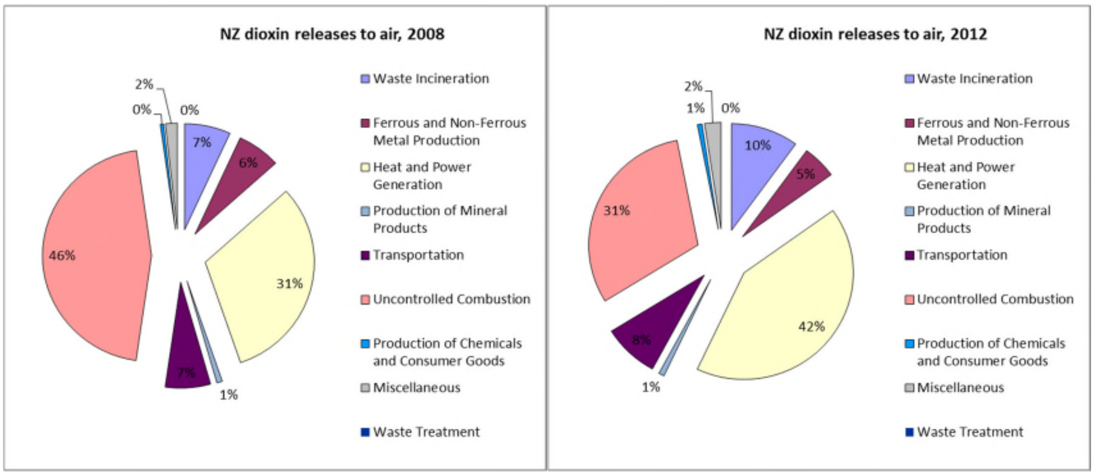


Figure 13-2: Releases to land by source category for 2008 and 2012

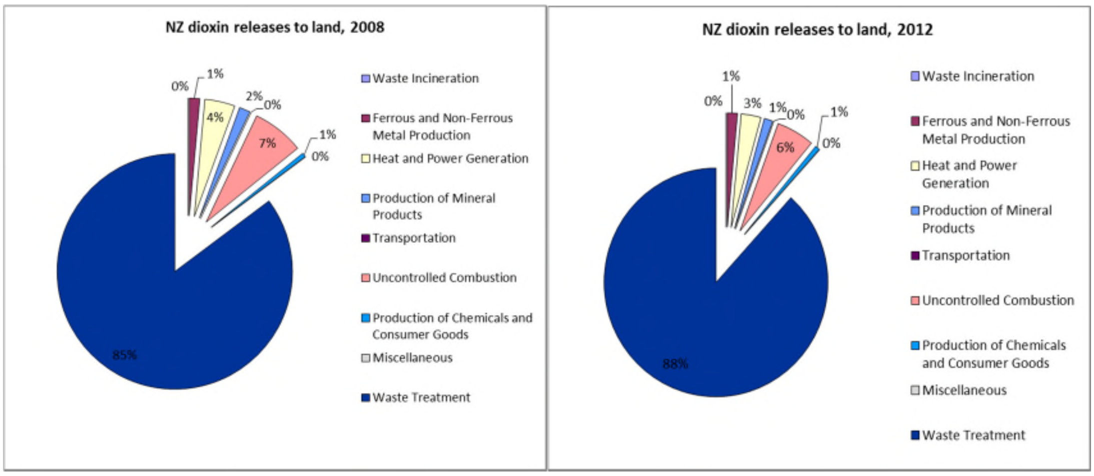
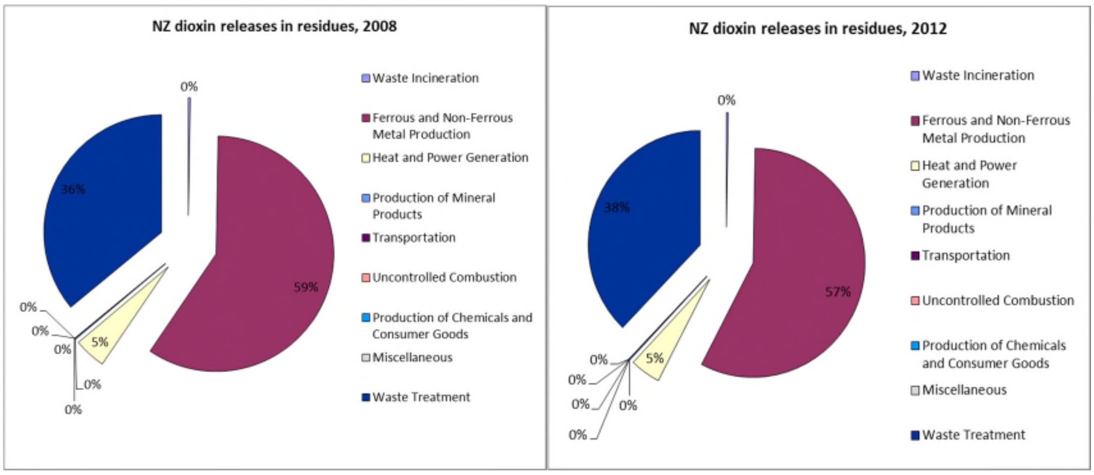


Figure 13-3: Releases in residues by source category for 2008 and 2012



13.2 Summaries of releases by vector for 2012

The 2012 releases to each vector are summarised by individual sub-categories in the following 4 figures.

Figure 13-4: Releases to air, by sub-categories for 2012

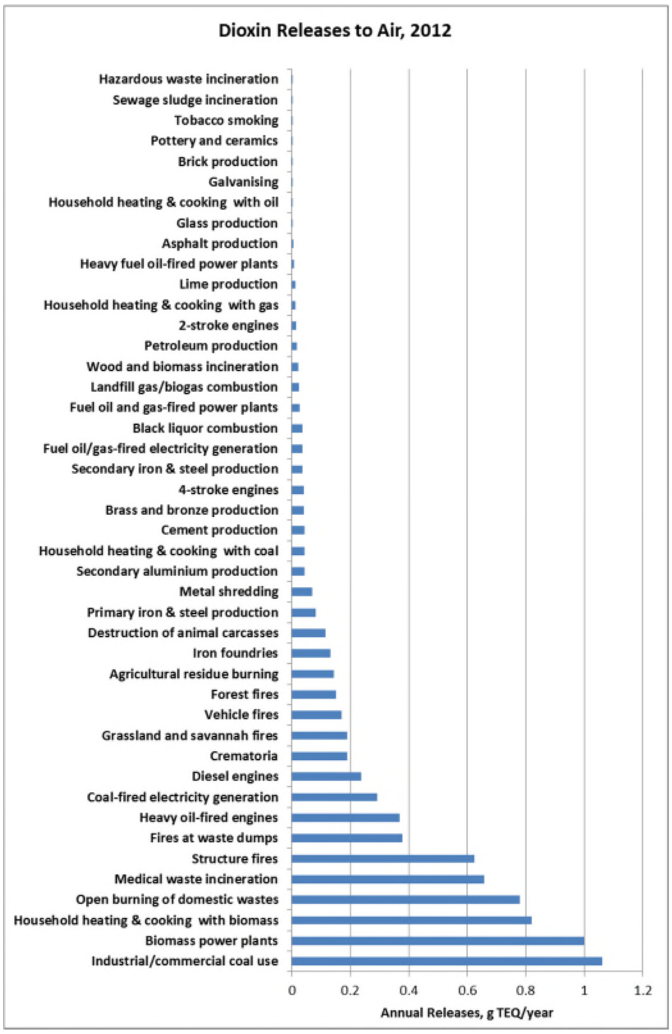


Figure 13-5: Releases to land, by sub-categories for 2012

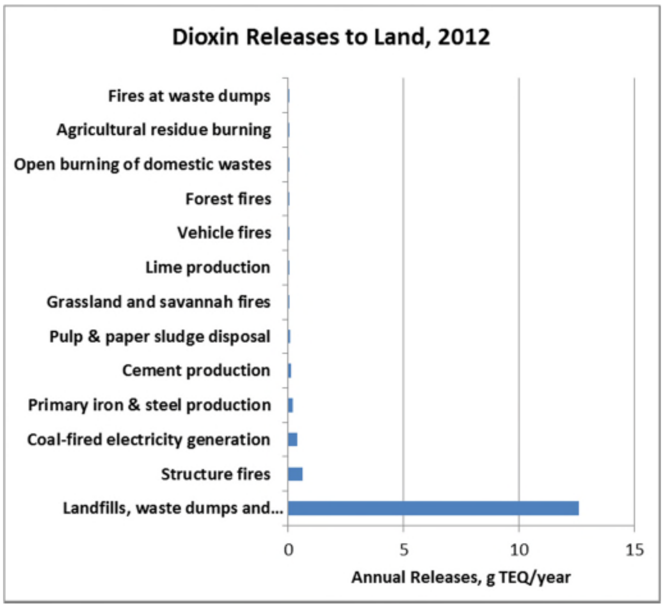


Figure 13-6: Releases in residues, by sub-categories for 2012

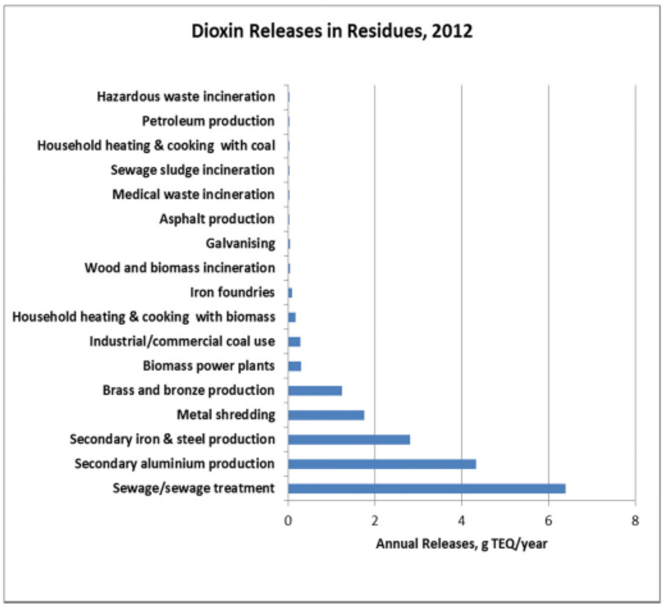
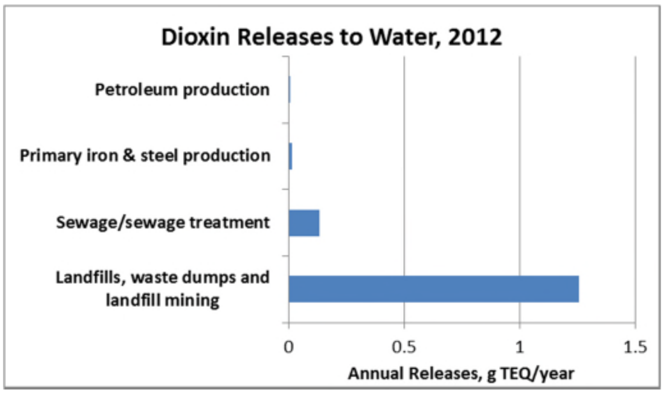


Figure 13-7: Releases to water, by sub-categories for 2012



As can be seen from Figure 13-4, the greatest releases of dioxins to air are produced by several fuel use categories. This is primarily determined by the very large numbers of these sources; for example, there are about 500 coal-fired boilers in New Zealand and more than 175 power plants fired on biomass, while the releases from household heating and cooking come from over 540,000 homes. By comparison, the releases from medical waste incineration are produced by only 2 facilities. Releases from structure fires and fires at rubbish dumps are the two next most significant sources, but the numbers of incidents for both of these have been steadily decreasing over time. The next 10 sources are associated with industrial fuel use, transport, secondary metal production, waste disposal and uncontrolled burning.

