Mercury Inventory for New Zealand: 2012

Report to the Ministry for the Environment

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Executive Summary

This report provides an inventory of the annual distribution of mercury and mercury-containing goods and materials in New Zealand, from anthropogenic (man-made) sources. It has been produced under a contract to the New Zealand Ministry for the Environment.

The inventory has been prepared generally in accordance with the guidance provided in the UNEP *Toolkit for identification and quantification of mercury releases* (the Toolkit), which aims to assist countries to build a knowledge base that identifies the sources of mercury releases in their country and estimates or quantifies the releases. This information is expected to assist in decision-making with regard to possible control measures on mercury releases; in communicating with stakeholders; and in monitoring changes over time.

The latest version of the Toolkit was published in April 2013 and has been used to provide the basic framework for this work. The methodology involves the collection of activity data for a wide range of possible mercury sources, coupled with calculations to determine the quantities of mercury brought into, or mobilised, within the country (the **Inputs**), and the quantities of mercury released into the different environmental compartments of air, water, land, and releases in wastes or in products (the **Outputs**).

The required activity data was obtained through published information sources and direct contact with government agencies, importers, manufacturers, industry associations, and regional and local councils, as appropriate. The reference year for this inventory is the 2012 calendar year, and the activity data for that year has been used wherever possible. The activity data was converted into mercury inputs and outputs using either locally available factors (such as the mercury content of a material, or a measured mercury emission rate) or the Toolkit default factors when local information was unavailable.

Estimated mercury inputs and outputs

The primary results of this assessment are summarised in Table ES1 on the next page (the numbers in brackets are the averages of the indicated ranges).

By far the greatest quantities in the inputs column are for category 9, waste disposal. However, describing these as inputs is not really correct – they would be better considered as secondary or down-stream inputs, in that they are the result of many of the past and current outputs from all other categories, plus contributions from indirect sources, such as mercury in foods and in airborne dust. A similar distinction applies to the inputs from waste incineration, metal recycling and cremations and burials. To assist with this distinction, the totals have been separated out into 3 different groupings in Table ES2.

Apart from the waste category, the next highest input is from primary metal production and, in particular gold mining. In this case, the bulk of the inputs and outputs are associated with the extraction of very large volumes of mercury-containing ore, which is processed to remove the gold and silver, and then 90% of it is returned to the land. It is debateable whether this should be regarded as a true mobilisation of mercury.

Table ES1: High-level summary of mercury inputs and outputs for 2012*

Category	Mercury Inputs, kg/year	Mercury Outputs, kg/yr				
		Air	Water	Land	Product	Waste
1. Extraction and use of fuels/energy sources	291 – 2,295 (1,293)	234.9 – 1,913.1 (1,074)	46.8 – 121 (83.9)	3.8 – 25.4 (14.6)	<0.01 – 3.7 (1.9)	5.3 – 231.2 (118.3)
2. Primary (virgin) metal production	1,310.5 – 2,681.9 (1,996)	74.3 – 184.9 (129.6)	33 – 58 (45.5)	1,133 – 2,258 (1,696)	50 – 100 (75)	20.3 – 80.9 (50.6)
3. Production of other minerals and materials	45.7 – 251 (148)	5.0 – 6.8 (5.9)	-	39 – 241.5 (140)	2.16 -2.9 (2.5)	-
4. Intentional use of mercury in industrial processes	-	-	-	-	-	-
5. Consumer products with intentional use of mercury	133.1 – 354.9 (244)	3.5 – 15.7 (9.6)	0.98 – 9.8 (5.4)	0.9 – 8.8 (4.8)	40.2	87.4 – 280.4 (183.9)
6. Other intentional product/process uses	205	5.8	26.5	-	90	82.8
7. Production of recycled metals	317	0.7	-	-	315	1.3
8. Waste incineration	20.8 – 190 (105.4)	20 – 189.2 (104.6)	-	-	-	0.8
9. Waste deposit/landfill and wastewater treatment	2,829 – 31,570 (17,199)	25 – 250 (137.5)	164.3 – 3,287.5 (1,726)	65.7 – 1,314 (689.9)	-	98.5 – 1,971 (1,034.8)
10. Crematoria and cemeteries	30.1 – 120.4 (75.2)	19.1 – 76.2 (47.7)	-	11 – 44 (27.6)	-	-
Totals, all groups	**5,182 – 37,986 (21,584)**	**388 – 2,642 (1,515)**	**272 – 3,503 (1,887)**	**1,253 – 3,892 (2,572)**	**498 – 552 (525)**	**296 – 2,649 (1,473)**

(* The totals in the table may not exactly equal the sum of displayed data, due to rounding)

Table ES2: High-level summary grouped by primary and secondary sources*

Category	Mercury Inputs, kg/year	Mercury Outputs, kg/yr				
		Air	Water	Land	Product	Waste
Total for groups 1 to 6	1,985.4 – 5,788.1 (3,886.8)	323.4 – 2,126.3 (1,224.8)	107.3 – 215.2 (161.2)	1,176.2 – 2,533.7 (1,854.9)	182.7 – 237.1 (209.9)	195.8 - 675.4 (435.6)
Totals for groups 7, 8 and 10	367.9 - 627.4 (497.7)	39.7 – 266 (152.9)	-	11 – 44.2 (27.6)	315	2.2
Total for group 9	2,828.5 – 31,570 (17,199)	25 – 250 (137.5)	164.6 – 3,287.5 (1,726)	65.7 – 1,314 (689.9)	-	98.5 – 1,971 (1,034.8)
Totals, all groups	**5,182 – 37,986 (21,584)**	**388 – 2,642 (1,515)**	**272 – 3,503 (1,887)**	**1,253 – 3,892 (2,572)**	**498 – 552 (525)**	**296 – 2,649 (1,473)**

(* The totals in the table may not exactly equal the sum of displayed data, due to rounding)

Several reservoirs and stocks were also noted at various points through the report, but have not been included in the table because they should not be classified as inputs or outputs. Instead, they are summarised below:

Existing stocks

Thermometers:	26.7 – 267 kg, with a mean of 147 kg
Switches and relays:	170 kg
Manometers/gauges:	270 kg
Laboratory chemicals:	260 kg (including elemental mercury)
Total identified stocks:	727 – 967 kg, with a mean of 847 kg

Addition to reservoirs

Landfills	2,475 – 24,748 kg per year, with a mean of 13,612 kg

It should be noted that the figure shown for landfills is simply the annual addition to the existing landfill reservoirs that will have been accumulated over many years.

The following mercury exports were also noted. These have been included in the high-level table, so should be subtracted from the relevant totals.

Mineral oil	5 kg
Gold mining wastes	55 kg
Lamps	3 kg
Pharmaceuticals (vaccines)	24 kg
Recycled mercury	240 kg
Total exports:	327 kg

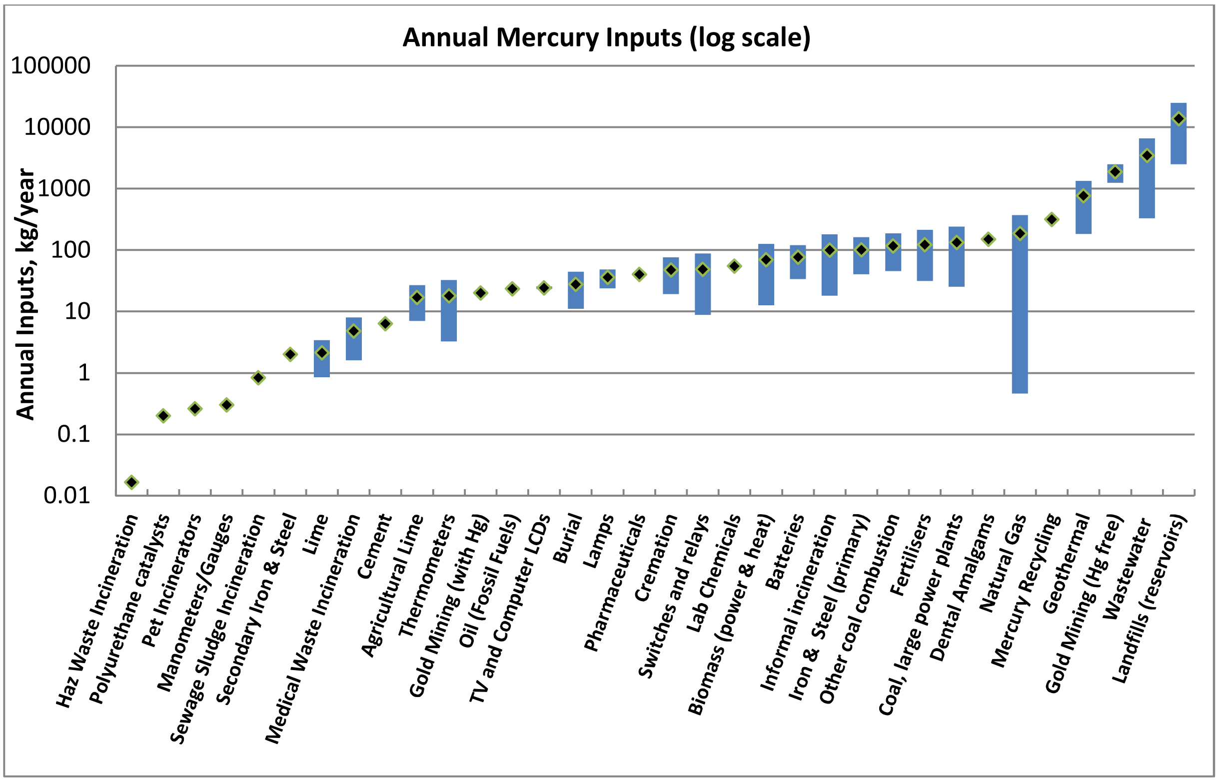
The relative inputs from each of the individual sources identified in the inventory are illustrated in Figure ES1, with the size of each bar giving an indication of the level of uncertainty associated with each estimate.

Output distribution by source category

The distributions of outputs to air, water, land, waste, and in products, are summarised in a series of charts given in Section 14 of this report. (It should be noted that the waste disposal category was excluded from all these charts to avoid having the presentations dominated by this secondary category). The key points noted from these charts are as follows:

- The outputs to air are dominated by fuel/energy use, especially geothermal, and to a lesser extent, primary metal production and waste incineration.
- The outputs to water are dominated by fuel/energy use and, to a lesser extent, primary metal production.
- The outputs to land are dominated by gold mining but this has been excluded from the chart.
- The outputs via products are dominated by the production of recycled metals, but with other significant contributions coming from other intentional products/processes, primary metal production and consumer products.
- The outputs to wastes are distributed across 4 categories, in the following order of decreasing significance: consumer products, fuel/energy use, other intentional products/processes, and primary metal production.

Figure ES1: Annual mercury inputs by individual sources



Relevance to the proposed convention requirements

Some of the findings from this inventory are relevant to a few of the specific requirements under the proposed text for the Minamata Convention, and these are noted briefly in section 14.3 of the report.

The 2008 Mercury Inventory

A previous Mercury Inventory for New Zealand was published by the Ministry for a base year of 2008 (the 2008 Inventory Report). The work was based around the use of an earlier version of the UNEP Toolkit, and there are some significant changes between the 2008 estimates and those presented here. The differences between the two estimates and the reasons for these are discussed at the end of each source sub-section in this report.

Overview of mercury inputs, outputs, reservoirs and stocks

An overview chart of the flows of mercury into and within the New Zealand environment is shown in Figure ES2. The key points to note from this are as follows:

Mercury inputs

- Approximately 600 kg of mercury is brought into New Zealand each year though imported fuels, manufactured articles and chemicals, as shown in the top left box.
- A further 3,270 kg of mercury is mobilised within New Zealand each year, through the extraction, processing and use of fuels, energy, metal ores and minerals (see middle-left box).
- Some mercury is also mobilised from the existing reservoirs of mercury. These are indicated in the top right box in the figure and include mercury-containing articles currently in use; the mercury stored in our bodies and in the general environment; and mercury taken up into food. The total amounts of mercury stored in these reservoirs is unknown, apart from the estimated 847 kg stored in some articles

in storage and in use (eg. thermometers, switches and relays, sphygmomanometers, lamps) and laboratory chemicals.

- One of the mobilisation routes for these reservoirs is the recycling of scrap metal and liquid mercury, which together contribute 335 kg to the total annual inputs (see the centre top box).
- The total annual mercury inputs to New Zealand via all of the above pathways are about 4,205 kg, as shown in the centre box.

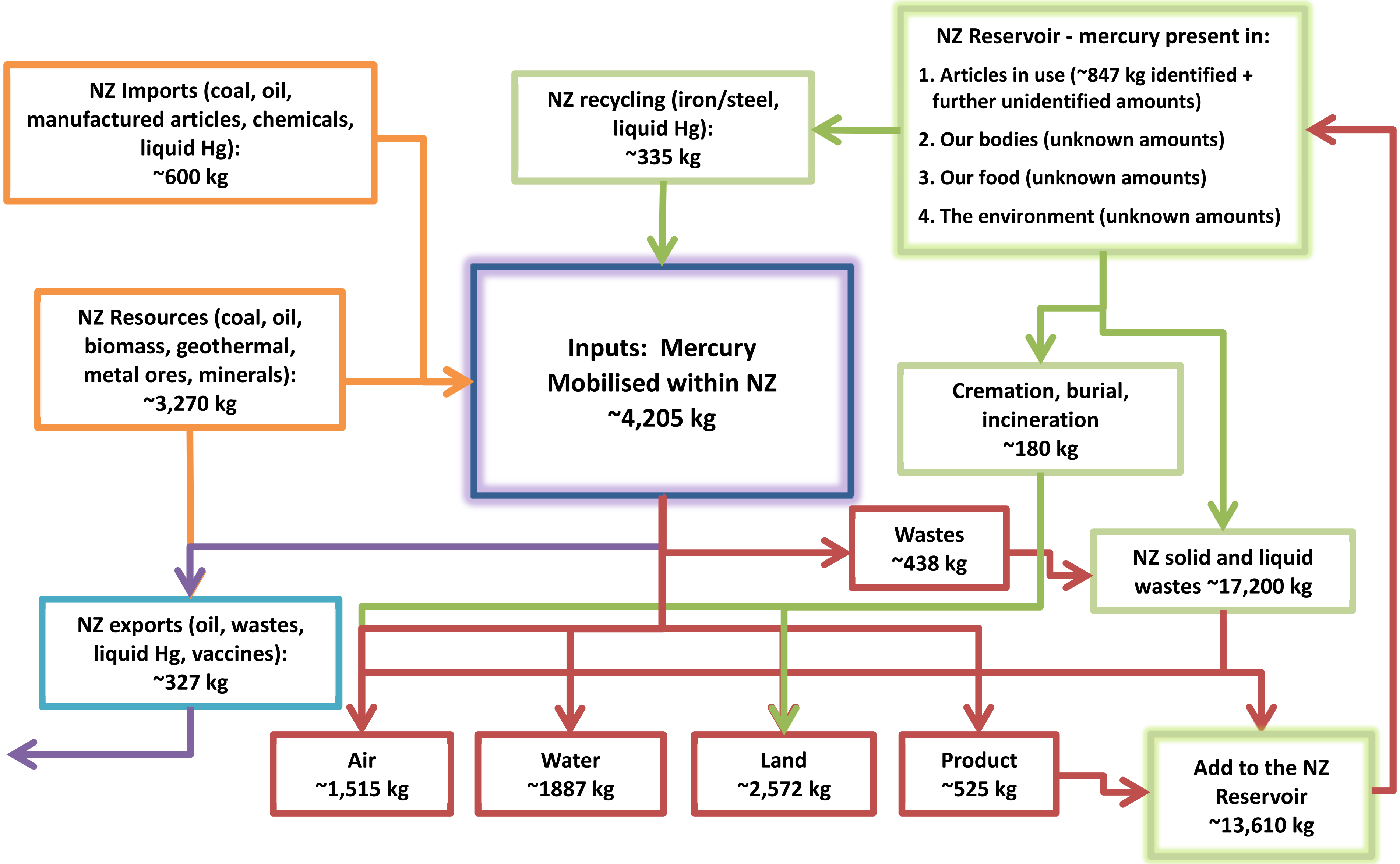
Mercury outputs

- The processing, use and disposal of the fuels, minerals, manufactured articles, and chemicals that contribute to the total mercury inputs, leads to the various outputs to air, water, land, and in products and in wastes, that are shown at the bottom of the chart.
- The burial and cremation of human bodies also contributes to these outputs (middle right box).
- In addition, there are significant mercury outputs, especially to water, land and wastes, through municipal solid and liquid waste streams, with the mercury coming primarily from the existing reservoirs (lower middle right box).

Stocks, reservoirs and exports

- Most of the outputs in products and in wastes remain in the New Zealand environment and therefore contribute further to the existing stocks and reservoirs shown in the top right box in the figure. However, there is also some exporting of products and wastes (bottom left box), which leads to a reduction in the overall mercury stocks.

Figure ES2: Overview of mercury flows into and within New Zealand



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Units and abbreviations

Units

°C	degrees Celsius or centigrade
g	gram
kg	kilogram (10^3 or 1 thousand grams)
tonne	10^6 or 1 million grams
Mt	megatonne (10^6 or 1 million tonnes)
µg	microgram (10^{-6} grams or 1 millionth of a gram)
MJ	megajoule (10^6 or 1 million joules)
GJ	gigajoule (10^9 or 1 thousand million joules)
TJ	terajoule (10^{12} or 1 million million joules)
PJ	petajoule (10^{15} or 1 thousand million million joules)
L	litre
m^3	cubic metre
ppm	parts per million
kW	kilowatt (10^3 or 1 thousand watts of thermal or electrical energy)
kWh	kilowatt-hour (equivalent to 1 kilowatt generated or consumed over 1 hour)
MW	megawatt (10^6 or 1 million watts of thermal energy)
MWe	megawatt of electrical energy
GWh	gigawatt-hour (equivalent to 1 thousand million watts consumed over 1 hour)

Abbreviations

EU	European Union
HSNO	Hazardous Substances and New Organisms Act 1996
LPG	liquefied petroleum gas
RMA	Resource Management Act 1991
RoHS	Restriction on Hazardous Substances (EU legislation)
UNEP	United Nations Environment Programme
UK	United Kingdom
USA	United States of America
US EPA	United States Environmental Protection Agency
WHO	World Health Organization

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1 Introduction

This report provides an inventory of the annual distribution of mercury and mercury-containing goods and materials in New Zealand, from anthropogenic (man-made) sources. It has been produced under a contract to the New Zealand Ministry for the Environment.

The inventory has been prepared generally in accordance with the guidance provided in the UNEP *Toolkit for identification and quantification of mercury releases* (the UNEP Toolkit), which aims to assist countries to build a knowledge base that identifies the sources of mercury releases in their country and estimates or quantifies the releases. This information is expected to assist in decision-making with regard to possible control measures on mercury releases; in communicating with stakeholders; and in monitoring changes over time.

1.1 Background

In January 2013, negotiations were concluded on the final text of an international mercury agreement, which will be known as the Minamata Convention on Mercury. The Convention will control most aspects of the mercury 'life cycle', including: man-made supplies and uses of mercury and mercury compounds; emissions to air, and releases to land and water; the environmentally sound management of mercury wastes and mercury-containing wastes, including trans-boundary movements; and the management of mercury contaminated sites. A decision on whether or not to sign the proposed convention will be made by governments at a Diplomatic Conference in October 2013, and then individual countries will consider whether to ratify the agreement.

The preparation of a national mercury inventory is intended to assist in this decision-making process, through the identification of the most significant sources of mercury and mercury-containing goods and materials, and the activities, and key individuals or organisations, associated with these (the stakeholders).

1.2 Methodology

The basic methodology used for this work was the latest version of the UNEP Toolkit, which was published in April 2013. This methodology was applied using the following general approach:

1. Reviews of the information given in the updated Toolkit for each source category, supported by an Internet search for other recent relevant publications.
2. Contacts with government agencies, importers, manufacturers, industry associations, regional and local councils, as appropriate, to obtain up to date activity data and/or release information.
3. Input/output calculations using the Toolkit spreadsheet and drafting of the relevant subsections of the inventory report, including overall summary and analysis sections.

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 11 Toolkit source categories, a summary and discussion section, and a section containing relevant industry profiles.

A previous Mercury Inventory for New Zealand was published by the Ministry for a base year of 2008 (the 2008 Inventory Report). The work was based around the use of an earlier version of the UNEP Toolkit, and there are some significant changes between the 2008 estimates and those presented here. The differences between the two estimates and the reasons for these are discussed at the end of each source sub-section in this report.

2 Inventory methodology

2.1 The UNEP Mercury Toolkit

The UNEP Toolkit was first published as a pilot draft in November 2005, and this was the version used in the preparation of the 2008 Inventory Report. A revised version of the Toolkit (v1.2) was published in January 2013, but was reissued with amendments in April 2013. The revisions were made in response to pilot testing and comments received by UNEP since 2005. Further updates and revisions will be undertaken as necessary, and will be made available on the UNEP Chemicals mercury web page at http://www.unep.org/hazardous-substances/Mercury/tabid/434/Default.aspx.

The Toolkit is intended to provide a simple methodology and accompanying database to enable the assembly of consistent national and regional mercury inventories. It comprises a UNEP recommended procedure for the effective compilation of source and release inventories of mercury. Comparable sets of mercury source release data should enhance international co-operation, discussion, goal definition and assistance.

The Toolkit includes two levels for inventory assessment; an overview Level 1, and a detailed source by source assessment, Level 2. The Level 2 option is designed to be adaptable to differences between countries, but it must be stressed that it is still just a screening tool. It is designed to ensure the positive identification of the bulk of significant sources, rather than the unattainable goal of 100 per cent accuracy.

The Level 2 option has been used for the current work. The Toolkit documentation is supported by an Excel spreadsheet, which has also been used for this assessment.

2.2 Toolkit methodology

The Toolkit considers potential mercury inputs and outputs for the following source categories[1]:

1. Extraction and use of fuels/energy sources
2. Primary (virgin) metal production
3. Production of other minerals and materials with mercury impurities
4. Intentional use of mercury in industrial processes
5. Consumer products with intentional use of mercury
6. Other intentional product/process uses
7. Production of recycled metals (secondary metal production)
8. Waste incineration
9. Waste deposition/landfilling and wastewater treatment
10. Crematoria and cemeteries
11. Identification of potential hot-spots

[1] The source categories are numbered 5.1, 5.2, 5.3, etc in the Toolkit, simply because the detailed source coverage appears in section 5 of the Toolkit document. This numbering has been included in the sub-category tables given at the start of each section, but in all other text references to category numbers the 5 has been ignored.

Terminology

The two key terms used in the Toolkit are inputs and outputs.

Inputs: refers to the quantities of mercury brought into, or mobilised, within the country.

Outputs: refers to the quantities of mercury released into different environmental compartments of air, water, land, and releases in wastes or in products.

There is potential for confusion round the use of some of the output terms, and especially the differences between discharges to land, materials disposed to land as wastes; and wastes that are recycled or reused. The following approach has been adopted for differentiating between these terms:

> The **land** output category has only been used for materials which are deposited directly to land during processing (eg drilling muds from oil exploration and production) or which are disposed in a waste treatment facility directly associated with the processing operation (eg. a tailings dam for a mining operation, or an ash disposal facility for a large power plant).
>
> Wastes that are sent directly to a municipal landfill and those taken away by a waste contractor for treatment and disposal (which may include disposal to landfill) have all been classified as **wastes**.
>
> Wastes that are sold, or taken away by a contractor, for recycling and reuse have been classified as **products**.

Methodology for estimating inputs and outputs

The basic methodology for estimating inputs and outputs starts with the annual activity rate for a source, which is multiplied by the mercury content of the input material. The activity data may be based on the numbers of individual items imported, the quantities of raw materials or fuels used, or the annual production rate.

The outputs are estimated from the information available for each source on the rates of release to the different environmental compartments. Generally this information takes the form of individual factors showing the proportion of inputs distributed to each compartment.

The overall methodology is summarised in the Toolkit as follows:

> *Estimated mercury release to each pathway = activity rate * input factor * output distribution factor for that pathway*

Toolkit default factors

The Toolkit provides default input and output factors for some, but not all, of the mercury sources. These are based on reviews of published information, and are intended for use when national factors are not available. Each of the default factors is usually expressed as a range of possible values, along with a recommended ‘intermediate’ value. The Toolkit default factors have been used for many of the current estimates.

2.3 Reference year

The reference year for this inventory is the 2012 calendar year, and the activity data for that year has been used wherever possible. However, the use of data from earlier years has been noted where relevant.

2.4 Reporting

The estimated mercury inputs and outputs have been reported for each source in units of kilograms of mercury per year. In most cases, the results are reported as a range of values, to reflect the uncertainties in the estimates. The results for each source are also given certainty estimates, in accordance with the following general approach:

Activity data

- A high certainty ranking was assigned if the assessment was based on national or specific industry data, or was derived from comprehensive survey data;
- A medium certainty ranking was applied if limited data were available, or the data were 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.

Input and output estimates

- A high certainty ranking was assigned if a reasonable amount of mercury content data and/or emissions data were available for the specific sources;
- A medium certainty ranking was assigned if the mercury content data and/or emissions data was limited;
- A low certainty was assigned if there were no New Zealand data available, and the estimates were based solely on the Toolkit default factors.

Precision

The input and output estimates have been calculated to a high level of precision – typically to 1 to 3 decimal places. However, the results have been rounded off when calculating group and overall totals, to better reflect the uncertainties in the estimates. As a result, the totals shown in some tables may not exactly equal the sum of the displayed data.

Double accounting

Wherever possible, double accounting has been avoided. For example the inputs and outputs from the coal used in steel manufacture were subtracted from the estimates for national coal usage. Another example of potential double accounting relates to the differentiation noted previously for waste materials that are taken away for recycling and reuse. One example of this is liquid mercury, which can be collected from a variety of sources; but is then transferred to a mercury recycler; and is then sold to small-scale gold miners and ultimately becomes a discharge to air, water and land. The double accounting here has been avoided by classifying the initial waste as a product.