Solid waste disposal is the most significant contributor to releases to land, but with other notable contributions coming from structure fires, coal-fired electricity generation and iron and steel production (Figure 13-5). The most significant sources of releases in residues are wastewater treatment plants, secondary metal production and industrial/commercial fuel use (Figure 13-6). In New Zealand, most of these residues are ultimately disposed to landfill. As a result, there may be an element of double accounting between these releases and the total estimated releases to landfills and waste dumps. However, there is insufficient detail in the Toolkit release factors to allow the estimates to be adjusted for this effect.

There are only 4 source categories for releases to water, with the greatest contributions coming from solid and liquid waste disposal activities (Figure 13-7). The releases in products have not been shown in a chart because there are only two very minor sources: brick production and the use of the herbicide 2,4-D.

13.3 Sub-category comparisons for 2008 and 2012

Appendix 1 includes charts that show the changes between 2008 and 2012 for each Toolkit sub-category. The most notable changes shown on these charts are as follows:

Releases to air

Secondary steel production – the release reduction here is due to a real reduction in plant emissions

Secondary lead production – releases ceased due to plant closure

Coal and gas-fired electricity generation – reductions due to reduced activity rates (fuel use)

Industrial/commercial coal use – increased releases due to increased fuel use

4-stroke engines – reduced releases due to improvements in the vehicle fleet

2-stroke engines – the reduction in releases is simply due to a more precise estimate of fuel use

Waste dumps, vehicles and structure fires – reduced releases due to reductions in fire numbers

Releases to land

Waste dumps, vehicle and structure fires – reduced releases due to reductions in fire numbers

Grassland and savannah fires – reduced releases due to reductions in the area burned

Lime kilns – the reduction in releases is simply due to a change in calculation method

Releases in residues

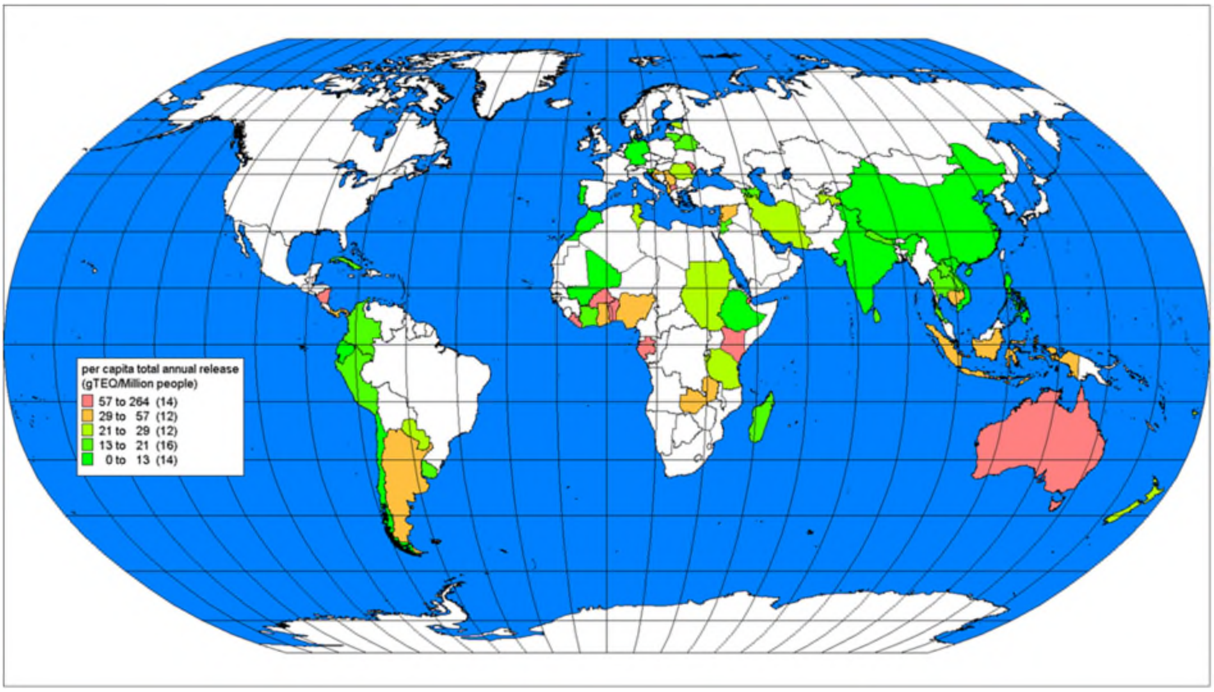
Secondary aluminium, brass and bronze – reduced releases due to reduced production rates

Metal shredding – increased releases due to the addition of a new plant

13.4 Global Perspective

The chart shown in Figure 13-7 provides a global perspective on the relative significance of the New Zealand dioxin releases. This has been copied from the UNEP Toolkit and shows the per-capita annual releases in grams TEQ per million people for 68 countries, with reference years ranging from 1999 to 2009. As shown, New Zealand is ranked in the third lowest category of 21 to 29 grams TEQ per million people. However, this is based on the original 2008 release estimates (as reported to the Stockholm Convention in 2010) which were produced using the 2nd edition of the UNEP Toolkit. The revised 2008 estimates (and also those for 2012) would give a per capita release of about 10 grams TEQ per million. However, the release estimates for other countries are likely to show similar reductions when adjusted for the new factors given in the 3rd edition of the Toolkit, so the overall rankings may not change significantly.

Figure 13-8: Global comparisons of total annual releases*



(Reproduced from Annex 7 of the Toolkit (United Nations Environment Programme, 2013))

13.5 Other New Zealand studies

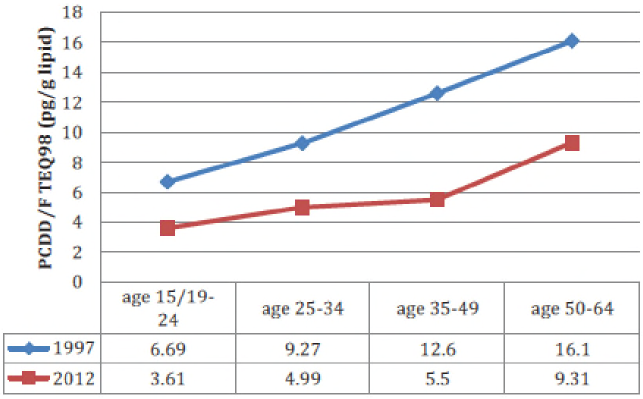
There are no official recommendations for 'acceptable' levels of national dioxin releases and it is also not possible to relate the release estimates to any potential health effects. The more relevant information is provided by national surveys of dioxin body burdens, for which there have been several New Zealand studies.

The levels of dioxins in mothers' milk have been measured on 3 occasions in New Zealand, 1988, 1998 and 2008 (Mannetje, Douwes, & Duckett, Concentrations of Persistent Organic Pollutants in the Milk of New Zealand Women, 2010). These studies showed that the dioxin concentrations in New Zealand mothers are relatively low by comparison with many other countries. Also, the levels have been steadily dropping, with a reduction of 70% observed from 1988 to 1998, and a further reduction of 40% from 1998 to 2008.

The levels of dioxins in blood serum have been monitored on two occasions in New Zealand, in 1997 and 2012 (Mannetje, Coakley, Bates, Borman, & Douwes, 2013). Once again, these studies showed the dioxin concentrations in New Zealanders are relatively low by comparison with many other countries, and the levels have dropped over time. This reduction is illustrated in the figure below and shows both a reduction from one ‘generation’ to the next (eg 25-34 year olds had lower dioxin levels in 2012 compared to 1997) but also a reduction as people get older (eg. 50-64 year olds have lower dioxin levels in 2012 than in 1997, when they were 35-49 years old).

The improvements shown by these studies are much more marked than the reductions shown by the dioxin release inventories but this would be partly because they would also reflect any changes that had occurred prior to 1998. The half-life for dioxins in the environment is typically around 15 to 25 years and the half-life in humans is about 8 to 10 years. Hence there can be a significant lag between reductions in releases and the resulting changes in humans.

Figure 13-9: Serum dioxin concentrations in New Zealanders, 1997 and 2012



	age 15/19-24	age 25-34	age 35-49	age 50-64
1997	6.69	9.27	12.6	16.1
2012	3.61	4.99	5.5	9.31

Figure 5.1. Comparison of PCDD/F serum concentrations between 2001 and current POPs studies (PCDD/F TEQ_{98})

(Reproduced with permission from (Mannetje, Coakley, Bates, Borman, & Douwes, 2013))

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Appendix 1: Summary of the current release estimates

Category	2008 and 2012 PCDD and PCDF releases (g TEQ/yr)									
	Air		Water		Land		Product		Residue	
	2008 (revised)	2012	2008 (revised)	2012	2008 (revised)	2012	2008 (revised)	2012	2008 (revised)	2012
Hazardous waste incineration	0.000029	0.000048	-	-	-	-	-	-	0.000019	0.000053
Medical waste incineration	0.657	0.657	-	-	-	-	-	-	0.0044	0.0044
Sewage sludge incineration	0.000086	0.000097	-	-	-	-	-	-	0.00075	0.00085
Wood and biomass incineration [a]	0.0235	0.021	-	-	-	-	-	-	0.042	0.042
Destruction of animal carcasses	0.130	0.116	-	-	-	-	-	-	-	-
Primary iron & steel production	0.083	0.082	0.0146	0.0143	0.210	0.206	-	-	-	-
Secondary iron & steel production	0.24	0.036	-	-	-	-	-	-	2.50	2.80
Iron foundries	0.148	0.131	-	-	-	-	-	-	0.094	0.083
Galvanising	0.0012	0.0013	-	-	-	-	-	-	0.025	0.033
Secondary aluminium production	0.058	0.044	-	-	-	-	-	-	5.40	4.05
Lead production	0.046	-	-	-	-	-	-	-	-	-
Brass and bronze production	0.081	0.042	-	-	-	-	-	-	1.920	0.993
Metal shredding	0.024	0.070	-	-	-	-	-	-	0.60	1.75
Coal-fired electricity generation	0.434	0.291	-	-	0.608	0.407	-	-	-	-
Industrial/commercial coal use	0.829	1.062	-	-	-	-	-	-	0.291	0.281