Reservoirs/stocks/exports

The focus of the inventory is on annual inputs and outputs for New Zealand. However, there are also some significant reservoirs or stock holdings, which may not change very much from year to year. One example of this is the mercury in blood pressure devices (sphygmomanometers) that are still used by many medical professionals. These reservoirs or stocks have been noted at the relevant points in the main body of the report and have also been identified separately in the data summaries.

Another matter that has also been noted is the export of mercury-containing materials, especially recycled mercury and mercury-containing wastes. These need to be identified in the overall national accounting, usually as a waste or product, but should also be flagged as eventually being removed from the national stocks.

3 Extraction and use of fuels/energy sources

This category covers all forms of energy use including fossil fuels, biomass, biogas and geothermal energy (UNEP, 2013). It includes the fuel and energy used for electricity generation and in cogeneration plants, direct fuel use in industrial facilities[2], and the fuel used for commercial and residential cooking and heating. It also covers fuel used for transportation, and the energy used in the initial production (refining) of that fuel. The seven sub-categories within this source group are shown in Table 3-1 below, which has been copied directly from the Toolkit. The main pathways of mercury releases are to air, water and waste/residues. Land may also be a release pathway in domestic heating and cooking, either using woody biomass or fossil fuels, and from the extraction of mineral oil. In addition, land is often the ultimate receptor for wastes and residues.

Table 3-1: Toolkit framework for category 1 - extraction and use of fuels/energy sources

Toolkit Chapter	Sub-category	Air	Water	Land	Product	Waste/ residue	Main approach
5.1.1	Coal combustion in large power plants	**X**	x	x	x	**X**	PS
5.1.2	Other coal combustion	**X**		x	x	x	OW
5.1.3	Extraction, refining and use of mineral oil	**X**	**X**	x	x	x	OW/PS
5.1.4	Extraction, refining and use of natural gas	**X**	**X**	**X**		**X**	OW/PS
5.1.5	Extraction and use of other fossil fuels	**X**	x	x		x	OW
5.1.6	Biomass fired power and heat production	**X**	x	x		x	OW
5.1.7	Geothermal power production	**X**					PS

Notes: PS = Point source by point source approach; OW = National/overview approach;

X - Release pathway expected to be predominant for the sub-category;

x - Additional release pathways to be considered, depending on specific source and national situation.

3.1 Coal combustion in large power plants

The UNEP Toolkit defines large power plants as those with a capacity greater than 300MW. The only coal-fired installation of this size within New Zealand is the Huntly Power Station which, when first built, had a capacity of 1000 MW (MBIE, 2013). 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. In fact, the *New Zealand Energy Data File 2012* (herein referred to as the Energy Data File) now shows their total installed capacity as

[2] Some industrial fuel use is also considered under other categories (eg. metal production, minerals) and is therefore excluded from the general fuel use category, to avoid double accounting.

only 800 MW (MBIE, 2013)[3]. This reduced utilisation is also reflected in the MED annual coal consumption statistics, which show a total coal energy usage of only 29.3 PJ[4] in 2012 and 16.5 PJ in 2011, compared to 43.0 PJ in 2008, and a peak level of around 70 PJ/year in 2005 and 2006. However, these data do not reflect the total plant utilisation, because there can be significant additional generation using natural gas.

The coal used at Huntly Power Station is a mixture of Waikato sub-bituminous coal, mainly from the Rotowaro mine, and coal imported from Indonesia. The latter supply accounted for about 10% of total coal consumption in 2012 and 25% in 2011, but it has sometimes been much higher (eg. about 50% in 2006). The total coal consumption by Huntly Power Station in 2012 was 1,270,000 tonnes (T McKenzie, Genesis Energy, pers comm, 2013) and in 2011 it was about 700,000 tonnes (MBIE, 2013).

Information on the mercury content of the coal used at Huntly Power Station is given in a technical report submitted in support of the 2011 application for renewal of the air discharge consent (SKM, 2011). The following ranges of values were indicated:

Rotowaro coal, 2004 - 2005: 0.04 – 0.09 mg/kg, with a mean of 0.066 mg/kg

Rotowaro coal, August 2010: 0.09 – 0.19 mg/kg, with a mean of 0.13 mg/kg

Indonesian coal, 2004 – 2005: 0.02 – 0.13 mg/kg, with a mean of 0.054.

The mercury input calculations have been based on the highest and lowest values shown above (ie 0.02 – 0.19 mg/kg), with no distinction between Rotowaro and Indonesian coal.

The Huntly Power Station units are fitted with electrostatic precipitators for the control of particulate emissions to air. No information is available on the collection efficiencies of these units, with regard to mercury emissions, so the Toolkit default factors have been used for the output calculations. The recommended distribution for sub-bituminous coal is 90% to air and 10% to ash, although some of the studies noted in the Toolkit have suggested a 75/25% distribution. Hence, the output calculations shown below may be over-estimating the releases to air and under-estimating the releases via ash. The fly ash collected by the Huntly precipitators is disposed to land in a specially designed ash disposal facility and, in accordance with the rationale provided in section 2.2, has been classed as a release to land. The ash disposal facility is regularly monitored for the leaching of some trace elements, such as boron, but there is no monitoring for mercury releases (Genesis Energy, 2010).

The mercury input and output calculations for the power station are shown in Table 3-2.

Table 3-2: Input and output estimates for coal combustion in large power plants

Source	Activity Rate, tonnes/yr	Mercury content, mg/kg	Annual Mercury Inputs, kg/yr	Annual Mercury Outputs, kg/yr	
				Air	Land
Huntly Power Station	1,270,000	0.02 - 0.19	25.4 – 241.3 (133.4)	22.86 – 217.2 (120.0)	2.54 – 24.13 (13.34)

3 The Energy Data file for 2013 has not yet been published. However 2012 consumption data has been obtained from the quarterly data files that are available on the Energy Data File web site, at: http://www.med.govt.nz/sectors-industries/energy/energy-modelling/data.

4 PJ = Petajoules, or 10^{15} Joules of energy. Most of the energy data in this section is expressed on both an energy and mass basis. The latter values will be more meaningful to the reader, but the energy-based values are used as a more precise measure of usage, because the energy content of coal is variable.

Certainty assessment

Activity data:	HIGH (because it was obtained from the plant operator)
Input estimates:	MEDIUM (because they are based on a range of coal analyses)
Output estimates:	LOW (because they are based on the default Toolkit output factors).

Comparison with 2008 estimates

The 2008 Inventory Report gave an input estimate of 216 kg/yr for coal use at Huntly Power Station. This is reasonably comparable to the upper end of the range shown in the table, although coal consumption in 2008 was about 50% higher than in 2012 (cf the 43 and 29.3 PJ data noted above). No information was provided on the coal quantities or mercury content used in arriving at the 2008 estimate, which is simply attributed to a personal communication from the regional council.

3.2 Other coal use

This Toolkit sub-category covers all other uses of coal. It also considers potential releases from coal washing.

Coal production and use

The Energy Data File (MBIE, 2013) shows a total national coal consumption in 2012 of about 3,407,600 tonnes, with a further 2,210,300 tonnes being exported, entirely from the West Coast. The distribution of the domestic coal consumption across different sectors was as follows:

Electricity generation (Huntly)	1,350,340 tonnes[5]
Use in co-generation plants	357,530 tonnes
Other transformation (steel manufacture)	509,250 tonnes
Industrial use, agriculture, forestry and fishing	1,086,500 tonnes
Commercial/institutional use	75,200 tonnes
Transport	280 tonnes
Residential use	22,850 tonnes
Production losses	5,690 tonnes

The figure for total coal consumption (3,407,600 tonnes) has been used as a starting point for the input estimates. However, the following uses have been subtracted from this total, because they are covered elsewhere:

Electricity generation	1,350,340 tonnes
Steel manufacturing	805,000 tonnes[6]
Cement and lime manufacturing	140,000 tonnes.

5 There is a discrepancy of 80,000 tonnes between this figure and the one noted in section 3.1, which was provided by Genesis energy. This is most likely because the NZEDF figure is based on supply while Genesis' figure is based on actual consumption. It is considered more appropriate to use the NZEDF figure in this section, because the calculations here are all based on the national data.

6 The coal used in steel manufacturing is a combination of that used in a cogeneration plant and in the actual manufacturing process (other transformation).

This gives a result for total coal consumption for the Other Coal Use category, of 1.112 million tonnes. This coal is produced in different parts of the country, with the following approximate distribution, which is based on the distribution of the coal production data given in the 2011 Energy Data File[7], after adjustment for the major uses noted previously:

Waikato coal	300,000 tonnes
South Island coal[8]	505,000 tonnes
Southland lignite	307,000 tonnes

Coal mercury content

The mercury content of coal varies across different coal mines, and can also vary markedly within each coal seam. For example, Li (2002) reported a range of 0.009 to 0.193 mg/kg, with a mean value of 0.034 mg/kg, for thirty samples taken from within a single coal seam at the Stockton mine.

The only published data available on the mercury content of New Zealand coals is that quoted previously for Huntly Power Station, the Stockton data noted above, and the following indicative values listed by Li (2002) from an unpublished CRL Energy report: West Coast coal, 0.07 mg/kg; Southland coal, 0.06 - 0.07 mg/kg; Waikato coal, 0.07 – 0.12 mg/kg. In addition, CRL Energy has provided the following indicative values: Waikato coal, 0.2 mg/kg; West Coast coal, 0.1 mg/kg, Southland lignite, 0.25 mg/kg (N. Newman, CRL Energy, pers comm, 2013).

The CRL Energy estimates for mercury content are either towards the top of, or above, the ranges given in the published sources, and have been taken as upper estimates for the range of possible mercury contents. In addition, the West Coast figure has been assumed to apply to all South Island coal. The lower limit for each of the coal types has been based on the following values: Waikato coal, 0.04 mg/kg; South Island coal, 0.03 mg/kg; Southland lignite, 0.06 mg/kg.

Input and output estimates

The coal usage in this category is split across numerous industrial and commercial boilers, with a very minor proportion (0.1%) used for domestic heating and cooking. There are about 160 coal-fired boilers in New Zealand ranging in size from 1 to 43 MW[9] (CRL Energy, 2011). Most New Zealand boilers have cyclones for the control of particulate emissions and some also have bag filters. However, the Toolkit makes no distinction between these systems and suggests default distribution factors of 95% mercury discharges to air and 5% to waste. As noted previously in section 3.1, some of the studies noted in the Toolkit have suggested a 75/25% distribution. Hence, the output calculations shown below may be over-estimating the releases to air and under-estimating the releases via ash. The Toolkit default factors have been applied to all of the coal usage in this category.

The mercury input and output calculations for Other Coal Combustion are shown in Table 3-3.

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7 The distribution data for 2012 is not yet available, so 2011 values have been used. However, the distribution doesn’t appear to change significantly from year to year.

8 Most South Island coal is produced in the West Coast and Southland regions, but with some minor quantities from Otago and Canterbury.

9 Further information on the boiler distribution across different sectors is given in section 15.

Table 3-3: Input and output estimates for other coal combustion

Source	Activity Rate, tonnes/yr	Mercury content, mg/kg	Annual Mercury Inputs, kg/yr	Annual Mercury Outputs, kg/yr	
				Air	Waste
Waikato Coal	300,000	0.04 - 0.20	12 - 60	11.4 – 57.0	0.6 - 3
South Island coal	505,000	0.03 – 0.10	15.15 – 50.5	14.4 – 48.0	0.75 – 2.5
Southland lignite	307,000	0.06 – 0.25	18.42 – 76.75	17.5 – 72.9	0.9 – 3.8
Totals	**1,112,000**		**45.57 – 187.25 (116.4)**	**43.3 – 177.9 (110.6)**	**2.25 – 9.3 (5.8)**

Certainty assessment

Activity data: HIGH (because it was obtained from a national database)

Input estimates: LOW (because they are based on a limited range of published data and industry estimates)

Output estimates: LOW (because they are based on the default Toolkit output factors).

Comparison with 2008 estimates

The 2008 Inventory Report gave input estimates for the following coal uses: 21 kg/yr from other power generation (cogeneration), 39 kg/yr from dairy factory boilers, 16 kg/yr from meat processing and 7 kg/yr from other sources. This gives a total of 83 kg/yr. It is not clear how any of these estimates were derived, and the total is significantly less than the mean of the range shown in the table above (116.4 kg/yr).

Coal washing

Coal washing is usually carried out when the coal is contaminated with significant amounts of clay and other mineral matter, and results in a cleaner, higher value product. There is only a limited amount of coal washing carried out in New Zealand and this is only done on a relatively small (non-industrial scale) on West Coast coal (N. Newman, CRL Energy, pers comm, 2013). A study by Li (2002) found that most of the mercury in Stockton coal was associated with the clay fraction and could, therefore be removed by washing. However, the effect of this would be to simply replace the potential discharge to air, when burned, with a discharge to land or water. The potential releases from coal washing have not been assessed, but this would not affect the estimates for total mercury inputs. It would only change the output distribution across the different environmental compartments.

3.3 Mineral oils - extraction, refining and use

This Toolkit sub-category covers the extraction, refining, and uses of mineral oil (ie. petroleum products). This includes the combustion of oil to provide power, heat, and transportation, and other related uses, such as in bitumen. However, despite the relative potential complexity of these different areas, the input and output estimates can be broken down into a set of relatively straightforward calculations for the following three basic stages: oil extraction, oil refining and oil/petroleum combustion.

Oil extraction

There are currently 17 productive oil fields in New Zealand, although the majority of production is accounted for by five of these; Maui, Pohokura, Tui, Maari and Kupe (MBIE, 2013). The combined production is a mixture of crude oil (52%) and natural gas liquids, condensates and naphtha (48%), with a total production in 2012 of 1,851,700 tonnes. No data has been obtained on the mercury content of any of this production, but the Toolkit recommends a default factor of 3.4 mg/tonne. Using this factor gives a total annual mercury input for New Zealand oil extraction of 6.3 kg/year.

The Toolkit indicates that there may be some minor releases of mercury (and other oil components) via the wastewater produced during oil extraction. This wastewater is usually processed through oil/water separators so only minor amounts of contaminants are released via the waste discharge. The Toolkit classifies the discharge as being to water but at the New Zealand on-shore oil fields it is more likely to be to land. The default distribution factor is 0.2 (ie 20%), which indicates a potential release to land of 1.26 kg/year.

Virtually all of New Zealand's indigenous oil production is exported (MBIE, 2013). Hence, the remainder of the 6.3 kg/yr of mercury inputs noted above (ie. 5.04 kg/yr) has not been included in this inventory.

Oil refining

The total intake of crude oil and refinery feedstock for the Marsden Point oil refinery in 2012 was 251.9 PJ, which is equivalent to about 5,529,000 tonnes (MBIE, 2013). No recent data has been obtained on the mercury content of any of the refinery inputs. The Toolkit default factor of 3.4 mg/tonne for crude oil has been used for the input calculations, to give a mercury input to the refinery of 18.8 kg/year.

The Toolkit indicates that just over 40% of the mercury inputs to a refinery are lost through discharges to air, and releases in refinery wastes and by-products, such as sulphur and bitumen. No data is available on the actual distribution through the Marsden Point refinery, so the Toolkit default factors have been used: 0.25 (25%) to air, 0.01 (1%) to water and 0.15 (15%) to wastes. The remaining 59% of mercury inputs (11.09 kg/year) are assumed to carry over into the refinery products, such as petrol, diesel, and heavy fuel oil, and are accounted for under the use category discussed below.

Use of refined products

The Toolkit makes very little distinction between the different ways in which oil products may be used, because it assumes that most of them will ultimately be burned, and all of the mercury will be discharged to air. The only sub-classes considered are residential heating and cooking, and industrial combustion facilities with a high degree of emission control. Residential heating and cooking only accounts for 1.3% of total petroleum product consumption in New Zealand (MBIE, 2013), and there are no oil-fired industrial facilities in New Zealand with an advanced level of emission control. Hence the total consumption of refined oil products has been accounted for under the 'other combustion' Toolkit category, which includes all uses in transportation, and in industrial and commercial applications.

As indicated above, the mercury inputs via products distributed from the Marsden Point refinery are 11.09 kg/year. However, about 30% of New Zealand's domestic petroleum consumption is contributed from imported refined product. There is no data available on the mercury content of these imports, but it should be reasonable to assume they would be similar to those produced in-country. This indicates a total mercury input from petroleum products of about 14.42 kg/year, and the same output quantity, in the form of discharges to air.

Input and output estimates

The mercury input and output calculations for Mineral Oils – Extraction, Refining and Use are summarised in Table 3-4.

Table 3-4: Input and output estimates for mineral oils - extraction, refining and use

Source	Activity Rate, tonnes/yr	Mercury content, mg/kg	Annual Mercury Inputs, kg/yr	Annual Mercury Outputs, kg/yr			
				Air	Water	Land	Waste
Oil extraction	1,851,000	0.0034	1.26[a]	-	-	1.26	-
Oil refining	5,529,000	0.0034	18.8	4.7	0.19	-	2.82
Oil use	-	-	14.42	14.42	-	-	-
Totals			**23.4**[b]	**19.12**	**0.19**	**1.26**	**2.82**

Notes: a a further 5.04 kg/year is removed through exports.

b individual inputs do not add up to this total because 59% of the refining input (11.09 kg/yr) carries over into the oil use inputs.

Certainty assessment

Activity data: HIGH (because it was obtained from a national database)

Input estimates: LOW (because they are based on the default Toolkit input factors)

Output estimates: LOW (because they are based on the default Toolkit output factors).

Comparison with 2008 estimates

The 2008 Inventory Report gave an input estimate of approximately 80 kg/yr for the refining of oil and use of liquid fuels in New Zealand. It was assumed that 55% (44 kg) of this would be distributed across refinery discharges, and 45% (36 kg) via the use of liquid fuels. The main reason for the differences in the estimates is that most crude oil was assumed to have a mercury content of 10 mg/tonne, which is about 3 times higher than the default Toolkit value, but in addition,11% had an even higher (but unspecified) level.

3.4 Natural gas - extraction, refining and use

As with mineral oils, the mercury releases from natural gas are considered through all three stages of gas extraction, processing and use.

Gas extraction and processing

Natural gas is produced from the same 17 fields as noted previously for oil (MBIE, 2013). About 85% of the gas production comes from the Maui, Pohokura, Kapuni, Maari and Kupe fields, and the total gas production in 2012 from all fields was 4,642 million cubic metres (Mm^3), with an energy content of about 180 PJ. However, net production is only about 90% of this total due to losses from reinjection, flaring, and other production processes.

Only a very limited amount of data has been obtained to date on the mercury content of New Zealand natural gas[10]. Recent testing on a recently-developed field[11], gave results in the range of 12 to 191 $\mu g/m^3$ with a mean of 79 $\mu g/m^3$ (8 samples). However, more regular testing on two more established production fields gave results of

10 The data quoted here was provided by various gas industry sources.

11 The oil industry has recently become more wary of the potential hazards from mercury in natural gas following a catastrophic failure of an LNG plant in Algeria, which may have been due to the weakening of aluminium components by amalgamation with the mercury.

<0.1 and <0.5 µg/m^3. The results for the new field are quite consistent with the range of 2 – 200 µg/m^3 noted in the Toolkit but the data for the established fields is much lower.

The Toolkit recommends that mercury inputs at the extraction stage be calculated using the concentration range noted above, or a default mid-range factor of 100 µg/m^3. Applying these factors to the New Zealand gas volumes gives a total mercury input of between 9 and 942 kg/year, with a mid-range value of 471 kg/year. However, on the basis of the New Zealand gas data noted above, it would be more appropriate to use a range of 0.1 to 80 µg/m^3, which gives input estimates of 0.46 to 371.4 kg/year, with a mid-range value of 185.9 kg/year.

The output factors given in the Toolkit show that about 50% of the mercury in the gas is carried over into product (ie 92.85 kg/year for New Zealand), and the remainder discharged to air (20%), water (20%) or in wastes (condensates, 10%). However, the indicated releases into products are puzzling, because the subsequent calculations for pipeline gas (see below) are based on much lower mercury concentrations than suggested by the 50% split. The Toolkit does provide an option of gas cleaning prior to distribution, which reduces the product distribution factor to 10%, with 60% of the mercury then going to wastes. However, this still gives an annual release into products of 18.59 kg/year for New Zealand, as opposed to the 0.94 kg/year derived using the Toolkit factor for pipeline gas (see below).

Information provided by the gas industry confirms that mercury is present in some production wastes but the total quantities have not been quantified. In addition, there is a limited amount of data that confirms that the mercury concentrations in pipeline gas are very low. On this basis, it has been assumed that the output factor for the distribution into pipeline gas is only 1%, and that the output factor for wastes is 59%.

Gas consumption

The total volume of pipeline gas distributed in New Zealand in 2012 was 4,277 Mm^3, with an energy content of about 170 PJ. Natural gas is only available in the North Island, and the main uses are as follows:

Electricity generation	32%
Cogeneration plants	12%
Consumer energy	35%
Non-energy use (urea)	15%

The remaining 6% of the total gas volumes are accounted for as production and distribution losses.

The Toolkit default factor for pipeline quality gas is 0.22 µg/m^3 and it is assumed that all of the mercury is released during combustion, although that may not be the case for the non-energy use. Using this factor, the total mercury inputs and outputs are both 0.94 kg/year.

Input and output estimates

The mercury input and output calculations for Natural Gas – Extraction, Refining and Use are summarised in Table 3-5. The figures shown in brackets are the means of the reported ranges.

Certainty assessment

Activity data:	HIGH (because it was obtained from a national database)
Input estimates:	LOW (because they are based on the default Toolkit input factors)
Output estimates:	LOW (because they are based on the default Toolkit output factors).

Table 3-5: Input and output estimates for natural gas - extraction, refining and use

Source	Activity Rate, Mm^3/yr	Mercury content, $\mu g/m^3$	Annual Mercury Inputs, kg/yr	Annual Mercury Outputs, kg/yr			
				Air	Water	Waste	Product
Gas extraction	4,642	0.1 - 80	0.46 – 371.4	0.09 – 74.3	0.09 – 74.3	0.27 – 219.1	<0.01 – 3.7
Gas use	4,277	0.22	0.94	0.94	-	-	-
Totals			**0.46 – 371.4 (185.9)**[a]	**0.09 – 74.3 (37.2)**[a]	**0.09 – 74.3 (37.2)**[a]	**0.27 – 219.1**[a] **(109.7)**	**<0.01 – 3.7**[a] **(1.86)**

Notes: a the mercury in pipeline gas has already been accounted for in the mercury from gas extraction.

Comparison with 2008 estimates

The 2008 Inventory estimated mercury releases of 60 kg/year for this sub-category, which was based on a natural gas volume of 4,700 Mm^3, and a mercury content of 13 $\mu g/m^3$. There was no distinction between the gas extraction/production stage and distribution and use of pipeline gas.

The total gas volume used in 2008 was much the same as in 2012 (4700 vs 4642 Mm^3), and the use of a factor of 13 $\mu g/m^3$ gives a total input value of about one sixth of the maximum value calculated for 2012 (60 vs 371.4). Therefore, if the various outputs had been calculated for 2008, they would also have been about one sixth of the maxima shown in the table for 2012.

3.5 Other fossil fuels – extraction and use

This Toolkit sub-category covers materials such as oil shale and peat. There is no oil shale extraction in New Zealand and peat is not used as a fuel. There may be some mercury releases from accidental fires in peat bogs, but the quantities involved in these (ie the activity rate) would be virtually impossible to determine. Hence this sub-category has not been assessed.

3.6 Biomass-fired power and heat production

The mercury in wood and other biomass originates from that taken up naturally from the soil, and mercury deposition from the atmosphere as a result of natural and anthropogenic emissions to air. Most of the mercury is discharged back into the air when the biomass is burned. This Toolkit sub-category is concerned with the burning of wood and other biomass as an industrial fuel, and in residential heating and cooking.

The Energy Data File indicates that the maximum amount of energy that would have been consumed in New Zealand from plants operating on biomass, in 2011[12], was 60.59 PJ, with 8.5% of this being used in cogeneration plants, 79.3% in industrial boilers, and 12.2% for residential heating and cooking (MBIE, 2013). However, the figure for total biomass is based on the assumption that industrial plants operate at full load for 24 hours a day and 365 days a year, which is not the case. An alternative approach to estimating industrial wood use was described in the report on the New Zealand dioxin inventory (MfE, 2011a), and is based on the assumption that plants are operated at 70% load (on average) for 320 days a year. Applying this approach to the current industrial wood-burning plant listed in the Heat Plant Database results in an estimated total annual wood consumption of

12 The NZEDF data is not yet available for 2012. However, there was virtually no change between 2010 and 2011, so it is reasonable to assume that the 2012 data will also be very similar.

36.8 PJ (including residential heating) (A Bingham, pers comm, 2013). This usage is roughly equivalent to 1.8 million tonnes/year of dry wood or 4 million tonnes/year of freshly harvested wood.

There is no published data available on the mercury content of New Zealand wood. A single set of unpublished data for wood waste that was to be used as supplementary fuel in a cement kiln (O Khanal, Northland Regional Council, pers comm, 2013) indicated a mercury content in the range of <0.01 – 0.09 mg/kg, with a mean of 0.012 mg/kg (12 samples). However, this data is too limited to be taken as representative of all New Zealand wood. The Toolkit recommends a default input factor of 0.03 mg/kg, or a range of 0.007 – 0.07 mg/kg, and the latter will be used in the release input calculations. It also recommends that all of the mercury be considered as being released to air, in the absence of any local distribution data.

The mercury input and output calculations for the biomass-fired power and heat are shown in Table 3-6. The figures shown in brackets are the means of the reported ranges.

Table 3-6: Input and output estimates for biomass-fired power and heat production

Source	Activity Rate, tonnes/yr	Mercury content, mg/kg	Annual Mercury Inputs, kg/yr	Annual Mercury Outputs, kg/yr
				Air
Biomass usage (dry basis)	1,800,000	0.007 - 0.07	12.6 – 126 (69.3)	12.6 – 126 (69.3)

Certainty assessment

Activity data: MEDIUM (because it was obtained from a combination of national data and estimated operating loads)

Input estimates: LOW (because they are based on the default Toolkit input factors)

Output estimates: LOW (because they are based on the default Toolkit output factors).