Category	2008 and 2012 PCDD and PCDF releases (g TEQ/yr)									
	Air		Water		Land		Product		Residue	
	2008 (revised)	2012	2008 (revised)	2012	2008 (revised)	2012	2008 (revised)	2012	2008 (revised)	2012
Heavy fuel oil-fired power plants	0.0077	0.0083	-	-	-	-	-	-	-	-
Fuel oil/gas-fired electricity generation	0.043	0.036	-	-	-	-	-	-	-	-
Fuel oil and gas-fired power plants	0.019	0.027	-	-	-	-	-	-	-	-
Biomass power plants	1.068	1.000	-	-	-	-	-	-	0.320	0.300
Landfill gas/biogas combustion	0.020	0.025	-	-	-	-	-	-	-	-
Household heating & cooking with biomass	0.84	0.82	-	-	-	-	-	-	0.168	0.164
Household heating & cooking with coal	0.038	0.044	-	-	-	-	-	-	0.00020	0.00023
Household heating & cooking with oil	0.0028	0.0029	-	-	-	-	-	-	-	-
Household heating & cooking with gas	0.0140	0.0135	-	-	-	-	-	-	-	-
Cement production	0.052	0.043	-	-	0.134	0.134	-	-	-	-
Lime production	0.025	0.0125	-	-	0.084	0.042	-	-	-	-
Brick production	0.00108	0.00089	-	-	-	-	0.00032	0.00027	-	-
Glass production	0.0022	0.0035	-	-	-	-	-	-	-	-
Pottery and ceramics	0.00036	0.00032	-	-	-	-	-	-	-	-
Asphalt production	0.006	0.006	-	-	-	-	-	-	0.026	0.026

Category	2008 and 2012 PCDD and PCDF releases (g TEQ/yr)									
	Air		Water		Land		Product		Residue	
	2008 (revised)	2012	2008 (revised)	2012	2008 (revised)	2012	2008 (revised)	2012	2008 (revised)	2012
4-stroke engines	0.096	0.040	-	-	-	-	-	-	-	-
2-stroke engines	0.059	0.014	-	-	-	-	-	-	-	-
Diesel engines	0.239	0.238	-	-	-	-	-	-	-	-
Heavy oil-fired engines	0.311	0.368	-	-	-	-	-	-	-	-
Agricultural residue burning	0.159	0.144	-	-	0.016	0.014		-	-	-
Forest fires	0.166	0.151	-	-	0.025	0.023	-	-	-	-
Grassland and savannah fires	0.252	0.189	-	-	0.076	0.057	-	-	-	-
Fires at waste dumps	0.675	0.378	-	-	0.0225	0.0126	-	-	-	-
Structure fires	0.850	0.625	-	-	0.850	0.625	-	-	-	-
Open burning of domestic wastes	0.720	0.780	-	-	0.018	0.020	-	-	-	-
Vehicle fires	0.333	0.171	-	-	0.060	0.031	-	-	-	-
Black liquor combustion	0.0325	0.036	-	-	-	-	-	-	-	-
Pulp & paper sludge disposal	-	-	-	-	0.083	0.093	-	-	-	-
Use of 2,4-D	-	-	-	-	-	-	0.000034	0.000034	-	-
Petroleum production	0.018	0.018	0.00775	0.00775	-	-	-	-	0.00007	0.00007
Crematoria	0.1829	0.1905	-	-	-	-	-	-	-	-
Tobacco smoking	0.00033	0.00028	-	-	-	-	-	-	-	-

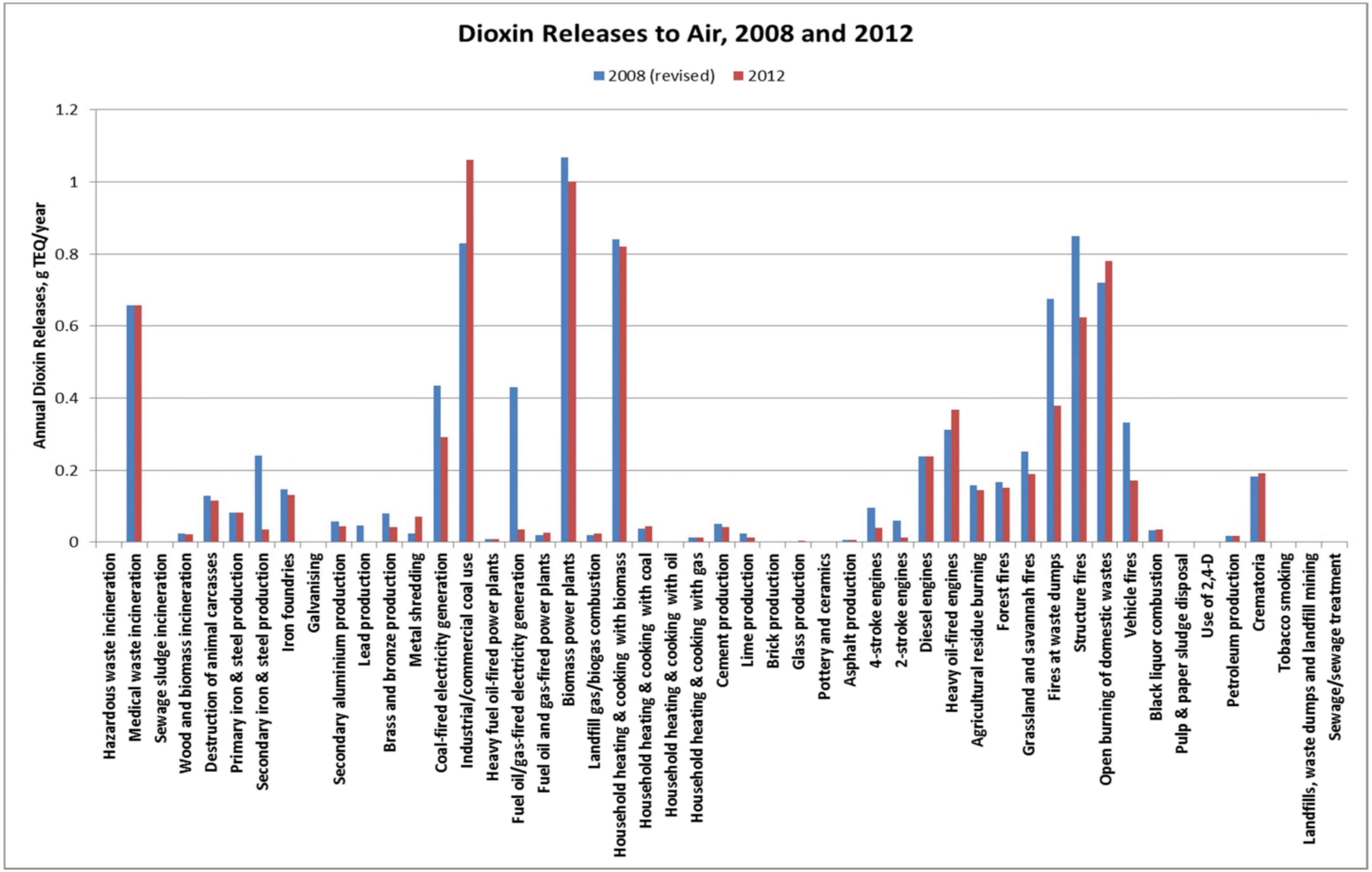
Category	**2008 and 2012 PCDD and PCDF releases (g TEQ/yr)**									
	Air		**Water**		**Land**		**Product**		**Residue**	
	2008 (revised)	**2012**	**2008 (revised)**	**2012**	**2008 (revised)**	**2012**	**2008 (revised)**	**2012**	**2008 (revised)**	**2012**
Landfills, waste dumps and landfill mining	-	-	1.228	1.257	12.276	12.571	-	-	-	-
Sewage/sewage treatment	-	-	0.134	0.134	-	-	-	-	6.400	6.400
Waste oil disposal	-	-	-	-	0.207	-	-	-	-	-
Totals	**10.507**	**7.937**	**1.384**	**1.413**	**14.646**	**14.235**	**0.000**	**0.000**	**17.791**	**16.928**

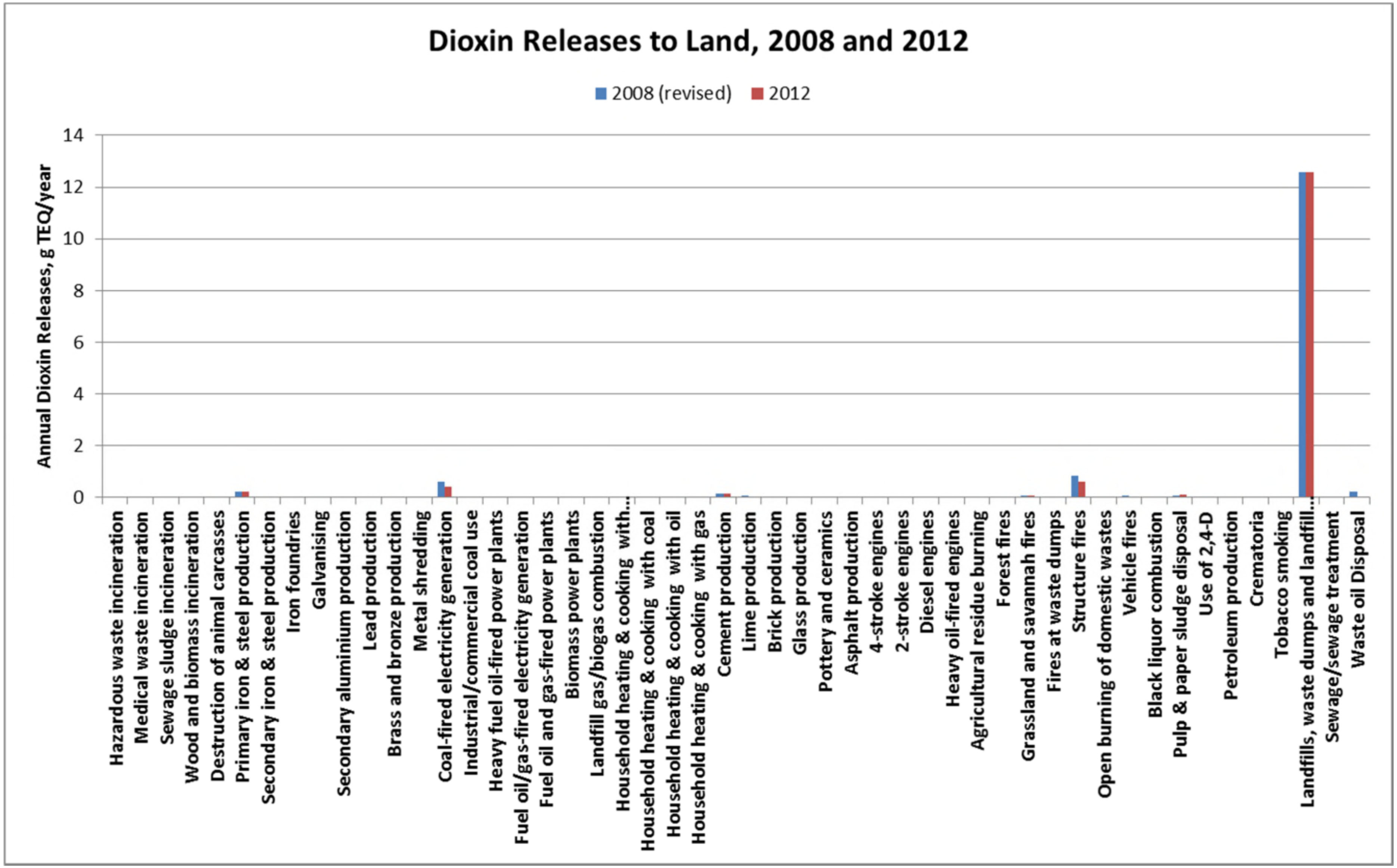
Footnotes

a For 2012 this category covers school incinerators. In 2008 it covered school incinerators and a document incinerator, which no longer operates.