Comparison with 2008 estimates

The 2008 Inventory Report gave an input estimate of 0.4 - 77 kg/yr for biomass combustion. However, this was based solely on residential wood burning, and the mercury content was assumed to be in the range of 0.0002 – 0.037 mg/kg.

3.7 Geothermal power production and use

Geothermal steam contains small quantities of mercury, and most of this is released to air if the steam is discharged to air after direct use as a source of heat, or if the steam is used for electricity generation. Most geothermal power stations in New Zealand re-inject the geothermal fluids back into the ground after use, to assist in maintaining reservoir pressures. However, the mercury is mainly present in the steam and non-condensable gases which are separated from the fluids, and are not 'captured' by the re-injection process (Thain, 2009).

The Energy Data File lists nine[13] geothermal power stations as operating in 2011, with a total installed capacity of 723 MW of electricity (MWe)[14]. This is a significant increase from 2007, when the installed capacity was 443

13 Other sources list 12 or more (eg. see Thain, 2009) but this is mainly due to some power stations having multiple generation units, some of which are known by different names.

14 The website for the NZ Geothermal Association provides a more detailed listing, and shows a total installed capacity in 2013 of 747 MWe. This includes the 23 MWe Te Huka plant commissioned in 2010 (see http://www.nzgeothermal.org.nz/elec_geo.html).

MWe, and the even lower level of 370 MWe, in 2004. This steady rate of increase is still continuing, with 2 other major power stations due to be commissioned during 2013 (Ngatamariki, 82 MWe, and Te Mihi, 235 MWe) and a third (Tauhara II, 250 MWe) planned for some time in the next few years. Thain (2009) lists several other smaller developments that are currently in the early planning stages. All of the current power stations and the proposed developments are concentrated in the Waikato and Bay of Plenty regions, apart from the existing 25 MWe Ngawha plant in Northland.

In 2011, New Zealand's total electricity generation from geothermal power was 5,770 GigaWatt-hours. (This is equivalent to all of the existing power stations (723 MW) operating for 7980 hours, or about 91% of the year).

The mercury content of geothermal fluids varies between different geothermal fields. The mercury emission rates for 10 of the existing and proposed[15] power stations have been obtained from the estimates given in the application documents for some of the more recent power station developments in the Bay of Plenty and Waikato regions (Contact Energy, 2007, 2009 and 2012, and Mighty River Power, 2010a and 2010b). The emission rates indicate mercury emission factors, for the discharges to air, in the range of 0.03 – 0.22 grams per MegaWatt-hour (MWh), with an average of 0.114 g/MWh. Unfortunately, no data is available for the Ngawha field, which is believed to have relatively high levels of mercury (but will be a relatively minor contributor overall, because of its small size). There are no input or output factors given in the Toolkit for this sub-category, so the calculated emission factors will be used for the release estimates.

The Wairakei Power Station differs from all of the others in that most of the condensed steam, is not re-injected after use, but is discharged to the Waikato River. This includes a portion of the mercury present in the associated gases, which in other stations is all discharged to air. In the 2008 Inventory report, the mercury releases from these discharges were estimated at 46.5 kg/year, and this figure still applies today (M Brockelsby, Waikato Regional Council, pers comm, 2013). Wairakei is New Zealand's oldest power station, and its generation rate is expected to be drastically reduced after the nearby Te Mihi plant is commissioned later this year.

The mercury input and output calculations for geothermal power are shown in Table 3-7 below. In addition to electricity generation, an allowance has been made for direct uses of total geothermal energy. These account for an additional 6% of geothermal use, on an energy basis, including a very minor contribution from residential uses in Rotorua (MBIE, 2013). The inputs from these have simply been assessed on a proportional basis from the power generation inputs. The figures shown in brackets are the means of the reported ranges.

Table 3-7: Input and output estimates for geothermal power production and use

Source	Activity Rate, GWh/yr	Mercury content, g/MWh	Annual Mercury Inputs, kg/yr	Annual Mercury Outputs, kg/yr	
				Air	Water
Geothermal power	5,770	0.03 - 0.22	173.1 – 1,269.4	126.6-1,222.9[a]	46.5
Direct use	based on 6% of the above		10.4 – 76.1	10.4 – 76.1	-
Total			**183.5 – 1,345.5 (764.5)**	**136.9 – 1,298.6 (718)**	**46.5**

Notes: a the Wairakei release to water have been subtracted from the total inputs to give the releases to air.

15 The mercury emission rates are calculated from gas composition data which is obtained from bore samples, and this can be done for both new and proposed power stations.

Certainty assessment

Activity data: HIGH (because it was obtained from a national database)

Input estimates: MEDIUM (because they are based on a range of published data)

Output estimates: MEDIUM (because they are based on a range of published data).

Comparison with 2008 estimates

The 2008 Inventory Report gave a total input/output estimate of 350 kg/yr for geothermal energy use, for a total generation capacity of about 523 MW. The mercury release rates were only based on gas data for the Wairakei and Ohaaki Power Stations.

3.8 Summary for this category

The estimated inputs and outputs for the Fuel/Energy Use category are summarised in Table 3-8. From this it can be seen that the greatest inputs are associated with the use of geothermal energy, followed by natural gas extraction and refining. The dominant release route is to air.

Table 3-8: Summary of inputs and outputs for the fuel use category

Category	Mercury Inputs, kg/year	Mercury Outputs, kg/yr				
		Air	Water	Land	Product	Waste
Coal – large power plants	25.4 – 241.3 (133.4)	22.86 – 217.2 (120.0)	-	2.54 – 24.13 (13.34)	-	-
Other coal combustion	45.57 – 187.25 (116.4)	43.3 – 177.9 (110.6)	-	-	-	2.25 – 9.3 (5.8)
Oil extraction, refining and use	23.4	19.12	0.19	1.26	-	2.82
Gas extraction, refining and use	0.46 – 371.4 (185.9)	0.09 – 74.3 (37.2)	0.09 – 74.3 (37.2)	-	<0.01 – 3.7 (1.86)	0.27 – 219.1 (109.7)
Other fossil fuels	-	-	-	-	-	-
Biomass fuel	12.6 – 126 (69.3)	12.6 – 126 (69.3)	-	-	-	-
Geothermal power	183.5 – 1,345.5 (764.5)	136.9 – 1,298.6 (718)	46.5	-	-	-
Totals	**291 – 2,295 (1,293)**	**234.9 – 1,913.1 (1,074)**	**46.8 – 121 (83.9)**	**3.8 – 25.4 (14.6)**	**<0.01 – 3.7 (1.9)**	**5.3 – 231.2 (118.3)**

The figures shown in brackets are the means of the reported ranges.

4 Primary (virgin) metal production

This category covers mercury releases from the mining and processing of metal-containing ores for the purposes of primary (virgin) metal production (UNEP, 2013). The sub-categories and the primary release pathways are summarised in Table 4-1, which has been copied directly from the UNEP Toolkit.

Table 4-1: Toolkit framework for category 2 – primary metal production

Toolkit Chapter	Sub-category	Air	Water	Land	Product	Waste/ residue	Main approach
5.2.1	Mercury	X	X	X	X	X	PS
5.2.2	Gold and silver, using mercury amalgamation	X	X	X			OW
5.2.3	Zinc	X	X	X	X	X	PS
5.2.4	Copper	X	X	X	X	X	PS
5.2.5	Lead	X	X	X	X	X	PS
5.2.6	Gold and silver, not using mercury	X	X	X	X	X	PS
5.2.7	Aluminium	X		x		X	PS
5.2.8	Other non-ferrous metals	X	X	X		X	PS
5.2.9	Ferrous metals (iron & steel)	X				x	PS

Notes: PS = Point source by point source approach; OW = National/overview approach;

X - Release pathway expected to be predominant for the sub-category;

x - Additional release pathways to be considered, depending on specific source and national situation.

4.1 Primary metals not produced in New Zealand

There is no significant primary metal production in New Zealand for the following Toolkit sub-categories: mercury, zinc, copper, lead and other non-ferrous metals. This was confirmed with the NZ Petroleum and Minerals group of the Ministry of Business and Innovation (N Sail, pers comm, 2013), and also by searching their mining licence database (using the GIS Viewer – Minerals and Coal option in the on-line services at www.nzpam.govt.nz). There are currently no permits granted for Mercury but a number of permits have been granted for zinc, copper and lead. However, these are mainly exploration permits, and there is only one mining permit which covers these three metals, plus numerous other minerals. The permit holder is the Hauraki Prospectors' Association, and they do not appear to be engaged in any commercial mining activities.

4.2 Gold and silver, using mercury amalgamation

The use of mercury amalgamation is a traditional method for recovering gold and silver from ore and it is still practised in many countries, including New Zealand, for small-scale gold mining (UNEP, 2013). Amalgamation was replaced at an industrial scale in the early 1900s by a cyanide extraction process (Newcombe, 2008). However, the cyanide process is relatively expensive and labour intensive, and not without its own potential hazards, so mercury amalgamation remains the method of choice for small-scale operations, which are referred to in the Toolkit as artisanal gold mining.

A New Zealand study published by Newcombe in 2008 indicated that mercury amalgamation was still being used by small-scale gold miners on the West Coast in 2007. More recently, the West Coast Regional Council has advised that there are up to 70 sites in the region where mercury is being used for gold recovery (J Adams, pers comm, 2013). However, the Council was unable to provide exact data on the numbers and locations of the processing sites, or the quantities of mercury being used.

The information obtained from several waste processing companies (eg. see section 11.6) indicates that at least 20kg of liquid mercury was sold to small-scale gold miners in 2012. In the absence of any more detailed data, this has been taken as a minimum estimate of the total mercury inputs for small-scale gold mining in New Zealand. Newcombe (2008) indicates that most of the mercury is recovered and recycled using simple retorts, although there are inevitably some mercury losses from these systems. On this basis, the Toolkit distribution factors for 'extraction from ore concentrate with use of retorts and recycling' can be used, which indicate that 20% of the mercury will ultimately be discharged to air, and 40% each to water and to land.

The mercury input and output calculations for gold and silver production using mercury are shown in Table 4-2.

Table 4-2: Input and output estimates for gold and silver production using mercury

Source	Annual Mercury Inputs, kg/yr	Annual Mercury Outputs, kg/yr		
		Air	Water	Land
Gold & silver, with mercury	20	4	8	8

Certainty assessment

Activity data: not relevant (because ore quantities were not considered in the estimates)

Input estimates: LOW (because the data was only obtained from indirect sources)

Output estimates: LOW (because they are based on the default Toolkit output factors).

Comparison with 2008 estimates

This process was noted in the 2008 Inventory Report as possibly still occurring in New Zealand, but was not assessed because no significant data could be found.

4.3 Gold and silver, not using mercury amalgamation

The only major gold and silver mining operations in New Zealand are at the Martha Hill, Trio and Favona mines in the Waikato region (all at Waihi), which are operated by Newmont Waihi Gold, and the Reefton, Macraes and Frasers mines operated by Oceana Gold, in the West Coast and Otago regions. The total national gold production in 2011 was 11,761 kg (MBIE, 2012), along with 14,324 kg of silver, which is produced in parallel with the gold. The Waihi mine accounts for about 25% of this production.

Detailed process information has been obtained from Oceana Gold (B O'Leary, pers comm, 2013). The total volume of rock and ore processed at both of their mines is 7.4 million tonnes per annum, and the average mercury content of the ore is 0.5 to 1 g/tonne. No information has been obtained directly on the quantities and mercury content of the ore processed at the Waihi mine, but evidence presented at a recent resource consent hearing indicated that the company was currently processing about 2,600,000 tonnes per year of ore and waste rock (Grindlay, 2013).

The waste rock is estimated to make up about 75% of the total volume of mined material (A Bingham, pers comm, 2013), and this is separated from the gold-bearing ore prior to processing for gold extraction, and is used for the construction of tailings dams. There is no reason to expect that this rock will contain significant amounts of mercury[16], so has not been included in the input calculations. The total volume of processed ore for both mines has therefore been estimated at 2,500,000 tonnes per year.

Oceana Gold indicated that some of the mercury in the ore is released during gold room operations (electro-winning and smelting), but this is captured in a scrubber system and the recovered mercury waste (~55 kg/year) is sold to a company in Australia. The waste slurry from ore processing is disposed to tailings dams and there are known to be some minor, but unquantified, mercury releases to water. As indicated in section 2.2, the waste disposal to a tailings dam has been classified as a release to land.

The Toolkit default factors for estimating the output distributions are 0.04 (4%) releases to air, 0.02 (2%) releases to water, 0.9 (90%) releases to land, and 0.04 (4%) releases in products.

The mercury input and output calculations for gold and silver production not using mercury are shown in Table 4-3, which shows that the most significant output is due to the tailings disposal to land. It is also interesting to note that the 55 kg/year of mercury indicated above as being recovered from the Oceana processing plant fits comfortably within the range of 49 – 98 kg/year indicated as being released in products. It is not known whether similar quantities of 'product' are recovered from the Waihi processing operations. The figures shown in brackets are the means of the reported ranges.

Table 4-3: Input and output estimates for gold and silver production not using mercury

Source	Activity Rate, Mt/yr	Mercury content, g/tonne	Annual Mercury Inputs, kg/yr	Annual Mercury Outputs, kg/yr				
				Air	Water	Land	Waste	Product
Gold & silver, no mercury	2.5	0.5 – 1.0	1,250 – 2,500 (1,875)	50 – 100 (75)	25 – 50 (37.5)	1,125 – 2,250 (1,687.5)	-	50 - 100 (75)

Certainty assessment

Activity data: MEDIUM (because they are based on company data plus an estimate of the ore/rock distribution)

Input estimates: MEDIUM (because they are based on incomplete company data)

Output estimates: LOW (because they are based on the default Toolkit output factors).

Comparison with 2008 estimates

The 2008 Inventory estimated mercury releases of 0.2 kg/year from ore processing and also noted that there were very low concentrations in wastewater. The overall discharges were assessed as being less than 1 kg/year. It is not clear as to why the release estimates were so low, and also why there were no estimates for releases to land, which is the primary route for waste ore disposal.

4.4 Aluminium production

The Toolkit covers two stages in the aluminium production cycle; initial refining of alumina from bauxite, and the production of aluminium metal from alumina, by smelting. The only primary aluminium production plant in New Zealand is the aluminium smelter at Tiwai Point in Southland and this fits into the latter category. The alumina is imported from other countries in a highly refined form, and is believed to contain no significant concentrations of mercury (C Scarlett, Pacific Aluminium, pers comm, 2013).

16 The mercury is concentrated in the ore by the same geophysical processes that form the gold deposits.

The Toolkit indicates that there may be some mercury releases from aluminium smelting, but does not provide any references to published data or recommended input factors. In addition, for the bauxite refining process it shows that all of the mercury is released to the environment, with no residual mercury in the alumina product. This tends to support the suggestion that the alumina brought into New Zealand is essential mercury-free.

Pacific Aluminium indicated that there may be some minor releases of mercury on the site from the use of fuel oil in ancillary processes, such as anode manufacture. The releases from fuel combustion were previously assessed in section 3.3 so do not need to be covered here.

On the basis of the above, the inputs and outputs from primary aluminium manufacture have been assessed as zero. A similar assessment was given in the 2008 Inventory Report.

4.5 Ferrous metal production (iron and steel)

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 quite unique in that it obtains the iron input from nearby reserves of iron sand, which is a mixture of magnetite and titanomagnetite, plus sand and clay (NZIC, 1998a). A concentrate of the iron sand is mixed with coal, and heated in special gas-fired multi-hearth furnaces, followed by further processing in rotary kilns, to form Reduced Primary Concentrate (RPC). The RPC is then heated in electric arc melters to produce metallic iron, which is further processed in a KOBM (Klockner Oxygen Blown Maxhutte) Converter to produce steel. The total steel production for the year ended June 2012 was 609,000 tonnes and the mill also used 805,000 tonnes of Waikato and Indonesian coal[17], and 43,000 tonnes of lime (C Jewel, BlueScope Steel, pers comm, 2013).

The ferrous metal sub-category in the Toolkit refers to a much more common iron making process which involves the processing of iron ore – usually haematite - in a sintering plant, followed by treatment in a blast furnace to produce pig iron, and subsequent processing into iron and steel. In terms of mercury inputs, the key differences between this and the New Zealand process would be the mercury content of the iron sand or iron ore, and the relative amounts of coal used. In both processes most of the mercury is likely to be released to air during the first two processing stages (ie for New Zealand, in the manufacture of RPC and processing in the KOBM).

No information on mercury inputs or releases from the New Zealand plant has been obtained from BlueScope Steel, although they advised that no leachable mercury has ever been detected in the solid wastes produced by the iron sand processing plant. In the absence of this data, an initial assessment of the likely mercury inputs and releases can be obtained from consideration of the coal and limestone inputs to the process, as these are likely to be the main contributors to the releases. The mercury content of Waikato coal was discussed in section 3.2, and the content of lime is discussed in section 5.3, and the same ranges of values have been used for the steel input estimates. The steel mill air emissions are passed through bag filters prior to discharge, so the Toolkit distribution factors for fabric filters on coal combustion plants have been used for the output distribution; ie. 50% to air and 50% to waste.

The mercury input and output calculations for primary ferrous metal production are shown in Table 4-4.

No allowance has been made for the potential contributions from any mercury present in the iron sand, although the leaching tests suggest that this is most likely very low. The figures shown in brackets are the means of the reported ranges.

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[17] 10% of the coal was from Indonesia.

Table 4-4: Input and output estimates for primary ferrous metal production

Source	Activity Rate, tonnes/yr	Mercury content, mg/kg	Annual Mercury Inputs, kg/yr	Annual Mercury Outputs, kg/yr	
				Air	Waste
Waikato coal	805,000	0.05 - 0.20	40.3 – 161	20.15 – 80.5	20.15 – 80.5
Limestone	43,000	0.005 – 0.02	0.22 – 0.86	0.11 – 0.43	0.11 – 0.43
Total			**40.5 – 161.9 (101.2)**	**20.3 – 80.9 (50.6)**	**20.3 – 80.9 (50.6)**

Certainty assessment

Activity data: MEDIUM (because it was based on partial company feedstock data)

Input estimates: LOW (because they are based on a limited range of published data and industry estimates)

Output estimates: LOW (because they are based on default Toolkit output factors for another category).

Comparison with 2008 estimates

The 2008 Inventory Report gave an input estimate of 26 kg/yr, based on a Toolkit default factor for primary ferrous metal production. However, this factor has now been superseded by the recommendation in the latest version of the Toolkit that releases should be calculated from each of the individual inputs (ie coal, ore, etc).

4.6 Summary for this category

The estimated inputs and outputs for the Primary Metal Production category are summarised in Table 4-5. From this it can be seen that the inputs are totally dominated by the use of ore in gold and silver production, most of which is returned to the land by disposal in the tailings dump.

Table 4-5: Summary of inputs and outputs for the primary metal production category

Category	Mercury Inputs, kg/year	Mercury Outputs, kg/yr				
		Air	Water	Land	Product	Waste
Mercury	-	-	-	-	-	-
Gold & silver, with mercury amalgamation	20	4	8	8	-	-
Zinc, copper, lead, other	-	-	-	-	-	-
Gold & silver, without mercury	1,250 – 2,500 (1,875)	50 – 100 (75)	25 – 50 (37.5)	1,125 – 2,250 (1,687.5)	50 – 100 (75)	-
Aluminium	-	-	-	-	-	-
Ferrous metals	40.5 – 161.9 (101.2)	20.3 – 80.9 (50.6)	-	-	-	20.3 - 80.9 (50.6)
Totals	**1,310.5 – 2,681.9 (1,996.2)**	**74.3 – 184.9 (129.6)**	**33 – 58 (45.5)**	**1,133 – 2,258 (1,695.5)**	**50 – 100 (75)**	**20.3 – 80.9 (50.6)**

The figures shown in brackets are the means of the reported ranges.

5 Production of minerals and materials with mercury impurities

This category covers mercury releases from the production of minerals and related materials with mercury impurities (UNEP, 2013). The sub-categories and the primary release pathways are summarised in Table 5-1, which has been copied directly from the UNEP Toolkit. For the New Zealand inventory, the use of phosphate-based fertilisers and agricultural lime will also be considered under the catch-all sub-category 'other minerals and materials'.

Table 5-1: Toolkit framework for category 3 –production of minerals and materials with mercury impurities

Toolkit Chapter	Sub-category	Air	Water	Land	Product	Waste/ residue	Main approach
5.3.1	Cement production	**X**		x	x	**x**	PS
5.3.2	Pulp and paper production	**X**	x	x		x	PS
5.3.3	Lime production and light-weight aggregate kilns	**X**			x		PS
5.3.4	Other minerals and materials						PS

Notes: PS = Point source by point source approach;

X - Release pathway expected to be predominant for the sub-category;

x - Additional release pathways to be considered, depending on specific source and national situation.

5.1 Cement production

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 per year, and the annual cement production in 2012 was about 1,110,000 tonnes of cement (A Krishna, Milburn Ltd, and O Khanal, Northland Regional Council, pers comm, 2013).

The primary raw ingredient for cement manufacture is limestone, which contains traces of mercury (see section 5.3). There is also mercury in the coal used as fuel and in the supplementary fuels. The mercury content of the waste lubricating oil used at the Holcim plant is unknown. Both plants carry out regular emission testing on their kilns, and the most recent results indicate annual mercury emissions to air of 2.6 kg/year from the Golden Bay plant (O Khanal, Northland Regional Council, pers comm, 2013) and 1.8 kg/year for the Holcim plant (A Krishna, Holcim Cement, pers comm, 2013). The sum of these two figures has been used to estimate the annual mercury inputs for cement production, including those due to fuel use.

The input factors given in the Toolkit cover a range of 0.004 to 0.5 g/tonne of cement. Applying these factors to a total annual production rate of 1,110,000 tonnes gives mercury inputs of from 4 to 555 kg/year. The bottom of this range is quite comparable to the inputs indicated by the New Zealand emission testing data, while the upper value is based on a highly conservative assessment of international information. The Toolkit default factors have not been used for this source category because the available emissions data provides a more relevant estimate.

The Toolkit indicates that there is some partitioning of the mercury between the air emissions and the clinker product. In the Toolkit terminology, the two New Zealand plants would be described as having simple particulate controls[18], with output distribution factors of 0.7 (70%) to air and 0.3 (30%) to product. Applying these to the combined air emission rate of 4.4 kg/year, gives an estimated release in product of 1.9 kg/year, and a total production input of 6.3 kg/year.

The mercury input and output estimates for cement production are shown in Table 5-2.

Table 5-2: Input and output estimates for cement production

Source	Activity Rate, tonnes/yr	Annual Mercury Inputs, kg/yr	Annual Mercury Outputs, kg/yr	
			Air	Product
Cement production	1,110,000	6.3	4.4	1.9

Certainty assessment

Activity data: HIGH (because it was based on plant production data).

Input estimates: MEDIUM (because they are based on measured data, but only for air emissions).

Output estimates: MEDIUM (because the product release was estimated from a default factor).

Comparison with 2008 estimates

The 2008 Inventory Report gave an input estimate of 13.2 kg/yr, based on a combination of measured data for the Holcim plant and the use of the Toolkit default factor for the Golden Bay plant. Both the measured emissions and the Toolkit factor were higher than those used for the current estimates.

5.2 Pulp and paper production

Pulp and paper production is treated as a separate sub-category in the Toolkit because historically there were significant uses of mercury within the industry; especially in chlor-alkali plants (see section 6.1), and as a slimicide (see section 7.6). However, both of these uses no longer occur in New Zealand, so the only significant source of mercury inputs and outputs is via the use of wood, as both a fuel and a raw material.

A previous assessment of New Zealand wood combustion indicated that the pulp and paper industry accounted for about 44% of the total national usage, on an energy basis (MfE, 2011a). If this factor is applied to the mercury inputs and outputs reported previously in section 3.5, the inputs due to pulp and paper production would be 9.2 – 92 kg/year, with the same quantities of outputs going to air. These estimates could be reported as a separate item within this source category, but there seems little value in separating it out from all other wood uses.

The 2008 Inventory Report took a similar approach to that given here, and simply noted that the inputs and outputs from wood use had been covered under the section on biomass fuel.

5.3 Production of lime and light-weight aggregate

This Toolkit sub-category covers the production of burnt lime from the high-temperature treatment (calcination) of limestone, and the similar processes used for manufacturing light-weight aggregate from clay, shale or slate, which is used in making concrete products. There are a number of lime kilns in New Zealand, but no evidence has been found to indicate any significant production of the type of aggregate covered by the Toolkit.

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[18] The particulate control systems on the New Zealand plants are actually quite complex. However, they do not include advanced control systems, such as selective non-catalytic reduction for NOx control.

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[19]. The other 5 kilns are located in Te Kuiti, Otorohanga (2), and Te Kumi, all in the Waikato region, and Dunback, in Otago. No data has been obtained for the total burnt lime production in New Zealand in 2012, but the annual data given in the New Zealand Greenhouse Gas Inventory reports indicates that in previous years it has been consistently in the range of 165,000 to 175,000 tonnes per year (MfE, 2012).

The Toolkit doesn't recommend any default factors for lime manufacture because the available data is very limited. However, it does note a US EPA study which reported a mercury release rate of 9 mg/tonne of lime produced. This is consistent with the results of <10 and 20 mg/tonne reported by McBride and Spiers (2001) for two samples of agricultural lime (limestone) sourced from the north-eastern United States. Within New Zealand, Curtis (2007) reported that a sample of Otago limestone collected had a mercury content of 20 mg/tonne.

No mercury emissions data is available for one of the Waikato lime kilns (M James, Perry Lime, pers comm, 2013) and this is expected to also be the case for the others. In the absence of any recommended Toolkit factors, a range of 5 to 20 mg/tonne[20] will be used for the mercury inputs estimates. Some of the lime kilns are fired on coal but the inputs and outputs from this component have already been accounted for under section 3.2. In accordance with the Toolkit guidance, the output distribution factors will be assumed to be the same as those used for cement production.

The mercury input and output estimates for lime production are shown in Table 5-3. The figures shown in brackets are the means of the reported ranges.