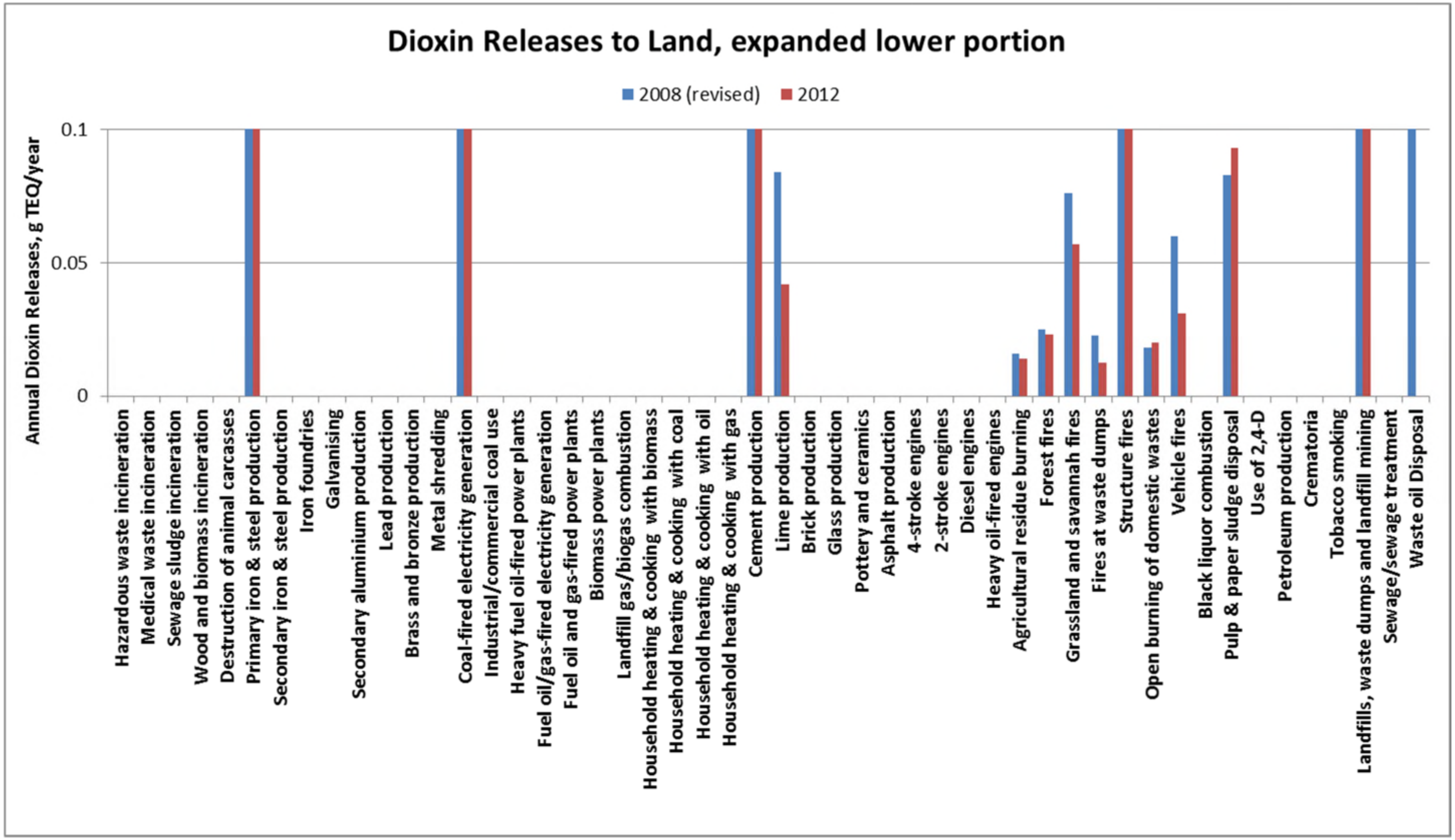
A1.1 Graphical Summaries

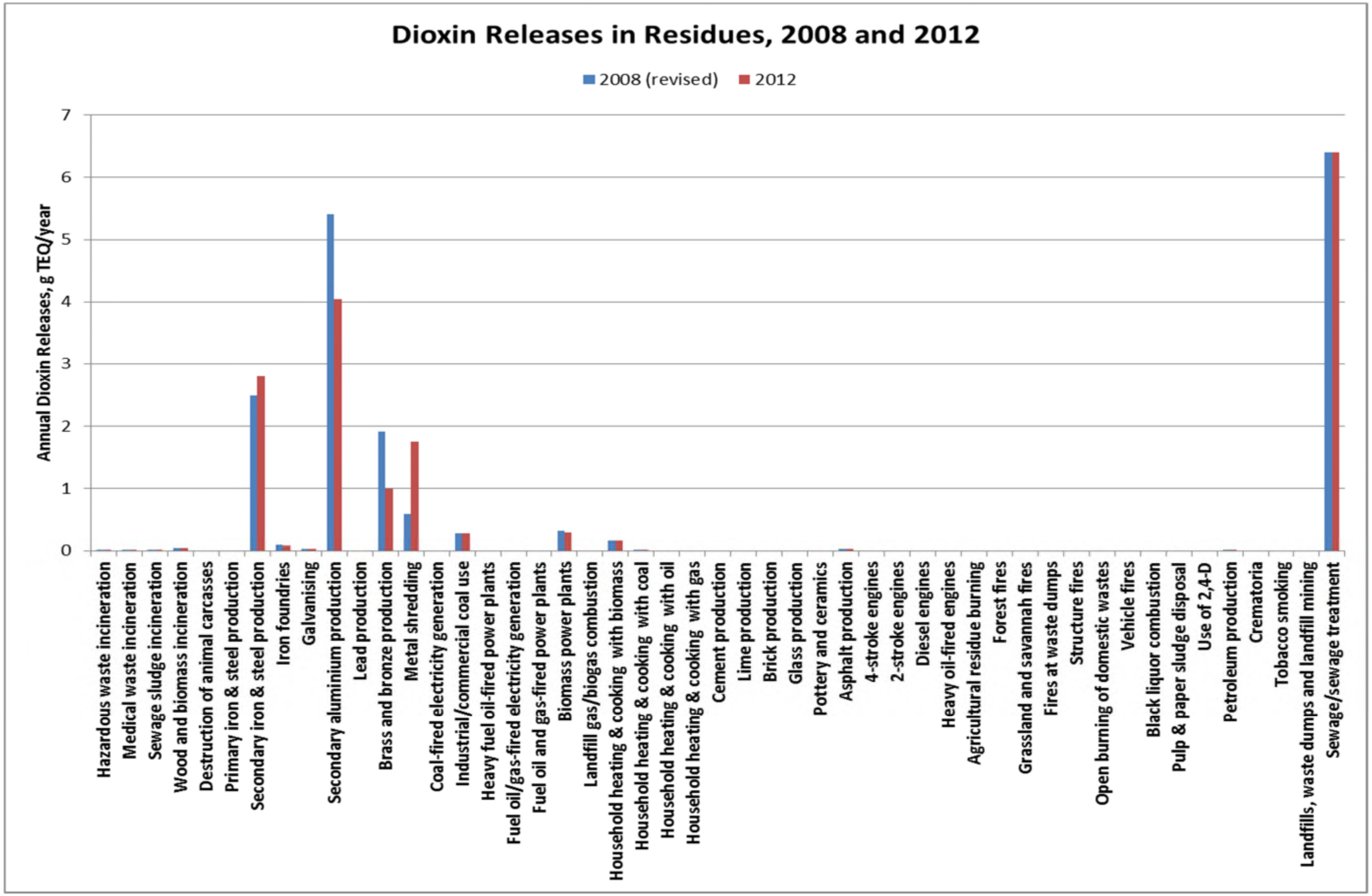
The charts shown on the following pages provide graphical comparisons of the release estimates by sub-category for 2008 and 2012. These changes are discussed in section 13.3.


Dioxin Releases to Air, 2008 and 2012
2008 (revised)
2012
Annual Dioxin Releases, g TEQ/year
1.2
1
0.8
0.6
0.4
0.2
0
Hazardous waste incineration
Medical waste incineration
Sewage sludge incineration
Wood and biomass incineration
Destruction of animal carcasses
Primary iron & steel production
Secondary iron & steel production
Iron foundries
Galvanising
Secondary aluminium production
Lead production
Brass and bronze production
Metal shredding
Coal-fired electricity generation
Industrial/commercial coal use
Heavy fuel oil-fired power plants
Fuel oil/gas-fired electricity generation
Fuel oil and gas-fired power plants
Biomass power plants
Landfill gas/biogas combustion
Household heating & cooking with biomass
Household heating & cooking with coal
Household heating & cooking with oil
Household heating & cooking with gas
Cement production
Lime production
Brick production
Glass production
Pottery and ceramics
Asphalt production
4-stroke engines
2-stroke engines
Diesel engines
Heavy oil-fired engines
Agricultural residue burning
Forest fires
Grassland and savannah fires
Fires at waste dumps
Structure fires
Open burning of domestic wastes
Vehicle fires
Black liquor combustion
Pulp & paper sludge disposal
Use of 2,4-D
Petroleum production
Crematoria
Tobacco smoking
Landfills, waste dumps and landfill mining
Sewage/sewage treatment

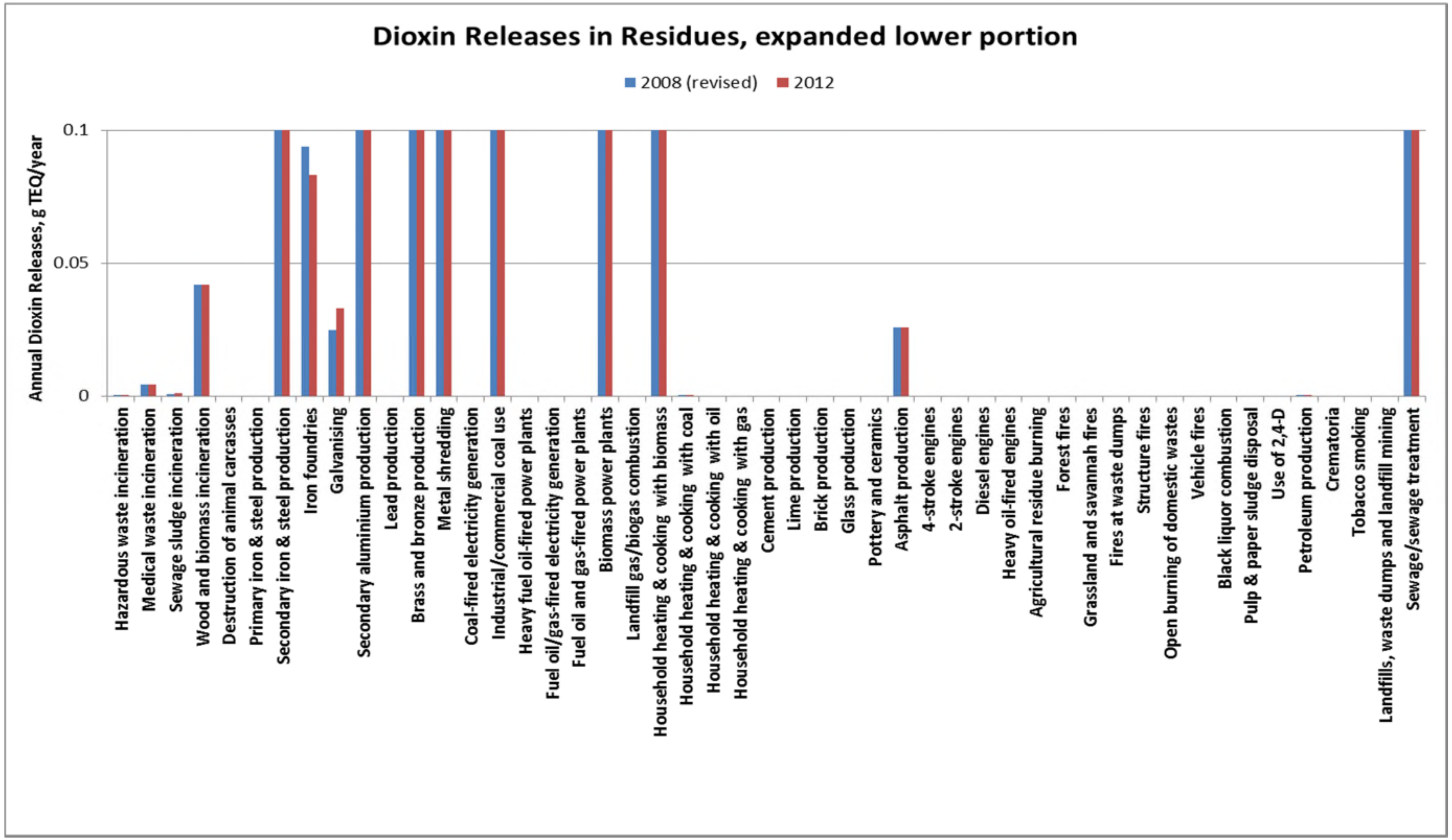

Dioxin Releases to Land, 2008 and 2012
2008 (revised)
2012
Annual Dioxin Releases, g TEQ/year
14
12
10
8
6
4
2
0
Hazardous waste incineration
Medical waste incineration
Sewage sludge incineration
Wood and biomass incineration
Destruction of animal carcasses
Primary iron & steel production
Secondary iron & steel production
Iron foundries
Galvanising
Secondary aluminium production
Lead production
Brass and bronze production
Metal shredding
Coal-fired electricity generation
Industrial/commercial coal use
Heavy fuel oil-fired power plants
Fuel oil/gas-fired electricity generation
Fuel oil and gas-fired power plants
Biomass power plants
Landfill gas/biogas combustion
Household heating & cooking with...
Household heating & cooking with coal
Household heating & cooking with oil
Household heating & cooking with gas
Cement production
Lime production
Brick production
Glass production
Pottery and ceramics
Asphalt production
4-stroke engines
2-stroke engines
Diesel engines
Heavy oil-fired engines
Agricultural residue burning
Forest fires
Grassland and savannah fires
Fires at waste dumps
Structure fires
Open burning of domestic wastes
Vehicle fires
Black liquor combustion
Pulp & paper sludge disposal
Use of 2,4-D
Petroleum production
Crematoria
Tobacco smoking
Landfills, waste dumps and landfill...
Sewage/sewage treatment
Waste oil Disposal

Note: this chart is simply an expanded form of the previous chart to allow the changes for the less significant sources to be more clearly identified.




Dioxin Releases in Residues, 2008 and 2012
2008 (revised)
2012
Annual Dioxin Releases, g TEQ/year
7
6
5
4
3
2
1
0
Hazardous waste incineration
Medical waste incineration
Sewage sludge incineration
Wood and biomass incineration
Destruction of animal carcasses
Primary iron & steel production
Secondary iron & steel production
Iron foundries
Galvanising
Secondary aluminium production
Lead production
Brass and bronze production
Metal shredding
Coal-fired electricity generation
Industrial/commercial coal use
Heavy fuel oil-fired power plants
Fuel oil/gas-fired electricity generation
Fuel oil and gas-fired power plants
Biomass power plants
Landfill gas/biogas combustion
Household heating & cooking with biomass
Household heating & cooking with coal
Household heating & cooking with oil
Household heating & cooking with gas
Cement production
Lime production
Brick production
Glass production
Pottery and ceramics
Asphalt production
4-stroke engines
2-stroke engines
Diesel engines
Heavy oil-fired engines
Agricultural residue burning
Forest fires
Grassland and savannah fires
Fires at waste dumps
Structure fires
Open burning of domestic wastes
Vehicle fires
Black liquor combustion
Pulp & paper sludge disposal
Use of 2,4-D
Petroleum production
Crematoria
Tobacco smoking
Landfills, waste dumps and landfill mining
Sewage/sewage treatment

Note: this chart is simply an expanded form of the previous chart to allow the changes for the less significant sources to be more clearly identified.



Appendix 2: Report on domestic rubbish burning

This appendix provides a summary of the information used in developing the activity data for the release estimates reported in section 8.2.3: Open burning of domestic waste. It includes a review of the current controls on domestic rubbish burning in regional plans, national and regional incident data for rubbish burning, and a summary of recent regional surveys. The latter have provided the key information required for section 8.2.3, which is an estimate of the number of households that burn rubbish and the average quantities burned per household.

A2.1 Controls on domestic rubbish burning

The operative Air Plans for the 12 Regional Councils and 4 Unitary Authorities have been reviewed for the extent to which they currently control domestic rubbish burning. A summary of the relevant information is given in the table at the end of this appendix, and the key points arising out of the analysis are as follows:

> **Domestic rubbish burning:** this has only been prohibited in 2 regions. It is regulated[12] in 5 others, although in some of these the controls only apply to parts of the region, such as urban areas. It is permitted in 2 regions, but is not specifically addressed in 7. In addition, some local authorities have banned the use of backyard rubbish incinerators.
>
> **Other domestic waste burning:** the burning of green wastes, paper, cardboard and untreated wood on domestic properties is permitted in 7 regions, and subject to controls in 3 others. It is prohibited in specified areas within 4 regions, and not addressed at all in 2.
>
> **Waste burning in rural areas:** the rural burning of green wastes, paper, cardboard and untreated wood is permitted in 15 of the regional air plans and not addressed in 1. The burning of other general wastes is permitted in 5 regions, regulated in 7, prohibited in 1 and not addressed in 3 of the regions.

It should be noted that where activities are not specifically addressed in a Plan, the default status for those activities would usually be discretionary (ie. requires a resource consent).

A2.2 National and regional incident data

The annual incident data reported by the New Zealand Fire Service for rubbish-related fires is given in Table A2.1 for the period 2008 to 2012. Despite the relatively high numbers of fires in 2008 and 2010, the figures do indicate an overall reduction in incident numbers. For example the average number of fires for these five years is 5,645, whereas for the period 2003 to 2007 the average was 6840.

Table A2.1: NZ Fire Service national incident data for rubbish burning

	Number of Incidents per Year				
Fire type	**2008**	**2009**	**2010**	**2011**	**2012**
Outside rubbish fire	4,644	3,111	4,519	2,813	3,282
Rubbish bin or skip fire	1,792	1,126	1,600	849	1,015
Bonfire	806	570	925	521	652
Total fire numbers	**7,242**	**4,807**	**7,044**	**4,183**	**4,949**

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[12] The term regulated is used here to refer to the normal plan classifications of controlled, restricted-discretionary, and discretionary.

Information on burning incidents has also been obtained from a number of regional councils. This relates to complaints received from members of the public in relation to nuisance effects such as smoke or odour, which are recorded in the councils' complaint databases. The information is summarised in the table below. It should be noted that the data covers all types of burning incidents (i.e. not just domestic rubbish burning) and some incidents may have attracted multiple complaints.

Table A2.2: Council complaint data for burning incidents

Region	Number of Complaints per Year		
	2011	**2012**	**2013**
Northland	197	172	190
Auckland		1700*	1766
Waikato	151	154	153
Hawkes Bay	55	84	86
West Coast	8	6	4
Otago	175	192	280
Southland**		94	163
Totals		2402	2642

(* Auckland data has been scaled up based on 850 complaints received over the second half of the year)

(**Southland data covers the 2011/2012 and 2012/2013 financial years)

The regions listed in the table represent about 58% of the current New Zealand population, which suggests a total national incident rate of about 4,140 to 4,555 fires per year. This is quite comparable to the 4,183 and 4,949 fires attended by the NZ Fire Services in 2011 and 2012, although it should be recognised that the data doesn't necessarily cover the same types of incidents. The Fire Service attends fires where there is a risk to public safety or property, whereas the council complaints relate to nuisance impacts. In addition, there would be numerous fires that are not picked up by either of these recording systems.

A2.3 Surveys of domestic rubbish burning

Some of the home heating surveys noted in section 5.4 of this report also collect information on domestic rubbish burning. The results from four such surveys were noted in the 2008 Inventory, for which it was reported that between 5 and 11% of households burned domestic rubbish or garden wastes and the annual waste-burning rates varied from about 200 to 1000 kg per household. The results from 6 more recent surveys are summarised in Table A2.3.

If the numbers shown in the table are adjusted for differences in the numbers of households covered by each survey, the results indicate that on average 6.3% of households burn rubbish on 7.6 occasions each year. However, these figures may not be entirely indicative of the situation throughout the country because, for example, the most recent home heating surveys for Auckland and Christchurch did not include domestic rubbish burning, since the practice is banned within those urban areas (although the complaints data in Table A2.3 indicates that some burning does still occur Auckland). The Auckland and Christchurch urban areas account for about 35% of all households in New Zealand.

For the previous dioxin inventory, it was assumed that rubbish burning was practiced by 5% of all households on 5 to 10 occasions per year, and the average quantity of material burned was 250 kg per household, per year (ie 25 to 50 kg per burn, based on estimates included in some of the regional reports). The results from the more recent surveys suggest that these assumptions should also be applicable for the current inventory.

Table A2.3: Survey results for domestic rubbish burning

Town or City	Number of households	% of households burning rubbish	Average number of fires per household	Information source
Taupo	7,944	5%	10 per yr	Wilton & Baynes, 2009
Thames	2,552	14%	17 per yr	Wilton & Baynes, 2009
Huntly	2,717	12%	26 per yr	Wilton & Baynes, 2009
Taumaranui	1,928	25%	21 per yr	Wilton & Baynes, 2010a
Taihape	714	23%	22 per yr	Wilton & Baynes, 2010a
Gore	3,174	10%	13 per yr	Wilton 2011
Invercargill	16,757	2%	14 per yr	Wilton 2011
Hamilton	49,137	4%	2 per yr	Wilton, 2012
Tokoroa	4,869	10%	20 per yr	Wilton 2012
Rotorua	17,421	11%	5 per yr	APR, 2012
Reefton	417	13%	17 per yr	Wilton, 2013
Averages*		6.3	7.6	

(* The averages are population-weighted figures)

Table A2.4: Summary of regional rules on rubbish burning

(Abbreviations: O/O/N effects = offensive, objectionable, or noxious effects (or similar))