Table 5-3: Input and output estimates for lime production

Source	Activity Rate, tonnes/yr	Mercury content, mg/t	Annual Mercury Inputs, kg/yr	Annual Mercury Outputs, kg/yr	
				Air	Product
Lime production	170,000	5 - 20	0.85 – 3.4 (2.1)	0.595 – 2.38 (1.5)	0.255– 1.02 (0.64)

Certainty assessment

Activity data: HIGH (because it was based on published data)

Input estimates: LOW (because they are based on limited published data)

Output estimates: LOW (because the releases were estimated from default factors for cement production).

Comparison with 2008 estimates

The 2008 Inventory Report gave an input estimate of 1.6 kg/year, based on an annual lime production rate of 175,000 tonnes and a mercury release factor of 9 mg/tonne.

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19 The pulp mill kilns form part of an internal chemical recycling process for the so-called 'lime mud' produced in the pulp making process. Some minor calcium additions are required to make up for losses in wastes, but these are obtained from baked lime rather than limestone.

20 The lower figure of 5 is based on half the limit of detection (LOD) reported by McBride and Spiers. This is the approach normally used when laboratory results are reported as being less than the LOD.

5.4 Other minerals and materials

Two other New Zealand sources of mercury releases from minerals have been identified for this inventory; the application of phosphatic fertilisers and agricultural lime to land.

Phosphatic fertilisers

New Zealand agriculture uses a significant amount of superphosphate fertiliser, which is manufactured from imported phosphate rock (NZIC, 1998b). There are 6 manufacturing plants in New Zealand, located in Northland, Bay of Plenty, Hawkes Bay, Canterbury, Otago and Southland regions.

The phosphate rock is imported from numerous other countries and contains varying amounts of mercury. A survey reported by Rudnick and Gao (2004) indicated a worldwide average level of 0.05 mg/kg, while a report from the International Fertiliser Association (2002) notes levels of up to 0.4 mg/kg in Moroccan phosphate, which is currently a significant source of rock for New Zealand. Within this country, the two major suppliers of superphosphate have adopted a maximum mercury guideline of 10 mg/kg in their products, but indicate that the levels are usually much lower (NZFRMA, 2013). This has been confirmed by the Executive Manager of the Fertiliser Association of New Zealand (G Sneath, pers comm, 2013), who indicated that the most recent results from regular testing of fertiliser by the manufacturers, gave values in the range of <0.05 to 1 mg/kg, with a mean of 0.34 mg/kg. This latter concentration figure has been used for the upper value in the input and output estimates, along with a lower level of 0.05 mg/kg.

The total New Zealand imports of phosphate rock in 2012 were 630,750 tonnes (import data obtained from Statistics New Zealand, 2013). Some of this is sold for direct application to land, but most is converted into superphosphate. It is not known whether any of the mercury is released from the rock during processing but, for the purposes of an initial estimate, it has been assumed to remain in the product and be discharged to land.

Agricultural lime

Agricultural lime is applied directly to pastures in New Zealand as a soil conditioner. This material is manufactured simply by grinding limestone to produce a coarse powder, and the total quantity produced in 2011 was about 1,370,000 tonnes (MBIE, 2012). The mercury content has been assumed to be the same as that noted previously in section 5.3; ie. 5 to 20 mg/tonne.

Input and output estimates

The mercury input and output estimates for the use of other mineral products are shown in Table 5-4. The figures shown in brackets are the means of the reported ranges.

Table 5-4: Input and output estimates for other mineral products

Source	Activity Rate, tonnes/yr	Mercury content, g/tonne	Annual Mercury Inputs, kg/yr	Annual Mercury Outputs, kg/yr
				Land
Phosphate fertiliser	630,750	0.05 – 0.34	31.5 – 214.5 (123)	31.5 – 214.5 (123)
Agricultural lime	1,370,000	0.005 -0.02	7 – 27 (17)	7 – 27 (17)

Certainty assessment

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

Input estimates: LOW (because they are based on limited published data)

Output estimates: LOW (because the no manufacturing release factors were available).

Comparison with 2008 estimates

The 2008 Inventory Report gave an input estimate of 38 kg/year for fertiliser use, but did not consider agricultural lime. The fertiliser estimate was based on annual usage rate of 1,270,000 tonnes, which presumably relates to the superphosphate product rather than the phosphate rock, and a mercury content of 0.03 mg/kg. Despite these differences, the 2008 result is reasonably comparable with the bottom end of the range shown in the table.

5.5 Summary for this category

The estimated inputs and outputs for the minerals category are summarised in Table 5-5, which shows that the inputs and outputs are totally dominated by the application of superphosphate to land.

Table 5-5: Summary of inputs and outputs for production of minerals and related materials with mercury impurities

Category	Mercury Inputs, kg/year	Mercury Outputs, kg/yr				
		Air	Water	Land	Product	Waste
Cement	6.3	4.4	-	-	1.9	-
Pulp and paper	-	-	-	-	-	-
Lime	0.85 – 3.4 (2.1)	0.595 – 2.4 (1.5)	-	-	0.255 – 1.02 (0.64)	-
Superphosphate	31.5 – 214.5 (123)	-	-	31.5 – 214.5 (123)	-	-
Agricultural lime	7 – 27 (17)	-	-	7 – 27 (17)	-	-
Totals	**45.7 – 251.2 (148.4)**	**5.0 – 6.8 (5.9)**	**-**	**38.5 – 241.5 (140)**	**2.16 -2.9 (2.5)**	**-**

The figures shown in brackets are the means of the reported ranges.

6 Intentional use of mercury in industrial processes

This category covers mercury releases from several industrial chemical processes (UNEP, 2013), none of which exist in New Zealand. However, for the sake of completeness, the sub-categories and the primary release pathways are summarised in Table 6-1, which has been copied directly from the UNEP Toolkit, and information on the relevance to New Zealand is presented below.

Table 6-1: Toolkit framework for category 4 – intentional use of mercury in industrial processes

Toolkit Chapter	Sub-category	Air	Water	Land	Product	Waste/ residue	Main approach
5.4.1	Chlor-alkali production with mercury technology	**X**	**X**	**X**	**X**	**X**	PS
5.4.2	VCM (vinyl chloride monomer) production with $HgCl_2$ catalyst	x	x			**X**	PS
5.4.3	Acetaldehyde production with $HgSO_4$ as catalyst						PS
5.4.4	Other chemicals and polymers with mercury catalysts						PS

Notes: PS = Point source by point source approach;

X - Release pathway expected to be predominant for the sub-category;

x - Additional release pathways to be considered, depending on specific source and national situation.

6.1 Industrial uses of mercury in New Zealand

Chlor-alkali plants were used at one of the pulp and paper mills until the early 1980s, when they were replaced with a modern system based on a membrane cell technology (NZIC, 1998b). This was confirmed by the Environmental Manager, Carter Holt Harvey Pulp and Paper (P Millichamp, pers comm, 2013).

Vinyl chloride monomer is not manufactured in New Zealand, although significant volumes of the polymerised form of vinyl chloride (ie polyvinyl chloride, PVC) are imported for use in making PVC products. The non-manufacture of VCM in New Zealand was confirmed by the Technical Director for Responsible Care New Zealand – the former Chemical Industry Council (W Birch, pers comm, 2013). He also confirmed that there is no manufacturing of acetaldehyde in New Zealand.

Another group of industrial chemicals that was considered here was sodium and potassium methylate and ethylate[21], which have been specifically mentioned in a draft annex to the proposed text for the Minimata Convention. These chemicals are sometimes manufactured using a modified form of the mercury/chlor-alkali plants, and can be used in the manufacture of biodiesel from materials such as tallow (Gok, 2011). However, the only major producer of biodiesel in New Zealand has confirmed that they do not use methoxides or ethoxides in their process (M Johnson, Green Fuels Ltd, pers comm, 2013).

Finally, mention should be made here of two-part polyurethanes involving mercury catalysts. There is no manufacturing in New Zealand of the base ingredients for these materials, although small quantities of the ready-to-use product are imported (see section 7.6).

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21 These are also referred to as methoxides and ethoxides.

7 Consumer products with intentional use of mercury

This category covers mercury uses in a wide range of different consumer products (UNEP, 2013). The various sub-categories and the primary release pathways are summarised in Table 7-1.

Table 7-1: Toolkit framework for category 5 – consumer products with intentional use of mercury

Toolkit Chapter	Sub-category	Air	Water	Land	Product	Waste/ residue	Main approach
5.5.1	Thermometers with mercury	**X**	**X**	**X**	**X**	**X**	OW
5.5.2	Electrical switches, contacts and relays with mercury	**X**	x	**X**	**X**	**X**	OW
5.5.3	Light sources with mercury	**X**	x	**X**	**X**	**X**	OW
5.5.4	Batteries containing mercury	**X**	x	**X**	**X**	**X**	OW
5.5.5	Polyurethane with mercury catalyst	**X**	x	**X**	**X**	**X**	OW
5.5.6	Biocides and pesticides	**X**	**X**	**X**	**X**	**X**	OW
5.5.7	Paints	**X**	x	x	**X**	x	OW
5.5.8	Pharmaceuticals for human and veterinary uses	**X**	x	x	x	**X**	OW
5.5.9	Cosmetics and related products		**X**		**X**	x	OW

Notes: OW = National/overview approach;

X - Release pathway expected to be predominant for the sub-category;

x - Additional release pathways to be considered, depending on specific source and national situation.

7.1 Mercury thermometers

No New Zealand manufacturers of mercury in glass thermometers were identified in this survey.

Imports/sales

(Note: this category would also include hygrometers, which are listed in the proposed text for the Minamata Convention, but are not specifically noted in the Toolkit. The most common form of hygrometer is also known as a wet-and-dry bulb thermometer, and these would have been picked up by the various enquiries on sales and use, noted below.)

Import data for Customs' code 9025.11.00.00 (liquid-filled, direct-reading, thermometers and pyrometers) was obtained from Statistics New Zealand for the period 2008 – 2012. However, this gave a significant over-estimate of the probable weight of the thermometers (a gross weight of product and packaging of around 6,000 kg).

As an alternative approach, 15 suppliers of medical and veterinary equipment were identified and contacted, from a list of companies provided by the Medical Technology Association of New Zealand. Responses were obtained from 12 of these, which indicated total sales of mercury thermometers of about 6100 units over the last 12 months. Three laboratory supply companies were also contacted and they reported annual sales of 255 units. Overall, a figure of 6500 units has been assumed to also account for the non-responses. An estimate of the amount of mercury included in these thermometers is given below.

It should be noted that some of the suppliers indicated that the majority of the thermometers were supplied to pharmacies, and sold for personal use (rather than for use by doctors and other professionals).

Current stocks

The number of thermometers in storage and in use has been estimated from surveys of hospitals, laboratories, universities, and calibration laboratories. All of the 7 major hospitals contacted (Auckland (3), Hamilton, Wellington, Christchurch, and Dunedin) have phased out mercury-containing equipment for general hospital use, although some continue to require mercury thermometers for special applications, such as in operating theatres.

Seven major laboratories were also contacted and they indicated total holdings of around 300 units. Eight universities were contacted, and the responses received from 5 of these indicate total thermometer stocks of about 1500 units. All of these universities indicated that mercury thermometer use has been discontinued in teaching practice.

All 16 temperature calibration facilities accredited by International Accreditation New Zealand were also surveyed. Only 2 of these were found to actually calibrate mercury-containing thermometers, and only 39 units were calibrated in 2012. However, these will not be included in the total shown below because most of them should have already been included in the laboratory total.

Although mercury use has been phased out in hospitals, mercury thermometers are likely to remain in use in general practice and veterinary practices. Some indicative data has been obtained through discussions with the New Zealand Medical Association and New Zealand Veterinary Association, and as an initial estimate it has been assumed that every GP will have at least one thermometer while most clinical veterinarians are likely to use up to six conventional mercury thermometers. There are about 3600 GPs in New Zealand and 2500 vets.

The number of thermometers held by individuals in New Zealand for personal use is unknown. However, the annual sales figure noted earlier (6500 units, mainly supplied to pharmacies) can be taken as an indication of the annual turnover of the current personal holdings. If thermometers are broken at a rate of once every 2 years, then the total personal stocks would be about 13,000 units; if they were broken once every 5 years the stocks would be 32,500, and so on (eg. 10 years, 65,000). For the purposes of giving an initial estimate, the 5 year rate has been assumed to apply.

On the basis of the above, the estimated total current stocks of thermometers are as follows:

Laboratories:	300 units
Universities (after adjustment for non-responses):	2000 units
Doctors and vets:	18,600 units
Individuals (for personal use)	32,500 units
Total:	53,400 units

Input and output estimates

The Toolkit indicates that medical thermometers typically contain 0.5 – 1.5 grams of mercury each, while laboratory thermometers can contain 1 – 40 grams per unit. The upper limit for laboratory thermometers appears quite extreme, so for the purposes of this inventory, the estimate has been based on an overall range of 0.5 – 5 grams/unit (also noting that the majority of units are ‘medical’ size).

For estimating outputs, the Toolkit recommends distribution factors of 0.1 (10%) to air, 0.3 (30%) to water and 0.6 (60%) to waste, for countries with publicly controlled waste collection services. However, it should be noted that these factors should only be applied to the annual imports/sales numbers, rather than the total thermometer stocks, on the basis that the former most likely represent the annual turnover rate for the current stocks. In addition, the current stocks should not be counted as part of the annual inputs because the mercury is not 'mobilised' until the thermometers are disposed. The Toolkit makes no provision for existing stocks such as these, but they have been shown in the table under a 'Stocks' heading.

The mercury input and output estimates for the use of thermometers are shown in Table 7-2. The figures shown in brackets are the means of the reported ranges.

Table 7-2: Input and output estimates for mercury thermometers

Source	Activity Rate, units/yr	Mercury content, g/unit	Annual Mercury Inputs, kg/yr	Annual Mercury Outputs, kg/yr			Stocks, kg
				Air	Water	Waste	
Current stocks	53,400	0.5 - 5	-	-	-	-	26.7 - 267
Annual turnover	6,500	0.5 – 5	3.25 – 32.5	0.325 – 3.25	0.975 – 9.75	1.95 – 19.5	-
Totals			**3.25 – 32.5 (17.9)**	**0.325 – 3.25 (1.8)**	**0.975 – 9.75 (5.4)**	**1.95 – 19.5 (10.7)**	**26.7 – 267 (146.9)**

Certainty assessment

Activity data: MEDIUM (because it is based on survey data plus estimates)

Input estimates: LOW (because they are based on the Toolkit default factors)

Output estimates: LOW (because they are based on the Toolkit default factors).

Comparison with 2008 estimates

No information on thermometer sales or usage was obtained for the 2008 Inventory Report.

7.2 Electrical and electronic switches, contacts and relays

Mercury has been used, and continues to be used, in a variety of electrical switches and relays. Historically, one of the largest uses by volumes of mercury, per unit, was in electrical rectifiers and mercury arc valves, which were used in electricity distribution networks and industrial facilities. This type of equipment has a long service life, so there may still be a significant number of items still in use, despite the ready availability of non-mercury alternatives. At the consumer level, small mercury tilt switches have been widely used in many electrical appliances, and in car boot light switches and ABS braking systems. Mercury switches can also be found in some electrical thermostats, flame sensors, and bilge pumps for boats (UNEP, 2013).

No New Zealand manufacturers of mercury switches or relays were identified in this survey.

Imports/sales and use

No import data was obtained for this source category because the HS codes make no distinction between switches that might contain mercury and those that don't. However, on the basis of the information on usage given below, it seems likely that the current imports of mercury-containing switches and relays are insignificant.

Seven suppliers of electronic componentry were contacted for this survey, including four that include mercury tilt switches in their on-line catalogues. A visit was made to one of these companies and they were found to have 200 small switches in stock, with a mercury content of about 1 gram per switch, and indicated annual sales of about 10 switches. No sales data has been received from any of the other companies, but it seems likely that, even if they do sell these switches, the total quantities of mercury will be very small.

New Zealand's largest home appliance manufacturer, Fisher and Paykel, was also contacted, and their spokesperson confirmed that they do not use mercury-containing components in any of their products. It was also noted that this was driven in part by their export markets, because the RoHS regulations in the EU and related controls in other countries (eg. China, Japan) had placed severe restrictions on mercury use. A similar situation most likely applies to imported home appliances, because most overseas manufacturers would also be targeting the EU and other larger markets, and would be driven by the need to comply with the EU and other regulations.

Current stocks

A request for information was sent to all 25 members of the Electricity Networks Association of New Zealand, and to Transpower New Zealand. The latter organisation advised that mercury arc valve technology had been used in the high-voltage direct-current transmission link between the North and South Islands. The system was installed in 1965, but has now been decommissioned and replaced by non-mercury technology. All of the elemental mercury associated with the equipment has been removed (the last of this being taken out within the last few weeks), and was/will be shipped to Germany for recycling or disposal. The waste management company associated with this exercise estimated that the equipment contained about 50 kilograms of mercury.

The responses received from 4 of the electricity network operators, including one of the largest (Vector) indicates that there are about 1000 mercury relays within their networks, and these contain approximately 6 kg of mercury in total. Scaling this up to all operators would suggest a total existing stock of less than 50 kilograms. The operators also advised that these relays are gradually being replaced by mercury-free devices.

Finally, the Museum of Transport and Technology in Auckland advised that they currently have one operational Hewittic mercury arc rectifier set containing 50kg mercury, and a further 70kg of liquid mercury in storage.

Input and output estimates

The Toolkit recommends default factors of 0.02 – 0.25 grams/year per capita for estimating current mercury inputs via electrical switches and relays. However, these factors are based on data which is 10 to 20 years old, and they are also dominated by relatively high usage rates in the USA. A range of 0.002 - 0.02 grams/year per capita has been used here with the aim of gaining an initial assessment of the possible scale.

For outputs, the Toolkit recommends distribution factors of 0.1 (10%) to air, 0.1 (10%) to land and 0.8 (80%) to waste, for countries with publicly controlled waste collection services, but only limited waste separation. These factors have only been applied to the per capita inputs estimated using the modified Toolkit factors. The current stocks will not be counted as part of the annual inputs because the mercury is not 'mobilised' until the switches and other stocks are disposed (generally through specialist waste contractors – see section 11.6). As with thermometers, these have been shown in the table under the Stocks heading.

The mercury input and output estimates for mercury switches and relays are shown in Table 7-3. The figures shown in brackets are the means of the reported ranges.

Certainty assessment

Activity data:	HIGH (because it is based on national population)
Input estimates:	LOW (because they are based on the Toolkit default factors)
Output estimates:	LOW (because they are based on the Toolkit default factors).

Table 7-3: Input and output estimates for mercury switches and relays

Source	'Activity' (population)	Mercury input rate, g/capita	Annual Mercury Inputs, kg/yr	Annual Mercury Outputs, kg/yr			Stocks, kg
				Air	Land	Waste	
Current stocks	-	-	-	-	-	-	170
Annual usage	4.4×10^6	0.002 – 0.02	8.8 – 88	0.9 – 8.8	0.9 – 8.8	7.0 – 70.4	-
Totals			**8.8 – 88 (48.4)**	**0.9 – 8.8 (4.8)**	**0.9 – 8.8 (4.8)**	**7.0 – 70.4 (38.7)**	**170**

Comparison with 2008 estimates

The use of mercury in electrical switches and relays was discussed in the 2008 Inventory Report but no estimates were provided because no data was available.

7.3 Light sources (lamps)

Mercury is used in small amounts (per lamp) in fluorescent tubes (LFLs) and compact fluorescent lamps (CFLs), and in high-pressure discharge types, such as metal halide, mercury vapour, sodium, and neon lamps (UNEP, 2013). The most common use for the discharge lamps is in street lighting. Significant progress has been made by some producers to reduce the amount of mercury per lamp, with reductions of about a factor of 10 achieved in newer mercury-lamps as compared to traditional types. Non-mercury alternatives for these lamps, with similar energy saving qualities, are not yet commercially available but are being actively developed. Other light sources reported to contain mercury include: lamps used in photography, laboratory analysers, ultraviolet sterilisers, and the back lights for the LCDs and some of the other flat-screen systems used in computers, televisions and, possibly, older mobile phones. The uses in flat screen application are discussed in the next section.

No New Zealand manufacturing of lamps has been identified in this survey. There is one significant New Zealand producer of CFLs (Energy Mad Ltd) but their manufacturing is done off-shore.

LFLs and CFLs

Import data for fluorescent lamps and tubes was obtained from Statistics New Zealand, covering the period 2008 to 2012 (HS Code: 8539.31.00.00). This indicated total annual imports of LFLs and CFLs of between 5.5 and 7.5 million units per year, with 5.65 million units imported in 2012. This data compares moderately well with the 2012 sales estimates provided by the Lighting Council of New Zealand (LCNZ) of 6.5 million units (R Ponting, pers comm, 2013), and by the Energy Efficiency and Conservation Authority, of 5.7 million units. The LCNZ estimates that the split between LFLs and CFLs is approximately 3.5:3 (ie 54% LFLs), and the current mercury contents are 3 and 1.8 mg/lamp, respectively.

Other discharge lamps

Import data was also obtained for a range of other discharge lamps, using 7 different HS codes (ie. those in the range 8539.32.00.01 to 8539.49.90.00). This showed total imports in 2012 of about 670,000 high-intensity discharge lamps, and about 100,000 'other' lamps. The mercury content for these varies from 5 to 30 mg/lamp (UNEP, 2013).

Input and output estimates

The estimates for the total mercury inputs for all types of lamps are summarised in Table 7-4. This has been based on the mercury content information given above or the Toolkit default factors when local information was not available.

Table 7-4: Input estimates for lamps

Lamp type	Mercury content, mg/lamp	Number of lamps, thousands	Total mercury input, kg/year
Fluorescent Tubes (LFLs)	2 – 5	3,000 – 3,500	6 – 17.5
Compact Fluorescent Lamps (CFLs)	1 – 3	2,500 – 3,500	2.5 – 10.5
High Pressure Mercury Vapour	30	50	1.5
High Pressure Sodium Lamps (HPS)	10 - 30	120	1.2 - 3.6
UV lamps for tanning	5 - 25	50 - 100	0.25 – 2.5
Metal halide lamps	25	500	12.5

For outputs, the Toolkit recommends distribution factors of 0.05 (5%) to air, and 0.95 (95%) to waste, for countries with publicly controlled waste collection services, but only limited waste separation. These factors will be applied to the New Zealand input estimates, although the output calculations should be applied to the mercury inputs from about 5 to 10 years ago, rather than the 2012 data (because the outputs occur when the lamps come to their end of the useful life). However, this older data is not available, so the indicated outputs should be regarded as a conservative over-estimate (but also a good indicator of future outputs). It should also be noted that a small proportion of lamps are collected by specialist waste contractors and exported to Australia. The exports for 2012 were estimated to contain about 3 kg of mercury (D Richardson, International Waste Ltd, pers comm, 2013).

The mercury input and output estimates for mercury lamps are shown in Table 7-5. The figures shown in brackets are the means of the reported ranges.

Table 7-5: Input and output estimates for mercury lamps

Source	Annual Mercury Inputs, kg/yr	Annual Mercury Outputs, kg/yr	
		Air	Waste
All lamps (see details above)	24 – 48.1 (36.0)	1.2 – 2.4 (1.8)	22.8 – 45.7 (34.2)*

(* this includes 3 kg of mercury waste which is exported)

Certainty assessment

Activity data: HIGH (because it is based on national import data)

Input estimates: MEDIUM (because they are based on published data and industry estimates)

Output estimates: LOW (because they are based on the Toolkit default factors).

Comparison with 2008 estimates

The 2008 Inventory Report estimated a total mercury input from lamps of 50.3 kg/year.

7.4 Light sources (LCD screens)

The use of mercury-containing lamps in television and computer screens was noted in the Toolkit but no quantitative data or input/output factors were provided. The lamps are either cold cathode fluorescent lamps (CCFLs) or external electrode fluorescent lamps (EEFLs) and they are mainly used for the back-lighting of liquid crystal displays (LCDs), which currently account for about 60% of the total TV sales market in New Zealand. Mercury is not used in LED screens (G Wylie, Executive Director, Electronics Consumer Association, pers comm, 2013).

No New Zealand manufacturers of CCFLs and EEFLs were identified in this survey.

Import data was obtained from Statistics New Zealand for all imports of televisions and computer monitors for the period 2008 to 2012, using the HS codes from 8528.51.00.00 to 8528.72.00.89. Import data was not requested for the codes covering laptop and desktop computer systems, because the classifications were too broad to be of any value. Hence, the estimates given below will be low.

The total imports of televisions over the last 5 years have ranged from 380,000 to 550,000 units/year, with 471,000 units imported in 2012[22]. The data is broken down into 2 groups, based on screen size, and shows that for 2012 about 10% of television sets were less than 500mm, and the remainder were greater than 500mm[23]. This allowed the total number of mercury lamps to be calculated using the size versus number distribution reported in a 2010 study from Switzerland (EMPA, 2010). This gave results of from 2 to 20 lamps per LCD screen, which is quite consistent with the 2 to 22 lamps reported in a UK study (WRAP, 2010). After adjusting for the 60% proportion of LCDs, the total number of mercury lamps was estimated to be 4.5 million, and at a mercury content of 5 mg per lamp (EMPA, 2010), this gave a total mercury input of 22.5 kg/year.

Import data was also available for computer monitors. This indicated total imports in 2012 of 82,270 units, but also showed a marked reduction in imports over the last 5 years of about 75% (ie the imports in 2008 were over 330,000 units). No size distribution data was available for these monitors. The proportion of monitors containing mercury lamps was assumed to be 90%, and the number of lamps per monitor varies between 2 to 8, with a mercury content per lamp of 5 mg (EMPA, 2010). Applying these factors to the 2012 imports give a total mercury input of 1 to 3 kg per year.

Input and output estimates

The Toolkit output factors recommended for mercury lamps were also applied to the LCD estimates, but recognising once again, that the calculations should really be applied to the mercury inputs from about 5 to 10 years ago[24], rather than the 2012 data (because the outputs occur when the lamps come to their end of the useful life). It should also be noted that a significant proportion of electronic wastes are now recovered through special collection programmes, rather than being disposed in general municipal wastes.

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22 The Electronic Consumer Association believes that the Statistics NZ figures for TV imports are too high, by as much as 50%, based on their members' sales data. However, it is not obvious why this would be the case, so the import data has been used here.

23 The lamp sizes will be generally related to screen size because the lamps usually run across the width of the screen.

24 One internet source suggests a lamp lifetime in TVs and computer monitors of 35-50,000 hours (www.byfort.com/ccfllamps). For 24 hours a day year round operation this would be equal to 4 to 5.7 years, or 8 to 11 years for 50% operating time.

The mercury input and output estimates for LCD screens are shown in Table 7-6. The figures shown in brackets are the means of the reported ranges.

Table 7-6: Input and output estimates for LCD screens in TVs and computers

Source	Activity, 10^6 lamps/year	Mercury input rate, mg/unit	Annual Mercury Inputs, kg/yr	Annual Mercury Outputs, kg/yr	
				Air	Waste
Lamps in TV LCDs	4.5	5	22.5	1.1	21.4
Lamps in LCD monitors	0.15 – 0.6	5	0.75 - 3	0.04 – 0.15	0.71 – 2.85
Totals			**23.25 – 25.5 (24.4)**	**1.14 – 1.25 (1.2)**	**22.11 – 24.25 (23.2)**

Certainty assessment

Activity data: HIGH (because it is based on national import data)

Input estimates: MEDIUM (because they are based on industry estimates and published information)

Output estimates: LOW (because they are based on the Toolkit default factors for lamps).

Comparison with 2008 estimates

The 2008 Inventory Report only provided a very rough estimate of 1 kg per 10,000 monitors. However, applying this to a total of 282,600 monitors (60% of 471,000) would give a total estimated input of 28.6 kg/year, which agrees reasonably well with the totals shown in the table.

7.5 Batteries

Mercury has been used extensively in batteries in the past, and it is still an essential component in mercury oxide batteries, where it accounts for 32% of the total battery weight. In most other batteries it is used as a reaction modifier and as a corrosion inhibitor. Its uses are predominantly restricted to non-rechargeable (primary) batteries (UNEP, 2013).

No New Zealand manufacturers of batteries were identified in this survey.

The methodology used for estimating mercury inputs from batteries was essentially the same as that used in the 2008 Inventory Report. Import data was obtained for each battery type, using HS codes 8506.10.00.01 to 8506.80.00.19, and the quantities of mercury were calculated by multiplying the number of units by their respective average weights and by the percentage of mercury present in each cell. The main difference between this and the previous inventory was that a range of mercury contents was used, based on a combination of the Toolkit default values and more recent information provided by three of the main importers, Energiser, Panasonic and Foodstuffs New Zealand. This is important because the mercury content of some batteries has been steadily reducing over time.

The estimated mercury inputs for the different battery types are shown in Table 7-7. For the outputs it was assumed that all of the batteries were disposed to waste, because no evidence was found of batteries being collected and/or exported for recycling. The input and output calculations are shown in Table 7-8. The figures shown in brackets are the means of the reported ranges.

Table 7-7: Estimated mercury inputs for batteries

Type	Size, cm^3	Mercury content g/kg	Number of batteries	Weight per battery, g	Total weight of batteries, kg	Mercury inputs, kg
Mercuric oxide	<300	320	98,126	1	98	31.4
Silver oxide	all	3.4 – 10	653,266	1	653	2.2 – 6.5
Zinc air	all	0 - 30	2,754,161	1	2,754	0 – 82.6
Alkaline	<300	0 – 0.00006	36,705,233	12	440,462	0 - 0.026
Carbon zinc	<300	0 – 0.00006	10,996,200	12	131,954	0 – 0.008
Other MnO_2	<300	0 – 0.00006	8,448	12	101.4	0.006
Other MnO_2	>300	0 – 0.00006	488,591	279	136,412	0 – 0.008
					Total	**33.6 – 120.6**

Table 7-8: Input and output estimates for batteries

Source	Activity Rate, units/yr	Mercury content, g/kg	Annual Mercury Inputs, kg/yr	Annual Mercury Outputs, kg/yr
				Waste
Batteries	51,704,015	0 - 320	33.6 – 120.6 (77.1)	33.6 – 120.6 (77.1)

Certainty assessment

Activity data: HIGH (because it was obtained from national import statistics)

Input estimates: MEDIUM (because they are based on product data and the default Toolkit factors)

Output estimates: HIGH (because essentially all batteries are disposed to landfill).

Comparison with 2008 estimates

The 2008 Inventory Report gave an input estimate of 170 kg/yr for batteries, but about 40% of this was attributed to inputs from manganese dioxide batteries. The more recent content data used for the current estimates shows that mercury levels in these batteries have been significantly reduced. The other differences are mainly due to changes in import quantities.

7.6 Polyurethanes with mercury catalyst

Until recently, organic mercury compounds were an important catalyst in the production of polyurethane elastomers (flexible plastics) that could be used for the moulding of complex shapes, synthetic (rubberised) flooring and a range of specialist surface coating or insulation materials (UNEP, 2013). A limited number of these products were identified through an internet search of New Zealand resin importers and distributors. However, only one of the companies reported any current sales. Four others reported that their products no longer contained mercury, with one noting in particular, that mercury was no longer allowed under EU regulations.

The one importer still selling polyurethanes with these catalysts indicated that they had made 3 sales to New Zealand manufacturing companies in the last 12 months, with a total quantity of about 200 grams of mercury-containing catalyst.

This sub-category was not discussed in the 2008 Inventory Report.

7.7 Biocides and pesticides

Most substances intended for use as agricultural or veterinary medicines in New Zealand are required to be registered under the Agricultural Chemicals and Veterinary Medicines Act. A database of current registrations is maintained by the Ministry for Primary Industries, and a search of this database in early May 2013 showed no mercury-containing chemicals. This finding is consistent with the findings of the 2008 Inventory Report.

On the basis of the above, it can be concluded that there is no current use of mercury-based biocides as agricultural or veterinary medicines in New Zealand. However, it should be noted that some minor uses have been identified in animal vaccines and eye drops, where the mercury compounds act as a preservative. These uses are covered under section 7.9.

7.8 Paints

The 2008 Inventory Report noted that mercury pigments were believed to be no longer used in New Zealand. This has been confirmed through discussions with the following people and organisations: Thor Specialties Pty Ltd (E Jones, Area Manager New Zealand) and the New Zealand Paint Manufacturers Association (D Vincent, responding on behalf of Dulux, Wattyl Paints, Altex Coatings, and Mirotone Paints). A similar response was given by Resene Paints in 2008.

7.9 Pharmaceuticals for human and veterinary use

Mercury compounds have been used in the past in various pharmaceuticals such as vaccines, eye drops, topical antiseptics, and other products, functioning mainly as a preservative. In addition, it is still used today in animal vaccines, with the most common additive being Thiomersal[25]. This chemical is listed in the specific exclusions given in Annex 1 of the draft text for the Minamata Convention.

A search of the Medsafe database (www.medsafe.govt.nz/regulatory/DbSearch.asp) showed that there were currently 26 mercury-containing human pharmaceutical products registered for use in New Zealand; 18 of these contain Thiomersal, 6 contain phenylmercuric nitrate, and 2 contain phenylmercuric acetate. The mercury concentrations in these products are typically in the range of 0.01 to 0.5%, but some products (eg eye drops) can contain up to 3%. It is believed that the mercury compounds are no longer used in human vaccines, and this was confirmed by Smith Glaxo Kline, for their particular products. The company behind the two major pharmacy brands in New Zealand was contacted for information on products such as eye drops and contact lens cleaners, but they have not responded.

The ACVM register of approved veterinary products lists 92 different products that contain mercury (S Tinalevu, Ministry for Primary Industries, pers comm, 2013). One of these contains phenylmercuric nitrate and all of the others contain Thiomersal. The mercury content ranges from 0.03 to 1 gram/litre, (ie. 0.003 – 0.1%)

Two New Zealand manufacturers of veterinary vaccines were contacted. One of these indicated that none of their products contained mercury. However, the other indicated that they manufactured many products containing

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[25] The chemical name for Thiomersal is ethyl(2-mercaptobenzoato-(2-)-O,S) Mercurate (1-) sodium, and it is also known as thiomerosal, and merthiolate)

Thiomersal preservative, and their total imports of this chemical were about 30 kg per year. It was also noted that about 80% of their products are exported for sale and use in other countries.

Two vaccine importers and distributors were also contacted, and they both confirmed that some of their vaccines contained Thiomersal. Both importers estimated annual mercury import quantities of about 2 to 3 kg per year, so a total mercury input of 10 kg per year has been assumed for this source to allow for other possible importers.

Annual import data was obtained from Statistics New Zealand for HS code 2852.00.19.00 (mercury compounds), and this showed annual imports of between 280 and 480 tonnes per year. However, after further enquiries it appears that this is a gross over-estimate of actual imports[26], and the total quantities are most likely in the order of kilograms rather than tonnes. The imports of Thiomersal noted above would have been included under this HS code, but it would also cover other imports, such as laboratory chemicals (see section 8.3).

7.10 Cosmetics and related products

The use of chemical substances in cosmetics is governed by the Cosmetic Products Group Standard (2006, with amendments to July 2012) issued under the Hazardous Substances and New Organisms Act 1996. Generally, the Group Standard prohibits the use of mercury compounds, but Thiomersal and phenylmercuric salts are permitted for use as preservatives, at concentrations of no more than 0.007% (as Hg). No evidence of mercury use has been found in checks with 5 cosmetics manufacturers (either directly or through their web sites).

7.11 Summary for this category

The estimated inputs and outputs for the consumer products category are summarised in Table 7-9, which shows that the most significant inputs are from pharmaceuticals (vaccines) and mercury switches and relays, lamps and batteries. The quantities shown for vaccines are based on the import data provided by one manufacturer, and this is believed to be the only such operation in New Zealand.

[26] The excessive estimates appear to be due to a combination of different factors. Statistics New Zealand advised that investigations of a sample of the records by New Zealand Customs' staff suggest that over 50% of the imports may have been incorrectly classified by the importers. In addition, many of the imports are manufactured products with no information available (to Customs) on the exact mercury content. Finally, the import quantities are only reported as gross weight rather than nett weight (ie free of packaging) (S Jones, Statistics New Zealand, pers. comm. 2013).

Table 7-9: Summary of inputs and outputs for consumer products with intentional use of mercury

Category	Mercury Inputs, kg/year	Mercury Outputs, kg/yr					Stocks, kg
		Air	Water	Land	Product	Waste	
Thermometers with mercury	3.25 – 32.5 (17.9)	0.325 – 3.25 (1.8)	0.975 – 9.75 (5.4)	-	-	1.95 – 19.5 (10.7)	26.7 – 267 (146.9)
Electrical switches, contacts and relays	8.8 – 88 (48.4)	0.9 – 8.8 (4.8)	-	0.9 – 8.8 (4.8)	-	7.0 – 70.4 (38.7)	170
Light sources - lamps	24 – 48.1 (36.0)	1.2 – 2.4 (1.8)	-	-	-	22.8 – 45.7 (34.2)*	-
Light sources - LCDs	23.25 – 25.5 (24.4)	1.14 – 1.25 (1.2)	-	-	-	22.11 – 24.25 (23.2)	-
Batteries containing mercury	33.6 – 120.6 (77.1)	-	-	-	-	33.6 – 120.6 (77.1)	-
Polyurethane with mercury catalyst	0.2	-	-	-	0.2	-	-
Biocides and pesticides	-	-	-	-	-	-	-
Paints	-	-	-	-	-	-	-
Pharmaceuticals for human and veterinary uses	40*	-	-	-	40*	-	-
Cosmetics and related products	-	-	-	-	-	-	-
Totals	**133.1 – 354.9 (244)**	**3.5 – 15.7 (9.6)**	**0.98 – 9.8 (5.4)**	**0.9 – 8.8 (4.8)**	**40.2***	**87.5 – 280.4 (183.9)**	**196.7 – 437 (316.9)**

(*approximately 3 kg of the lamp wastes and 24 kg of the pharmaceuticals (vaccines) are exported)

The figures shown in brackets are the means of the reported ranges.

8 Other intentional product/process uses

This category covers mercury uses in a range of other intentional products and uses (UNEP, 2013). The various sub-categories and the primary release pathways are summarised in Table 8-1, which has been copied directly from the UNEP Toolkit.

Table 8-1: Toolkit framework for category 6 – other intentional product/process uses

Toolkit Chapter	Sub-category	Air	Water	Land	Product	Waste/ residue	Main approach
5.6.1	Dental mercury amalgam fillings	x	X		X	X	OW
5.6.2	Manometers and gauges	x	X	x	X	X	OW
5.6.3	Laboratory chemicals and equipment	x	X		X	X	OW
5.6.4	Mercury use in religious rituals and folklore	X	X	X	X	X	OW
5.6.5	Miscellaneous product uses, mercury metal and other sources	X	X	X	X	X	OW

Notes: OW = National/overview approach;

X - Release pathway expected to be predominant for the sub-category;

x - Additional release pathways to be considered, depending on specific source and national situation.

8.1 Dental mercury amalgam fillings

Mercury is used in a range of dental amalgams, with the mercury content typically around 45 to 50%. These amalgams are still widely used in New Zealand, although non-mercury alternatives are readily available (MoH, 2010, and H Trengrove, NZ Dental Association, pers comm, 2013).

Import data were obtained from Statistics New Zealand for the HS code 3006.40.01.00, dental cements and other dental fillings. The total imports under this code over the last 5 years have averaged about 13,500 kg/year, but this figure is for gross weight (ie. including packaging).

Three major suppliers of dental amalgam were contacted and the information provided by 2 of these indicates current total imports for New Zealand of about 320 kg/year of dental amalgam, which equate to a total annual mercury input of about 150 kg/year. A dentist in Napier that makes mercury dental amalgam from liquid mercury was also identified, but their total annual mercury consumption is only 4 - 5 kg/year[27].

Input and output estimates

The Toolkit recommends default factors of 0.05 – 0.2 grams/year per capita for estimating current mercury inputs via dental amalgams, which would give input rates for New Zealand (pop. 4.4 million) of between 220 and 880 kg/year. However, the information obtained from amalgam suppliers indicate that a more appropriate figure would be 150 kg/year, and this has been used for the estimates.

[27] This person is the recipient of the recycled mercury noted in section 9.1

The output factors given in the Toolkit are 0.02 (2%) to air, 0.14 (14%) to water, 0.6 (60%) in products (ie teeth), and 0.24 (24 %) to waste. The outputs to water and wastes may be modified if the dental surgeries are fitted with high efficiency amalgam filters, which can remove up to 95% of the mercury from the water outputs. However, it is believed that these are not widely used in New Zealand, with about 50% of dentists using basic filter systems and the remainder having no filtration at all (M Lund, Cattani Ltd, pers comm, 2013). The limited quantities of wastes collected by the filters are either disposed to landfill, recycled (see section 9.1) or exported (see section 11.4). No specific data is available on the quantities of dental wastes that are recycled or exported.

The mercury input and output estimates for mercury dental amalgam are shown in Table 8-2. The figure shown for product represents an annual addition to the existing stocks of mercury in the teeth of most New Zealanders, which have not been assessed. Similarly, the figure shown for wastes does not include any amounts removed during filling replacement or tooth extraction, which would be very difficult to determine. The figures shown in brackets are the means of the reported ranges.

Table 8-2: Input and output estimates for mercury dental amalgam

Source	Activity, kg of amalgam/yr	Mercury content, %	Annual Mercury Inputs, kg/yr	Annual Mercury Outputs, kg/yr			
				Air	Water	Product	Waste
Dental amalgam	320	47%	150	3	21	90	36*

(* some unquantified proportions of these wastes are either recycled within New Zealand or exported)

Certainty assessment

Activity data: HIGH (because it is based on supplier estimates)

Input estimates: LOW (because they are based on the Toolkit default factors)

Output estimates: LOW (because they are based on the Toolkit default factors).

Comparison with 2008 estimates

The releases of mercury from dental amalgam were assessed as 30 kg/year in the 2008 Inventory Report. However, this figure mainly related to the amount of mercury absorbed into the body and subsequently excreted, and there were no estimates for inputs.

8.2 Manometers and gauges

The most common uses of mercury in this sub-category are in blood pressure devices (sphygmomanometers) and in barometers. However, mercury may also be used for pressure (or vacuum) measurement in a range of industrial and laboratory applications (UNEP, 2013).

Fifteen New Zealand suppliers of medical equipment were contacted with regard to current stocks and annual sales of sphygmomanometers. However only one of these reported any sales and this was only 3 units in 2012, and a stock holding of 8 units. They also advised that each unit held about 75 grams of mercury, which is consistent with the information given in the Toolkit.

It was noted previously in section 7.1, that all of the major hospitals had taken action to eliminate most mercury uses, and this includes sphygmomanometers. The NZ Medical Association advised that most general practices had phased out mercury sphygmomanometers, but still do have and use these instruments (L Clarke, pers comm, 2013). There are about 3,600 General Practitioners currently registered in New Zealand (Medical Council, 2011). As an initial estimate, if it is assumed that each GP has their own sphygmomanometer, the current in-use mercury stock would be 270 kg. On the basis of the above supplier information, it appears that the additional annual sales would make only a very minor change to this total (0.23 kg), and this is possibly offset by losses due to equipment breakage.

In the case of barometers, the New Zealand Meteorological Service advised that they are phasing out most uses of mercury, and no longer hold any mercury barometers (T Davie, pers comm, 2013). The same situation applies at the National Measurement Laboratory[28] (A Hockings, pers comm, 2013), and the National Institute of Water and Atmosphere (C Hickey, pers comm, 2013).

The uses of mercury within universities are covered in the next section, and some of the liquid mercury noted there may well be used for pressure measurement.

Finally, no evidence has been found of any significant uses at a range of other facilities, including at Huntly Power Station (S Hurricks, pers comm, 2013), and Dow AgroSciences (T Gellen, pers comm, 2013).

On the basis of all the above, the annual mercury inputs for this sub-category will be taken as 0.3kg/year, and the estimated stocks in sphygmomanometers (270 kg) will be shown under a Stock heading. Any other outputs will be accounted for under other source sub-categories (eg sections 8.3 and 11.4).

Mercury uses in sphygmomanometers and barometers were discussed but not quantified in the 2008 Inventory Report.

8.3 Laboratory chemicals and equipment

Mercury is used in laboratories in instruments, reagents, preservatives, and catalysts. Some of this mercury is released to air, primarily through lab vents. However, most of the mercury may be released in wastewater or disposed of as hazardous or municipal wastes (UNEP 2013). The Toolkit recommends assessing this sub-category on a source by source basis, and that has been the main approach taken here.

The 3 main laboratory supply companies were contacted and asked to provide information on current stocks of mercury-containing chemicals, and annual sales in 2012. Responses were received from two of these indicating current stocks of 2.3 kg, and the same quantity of annual sales. Seven government and commercial laboratories were also contacted, and the replies from these indicated current stocks of 2.02 kg. Seven universities were also contacted and the responses from 4 of these indicated current stocks of 113.23 kg of elemental mercury and 31.58 kg of mercury chemicals. Adjusting these figures for the non-returns suggests total stock holdings of about 200 kg of elemental mercury and 60 kg of mercury-containing chemicals, and annual inputs of about 3 kg/year.

Import data were also obtained from Statistics New Zealand, using the HS codes 2805.40.00.00 (mercury), 2852.00.15.00 (diagnostic reagents), and 2852.00.19.00 (mercury compounds). The first of these showed annual imports over the last 5 years of up to 5 kg/year. This may not all be for laboratory use but will be accounted here for convenience. The second code showed annual imports of 403 and 684 kg in 2008 and 2009, respectively, but then only 33, 2 and 42 kg in 2010, 2011 and 2012, which suggests that this area of use is being phased out. A similar pattern was seen for diagnostic reagents on backing paper, but the actual chemical quantities could not be quantified (because the imports are expressed in gross weight). Overall, these figures indicate current imports of around 5 kg/year for elemental mercury and no more than about 50 kg/year for diagnostic reagents. Some of the mercury is most likely used in other applications, such as mining, so only 2 kg/year has been counted here.

As indicated previously in section 7.9, the import data for HS code 2852.00.19.00 (mercury compounds) showed annual imports of between 280 and 480 tonnes per year. However, after further enquiries it appears that this is a

[28] This organisation is now part of Callaghan Innovations.

gross over-estimate of actual imports, and the total quantities are most likely in the order of kilograms rather than tonnes[29]. The imports of Thiomersal noted in section 7.9 would have been included under this HS code, but it would also cover other imports, such as laboratory chemicals. However, there is no reason to believe that the imports of laboratory chemicals are significantly greater than the small amounts noted above, because most of the main importers and users have been contacted directly for information.

Input and output estimates

The annual import data for elemental mercury and diagnostic reagents has been taken as representing the total annual inputs for this sub-category. The Toolkit doesn't provide any specific output factors and notes that this is highly dependent on the waste management practices of individual laboratories. The feedback received from some of the New Zealand laboratories and universities indicates that the bulk of the wastes are taken away by waste contractors. On this basis it has been assumed (through familiarity with laboratory practices) that only 5% of the inputs are discharged to air and 10% to wastewater, with the remainder going to wastes. In accordance with the approach taken in some other sub-sections, the current stock holdings will be assigned to separate Stocks column.

The mercury input and output estimates for laboratory chemicals are shown in Table 8-3. The figures shown in brackets are the means of the reported ranges.

Table 8-3: Input and output estimates for laboratory chemicals

Source	Annual Mercury Inputs, kg/yr	Annual Mercury Outputs, kg/yr			Stocks, Kg
		Air	Water	Waste	
Current stocks	-	-	-	-	260
Annual turnover	55	2.75	5.5	46.75	-
Totals	**55**	**2.75**	**5.5**	**46.75**	**260**

Certainty assessment

Activity data: not relevant

Input estimates: MEDIUM (because they are based on the import statistics and partial survey responses)

Output estimates: LOW (because they are based on the assumed output factors).

Comparison with 2008 estimates

The 2008 Inventory Report included information on laboratory stocks of mercury chemicals, and the quantities quoted appear to be reasonably consistent with those given here.

8.4 Mercury use in religious rituals and folklore medicine

According to the Toolkit, mercury is used in certain cultural and religious practices, such as some Latin American and Afro-Caribbean communities, in the USA, Mexico, and probably elsewhere. Uses include carrying it in a sealed pouch or in a pocket as an amulet, sprinkling mercury on floors of homes or automobiles,

[29] Further information on the reasons for the over estimates in the import data is provided in a footnote accompanying section 7.9.

burning it in candles, and mixing it with perfumes (UNEP, 2013). However, no information has been found on any such uses in New Zealand.

8.5 Miscellaneous product uses and other sources

The only other possible use considered for this category was explosives. Mercury fulminate has been used as an explosive in the past, but it is believed that this use was phased out about 50 or more years ago. Three explosives distributors were contacted to check that this was the case, and all confirmed that there was no longer any mercury in any of their products.

The 2008 Inventory Report noted the potential for mercury use in explosives, but no information was obtained.

8.6 Summary for this category

The estimated inputs and outputs for the other intentional product/process uses are summarised in Table 8-4.

Table 8-4: Summary of inputs and outputs for other intentional product/process uses

Category	Mercury Inputs, kg/year	Mercury Outputs, kg/yr					
		Air	Water	Land	Product	Waste	Stocks
Dental mercury amalgam fillings	150	3	21	-	90	36*	-
Manometers and gauges	0.3	-	-	-	0.3	-	270
Laboratory chemicals and equipment	55	2.75	5.5	-	-	46.75	260
Mercury use in religious rituals and folklore	-	-	-	-	-	-	-
Miscellaneous product uses, mercury metal, other sources	-	-	-	-	-	-	-
Totals	**205.3**	**5.75**	**26.5**	**-**	**90.3**	**82.75***	**530**

(* some unquantified proportions of these wastes are either recycled within New Zealand or exported)

9 Production of recycled metals (secondary metal production)

This category covers mercury releases from the production of recycled metals, which is also referred to as secondary metal production (UNEP, 2013). The various sub-categories and the primary release pathways are summarised in Table 9-1, which has been copied directly from the UNEP Toolkit.

Table 9-1: Toolkit framework for category 7 –production of recycled metals (secondary metal production)

Toolkit Chapter	Sub-category	Air	Water	Land	Product	Waste/ residue	Main approach
5.2.1	Recycled mercury	**X**	**X**	**X**	**X**	**X**	PS
5.2.2	Ferrous metals (iron and steel)	**X**	x	x		x	PS
5.2.3	Other recycled metals	**X**	x	x		x	PS

Notes: PS = Point source by point source approach;

X - Release pathway expected to be predominant for the sub-category;

x - Additional release pathways to be considered, depending on specific source and national situation.

9.1 Recycled mercury

Metallic mercury can be recovered from a variety of waste materials by distillation, or retorting, and this forms the basis of its use in gold and silver mining. Three mercury recyclers have been identified in New Zealand, but only one of these was able to be contacted. This is a one-man operation based in Waihi, which is mainly concerned with silver recovery from dental, photographic and printing wastes, and the other two companies are believed to processing similar types of materials. It is also believed that they accept a range of other materials from waste management companies (see section 11.4).

The total quantity of mercury recovered by the Waihi operation in the last 12 months was about 315 kg (E Coppard, Silcop, pers comm, 2013). Of this total; 240 kg was exported to Papua New Guinea, 20 kg was sold to small-scale miners, 5 kg was sold to a dentist in Napier, 2kg was sold to an unidentified customer for use in vacuum testing, and the current stock holding is about 50 kg. The total throughput of 315 kg/year has been listed in the summary table at the end of this section as an input to the total New Zealand quantities of mercury, and also as an output via products. However, it should be noted that this represents double accounting, because most of the mercury will also be counted as waste outputs for other source categories. In addition, the mercury sold for small-scale gold mining is counted as an input for that sub-category.

In addition to the above, the EPA has advised that 3 companies are known to be exporting recycled mercury (O Cox, pers comm, 2013). However, there is no data available on the quantities involved because the exports do not require any specific approvals. It is reasonable to assume that these are the same 3 recycling companies as noted above.