Region and Information Source	Urban/Domestic Burning	Rural Burning
Northland Northland Regional Air Plan with amendments to 1/12/2008	Rule 10.3.2 Open burning or incineration of any material within the Whangarei Airshed on properties <1 ha, and on properties >1ha during June, August, August, is a Restricted Discretionary activity. Burning or incineration is permitted in all locations under Rule 10.2.8, except for some specified wastes, provided alternative disposal methods have been considered, and no O/O/N effects.	
Auckland Auckland Regional Plan: Air, Land and Water, operative in part, 21/10/2010, Chapter 4 (Air)	Rule 4.5.21.Outdoor burning or burning in a backyard or single chamber incinerator (except for barbeques, hangi, etc) is prohibited in all Urban, Industrial and Coastal Marine Air Quality Management Areas.	Rule 4.5.12 open burning or incineration of untreated wood, paper or vegetation is permitted in Rural Air Quality Management Areas, parts of Urban AQMs not zoned as urban, and the Waiheke Outdoor Burning Area.
Waikato Waikato Regional Plan, operative in full 10/4/2012, Module 6 (Air)	Rule 6.1.13.1 The discharges to air from open burning or incineration of untreated wood and vegetative matter, paper and cardboard, food waste, non-halogenated plastics, and animal carcasses (on production land) are permitted activities, provided no O/O/N effects, the material is sourced only from the property where burning occurs. The burning of a range of specified materials, such as chlorinated plastics, is prohibited by Rule 6.1.13.4 and most other burning is a discretionary activity under Rule 6.1.13.2.	
Bay of Plenty Bay of Plenty Regional Air Plan, operative 31/8/2006 and updated 1/8/2012	Rule 5 The discharge of contaminants into air from combustion in the open air is a permitted activity provided no O/O/N effects, all reasonable measures must be taken to ensure good management practice when burning (guidance given in a schedule), and fires must not be lit when there is a likelihood of an inversion layer, and a list of specified substances may not be burned. Burning of the specified substances is prohibited under Rule 20.	
Gisborne District Regional Air Quality Management Plan, fully operational 14/1/2008	Rule 4 Burning of untreated wood, dry vegetative matter, paper and cardboard in an incinerator complying with specified design features and with a capacity of no more than 200 litres (40-gal drum) is permitted, provided no O/O/N effects.	
Taranaki Regional Air Quality Plan for Taranaki, operative 25/7/2011	The outdoor burning of domestic waste products and green waste within a defined urban area is prohibited under Rule 31, where the allotment is less than 0.5 ha, and is used primarily for residential purposes, and is serviced by a weekly municipal refuse collection service	The burning of waste material on production land is permitted under Rule 30, provided the wastes are only generated on the property, burning rate is less than 1000 kg/hr, and wastes are limited to untreated wood or sawdust, non-chlorinated plastics, paper, cardboard and like materials.
Hawkes Bay Hawkes Bay Regional Resource Management Plan, with amendments, 17/3/2010 and Air Quality Plan Change 2, operative 1/1/2012	Rule 19 Except as provided for under Rule 20, the open burning of waste is a permitted activity, provided the waste has been generated on the same property or on another property with the same owner, the waste does not contain specified materials, and there are no O/O/N effects. Rule 19a permits the open burning of vegetative matter, paper, cardboard and untreated wood, with similar controls, but burning within the Napier and Hastings Airsheds during the period May to August is a non-complying activity under Rule 19c.	
Horizons Manawatu Horizons Regional Council Proposed One Plan, Chapter 14 (Air) as amended August 2010	Rule 14-5 The outdoor burning of untreated wood, vegetative matter, waste paper and cardboard, food waste, non-halogenated plastics and animal carcasses or animal waste (on production land) is permitted under this rule provided the material is sourced on-site and there are no O/O/N effects.	

Region and Information Source	Urban/Domestic Burning	Rural Burning
Wellington Wellington Regional Air Quality Management Plan, operative 1/9/2003	Burn-offs associated with land clearance activities are permitted under Rule 18, subject to conditions around visibility and other adverse environmental effects. The combustion of 'other materials' is permitted under Rule 19 provided there are no O/O/N effects and specified wastes are excluded.	
Marlborough District Marlborough Sounds Resource Management Plan, operative 28/3/2003 and Wairau Awatere Resource Management Plan, operative 1/3/2009	The discharge of contaminants to air from the incineration of untreated wood, vegetation, newspapers, magazines and cardboard is a Permitted Activity provided an incinerator is used, the waste is generated on-site and there are no O/O/N effects. (This rule is reproduced at several places within both of these Plans to cover the different land-use zones (rural, rural-residential and urban).	
Nelson City Nelson Air Quality Plan, operational 3/11/2008 with air quality rules updated August 2012	Under Rule AQr54.1, outdoor burning is only permitted within the Urban Zone or the Higher Density Small Holdings Area of the Rural Zone for purposes such as cooking and traditional crafts, and the material burned must not include clippings, prunings, leaves or other garden waste and no household waste. Any outdoor burning that cannot comply with these requirements but is to be done on sites greater than 1ha (urban) or 2 ha (rural) is classed as Restricted Discretionary, while burning on smaller sites is prohibited. Outdoor burning is permitted in the Rural Zone under Rule AQr55.1, subject to various conditions, and provided it does not include the burning of municipal, industrial or trade waste, nor of any material not generated on the site.	
Tasman District Tasman Resource Management Plan, operative 28/9/2013	Outdoor burning, including burning in an incinerator is a permitted activity under Rule 36.3.2.3, in most parts of the District. The material to be burned must not include any municipal, domestic, industrial or trade wastes, or plastics (with some agricultural plastic exceptions), and any vegetation, paper and cardboard must be sourced from no more than three adjoining properties. In addition, vegetation must have been dried for at least seven days, and there must be no O/O/N effects. Additional restrictions apply to burning in specified Fire Ban and Fire Sensitive Areas, which is a controlled activity under Rule 36.3.3.3.	
West Coast West Coast Regional Air Plan, 31/7/2002	Domestic waste burning is not covered under the Plan and is left to the control of local authorities under the nuisance provisions of the Health Act.	
Canterbury Canterbury Natural Resources Regional Plan, Chapter 3, Air Quality, operative 11/6/2011	The outdoor burning of vegetation, paper, cardboard and untreated wood is generally permitted under Rule ALQ29 and the burning of standing crop residues or vegetative stubble is permitted under Rule ALQ28. However it is classified as a non-complying activity under Rule ALQ29A for residential or living zones when appropriate waste collection services are provided. Outdoor burning in Christchurch Clean Air Zones during May to August is classified as non-complying under Rule 35, but there are some exemptions for production land under Rules ALQ35A and 35B. Outdoor burning not covered under other rules is discretionary under Rule ALQ34.	
Otago Regional Plan: Air for Otago, operative 1/1/2009	The outdoor burning of paper, cardboard, vegetative matter or untreated wood on residential and non-residential properties, including production land, is permitted under Rules 16.3.2.1 to 16.3.2.4, with minor variations in conditions depending on the location and type of property within 3 Air Zones. Rule 16.3.2.5 permits outdoor burning for activities such as campfires and cooking, while Rule 16.3.2.6 classifies all other outdoor burning as discretionary. The burning of a wide range of specific materials is prohibited under Rule 16.3.3.1 and is discretionary under 16.3.3.2 for any other materials not listed.	
Southland Regional Air Quality Plan for Southland operative 1/3/1999 (currently under review)	No specific rules.	

Appendix 3: Report on waste oil use and disposal

A3.1 Introduction

Significant quantities of used lubricating oil are produced annually in New Zealand. Whereas in the past a significant proportion was disposed of to land and its energy lost, it would appear that most of this waste oil is now used to replace or supplement fossil fuels in a variety of industries.

The categories and sub-categories for which the UNEP Toolkit sees waste oil being involved in the dioxin release process are waste incineration, power plants, domestic heating and cooking, cement kilns, brick works, asphalt plants and transportation. However the quantities of used oil are not captured in the release calculations because the Toolkit factors are based on activity rates associated with production rates or vehicle kilometres travelled. There is a lack of information concerning firstly the amount of waste oil that is generated in New Zealand and secondly the fate of that oil.

To bridge the knowledge gap, information has been sought both directly and indirectly from a number of sources including oil import statistics, collectors, processors and distributors of waste oil, and companies involved with using waste oil as an energy source. Guidelines and legislative requirements for waste oil are also discussed as these provide restrictions on the way the material can be used and disposed. Historical aspects of waste oil treatment and use have been investigated too as these are often useful in helping to fill information gaps by inference.

A3.2 Background

Every year about 68 million litres of lubricating oil is imported to New Zealand for use in petrol and diesel engines and hydraulics (data obtained from www.stats.govt.nz/infoshare). Lubricating oil is composed of highly stable long chain hydrocarbons which themselves do not wear out with use. Rather lubricating oil loses its efficacy partly because over time it is affected by the build-up of contaminants such as carbon and metal oxidation products, water and sludge, and partly because additives which are blended in to improve the oil's lubricating and protective qualities become exhausted and fail to protect the engine (Auckland Regional Council, 1999).

When an engine is serviced and the oil is changed, the left-over used oil contributes to the single largest non-watery liquid waste stream in New Zealand – about 35 million litres of waste oil per year (P de Goldi, Fulton Hogan, pers comm, 2014) (Slaughter & Halliday, 2008). This waste is a valuable resource because it has a high calorific value. It can be used as a fuel to replace or to supplement existing fossil fuels such as coal, diesel or natural gas. Waste oil has been used in New Zealand to supplement the energy requirements of a number of industries including cement, lime and brick manufacturing, horticulture, road building, pulp and paper mills and food manufacturing.

Although waste oil may be valuable to its industrial end-users there are a great many small-scale domestic oil users who change their own oil and for whom the material has no value. It has been estimated that over 2 million litres of waste oil is produced by New Zealand households each year (see: http://www.oilrecycling.org.nz) and initiatives are currently being developed to facilitate waste oil disposal for these small domestic generators.

In addition to imported oils there is another source which contributes to the New Zealand waste oil pool – oily ships' slops. This waste consists of an oil and water mixture (oily slops) produced from bunker fuel oil and lubricant drainage. About 14 million litres of ships' slops (which on average contain 50% water prior to treatment) are processed annually by Transpacific Technical Services (M Hollands, Transpacific Technical Services, pers comm, 2014).

A3.3 Processes leading to lubricating oil consumption and loss

At first glance it would appear that there is a significant mismatch between the 35 million litres of waste oil available for re-use compared with the 68 million litres of new oil introduced to New Zealand annually. However, it should be remembered that in some processes such as 2-stroke engines, and chain-bar lubrication, the oil is actively consumed. More significantly, 4-stroke internal combustion engines can consume between 40 and 60% of their lubricating oil during use (Ministry for the Environment, 1997). Oil consumption occurs at varying rates amongst individual vehicles and depends on a variety of factors including engine age, engine design and materials used, such as hard or soft piston rings, engine size and average rpm (Lubrication Engineers, 1991). A trend towards lower overall oil consumption per vehicle, most likely attributable to technological improvements, is evident from declining lubrication oil import figures despite the size of the vehicle fleet increasing.

2-stroke engines are lubricated by adding oil to the fuel at a rate of 2 to 4% by volume. It has previously been estimated that 500,000 litres of marine 2-stroke oil were consumed in New Zealand in 2003 (Ministry of Economic Development, 2008b). Land based 2-stroke engines tend to be small and light with high power to weight ratios. They are used extensively in portable equipment such as chain-saws, and tools used in park maintenance and domestic gardening. However there is no statistical information available on fuel consumption for this group. Information is available for another use of 2- stroke engines – mopeds or scooters. The Ministry of Transport estimated that 356 million kilometres were travelled by motorcycles and mopeds in 2012 (Ministry of Transport, 2013). Of a total fleet of 112,000 vehicles, 30,000 had an engine capacity less than 60 cc, and half of these are assumed to be 2-stroke scooters. Assuming firstly a simple proportional share of distance travelled at 97.1 million kilometres, and secondly a fuel efficiency for scooters of 4 litres per 100 kilometres[13], and thirdly that oil is added at the rate of 2% of the fuel volume, it can be estimated that 39,000 litres of lubricating oil are consumed directly by scooters annually.