Certainty assessment

Activity data: MEDIUM (because it was based on company data)

Input estimates: HIGH (because it was based on company data)

Output estimates: HIGH (because the product outputs should be the same as the inputs).

Comparison with 2008 estimates

This operation was not covered in the 2008 Inventory Report.

9.2 Ferrous metals (secondary steel)

The only secondary steel mill in New Zealand is the plant in South Auckland, which is owned and operated by Pacific Steel Ltd. This plant processes scrap steel received from the adjoining Sims Pacific scrap processing operation, and it is important to also consider this and other earlier upstream processes that can have a bearing on the potential for mercury contamination of the incoming scrap.

The Toolkit gives particular attention in this sub-category to the potential for mercury contamination arising from the use of mercury switches in motor vehicles and in household appliances (whiteware), because these can make up a significant component of the incoming scrap. In New Zealand, the initial processing of these waste materials is done by a myriad of scrap dealers throughout the country, who generally strip out any potentially valuable and/or re-usable components prior to selling the steel to Sims Pacific or exporting it (D Chapman, Sims Pacific, pers comm, 2013).

At a national level, the Scrap Metals Recycling Association of New Zealand have indicated that their industry processes about 500,000 tonnes of ferrous scrap metal per year, and most operators will remove mercury-containing items where they are readily identifiable (K Kirk, President SMRANZ, pers comm, 2013). The quantities of mercury collected by individual dealers are typically less than 2 kg/year, and they would each have their own arrangements for selling this to mercury users.

Once received at the Sims Pacific site, the car shells and other scrap steel are processed through a heavy duty shredder and this is followed by magnetic separation to isolate the shredded steel from other non-ferrous components. If any liquid mercury is present in the scrap it is likely that most of it would be 'lost' at this stage of the process. One of the major waste by-products here is a so-called 'fluff', which is collected and disposed to landfill. No information is available on the mercury content of this waste.

The shredded scrap passed on to the Pacific Steel operation is required to comply with a range of quality specifications to minimise the potential for adverse impurity effects on final steel quality, and also to ensure that the company remains within the conditions laid down in their air discharge permit (J McLaren, Pacific Steel Ltd, pers comm, 2013). The total steel production at the mill in 2012was about 240,000 tonnes.

The particulate emissions to air from the steel mill are routinely tested and analysed for a range of metals, but this does not include mercury. However, results are available from some tests carried out in 2004, which showed no detectable mercury emissions. The limit of detection for the test method indicates an emission rate of <0.03 mg/second, or <0.11 g/hour (AES, 2008). The steel mill operates for about 250 days per year, which indicates a maximum annual mercury emission of less than 0.66 kg/year.

The Toolkit does not provide any specific input factors for secondary steel mills because they are highly dependent on the quality of the incoming scrap. However, they do indicate default distribution factors for the mill outputs, which are 0.33 (33%) to air, 0.34 (34%) to land and 0.33 (33%) to wastes. These factors have been used to back-calculate the overall Pacific Steel inputs, and the outputs to land and to waste, starting from the air emission data. In addition, however, the land and waste outputs have been combined into a single waste output, because all of the Pacific Steel wastes are collected and removed off-site for treatment and reuse, or disposal.

The mercury input and output estimates for secondary steel production are shown in Table 9-2.

Table 9-2: Input and output estimates for secondary steel production

Source	Activity Rate, tonnes/yr	Annual Mercury Inputs, kg/yr	Annual Mercury Outputs, kg/yr	
			Air	Waste
Secondary steel production	240,000	2.0	0.66	1.34

Certainty assessment

Activity data: HIGH (because it was based on company production data)

Input estimates: LOW (because it was inferred from the air emissions data)

Output estimates: MEDIUM (because the air output was based on a single test exercise).

Comparison with 2008 estimates

The 2008 Inventory Report noted the potential for releases from this source but gave no estimates because no data could be found.

9.3 Production of other recycled metals

This Toolkit sub-category covers the recycling of aluminium, zinc and other metals, but it is noted that very little is known about the mercury inputs and outputs for these activities. A similar situation applies in New Zealand, and the lack of any relevant information was noted in the 2008 Inventory Report.

The 2011 Dioxin Inventory for New Zealand (MfE, 2011a) estimated the following annual production rates for various secondary metal processes: aluminium, 28,000 tonnes/year; iron foundries, 18,000 tonnes/year; other non-ferrous metals, 36,000 tonnes per year. This gives a total production rate of 82,000 tonnes per year, and if the emission rates are comparable to secondary steel, the total mercury inputs would be less than 0.6 kg/year. No New Zealand information has been found on the discharges from these sources. However, this very crude estimate suggests the inputs and outputs are likely to be minor.

9.4 Summary for this category

The estimated inputs and outputs for the metal recycling category are summarised in Table 9-3.

Table 9-3: Summary of inputs and outputs for production of recycled metals

Category	Mercury Inputs, kg/year	Mercury Outputs, kg/yr				
		Air	Water	Land	Product	Waste
Recycled mercury	315	-	-	-	315*	-
Ferrous metals (iron and steel)	2.0	0.66	-	-	-	1.34
Other recycled metals	-	-	-	-	-	-
Totals	**317**	**0.66**	**-**	**-**	**315***	**1.34**

(* 240 kg of this total was exported)

10 Waste incineration

This category covers mercury releases from the incineration of different types of wastes (UNEP, 2013). The various sub-categories and the primary release pathways are summarised in Table 10-1, which has been copied directly from the UNEP Toolkit.

Table 10-1: Toolkit framework for category 8 – waste incineration

Toolkit Chapter	Sub-category	Air	Water	Land	Product	Waste/ residue	Main approach
5.8.1	Municipal waste incineration	**X**	x	x	x	**X**	PS
5.8.2	Hazardous waste incineration	**X**	x			**X**	PS
5.8.3	Medical waste incineration	**X**	x			**X**	PS
5.8.4	Sewage sludge incineration	**X**	**X**			**X**	PS
5.8.5	Informal waste incineration	**X**	**X**	**X**	**X**		PS

Notes: PS = Point source by point source approach;

X - Release pathway expected to be predominant for the sub-category;

x - Additional release pathways to be considered, depending on specific source and national situation.

10.1 Municipal waste incineration

There are no municipal waste incinerators in New Zealand (MfE, 2000).

10.2 Hazardous waste incineration

There is only one high-temperature hazardous waste incinerator in New Zealand, which is operated by Dow AgroSciences Ltd at their agrichemical formulation plant in New Plymouth. This is used for the treatment and disposal of some of the wastes generated on-site that are potentially contaminated with agrichemicals. It is the only high-temperature hazardous waste incinerator currently permitted to operate in New Zealand under the *Resource Management (National Environmental Standards for Air Quality) Regulations 2004*.

The mercury emissions from the incinerator were recently tested by an external contractor and found to be 1 mg/hour when burning liquid wastes and 3 mg/hour for other general wastes. The incinerator is usually operated for about 8000 hours per year, and the annual mercury emission rate was estimated to be 16.5 grams/year (T Gellen, Dow AgroSciences, pers comm, 2013). There is no information on the possible releases to other media, such as in wastes. However, the unit is not fitted with any particulate control equipment so it is reasonable to expect that all of the mercury will be emitted to air.

Certainty assessment

Activity data: not relevant

Input estimates: MEDIUM (because it was inferred from the air emissions data)

Output estimates: MEDIUM (because the air output was based on a single test exercise).

Comparison with 2008 estimates

No emissions data were available for this source when the 2008 Inventory Report was being prepared.

10.3 Medical waste incineration

There is only 1 medical waste incinerator in New Zealand, at the Grey Hospital in Greymouth. Medical waste incineration was widely practised in the past, but has been phased out in favour of alternative methods, such as steam sterilisation (MfE, 2011a).

The Grey Hospital incinerator 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 never been tested for mercury. The Toolkit recommends default input factors for medical waste of 8 – 40 g/tonne, and indicates that all of the mercury will be emitted to air on units with no emission control equipment. Applying these factors to the Grey Hospital incinerator indicates an annual input rate of 1.6 to 8 kg/year. However, given the efforts made by most New Zealand hospitals to reduce their use of mercury (see sections 7.1 and 8.2) it is likely to be closer to the bottom end of this range. The outputs to air will be the same as the inputs.

Certainty assessment

Activity data: MEDIUM (because it was an operator estimate)

Input estimates: LOW (because it was based on the Toolkit default factor)

Output estimates: LOW (because the output distribution was based on the Toolkit default factors).

Comparison with the 2008 estimates

This source was not covered in the 2008 Inventory Report.

10.4 Sewage sludge incineration

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 (MfE, 2011a).

The incinerator currently processes about 1700 tonnes of wastewater solids per year, on a dry basis (B Turner, Dunedin City Council, pers comm, 2013). The mercury inputs can be estimated from the composition data for biosolids, which is discussed in section 11.5. This indicates a mercury composition of 0.56 mg/kg for Dunedin (Green Island) biosolids, which suggests an annual input to the incinerator of 0.84 kg/year. The incinerator off-gases are tested annually for mercury, and the results over the last 5 years indicate annual releases of mercury from the wastes of 0.2 to 1.1 kg/year, which agrees well with the estimate based on biosolids composition. The incinerator off-gases are treated by passing through the biofilter, and the tests on the latter shows that it captures more than 99% of the total mercury.

The Toolkit doesn't recommend any default output factors for sewage sludge incinerators, but quotes some US data that indicates that the emissions to air are minimal when the incinerators are fitted with scrubber systems. The results for the Dunedin plant are totally consistent with this observation, and it has been assumed that all of the mercury will be discharged via solid wastes, either in scrubber residues or in waste bark removed from the biofilter.

Certainty assessment

Activity data: MEDIUM (because it was an operator estimate)

Input estimates: MEDIUM (because it was based on previous data for biosolids composition)

Output estimates: LOW (because the output distribution was based on indicative US information).

Comparison with 2008 estimates

This source was not covered in the 2008 Inventory Report.

10.5 Informal incineration

This Toolkit category covers unregulated waste disposal practices such as backyard rubbish burning. The Dioxin Inventory (MfE, 2011a) estimated that the quantity of domestic wastes burned annually in New Zealand, in 2008, was about 18,000 tonnes/year. There is no data available on the mercury content of New Zealand municipal solid wastes, but the Toolkit recommends default factors of 1 – 10 g/tonne. Applying this to the annual waste quantities indicates an annual mercury input of 18 - 180 kg/yr. However the inputs are more likely to be at the lower end of this range because much of the waste burned in domestic rubbish fires is unlikely to be contaminated with mercury. For the output calculations, it has been assumed that all of the mercury will be discharged to air.

It should be noted that the above input and output data have been increased by 0.5% to account for two of the other incineration sources discussed under section 10.6 below.

Certainty assessment

Activity data: LOW (because it was based on a limited amount of published survey data)

Input estimates: LOW (because it was based on the default Toolkit factors)

Output estimates: LOW (because the output distribution was assumed).

Comparison with 2008 estimates

This source was not covered in the 2008 Inventory Report.

10.6 Other incineration

(Note: this is not a Toolkit category, but has been added to accommodate several other New Zealand incinerators).

The Dioxin Inventory (MfE, 2011a) lists several other incineration sources in New Zealand, including 71 school incinerators, a quarantine incinerator, a single document incinerator, and 13 pet incinerators. However, the document incinerator has since been shut down. The estimated waste throughput for the school incinerators was only 70 tonnes/year, in total, and the quarantine incinerator throughput was 25 tonnes/year, respectively. The wastes burned in these units would have a similar composition to that burned in backyard rubbish fires, and would only add a further 0.5% to the estimated mercury inputs. Therefore, these sources will simply be added to the total informal waste incineration category.

The total estimated throughput for the pet cremators was about 260 tonnes/year, in 2008. These units are similar in design to crematoria and can be assessed using the same approach as described in section 12.1, but with adjustment for a lower mercury content. Some indication of the likely mercury level in pets and other animals is given by the following 2 publications. A study on a range of healthy US animals found no mercury in dog tissues at a detection limit of 0.0002 g/kilogram (Penumarthy *et al*, 1980). However, a report on a small dog suspected of suffering from mercury poisoning found concentrations of 0.003 mg/kg (Farrar *et al*, 1994). On the basis of these studies, a mercury concentration of 0.001 g/kg has been used for the input estimates, to give an annual mercury input of 0.26 kg/year. It has been assumed that all of the mercury outputs will be released to air.

Certainty assessment

Activity data: LOW (because it was based on a limited amount of published source information)

Input estimates: LOW (because it was based on the default Toolkit factors for humans)

Output estimates: LOW (because the output distribution was assumed).

Comparison with 2008 estimates

This source was not covered in the 2008 Inventory Report.

10.7 Summary for this category

The estimated inputs and outputs for waste incineration are summarised in Table 10-2.

Table 10-2: Summary of inputs and outputs for waste incineration

Category	Mercury Inputs, kg/year	Mercury Outputs, kg/yr				
		Air	Water	Land	Product	Waste
Municipal waste incineration	-	-	-	-	-	-
Hazardous waste incineration	0.0165	0.0165	-	-	-	-
Medical waste incineration	1.6 – 8 (4.8)	1.6 – 8 (4.8)	-	-	-	-
Sewage sludge incineration	0.84	-	-	-	-	0.84
Informal waste incineration	18.1 – 180.9 (99.5)	18.1 – 180.9 (99.5)	-	-	-	-
Other (pet incinerators)	0.26	0.26	-	-	-	-
Totals	**20.82 – 190.02 (105.4)**	**19.98 – 189.18 (104.6)**	**-**	**-**	**-**	**0.84**

The figures shown in brackets are the means of the reported ranges.

11 Waste deposition/landfilling and wastewater treatment

This category covers mercury releases from the disposal of solid and liquid wastes by landfilling, dumping, or discharge to wastewater treatment systems (UNEP, 2013). The various sub-categories and the primary release pathways are summarised in Table 11-1, which has been copied directly from the UNEP Toolkit.

Information on the handling and disposal of mercury-containing wastes by specialist waste management companies will also be covered at the end of this section. This includes exporting for treatment and disposal in other countries.

Table 11-1: Toolkit framework for category 9 – waste deposition/landfilling and wastewater treatment

Toolkit Chapter	Sub-category	Air	Water	Land	Product	Waste/ residue	Main approach
5.9.1	Controlled landfills/deposits	x	x	**X**		**X**	OW
5.9.2	Diffuse deposition with some control	x	**X**	**X**		**X**	OW
5.9.3	Informal local disposal of industrial wastes	**X**	**X**	**X**			PS
5.9.4	Informal dumping of general waste	**X**	**X**	**X**			OW
5.9.5	Wastewater treatment systems	x	**X**	**X**		x	OW/PS

Notes: PS = Point source by point source approach; OW = National/overview approach;

X - Release pathway expected to be predominant for the sub-category;

x - Additional release pathways to be considered, depending on specific source and national situation.

One of the key points to recognise for this category is that it includes the wastes that are generated by many of the sources discussed under previous categories. This means that there is inevitably some double accounting. To accommodate this, at least in part, the mercury inputs calculated in this section will not be added to the totals determined for all other source categories.

11.1 Controlled landfill/deposition

The mercury content in the general municipal waste stream can come from four main sources: 1) intentionally used mercury in spent products and process wastes; 2) mercury impurities in bulk materials (eg. paper, plastics, and metals); 3) mercury as an anthropogenic trace pollutant in bulk materials, and; 4) trace levels of mercury contamination of food wastes. In New Zealand, most municipal solid wastes are disposed to controlled landfills.

The key requirements for quantifying the inputs and outputs for this source are the total quantities of waste disposed to landfill in each year, and the average mercury content of that waste. The first of these is now readily available in New Zealand through the data collected through the Waste Disposal Levy scheme[30]. The provisional information available on the Ministry for the Environment web site shows that a total of 2,513,927 tonnes of waste was disposed at New Zealand landfills in 2012.

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[30] See: http://www.mfe.govt.nz/issues/waste/waste-disposal-levy/index.html and http://www.mfe.govt.nz/issues/waste/progress-and-outcomes/waste-disposal-levy.html.

The Waste Levy data only applies to commercial landfills accepting household waste, and does not include the waste disposed to cleanfill sites. However, there is no reason to expect significant levels of mercury contamination in cleanfill wastes, because mercury-containing wastes are usually excluded from these sites (eg. see MfE, 2002). The wastes disposed at privately-owned waste facilities, such as those operated by the pulp and paper mills, Huntly Power Station, and the gold mine tailings dams, have already been addressed in other sections (when relevant).

The general composition of the New Zealand municipal waste stream is reasonably well characterised, but there is no information available on the mercury content of the wastes. In the absence of this data, the Toolkit factors have been used. These recommend default factors of 1 – 10 g/tonne of waste for estimating the inputs, and output distribution factors of 0.01 (1%) to air and 0.0001 (0.01%) to water, with the remainder of the inputs being regarded as disposal to a reservoir.

The mercury input and output calculations for controlled landfill are shown in Table 11-2. It should be noted that the Toolkit indicates that the lower rates would apply in countries where there was a high rate of removal of mercury-containing wastes from the municipal waste stream, and the upper rates apply where there is none. New Zealand is probably intermediate between these two options. The figures shown in brackets are the means of the reported ranges.

Table 11-2: Input and output estimates for controlled landfill

Source	Activity Rate, tonnes/yr	Mercury Content, g/tonne	Annual Inputs, kg/yr	Annual Mercury Outputs, kg/yr		
				Air	Water	Reservoir
Landfilling of municipal wastes	2.5 x 10^6	1 - 10	2,500 – 25,000 (13,750)	25 – 250 (137.5)	0.25 – 2.5 (1.375)	2,475 – 24,748 (13,611.5)

Certainty assessment

Activity data: HIGH (because it is based on national levy data)

Input estimates: LOW (because they are based on the default Toolkit input factors)

Output estimates: LOW (because they are based on the default Toolkit output factors).

Comparison with 2008 estimates

The mercury inputs to landfill were discussed in the 2008 Inventory Report but were not quantified.

11.2 Diffuse deposition, informal disposal and dumping

These 3 Toolkit sub-categories have not been assessed. The first, controlled diffuse deposition, relates to the use of industrial wastes in road and building foundations. It is not known whether this occurs to any extent within New Zealand, although waste quantities of greater than about 0.5 tonnes would generally require a resource consent under the RMA.

Informal disposal also relates to industrial wastes, and especially those that may have been dumped in the past without any regulatory control. If this has occurred in New Zealand, the sites should show up in the list of hot-spots (ie contaminated sites) discussed in section 13.

Finally, the informal dumping category relates to uncontrolled dumping of general wastes. There is almost certainly some uncontrolled dumping of solid wastes in New Zealand. However, no data is available on the likely extent of any of this.

11.3 Wastewater treatment systems

The most important factors determining releases of mercury from wastewater are the amount of mercury-containing wastes that are discharged to the system and the concentration of mercury in those wastes. Mercury content in wastewater mainly originates from two source groups: 1) intentionally used mercury in products and processes (such as from dental amalgams, spillage from thermometers and other devices, and industrial discharges); and 2) atmospheric mercury washed out by precipitation and carried along in stormwater. As such, waste water treatment is an intermediate mercury release source where mercury inputs from original mercury contamination are treated and then re-distributed to water, land (through the application of sludge) and air (through sludge incineration). In addition some sludge is disposed to landfill (UNEP, 2013).

No current information has been obtained on the total volumes of liquid wastes treated through New Zealand wastewater plants. This data has been available in the past through the WINFO database which was set up and maintained by Water New Zealand. However, that system was never fully utilised by all of the wastewater operators, and has been replaced by a new database, which is still under development.

Previous reports on wastewater treatment plants have reported total throughput volumes of 1,800 million litres of wastewater per day, or 657,000 million litres/year (MfE, 2008b). There is no reason to expect any significant changes in these volumes since then, so this rate will be used for the input and output estimates.

The other parameter of interest for wastewater treatment plants is the volumes of sludge and/or biosolids produced. In 2008 these were estimated to be 234,000 tonnes/year but, more recently, Walmsley (2012) estimated that the current rate would be around 340,000 tonnes/year.

There is no information available on the average mercury content of the wastes entering New Zealand wastewater plants. The Toolkit recommends default factors of 0.5 – 10 µg/litre, and output factors of 0.5 (50%) to water, 0.2 (20%) to land, and 0.3 (30%) to waste. The latter two factors reflect the fact that some biosolids are disposed to land (including use in compost) and some are disposed to landfills, although the exact distribution for New Zealand is unknown.

The mercury input and output calculations for wastewater treatment plants are shown in Table 11-3. The figures shown in brackets are the means of the reported ranges.

Table 11-3: Input and output estimates for wastewater treatment plants

Source	Activity Rate, Litres/yr	Mercury Content, µg/L	Annual Inputs, kg/yr	Annual Mercury Outputs, kg/yr		
				Water	Land	Waste
Municipal WWTP	657×10^9	0.5 - 10	328.5 – 6,570 (3,449.3)	164.3 – 3,285 (1,724.7)	65.7 – 1,314 (689.9)	98.5 – 1,971 (1,034.8)

It is interesting to compare the land estimates to an alternative approach based on the quantities of biosolids noted above. The 2008 Inventory report calculated an average mercury content for New Zealand biosolids of 0.78 mg/kg. Applying this to the biosolids quantities gives a combined discharge to land and waste of 265.2 kg/year, which is towards the lower end of the range calculated using the Toolkit (164.2 – 3285 kg/year for land + waste). This suggests that the upper values for the factors recommended in the Toolkit are very conservative, and the lower values may be more appropriate for use in New Zealand.

Certainty assessment

Activity data: MEDIUM (because it is based on past national data)

Input estimates: LOW (because they are based on the default Toolkit output factors)

Output estimates: LOW (because they are based on the default Toolkit output factors).

Comparison with 2008 estimates

The mercury inputs and outputs for wastewater treatment plants were discussed in the 2008 Inventory Report but were not quantified, apart from biosolids disposal, which was assessed as contributing 182 kg/year to land.

11.4 Specialist waste disposal services

This category is not specifically listed in the Toolkit, but has been included here for the purposes of providing additional information on some of the New Zealand management practices for mercury-containing wastes.

Waste exports and imports

Exports of mercury-containing wastes require a permit under the Imports and Exports (Restrictions) Act 1988. These permits are issued by the EPA, and in 2012 the only permits for mercury-containing wastes were for a shipment of 2.5 tonnes of mercury and associated containers, to Germany (from Transpower), and about 100 tonnes of wastes to Australia, which contained approximately 3 kg of mercury from lamps and 50 kg of liquid mercury from electrical switchgear. Similar types and quantities of wastes were recorded in earlier years. Unfortunately, the quantities shown in the permits tend to give a significant over-estimate of the actual weights of the mercury components.

There have also been some minor waste imports, mainly from New Caledonia.

Waste disposal services

There are four companies providing hazardous waste treatment and disposal services in New Zealand. Three of these have provided a range of information which indicates that they regularly accept relatively small quantities of mercury and mercury-containing wastes, especially from dentists, hospitals, schools, universities and laboratories. These are either passed on to other users (eg see section 9.1 on recycling) or diluted and disposed to landfill or wastewater treatment plants.

11.5 Summary for this category

The estimated inputs and outputs for waste deposition/landfilling and wastewater treatment are summarised in Table 11-4.

Table 11-4: Summary of inputs and outputs for waste deposition/landfilling and wastewater treatment

Category	Mercury Inputs, kg/year	Mercury Outputs, kg/yr				
		Air	Water	Land	Waste	Reservoir
Controlled landfills/deposits	2,500 – 25,000 (13,750)	25 – 250 (137.5)	0.25 – 2.5 (1.4)	-	-	2,475 - 24,748 (13,612)
Diffuse deposition with some control	-	-	-	-	-	-
Informal local disposal of industrial wastes	-	-	-	-	-	-
Informal dumping of general waste	-	-	-	-	-	-
Wastewater treatment	328.5 – 6,570 (3,449.3)	-	164.3 – 3,285 (1,724.7)	65.7 – 1,314 (689.9)	98.5 – 1,971 (1,034.8)	-
Totals	**2,828.5 – 31,570 (17,199)**	**25 – 250 (137.5)**	**164.6 – 3,288 (1,726)**	**65.7 – 1,314 (689.9)**	**98.5 – 1,971 (1,034.8)**	**2,475 24,748 (13,612)**

The figures shown in brackets are the means of the reported ranges.

12 Crematoria and cemeteries

This category covers mercury releases from cremation and burial of human bodies (UNEP, 2013). The various sub-categories and the primary release pathways are summarised in Table 12-1, which has been copied directly from the UNEP Toolkit.

Table 12-1: Toolkit framework for category 10 – crematoria and cemeteries

Toolkit Chapter	Sub-category	Air	Water	Land	Product	Waste/ residue	Main approach
5.2.1	Crematoria	X				X	OW
5.2.2	Cemeteries			X			OW

Notes: OW = National/overview approach;

X - Release pathway expected to be predominant for the sub-category;

x - Additional release pathways to be considered, depending on specific source and national situation.

12.1 Crematoria and cemeteries

The mercury releases from this source, and also in cemeteries, comes from the mercury present in the corpses, mainly as a result of the mercury in dental amalgam fillings. In cremation, this is predominantly released to air, while in cemeteries it is released to land.

Annual data obtained from Statistics New Zealand and the Department of Internal Affairs (J Arnold, pers comm, 2013) show that in 2012, the total number of deaths in New Zealand was 30,099 and that approximately 63% of these people were cremated[31].

No information has been found on the mercury content of New Zealanders, so the Toolkit default factors of 1 – 4 g/body have been used. The mercury input and output estimates for cremation and cemeteries are shown in Table 12-2. The figures shown in brackets are the means of the reported ranges.

Table 12-2: Input and output estimates for cremation and cemeteries

Source	Activity Rate, corpses/yr	Mercury content, g/corpse	Annual Mercury Inputs, kg/yr	Annual Mercury Outputs, kg/yr	
				Air	Land
Cremation	19,053	1 – 4	19.1 – 76.2 (47.7)	19.1 – 76.2 (47.7)	-
Cemeteries	11,046	1 - 4	11.0 – 44.2 (27.6)	-	11.0 – 44.2 (27.6)

Certainty assessment

Activity data: MEDIUM (because it was based on national data, but with some uncertainties)

Input estimates: LOW (because it was based on the Toolkit default factors)

Output estimates: MEDIUM (because the air/land distribution is quite clear-cut. The only uncertainty is in the small amounts of mercury that may be present in crematoria ash).