On the whole, industrial generators of waste oil in New Zealand are now well catered for in terms of collection services and are probably more conscious of their disposal obligations, as specified in the code of practice for the *Handling and Management of Used Oil* (Environmental Protection Authority, 2013). Waste oil economics are such that disposal companies offer free collection for generators of 400 litres or more.

There is evidence to suggest that domestic users are less aware of their responsibilities to dispose of oil properly. For instance it is estimated that 656,000 litres of waste oil produced by non-commercial users is in need of collection in the Auckland region and that only 31% of this is being recovered by existing services such as the Hazmobile, waste oil collection agents and other known sources (see: http://www.oilrecycling.org.nz).

A snapshot survey conducted by the Auckland Regional Council of individuals undertaking their own engine oil changes revealed that 12% disposed of their waste oil through the Hazmobile, 21% took it to a garage or mechanic, and the remainder used methods such as pouring it down the drain, digging a hole in the garden or storing it at home. Disposal to sewer or burying are inappropriate methods of disposal (Environmental Protection Authority, 2013).

Assuming that Auckland's domestic oil producers are representative of New Zealand as a whole, the 453,000 litres of waste oil unaccounted for in Auckland can be extrapolated to a national figure of 1.41 million litres.

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[13] This equates to a 2-stroke fuel consumption of 3.8 million litres, or 2,800 tonnes per year. This figure has been used in the transport emission calculations given in Section 7.2.2.

A3.4 Current legislative requirements

The New Zealand Environmental Protection Authority has published a code of practice for the *Handling and Management of Used Oil* (herein referred to as the Code of Practice) (Environmental Protection Authority, 2013). The document sets out the responsibilities of industrial and domestic generators, collectors, transporters, processors and end-users.

The Code of Practice states that used oil re-processed as a fuel must be converted into a distinct marketable substance with maximum permissible levels of lead, arsenic, cadmium, chromium, and total halogens, and a flashpoint higher than 60°C. These levels may be exceeded if permitted by a resource consent, and where the waste oil is used as a heat source the code requires that the burner conforms to standard EN746-2:2010.

Where waste oil is not conditioned for re-use or used as a fuel, the Code of Practice states that it can only be disposed of either by export or by treatment so that it becomes non-hazardous. Options for the latter include combustion in a managed incineration facility and depositing in a landfill, provided the landfill is licensed to accept the waste oil. However the Ministry for the Environment's landfill guidelines prohibit the disposal of used oil in sanitary landfills (Class A and Class B) and also cleanfills. An update of the guidelines is currently in preparation (Waste Management Institute of New Zealand, 2013).

The Code of Practice also advises that the following methods of used oil disposal are inappropriate and in contravention of requirements under the HSNO and Resource Management Acts, and the National Environmental Standards for Air Quality:

- unauthorised disposal on the ground, or into watercourses, sewers or drainage systems
- burial
- use for dust control, weed abatement, or vegetation control
- timber preservation by painting, staining or dipping
- pest control or as a carrier fluid for agrichemicals (pesticides or herbicides)
- use as a marker, e.g. on playing fields
- placing used oil in rubbish bins to be collected as part of household waste (except for the disposal of well drained used oil filters and oily rags)
- open-air burning
- combustion in, for example, kerosene burners, or as a fuel without an appropriate consent under the RMA
- any other practices, in which the used oil may cause contamination of the ground and ground water, migrate to watercourses, contaminate air or have negative impacts on humans, plants, animals or other organisms.

A3.5 Previous New Zealand waste oil apportionment studies

A Ministry for the Environment analysis of waste oil production and fate performed in 1997 gave the following facts for the period (Ministry for the Environment, 1997). New Zealand used 60 – 70 million litres of lubricating oil annually, 40 million litres of which was used in the transport industry, with the remainder in industrial and other processes. About 23 million litres found its way into waterways, harbours and oceans or was dumped into landfills. Of a total pool of 31 million litres of waste oil available for further use it was estimated that 7 million litres was refined by the Dominion Oil Recycling Plant, 7 million litres was used for road oiling, 4 million litres was used in low temperature burning (e.g. greenhouse heating), 4 million litres went to landfill, and wood staining and chain bar oiling accounted for 4 million litres. The remaining 5 million litres was unaccounted for.

More recently, in a paper presented to the annual conference of the Waste Management Institute of New Zealand it was estimated that the total amount of waste oil produced in New Zealand for 2007 was 35 million litres (Slaughter & Halliday, 2008). The authors reported that a survey of Regional Councils and unitary authorities showed that activities covered by a resource consent could account for 18.4 million litres of used oil in 2007. Major consented users were identified as cement (13 million litres), hot mix asphalt (3.8 million litres) and burnt lime (1.3 million litres). Smaller non-specified consent holders accounted for a further 1.3 million litres. Southland, Otago, Taranaki and Gisborne Regional Councils were able to account for 740,000 litres that were used as a dust suppressant on roads as a permitted activity. The authors contended that the remaining 15.9 million litres was being directed to unconsented activities.

Horticulture was identified as a major source of unconsented used oil practices. The authors derived estimates of 3.9 million litres used for floriculture greenhouse heating and 3.8 million litres for vegetable greenhouse heating. The remaining 7.2 million litres were not accounted for.

A3.6 Historic oil recovery schemes – the used oil recovery programme

The Used Oil Recovery Programme (UORP) was set up in 1996 by a consortium of Holcim, Shell, BP, Caltex and DR Britten Ltd (Valvoline). This was done in response to industry concerns at the time that used oil was not being recovered and used responsibly. Its purpose was to collect used oil and supply it to the Holcim cement plant in Westport, and to the re-refining plant operated by Dominion Oil Refining Company in Auckland (Halliday, Slaughter, Rynne, & Totty, 2007). Combustion of used oil as a supplementary fuel for coal began at Westport in 1996 but Dominion Oil ceased operations in 1999, making Holcim the sole outlet for used oil from the UORP.

A3.7 Current oil recovery schemes and quantities handled

A3.7.1 Stewardship schemes

There is provision in the Waste Minimisation Act for the Minister for the Environment to recognise product stewardship schemes and award them with accreditation, and there are two such schemes related to waste oil collection which have been accredited by the Minister (www.mfe.govt.nz/issues/waste/product-stewardship/-accredited-schemes-in-nz).

The Geocycle scheme, which is a continuation of the 1996 UORP, involves the New Zealand-wide collection of used oil by contracted service providers, for the purpose of supplying the Holcim cement plant in Westport. The scheme is managed by Geocycle, which is a Holcim subsidiary company. At one stage Geocycle collected used oil from hundreds of enterprises which ranged from oil producers and major industrial oil consumers, to small garages and workshops and the total amount collected was up to 15 million litres per year (Halliday, Slaughter, Rynne, & Totty, 2007). However, increased competition for used oil combined with significant costs in transporting the oil to Westport has seen the amount of used oil drop significantly in recent years Less than a hundred tonnes (100,000 litres) has been collected in 2014. Holcim recently announced that final approvals have been granted to begin construction of two cement import terminals in Auckland and Timaru. These are expected to be operational in the second half of 2016 at which point cement manufacturing at the Westport plant will cease. This combination of factors has led to the scheme being discontinued, with effect from 1 August 2014 (A J Krishna, Holcim, pers comm, 2014). As a result, the Geocycle UORP scheme is no longer accredited as a product stewardship scheme.

Another programme, the ROSE New Zealand scheme, was first accredited in 2011 and is managed by Fulton Hogan Ltd. Petroleum Services Ltd and Salters Cartage Ltd are also listed on the accreditation certificate as scheme managers. The scheme has as its purpose the collection of used oil for reuse as an alternative fuel source to diesel, light fuel oil and gas. Only consented waste oil users, including Holcim (NZ) Ltd, Goodman Fielder Ltd, Carter Holt Harvey Ltd and Fulton Hogan Ltd, may consume oil collected under this scheme (www.mfe.govt.nz/issues/waste/product-stewardship/accredited-schemes-in-nz).

Currently the ROSE group collects about 12.8 million litres of waste oil annually. Asphalt manufacturing, pulp and paper processing, food manufacturing and horticulture each receive about 20%, or about 2.56 million litres. Cement production receives 5%, or 640,000 litres, and non-specified recipients receive the remaining 15%, or 1.92 million litres.

A3.7.2 Other schemes or firms involved with oil collection

Transpacific Technical Services collects used mineral oil from more than 5,000 workshops, businesses and ships around New Zealand and processes it into high quality industrial fuel oil (www.transpac.co.nz/content/used-industrial-and-automotive-oil). 14 million litres of ships' slops (containing 50 % water) and 3 million litres of used lubricating oil (10 – 15% water) are processed by the company annually. Industries using the refined product include lime production (4.4 million litres), pulp and paper manufacturing (2 million litres), asphalt production (900,000 litres), brick manufacturing (700,000 litres) and horticulture (500,000 litres) (M Hollands, Transpacific Technical Services, pers comm, 2014).

The Waste Petroleum Combustion website (www.oilrecovery.co.nz) indicates that the company collects waste oil throughout the North Island. The oil is brought to its Pukekohe depot for processing prior to re-sale to various businesses, which include glasshouses, timber mills, meat processing plants, asphalt plants and dry cleaners.

The Oil Recycling Engine Oil Recovery Project is another service based in Auckland which aims to make it easy for small domestic producers to dispose of their waste oil. Oil recycling drop-off bins are located at 35 stores operated throughout the region by Repco, SuperCheap Auto and Segedins AutoSpares. Used oil in sealed leak-proof containers can be deposited in the bins during opening hours. The scheme was launched as a pilot by Auckland Council in 2011 with the support of the Waste Minimisation Fund and industry participants, and was later transferred to the industry partners (see: www.oilrecycling.org.nz).

A3.8 Other estimates of waste oil utilisation in New Zealand

A3.8.1 Reporting under the Climate Change Response Act

The Climate Change Response Act (2002) requires that firms producing stationary energy from the combustion of 1500 tonnes or more of "used or waste oil, tyres or waste" have to report their emissions of carbon dioxide equivalents. Under the Act "stationary energy" includes the use of fuels used in generating electricity, industrial heat and petroleum refining.

Four companies were listed for the 2011/2012 and 2012/2013 fiscal years, with total reported CO_2 emissions of 47,262 and 39,025 tonnes respectively (Environmental Protection Authority, 2012 and 2013). Using the emission factor of 3.0 tonnes of CO_2 equivalents per 1000 litres of heavy fuel oil (*Climate Change (Liquid Fossil Fuels) Regulations, 2008*) the CO_2 emissions for the two periods can be converted to up to 15.8 and 13.0 million litres of waste oil respectively. The authors are not aware of any large-scale waste to energy facilities in New Zealand that burn tyres or wastes, so it is appropriate to attribute all of these emissions to waste oil combustion.

A3.8.2 The New Zealand Heat Plant Database

The New Zealand Heat Plant Database (CRL Energy, 2011) provides information on boilers and other heat raising equipment in New Zealand. Where available, data is provided for individual pieces of plant relating to the gross energy capacity, gross energy produced, fuel type burnt and amount of fuel consumed. There are a number of entries which make specific reference to waste oil as the primary fuel type and other entries which refer to oil/diesel mixtures, and these were used to identify the following specific waste oil users (Note: if fuel consumption data was missing from the database but gross energy production figures were available the corresponding fuel amount was calculated using a calorific value of 40.8 MJ/litre):

Horticulture Operations

Karaka: 100,000 litres per annum

Cambridge: 90,000 litres per annum

Ohaupo: 900,000 litres per annum

Clevedon: 100,000 litres per annum

Drury: 140,000 litres per annum

Other Manufacturing

Brick manufacturing, Canterbury: 1,379,000 litres per annum (estimated from 21 GWh energy production and a statement on the company's website which indicates that waste oil comprises 75% of its liquid fuel use).

A3.8.3 Specific waste oil consumption figures provided by industry

The pulp and paper industry used 7,062 tonnes and 8,484 tonnes of waste oil as a supplementary fuel in their production activities in 2012 and 2013, respectively (C. Church, Carter Holt Harvey, pers comm). Assuming waste oil has a density of 0.83 g/litre these weights are equivalent to 8,508,000 and 10,222,000 litres.

About 2.5 million litres of waste oil was used in asphalt manufacturing activities in 2012 (P. de Goldi, Fulton Hogan, pers comm, 2014).

A3.9 Used oil as a dust suppressant

An Environment Southland *Pollution Prevention Guide* acknowledges that Southland is one of the last regions in New Zealand that still allows used engine oil to be applied to gravel roads to supress dust, but also promotes safer alternative methods such as bitumen emulsions or bitumen seal treatments (Environment Southland, 2013). In 2013 126,000 litres of waste oil was spread by two contractors in Southland. The total for the region as a whole will be higher because some farmers independently apply oil to their roads. (O. West, Environment Southland, pers comm, 2014).

The Otago Regional Council's *Regional Plan: Waste* describes the discharge of oil or substances containing oil as a dust suppressant on roads as a permitted activity depending on certain restrictions relating to lead concentration, ponding and run-off. No information has been obtained on the quantities of oil applied to roads, but it would be reasonable to expect similar quantities to those being used in Southland.

A3.10 Summary

- About 68 million litres of lubricating oil is imported into New Zealand each year.
- An estimated 35-40 million litres of waste oil is available for re-use annually. The difference is effectively lost; either consumed directly (e.g. 2-stroke petrol engines and chain bar lubrication) or indirectly (e.g. 4-stroke petrol and diesel engines) or through inappropriate disposal. For the latter about 1.4 million litres annually is estimated to be disposed of by domestic consumers. Initiatives are being introduced in Auckland to recover some of this waste oil.
- The majority of New Zealand's waste oil is collected by a limited number of companies or collection schemes.
- The Code of Practice (Environmental Protection Authority, 2013) requires that waste oil reprocessed as a fuel should comply with maximum permissible levels of heavy metals, total halogens and a flashpoint higher than 60°C.
- The Code of Practice restricts the use of untreated waste oil as a fuel to consented operations.
- The Code of Practice recommends that waste oil disposal to landfill should only be carried out at those sites specifically licenced to accept waste oil.
- Activities which could lead to soil or water contamination or air pollution, such as road dust abatement, burial and open air burning are considered inappropriate by the Code of Practice.
- Combustion of about 25 million litres of waste oil can currently be assigned to individual companies involved with asphalt, pulp and paper, cement, lime, food and brick manufacturing, horticultural production and the use of oil as a dust suppressant.

On the basis of the above, there are about 10 million litres of recovered waste oil that have not yet been assigned to either a specific industry or a specific company.

A3.11 Relevance to the dioxin inventory

Much of the used oil consumption identified in this survey is not specifically assigned to any dioxin emission because the release estimates are based on total production rates or total fuel use. More specifically, the following applies:

- Used oil is used as a supplementary fuel in asphalt plants, lime and cement kilns and pulp and paper mills. However, for these, the dioxin emissions are determined primarily by the overall nature of the manufacturing processes rather than the fuel used. Hence, the dioxin releases are usually calculated on the basis of total plant production rates.
- The nature of the fuel is a determining factor when the oil is used for power and heat production (section 5) or in transport engines (section 7). However, the UNEP Toolkit makes no distinction between new (virgin) and used oil for these sources so the releases due to used oil are not specifically identified here either.
- The only source in the Toolkit where used oil is specifically considered is the Waste Oil Disposal category, which is discussed in section 11.5. However, for this the Toolkit simply notes that there may be dioxin releases associated with the processing of waste oil, or the disposal of waste oil to land. No specific release factors are noted and the Toolkit advises that each operation should be assessed on a case by case basis.

Three dioxin releases were specifically considered in the report on the 2008 dioxin inventory; emissions to air from low-temperature oil burning (e.g. in glasshouse heaters), releases to land from the use of waste oil for dust suppression, and releases through landfill disposal and land dumping. The way in which these estimates have been carried over into the current inventory is as follows:

1. The total oil usage for low-temperature oil burning in 2008 was estimated at 7 million litres per year, or 5,600 tonnes. However, this usage has now been captured under the broader category for industrial/commercial heavy-oil burning, which was not considered in the previous inventory but is now covered in section 5.1.2. The total oil consumption (new and used) for 2012 was 76,000 tonnes.
2. A further 92,000 tonnes of new and used oil is noted in section 7.4, for use in coastal shipping. Once again, this is a new addition to the 2012 inventory
3. The potential releases to land from the use of waste oil as a dust suppressant, or through dumping/disposal, are discussed in section 11.5. The 2008 inventory assumed that 2,400 tonnes (3 million litres) of oil were used for dust suppression and 3,200 tonnes (4 million litres) were dumped, and the total dioxin releases to land were estimated to be 0.207 g TEQ. However, the information sources used for these estimates are now very dated and there is no more recent data available. Hence no release estimates have been provided for 2012.

Appendix 4: Report on the secondary metal production survey

A4.1 Introduction

Secondary metal production was identified as a potentially significant source of dioxins for New Zealand in the 1998 dioxin inventory (Ministry for the Environment, 2000). In response to this, an industry survey was carried out in 2002. This identified 122 'probable' secondary metal production businesses in New Zealand, although survey data was only obtained for 82 (67%) of these (Ministry for the Environment, 2004). The results of this survey were reviewed in 2009 and adjusted for known changes in the industry, and the resulting annual production estimates were used for the 2008 dioxin release estimates.

The 2002 survey data is now well out of date, and it would not be appropriate to simply extrapolate from that data for the 2012 release estimates. Instead, a new industry survey was undertaken using essentially the same approach as used for the 2002 study.

A4.2 Methodology

The approach used for this survey involved distribution of a 1-page questionnaire to the members of Casting Technologies New Zealand (CTNZ), which is the main industry body for this sector. Other non-member companies were identified through searches of the Yellow Pages® on-line telephone directory and other on-line business directories. The directory searches produced a list of 68 companies in total. However, more specific company searches showed that some of these were no longer in business, and the final target list was reduced to 57 companies. Each of these companies was sent the questionnaire by email, with a follow-up by telephone. Unfortunately, some of the companies were reluctant to provide detailed information, and the overall response rate achieved was only 44% (25 companies). However, this did include responses from most of the larger operators, so the effective coverage on a mass (of metal) basis was about 65%.

The questionnaire used for the survey requested information on the types of metals being processed, the types of furnaces and air pollution control equipment, the annual metal throughput, and the methods used for the disposal of waste by-products, such as slag and dross.

A4.3 Survey results and analysis

The results from the 2002 survey were broken down into 3 sub-categories - iron foundries, secondary aluminium and other non-ferrous metals - and the same approach has been taken here. It is not possible to break the third of these groups into the different types of secondary metal processes listed separately in the Toolkit, because many of the New Zealand plants process relatively small amounts of multiple metals and were unable to provide a detailed breakdown into the different ones.

A4.3.1 Iron foundries

Iron foundries manufacture cast-iron products from scrap iron, pig iron and internal plant returns (manufacturing rejects and wastes). A variety of furnaces can be used for metal melting, including electric arc and induction furnaces, cupolas and oil- or gas-fired crucibles. The melting operations have the greatest potential for dioxin releases to air, especially when processing contaminated scrap.

The 2002 industry survey identified 27 companies engaged in the processing of ferrous metals. The total annual ferrous metal production in 2002 was estimated at 21,000 tonnes per year. For the 2008 Inventory it was noted that there had been a significant drop in production at the largest plant identified in the survey, and the 2008 annual production for all sites was estimated to be about 18,000 tonnes per year.

In the current survey a total of 24 iron foundries have been identified[14], and the total annual production for all plants is estimated to be 16,000 tonnes. This estimate is based on specific information received from 8 of the companies, with a pro rata adjustment for non-responses.

Most of the metal input used by these foundries is a mixture of clean and contaminated scrap steel, and most plants are fitted with bag filters for air emission control. Furnace wastes are usually disposed of to landfill.

A4.3.2 Secondary aluminium

The industries included in this subcategory are metal recyclers, who recover aluminium from mixed scrap, and manufacturers of cast aluminium products, such as alloy wheels and engine parts. Much of the manufacturing uses aluminium ingots and clean aluminium scrap, but may also include aluminium recovered from in-house metal wastes. Scrap metal and mixed metal wastes may contain organic impurities such as plastics, paints and solvents, and their presence during the reclamation processes can result in the formation and emission of dioxins.

The 2002 industry survey identified 48 companies engaged in secondary aluminium production and the total annual aluminium production was estimated at 47,000 tonnes per year, of which 94% was attributed to four large sites. For the 2008 release estimates it was noted that one of these plants had been shut down, and another had reduced its production by about 90%. In addition, many of the smaller plants were operating at significantly lower production rates. As a result, the annual metal production for 2008 was estimated to be no more than about 20,000 tonnes per year.

A total of 35 secondary aluminium processors have been identified in the current survey, and the total annual production for all plants is now estimated to be 15,000 tonnes. This estimate is based on specific information received from 11 of the companies, with a pro rata adjustment for non-responses.

Most of the metal input used by these foundries is a mixture of clean and contaminated scrap, and most plants are fitted with bag filters for air emission control. Furnace wastes are usually disposed of to landfill.

A4.3.3 Other non-ferrous metals

Other secondary non-ferrous metal production can involve the recovery of metals such as copper, tin and lead from scrap metal; the manufacture of metal alloys such as brass and bronze; and the processing of metal ingots, scrap metal and internal plant returns to make cast metal products. As with the iron foundries, the potential for dioxin formation mainly arises during the heating stages and is greatest when processing contaminated scrap.

The 2002 industry survey identified 45 companies engaged in copper processing, but 20 of these also included other metals such as tin, lead and zinc, including for the production of brass and bronze. The total annual metal production for all of these companies in 2002 was estimated at 23,200 tonnes per year. For the 2008 estimates it was noted that there had been a significant number of changes in this source subcategory, with some plants being upgraded, others relocated and others shut down. However, it was not possible to accurately estimate the effect of these changes on overall production rates, and the 2002 data was used for the 2008 release estimates

A total of 35 secondary processors of other non-ferrous metals have been identified in the current survey, and the total annual production for all plants is now estimated to be 12,000 tonnes. This estimate is based on specific information received from 11 of the companies, with a pro rata adjustment for non-responses.

Most of the metal input used by these foundries is clean ingots, with only minor amounts of contaminated scrap, and most plants are fitted with bag filters for air emission control. Furnace wastes are usually disposed of to landfill.

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[14] Many of the companies process more than one type of metal. As a result, the company and response numbers given in sections A4.3.1 to A4.3.3 will add up to more than the numbers given in section A4.2.