31 The cremation/burial split is a little uncertain because it is based on the place of disposal, rather than the method of disposal (which is not recorded). Also, a small number of the burials may have taken place in other countries.

Comparison with the 2008 estimates

The 2008 Inventory Report estimated cremation inputs/outputs of 70 kg/year and cemetery inputs/outputs of 50 kg/year. These were based on slightly lower death numbers and the upper Toolkit factor.

12.2 Summary for this category

The estimated inputs and outputs for crematoria and cemeteries are summarised in Table 12-3.

Table 12-3: Summary of inputs and outputs for crematoria and cemeteries

Category	Mercury Inputs, kg/year	Mercury Outputs, kg/yr				
		Air	Water	Land	Product	Waste
Crematoria	19.1 – 76.2 (47.7)	19.1 – 76.2 (47.7)	-	-	-	-
Cemeteries	11.0 – 44.2 (27.6)	-	-	11.0 – 44.2 (27.6)	-	-
Totals	**30.1 – 120.4 (75.25)**	**19 – 76 (47.7)**	**-**	**11 – 44.2 (27.6)**	**-**	**-**

The figures shown in brackets are the means of the reported ranges.

13 Potential hotspots

This category covers sites where previous land use activities may have caused contamination. A generic list of the types of sites that might be considered was given in the 2008 Inventory Report, and included:

- Historical gold and mercury mining sites
- Closed landfills
- Former agricultural sites, include pesticide manufacturing and storage, and market gardens/orchards
- Old industrial sites, such as tanneries, chlor-alkali plants, and battery manufacturers
- Government properties, including dental schools and defence bases
- Boat repair yards and slipways

All Regional Councils and Unitary Authorities were contacted through the Land Mangers Forum, regarding their current knowledge of contaminated sites. Replies were received from 14 of these councils, with 10 indicating that they had no knowledge of any mercury-contaminated sites within their regions (other than sites where the mercury is simply an incidental, low level, contaminant). Other responses covered the following matters:

- A former mercury mine site in Northland is likely to be contaminated, though levels have not been confirmed.
- Both the Tasman and West Coast regions have old gold mining sites that may be contaminated with mercury.
- A power station site in Canterbury is known to be contaminated with mercury, but the extent of contamination has not been determined.
- Elevated mercury levels have been detected in many orchards and ex-mine sites, however generally not above the rural residential standard of 300mg/kg for inorganic mercury in soils. As an example, the Waikato Regional Council noted that at one highly contaminated former tailings dam (the Tui mine), the average concentration of mercury is less than 30mg/kg.

Additionally, one company specialising in site remediation work noted that they had not been involved with any sites specifically involving mercury over the past five years (J O'Grady, Contract Environmental pers comm, 2013). However, there have been some sites where mercury was detected at only slightly elevated levels (ie incidental contamination), and these wastes were generally sent to landfill.

It can also be confirmed that there are no contaminated sites specifically associated with the two chlor-alkali plants that were previously operated at the two North Island kraft pulp paper mills (see section 6.1). These plants were shut down in the 1980s and it is believed that the sludge and other residues were disposed to the companies' solid waste disposal facilities (J Newfield, Carter Holt Harvey, pers comm, 2010, as reported in MfE, 2011a).

14 Summary and discussion

14.1 High level summary of mercury inputs and outputs

A summary of the mercury inputs and outputs for New Zealand, at the level of the main Toolkit source categories, is given in Table 14-1. (Note: The numbers have been rounded down from previous tables)

Table 14-1: High level summary of mercury inputs and outputs for New Zealand*

Category	Mercury Inputs, kg/year	Mercury Outputs, kg/yr				
		Air	Water	Land	Product	Waste
1. Extraction and use of fuels/energy sources	291 – 2,295 (1,293)	234.9 – 1,913.1 (1,074)	46.8 – 121 (83.9)	3.8 – 25.4 (14.6)	<0.01 – 3.7 (1.9)	5.3 – 231.2 (118.3)
2. Primary (virgin) metal production	1,310.5 – 2,681.9 (1,996)	74.3 – 184.9 (129.6)	33 – 58 (45.5)	1,133 – 2,258 (1,695.5)	50 – 100 (75)	20.3 – 80.9 (50.6)
3. Production of other minerals and materials	45.7 – 251 (148)	5.0 – 6.8 (5.9)	-	38.5 – 241.5 (140)	2.16 -2.9 (2.5)	-
4. Intentional use of mercury in industrial processes	-	-	-	-	-	-
5. Consumer products with intentional use of mercury	133.1 – 354.9 (244)	3.5 – 15.7 (9.6)	0.98 – 9.8 (5.4)	0.9 – 8.8 (4.8)	40.2	87.4 – 280.4 (183.9)
6. Other intentional product/process uses	205	5.8	26.5	-	90	82.8
7. Production of recycled metals	317	0.7	-	-	315	1.3
8. Waste incineration	20.8 – 190.1 (105.4)	20 – 189.2 (104.6)	-	-	-	0.8
9. Waste deposit/landfill and wastewater treatment	2,829 – 31,570 (17,199)	25 – 250 (137.5)	164.3 – 3,287.5 (1,726)	65.7 – 1,314 (689.9)	-	98.5 – 1,971 (1034.8)
10. Crematoria and cemeteries	30.1 – 120.4 (75.3)	19.1 – 76.2 (47.7)	-	11 – 44.2 (27.6)	-	-
Totals, all groups	**5,182 – 37,986 (21,584)**	**388 – 2,642 (1,515)**	**272 – 3,503 (1,887)**	**1,253 – 3,892 (2,572)**	**498 – 552 (525)**	**296 – 2,649 (1,473)**

(* The totals in the table may not exactly equal the sum of displayed data, due to rounding)

By far the greatest quantities in the inputs column are for category 9, waste disposal. However, describing these as inputs is not really correct – they would be better considered as secondary or down-stream inputs, in that they are the result of many of the past and current outputs from all other categories, plus contributions from indirect sources, such as mercury in foods and in airborne dust. A similar distinction applies to the inputs from waste incineration, metal recycling and cremations and burials. To assist with this distinction, the totals inputs have been separated out into 3 different groupings in Table 14-2.

Table 14-2: High-level summary grouped by primary and secondary sources*

Category	Mercury Inputs, kg/year	Mercury Outputs, kg/yr				
		Air	Water	Land	Product	Waste
Total for groups 1 to 6	1,985.4 – 5,788.1 (3,886.8)	323.4 – 2,126.3 (1,224.8)	107.3 – 215.2 (161.2)	1,176.2 – 2,533.7 (1,854.9)	182.7 – 237.1 (209.9)	195.8 - 675.4 (435.6)
Totals for groups 7, 8 and 10	367.9 - 627.4 (497.7)	39.7 – 266 (152.9)	-	11 – 44.2 (27.6)	315	2.2
Total for group 9	2,828.5 – 31,570 (17,199)	25 – 250 (137.5)	164.6 – 3,287.5 (1,726)	65.7 – 1,314 (689.9)	-	98.5 – 1,971 (1,034.8)
Totals, all groups	**5,182 – 37,986 (21,584)**	**388 – 2,642 (1,515)**	**272 – 3,503 (1,887)**	**1,253 – 3,892 (2,572)**	**498 – 552 (525)**	**296 – 2,649 (1,473)**

(* The totals in the table may not exactly equal the sum of displayed data, due to rounding)

Apart from the waste category, the next highest input is from primary metal production and, in particular gold and silver mining. In this case, the bulk of the inputs and outputs are associated with the extraction of very large volumes of mercury-containing ore, which is processed to remove the gold and silver, and then 90% of it is returned to the land. It is debateable whether this should be regarded as a true mobilisation of mercury.

The next highest input category is the extraction and use of fuels and other energy sources, with the dominant contributors here being geothermal energy and natural gas.

The inputs from the remaining categories are in the following approximate order:

- production of recycled metals, which is dominated by mercury recycling
- consumer products; which has significant contributions from lamps, batteries and electrical switches
- other intentional products/uses; which is dominated by dental amalgam
- other minerals and materials; which is dominated by the inputs from phosphate fertilisers
- waste incineration; which is dominated by uncontrolled rubbish burning
- cremation and burials.

There is no significant industrial use of mercury in New Zealand and hence, no inputs.

This relative significance of each of the categories is also illustrated in Figure 14-1 below (excluding the category 9, waste disposal, sources). Once again, this shows the dominant effect of gold and silver mining (primary metals) and, to a lesser extent, fuel/energy extraction and use.

Reservoirs, stocks and exports

The reservoirs and stocks noted at various points through the report have not been included in the high-level table because they should not be classified as inputs or outputs. Instead, they are summarised below:

Existing stocks

Thermometers:	26.7 – 267 kg, with a mean of 147 kg
Switches and relays:	170 kg
Manometers/gauges:	270 kg
Laboratory chemicals:	260 kg (including elemental mercury)
Total identified stocks:	727 – 967 kg, with a mean of 847 kg

Addition to reservoirs

Landfills	2,475 – 24,748 kg per year, with a mean of 13,612 kg per year

It should be noted that the figure shown for landfills is simply the annual addition to the existing landfill reservoirs that will have been accumulated over many years.

The following mercury exports were also noted. These have been included in the high-level table, so should be subtracted from the relevant totals.

Mineral oil	5 kg
Gold mining wastes	55 kg
Lamps	3 kg
Pharmaceuticals (vaccines)	24 kg
Recycled mercury	240 kg
Total exports:	327 kg

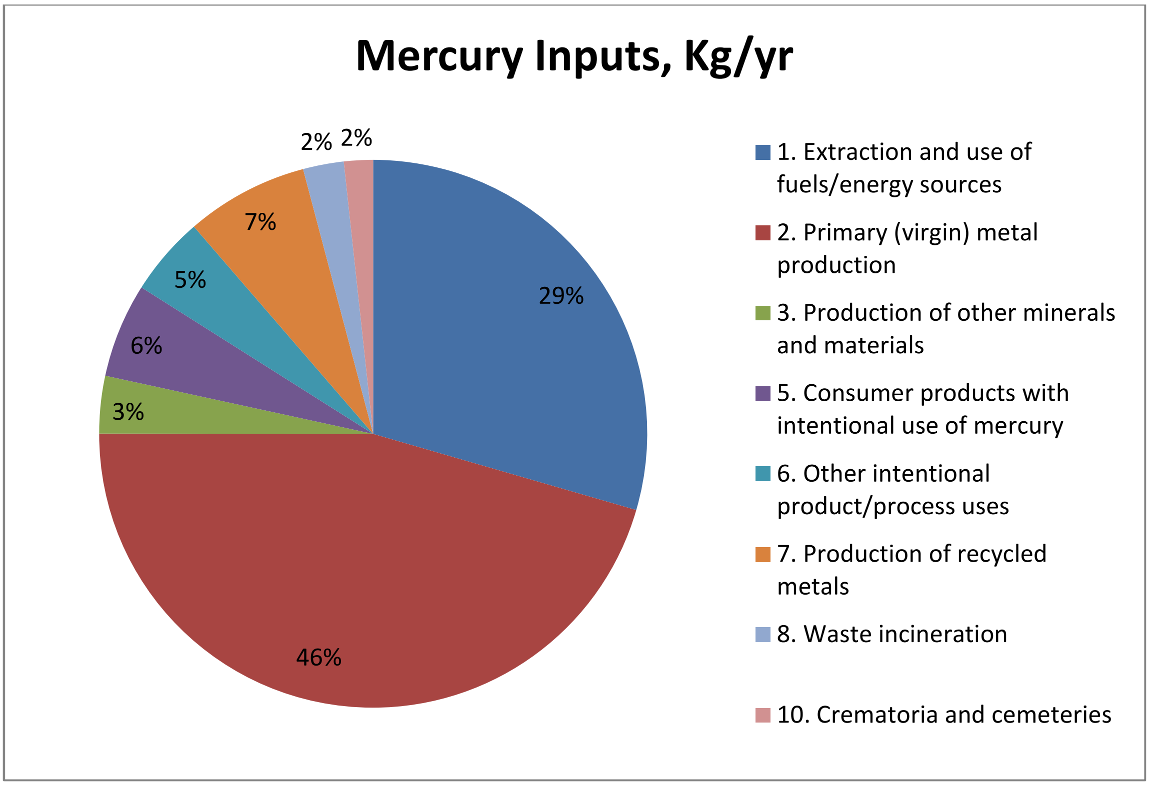

Figure 14-1: High level graphical summary of mercury inputs (excluding the waste category)

14.2 Source by source summary of mercury inputs and outputs

A detailed source by source listing of all of the individual inputs and outputs is given in Table 14-3 (at the end of this section), but excluding those sources identified as not relevant to New Zealand. A relative ranking of the inputs from each of the sources is also illustrated in Figure 14-2, with the size of each bar giving a simple indication of the level of uncertainty associated with each estimate.

Once again, this shows that the greatest input sources the two waste disposal categories, followed by gold and silver mining, geothermal energy, the recycling of elemental (liquid) mercury, extraction and processing of natural gas, and the use of dental amalgams.

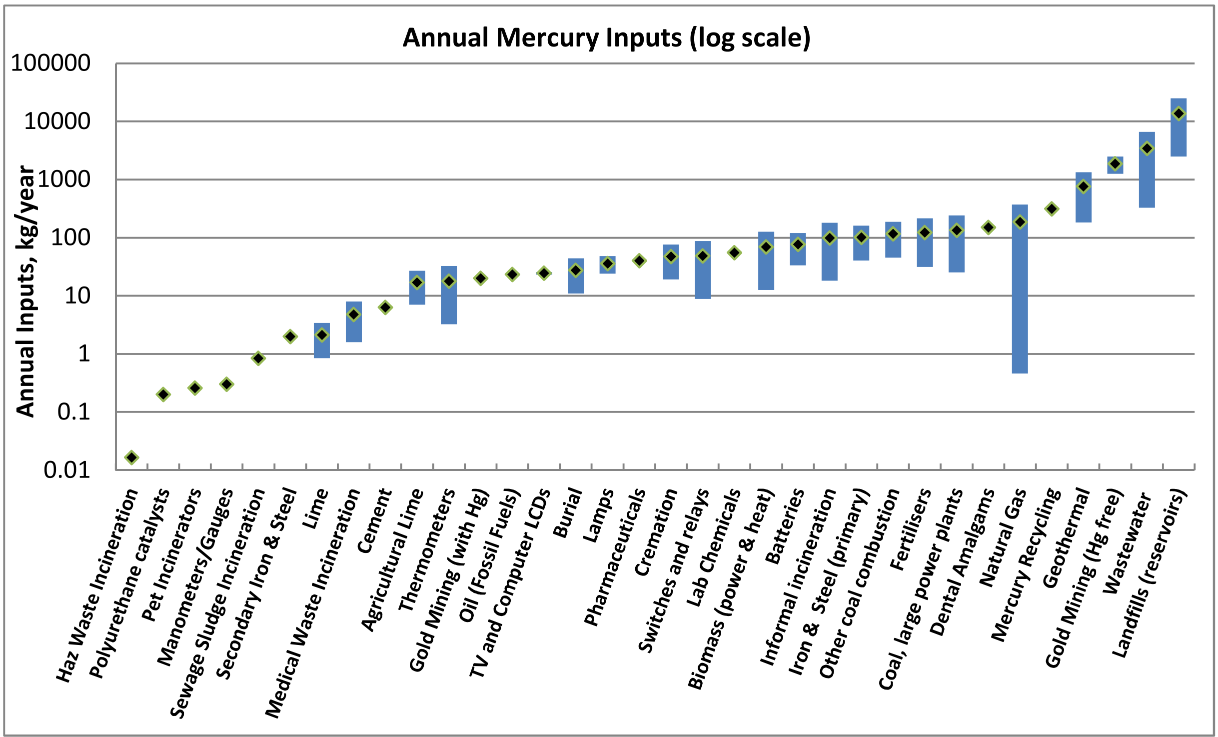

Figure 14-2: Ranking of mercury inputs by individual sources

Five more summary charts are shown on the following pages, for the distribution of outputs to air, water, land waste and in products. However, it should be noted that the category 9 waste disposal sources have been excluded from all these charts to avoid having the presentations dominated by this secondary category.

The key points to note from these charts are as follows:

- The outputs to air are dominated by fuel/energy use, especially geothermal, and to a lesser extent, primary metal production and waste incineration.
- The outputs to water are dominated by fuel/energy use and, to a lesser extent, primary metal production.
- The outputs to land are dominated by gold mining but this has been excluded from the chart,
- The outputs via products are dominated by the production of recycled metals, but with other significant contributions coming from other intentional products/processes, primary metal production and consumer products.
- The outputs to wastes are distributed across 4 categories, in the following order of decreasing significance: consumer products, fuel/energy use, other intentional products/processes, and primary metal production.

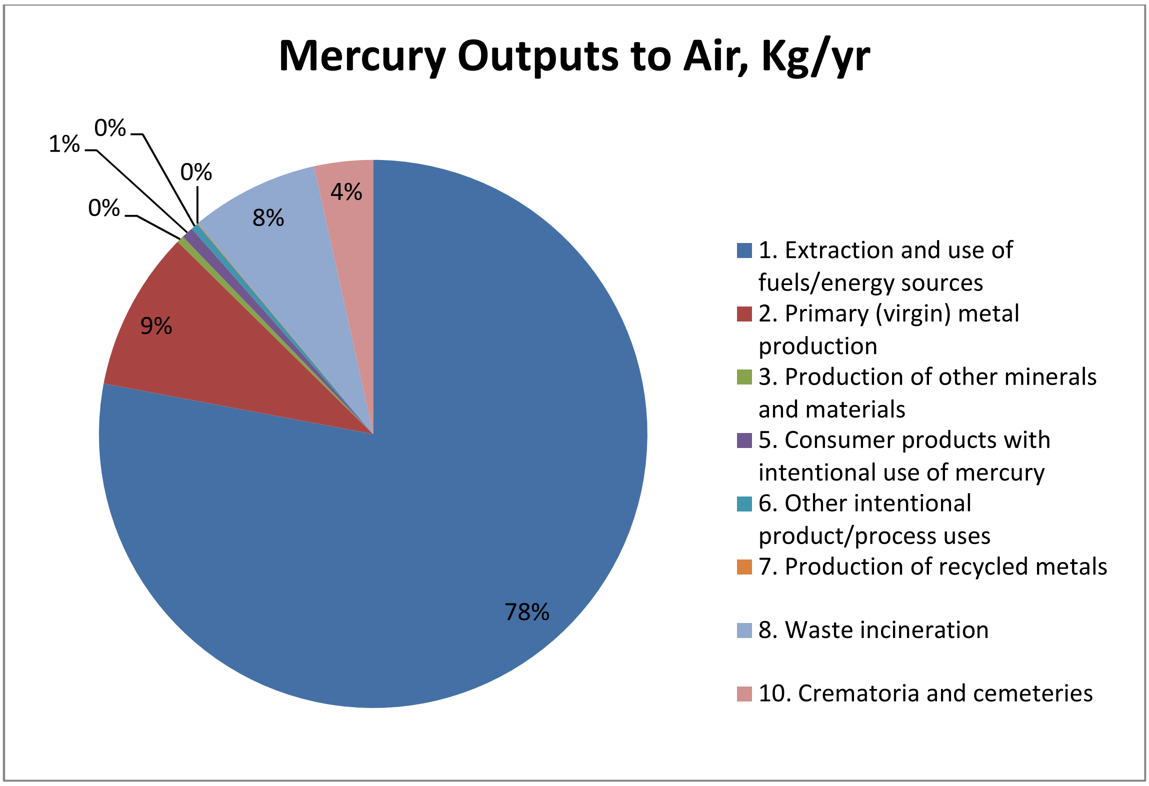

Figure 14-3: Relative mercury outputs to air, by source category

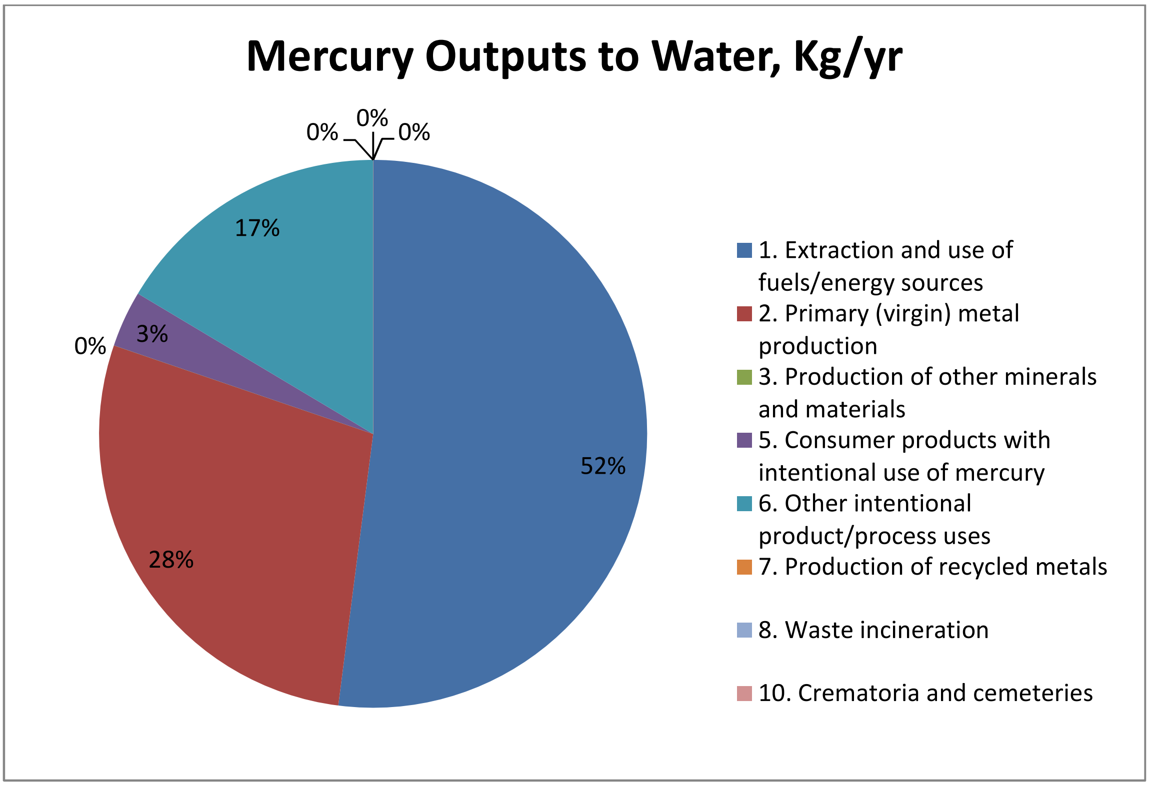

Figure 14-4: Relative mercury outputs to water, by source category

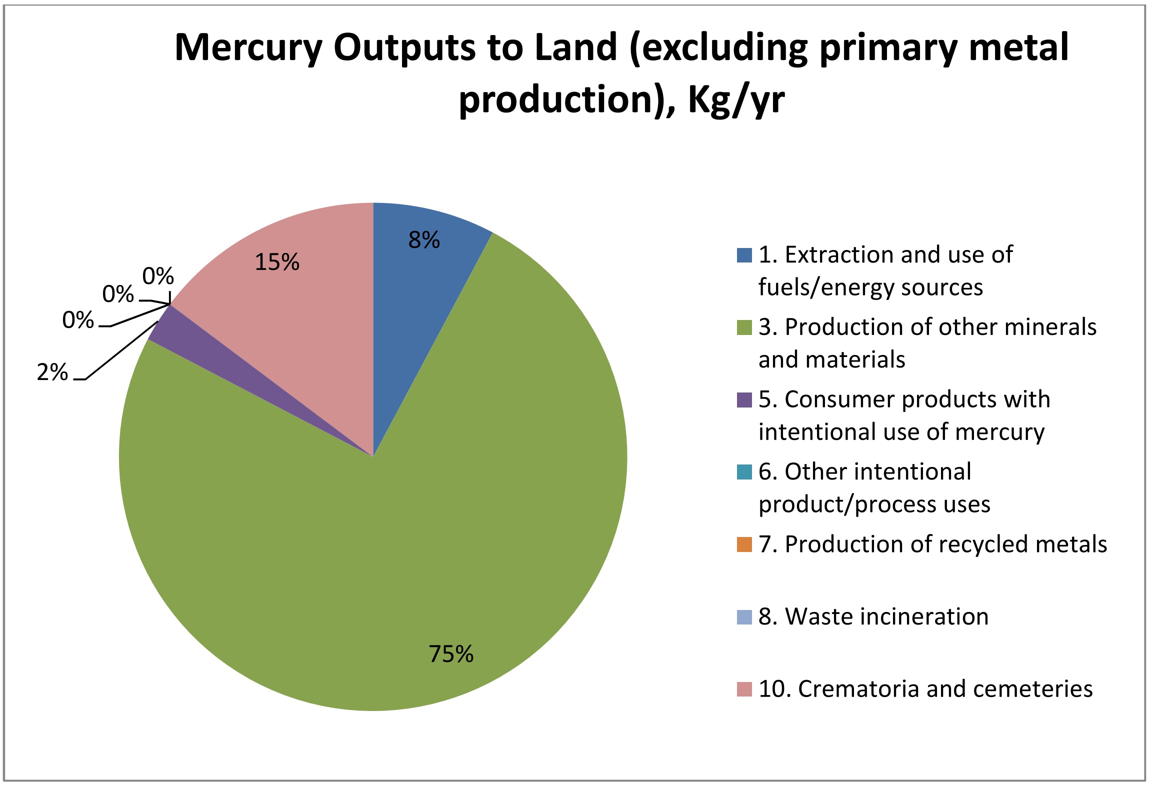

Figure 14-5: Relative mercury outputs to land, by source category (excluding primary metal production)

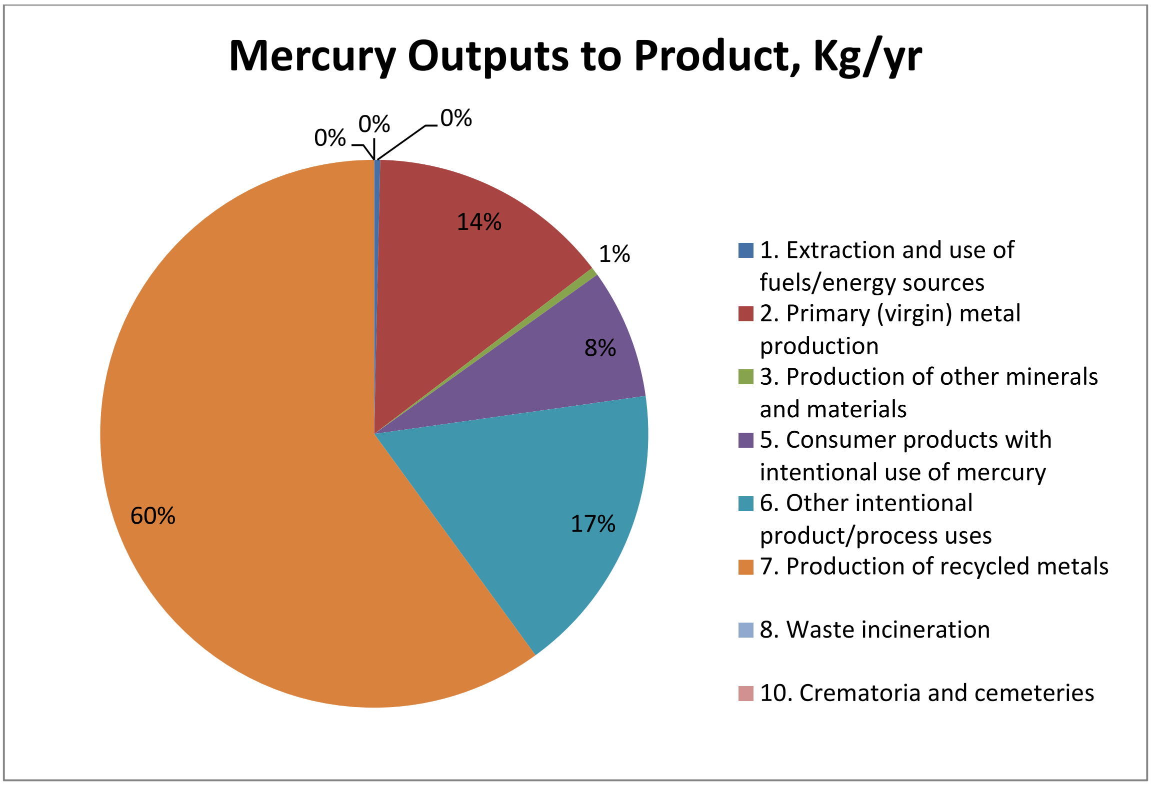

Figure 14-6: Relative mercury outputs to products, by source category

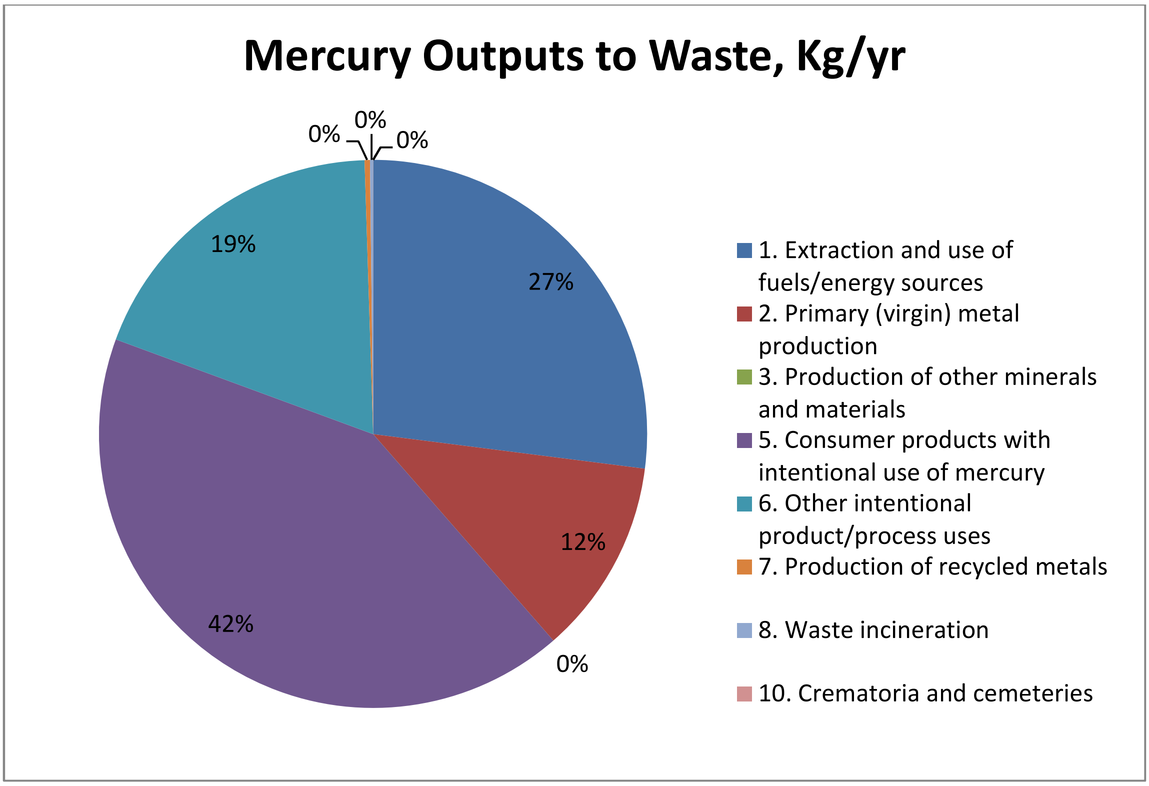

Figure 14-7: Relative mercury outputs to waste, by source category

14.3 Commentary on some of the proposed convention requirements

Some of the findings from this inventory are relevant to a few of the specific requirements under the proposed text for the Minamata Convention, and these are noted briefly below.

Stocks of mercury or mercury compounds in excess of 10 or 50 tonnes (Article 3)

The stocks identified in the inventory are of the order of kilograms rather than tonnes.

Switches and relays (Annex A)

Some of the older switches and relays identified in the survey may fall under the proposed exemption (very high accuracy capacitance and loss measurement bridges and high frequency radio frequency switches and relays in monitoring and control instruments with a maximum mercury content of 20 mg per bridge, switch or relay). However, these are all being phased out.

The current imports and sales of switches would not fall under the exemption, but the quantities are minor.

Lamps (Annex A)

Most of the CFLs sold in New Zealand for general lighting purposes are less than 30 watts so may fall under the proposed restrictions. However, the information provided by the importer indicates that the mercury content is now below the 5 mg per lamp threshold.

Most of the LFLs sold in New Zealand for general lighting purposes are less than 40 or 60 watts (depending on type) so may fall under the proposed restrictions. However, the information provided by the importer indicates that the mercury content in most of these is now at or below the 5 or 10 mg per lamp threshold.

There are significant quantities of high pressure mercury vapour lamps currently being used in New Zealand, in applications such as street lighting (see Table 7-4), although LED-based alternatives are now being trialled.

The current imports of cold cathode fluorescent lamps and external electrode fluorescent lamps for televisions and other electronic displays are not specifically identified in the import statistics, other than indirectly through the data for TVs and computers. However, discussions with industry representatives indicate that there is a general move away from these in favour of other options such as LEDs.

Cosmetics (Annex A)

No significant uses of mercury in cosmetics have been identified.

Manufacturing processes (Annex B)

It has been confirmed that none of the following manufacturing processes involving mercury exist in New Zealand:

- Chlor-alkali production
- Acetaldehyde production
- Vinyl chloride monomer production
- Sodium or potassium methylate or ethylate production
- Production of polyurethane using mercury containing catalysts

Table 14-3: Detailed listing of mercury inputs and outputs*

Category	Mercury Inputs, kg/year	Mercury Outputs, kg/yr				
		Air	Water	Land	Product	Waste
Coal – large power plants	25.4 – 241.3 (133.4)	22.86 – 217.2 (120.0)	-	2.54 – 24.13 (13.34)	-	-
Other coal combustion	45.57 – 187.25 (116.4)	43.3 – 177.9 (110.6)	-	-	-	2.25 – 9.3 (5.8)
Oil extraction, refining and use	23.4	19.12	0.19	1.26	-	2.82
Gas extraction, refining and use	0.46 – 371.4 (185.9)	0.09 – 74.3 (37.2)	0.09 – 74.3 (37.2)	-	<0.01 – 3.7 (1.86)	0.27 – 219.1 (109.7)
Biomass fuel	12.6 – 126 (69.3)	12.6 – 126 (69.3)	-	-	-	-
Geothermal power	183.5 – 1,345.5 (764.5)	136.9 – 1,298.6 (718)	46.5	-	-	-
Gold & silver production, with mercury	20	4	8	8	-	-
Gold & silver production, without mercury	1,250 – 2,500 (1,875)	50 – 100 (75)	25 – 50 (37.5)	1,125 – 2,250 (1,688)	50 – 100 (75)	-
Ferrous metals production (iron & steel)	40.5 – 161.9 (101.2)	20.3 – 80.9 (50.6)	-	-	-	20.3 - 80.9 (50.6)
Cement production	6.3	4.4	-	-	1.9	-
Lime production	0.85 – 3.4 (2.1)	0.595 – 2.38 (1.5)	-	-	0.26 – 1.0 (0.64)	-
Superphosphate use	31.5 – 214.5 (123)	-	-	31.5 – 214.5 (123)	-	-
Agricultural lime application	7 – 27 (17)	-	-	7 – 27 (17)	-	-
Thermometers with mercury	3.25 – 32.5 (17.9)	0.325 – 3.25 (1.8)	0.975 – 9.75 (5.4)	-	-	1.95 – 19.5 (10.7)
Electrical switches, contacts and relays with mercury	8.8 – 88 (48.4)	0.9 – 8.8 (4.8)	-	0.9 – 8.8 (4.8)	-	7.0 – 70.4 (38.7)
Light sources - lamps	24 – 48.1 (36.0)	1.2 – 2.4 (1.8)	-	-	-	22.8 – 45.7 (34.2)
Light sources - LCDs	23.25 – 25.5 (24.4)	1.14 – 1.25 (1.2)	-	-	-	22.11 – 24.25 (23.2)
Batteries containing mercury	33.6 – 120.6 (77.1)	-	-	-	-	33.6 – 120.6 (77.1)
Polyurethane with mercury catalyst	0.2	-	-	-	0.2	-
Pharmaceuticals for human and veterinary uses	40	-	-	-	40	-

Category	Mercury Inputs, kg/year	Mercury Outputs, kg/yr				
		Air	Water	Land	Product	Waste
Dental mercury amalgam fillings	150	3	21	-	90	36
Manometers and gauges	0.3	-	-	-	0.3	-
Laboratory chemicals and equipment	55	2.75	5.5	-	-	46.75
Recycled mercury	315	-	-	-	315	-
Ferrous metals (iron and steel)	2.0	0.66	-	-	-	1.34
Hazardous waste incineration	0.0165	0.0165	-	-	-	-
Medical waste incineration	1.6 – 8 (4.8)	1.6 – 8 (4.8)	-	-	-	-
Sewage sludge incineration	0.84	-	-	-	-	0.84
Informal waste incineration	18.1 – 180.9 (99.5)	18.1 – 180.9 (99.5)	-	-	-	-
Other (pet incinerators)	0.26	0.26	-	-	-	-
Controlled landfills/deposits	2,500 – 25,000 (13,750)	25 – 250 (137.5)	0.25 – 2.5 (1.4)	-	-	-
Wastewater treatment systems	328.5 – 6,570 (3,449)	-	164.3 – 3,285 (1,725)	65.7 – 1,314 (690)	-	98.5 – 1,971 (1,034.8)
Crematoria	19.1 – 76.2 (47.7)	19.1 – 76.2 (47.7)	-	-	-	-
Cemeteries	11.0 – 44.2 (27.6)	-	-	11.0 – 44.2 (27.6)	-	-
Totals, all sources	**5,182 – 37,986 (21,584)**	**388 – 2,642 (1,515)**	**272 – 3,503 (1,887)**	**1,253 – 3,892 (2,572)**	**498 – 552 (525)**	**296 – 2,649 (1,473)**

(* The totals in the table may not exactly equal the sum of displayed data, due to rounding)

15 Stakeholder analysis and other source information

This section provides a brief summary of the key stakeholders identified for each source category, and other relevant information, such as the countries of origin of imported materials and products.

15.1 Extraction and use of fuels/energy sources

Coal

There is one large (800 MW) coal-fired power station in New Zealand. This is owned and operated by Genesis Energy and, in 2011, accounted for about 28% of total national coal use. The largest industrial coal users are BlueScope Steel, which operates a steel mill and cogeneration plant at Glenbrook, South Auckland, two cement plants (Golden Bay Cement, Whangarei and Holcim, Westport) and five lime kilns (McDonald's Lime (4) and Perry Resources (1)). Coal is also used as supplementary fuel in several cogeneration plants, although these are fired predominantly on wood and other biomass (Carter Holt Harvey, Tasman, Carter Holt Harvey, Kinleith and Pan Pacific, Napier). In total, these industrial uses account for a further 40% of total coal use, and the remaining coal usage is split across numerous industrial and commercial boilers, with a very minor proportion (0.1%) used for domestic heating and cooking.

The Heat Plant Database (CRL Energy, 2012) provides a detailed inventory of all of the coal-fired boilers operating in New Zealand. This information has been summarised in Table 15-1, and further information can be obtained from the spreadsheet and report, which can be found at: http://www.eeca.govt.nz/resource/heat-plant-database. It should be noted that capacity data was not reported for all of the boilers identified in the survey, and this is indicated by the differences between the second and third columns in the table. Also, the total capacities and capacity ranges are only for those boilers with reported data.

Table 15-1: Summary of coal-fired boilers in New Zealand

Category	Total Number of Boilers Identified	Number of Boilers with Reported Capacities	Total MW reported for each Category	Reported Boiler Range (MW)
Accommodation	3	2	2.0	0.8 - 1
Correction/ Detention	0	0	0	0
Councils	13	10	4.8	0.3- 1.5
Dairy Processing	27	26	538	0.3 - 43
Defence	2	2	13	4.5 - 8
Education	234	114	50	0.1 – 2.4
Food Processing	18	13	31	0.4 - 5
Horticulture	46	42	69	0.4 - 6
Hospitals	37	36	106	0.9 – 7.7
Meat Processing	56	55	254	1 - 18
Miscellaneous	6	5	11	0.1 – 1.5
Other Manufacturing	13	13	46	1.4 - 8
Research Institutes	0	0	0	0
Rest Homes	2	0	0	0
Universities/Polytechnics	11	11	36	0.3 - 12
Venues	0	0	0	0
Wood Processing	28	27	105	0.2 - 16

Most of the coal used in New Zealand is produced from local coal mines. The only notable exception is the small quantities imported from Indonesia for use in Huntly Power Station. In 2012 these imports accounted for about 10% of the total power station coal consumption, but less than 3% of the total national consumption.

Oil

There are currently 17 productive oil and gas fields in New Zealand, most of which are owned and operated by a consortium of companies. The key participants include Origin Energy, Genesis Energy, Todd Energy, Shell Exploration, NZ Oil and Gas, Mitsui E & P Australia Pty, Pan Pacific Petroleum NL, and Australia Worldwide Exploration (MBIE, 2013).

The oil refinery at Marsden Point is owned and operated by a consortium of 5 oil companies. These companies are also involved with the distribution of refined products, along with several independent distributors.

The refined products are used in a wide variety of different applications. However, the primary uses are in transport (82%), industry (6%), fishing and forestry (7.4%), and commercial/residential (< 4%).

Virtually all of the oil produced in New Zealand is exported. Conversely, most of the oil processed at the refinery is imported, and the resulting outputs of refined products are further supplemented by imported supplies, mainly petrol and diesel.

Natural gas

The gas field operators are the same as noted above for oil production. Natural gas is currently only produced in Taranaki and distributed around the North Island (MBIE, 2013). The bulk of the usage is in Taranaki (43%), Waikato (24%), and Auckland (21%). The major commercial uses are in dairy factories, meat processing, pulp and paper, oil refining, urea manufacturing, organic industrial chemicals (formaldehyde), and steel manufacture.

All of the natural gas produced in New Zealand is used here.

Wood and other biomass

The Energy Data File lists 3 biomass-fired cogeneration plants, with a total installed capacity of 72 MW (MBIE, 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 176 industrial wood-fired installations rated at greater than 1 MW capacity, but capacity data was only reported for about 120 of those. For the latter group, the total installed capacity is 1,035 MW (CRL Energy, 2011), Industrial wood combustion accounts for about 80% of New Zealand's total wood combustion, with the rest being used mainly for residential heating.

Virtually all of the wood and other biomass used as fuel in New Zealand is grown here.

Geothermal power

There are currently 9 geothermal power stations operating in New Zealand, mainly in the Bay of Plenty and Waikato regions. Generally, the larger power stations are owned and operated by Contact Energy or Mighty River Power. However, some of these stations, and other smaller ones, are operated as joint ventures with various iwi trusts. The Ngawha Power Station in Northland is operated by Top Energy.

Geothermal energy is a natural resource and there is no importing or exporting.

15.2 Primary (virgin) metal production

The key producers within this source category are Newmont Waihi Gold and Oceana Gold, Pacific Aluminium, and BlueScope Steel. In addition, there are numerous small-scale gold mining operators on the West Coast of the South Island.

Gold mining utilises an existing natural resource and there are no imports of gold-containing ores. The only imports possibly relevant to this sub-category are the small quantities of liquid mercury noted in section 8.3.

Aluminium production in New Zealand uses imported alumina, but this has been assessed as contributing no significant mercury inputs.

Primary iron and steel production uses iron sand, coal and lime, which are sourced, respectively, from the West Coast of the North Island, Huntly, and Te Kuiti.

15.3 Minerals and materials with mercury impurities

The two cement plants in New Zealand are operated by Golden Bay Cement, in Northland, and Holcim, on the West Coast of the South Island. Holcim do have resource consents for the construction of a new plant in Otago, which would replace the West Coast plant. However, these plans are currently on hold. Both plants utilise locally-available natural resources and fuels, but Holcim also use waste oil as a supplementary fuel, some of which may be imported.

Both of the pulp and paper mills in the Waikato and Bay of Plenty regions are owned by Carter Holt Harvey, and utilise locally produced resources. However, most of the pulp and paper products are exported.

There are 9 lime kilns in New Zealand, 4 associated with the pulp and paper mills, 4 others in the Waikato region and 1 in Otago. Four of these plants are owned by McDonald’s Lime, a division of Holcim, and the other is owned by Perry Resources. All of the plants use locally produced resources and fuels.

The agricultural lime used in New Zealand is produced from numerous quarries throughout the country.

The superphosphate fertiliser manufactured in New Zealand is produced at 6 plants in Whangarei, Mt Maunganui, Napier, Christchurch, Dunedin and Southland, which are owned by Ballance Agri-Nutrients (3) and Ravensdown Ltd (3). There are also quantities of processed phosphate rock imported by several other suppliers for direct application to pasture. A small proportion (< 2%) of the superphosphate manufactured here is exported, mainly to Australia, and the rest is used within New Zealand.

The supplies of phosphate rock (both for processing and direct use) are obtained from many different countries, and the distribution between source countries varies over time. In 2012, the majority suppliers were Morocco (53%), Nauru (13%), Vietnam (9.5%), Peru (8%), China (5%), and South Africa (4%).

15.4 Consumer Products with intentional use of mercury

Thermometers

Eighteen suppliers of thermometers were identified in this survey, and their products are intended for medical, veterinary, laboratory or personal use. There may also be numerous other importers of general consumer goods that also import thermometers intended for personal use. The import statistics noted in section 7.1 indicated that the thermometers were obtained from about 15 different countries, but with a major proportion coming from China (67%), and others from Australia (4.5%), Taiwan (5.8%), United Kingdom (6.7%) and the United States of America (8.6%).

Electrical switches and relays

The main holders of existing, readily identifiable, mercury switches and related equipment are believed to be the 26 electricity network operators. However, there may also be small mercury switches in numerous items of older cars and electronic equipment being used or stored by individual owners throughout the country.

The current imports of mercury switches are believed to be very minor, and would be brought into the country by suppliers of electronic componentry – for which 7 companies were identified – and, possibly, individual electronics hobbyists.

Light sources (lamps)

The main industry contact body for this sub-category was the Lighting Council of New Zealand, which lists 36 member companies on its web site (http://www.lightingcouncil.org.nz/members), and is believed to represent all but a small number of lamp importers.

The import data noted in section 7.3 indicates that lamps are imported from more than 50 different countries, but with the dominant suppliers of CFLs and LFLs being China (60%), Thailand (17%), Hungary (10%) and Indonesia (3%). For high pressure discharge lamps the main sources were Hungary (50%), China (25%), Belgium (7%) and Germany, Slovakia and Italy (3 – 4% each).

Light sources (LCDs)

One industry body that provided useful input for this sub-category was the Electronics Consumer Association of New Zealand. Membership is open to any manufacturer or supplier of consumer electronics in New Zealand, but not including retailers. The primary members appear to be LG, Panasonic, Sharp, Sony and Samsung, and information was also obtained directly from some of these, along with several of the main computer companies (from the initial contact list of Apple, Dell, Hewlett Packard, and IBM).

There are, of course, numerous other importers and distributors of computers and other equipment containing LCDs. This is illustrated by the import data for computer monitors, computers, and laptops, which shows imports coming from more than 20 different countries. However, the predominant source countries for TVs were Malaysia (53%), China (25%), Thailand (8%), Indonesia (7%) and South Korea (4%), while for computer monitors they were China (81%), Australia (9%), Taiwan (3%) and South Korea (2%). The imports from Australia are possibly from distributors rather than manufacturers.

Batteries

Information on the mercury content of batteries was obtained from the local offices for two of the major international brands, Energiser and Panasonic, and a major importer, the Warehouse. There is no battery manufacturing in New Zealand and all supplies are imported, distributed and sold through these companies and numerous others. The import data noted in section 7.5 indicates that batteries are imported from about 40 different countries, but with the dominant suppliers being as follows:

Alkaline:	China (47%), Indonesia (14%), USA (14%) and Singapore (9%)
Mercury oxide:	China (99.9%)
Silver oxide:	Japan (61%), USA (17%), China (15%)
Zinc-air:	United Kingdom (22%), China (21%), Germany (13%), USA (13%), Australia (12%) and Singapore (11%)

Polyurethanes

The one identified distributor of polyurethanes containing mercury catalysts was an Australian company, Era Polymers Pty Ltd. The other importers/distributors who provided responses were Dotmar Universal Plastics, Polymer Technologies Ltd, Thor Specialties Pty Ltd (Australia), Selleys and Sika (NZ) Ltd.

Paints

This industry is represented by the New Zealand Paint Manufacturers Association and its members include Dulux, Wattyl Paints, Altex Coatings, Mirotone Paints, Resene Paints and Thor Specialties Pty Ltd (Australia).

Pharmaceuticals for human and veterinary use

The 26 registered pharmaceutical products (containing mercury) in the Medsafe database are associated with 7 different companies, but no information has been obtained on the countries of origin for any of these.

The 92 approved veterinary products (containing mercury) listed in the ACVM register are associated with 18 different companies. Some of these vaccines are manufactured in New Zealand, while others are imported. The 2 main local manufacturers are MSD Animal Health, which is located in Upper Hutt, and BioCell Corporation Limited, a contract manufacturer based in South Auckland.

Cosmetics and related products

No evidence of mercury use has been found in checks with 5 cosmetics manufacturers (either directly or through their web sites).

15.5 Miscellaneous products and uses

Dental mercury amalgams

There are approximately 2,500 practising dentists in New Zealand, and about 80% of those use mercury amalgam. It appears that a small amount of amalgam is made locally but most is imported, with the main source countries being Germany (16.3%), USA (16.1%), Italy (7.2%), the United Kingdom (6.2%) and Japan (4.4%). The 3 main importers were identified as Ivoclar Vivadent, Henry Schein Shalfoon and Dentsply.

Manometers and gauges

The main use of mercury identified here was in sphygmomanometers. As indicated in section 8.2, most of these have been phased out in hospitals, but they are still used by many doctors in General Practice. There are currently 3,600 registered General Practitioners in New Zealand.

Laboratory chemicals and equipment

Small quantities of mercury-containing laboratory chemicals are imported each year, mainly through laboratory and medical supply houses. The imports include diagnostic reagents, which will be used in hospital laboratories, and general laboratory chemicals. The latter may be used in some of the numerous chemical laboratories throughout the country, including in Crown Research Institutes, universities, industry, and the providers of commercial testing and analysis services. Some imports of elemental mercury were also identified, and this is most likely being used in some of the university laboratories, or in some of the direct applications noted in other sub-sections, such as small-scale gold mining, or for the manufacture of dental amalgam.

In 2012, 95% of the mercury-containing diagnostics reagents were imported from the USA, while in earlier years, the USA accounted for about 75% of the imports[32] with others coming from Australia (10%) and

32 The percentages given for this sub-category are based on value rather than weight, because the latter data appeared to be unreliable.

Germany, Switzerland and the United Kingdom (15% in total). It was not possible to identify the source countries for laboratory chemicals because the import data also included high volume chemical imports, such as Thiomersal (see section 7.9).

Most (78%) of the liquid mercury was imported from France, with other minor quantities coming from Germany, Switzerland and the United Kingdom.

Miscellaneous (explosives)

The 3 distributors contacted for mercury-based explosives were Red Bull Powder Company, Orica New Zealand and Prime Explosives.

15.6 Metal recycling

The only mercury recycling operation identified in this survey was Silcop, precious metal refiners & reclaimers, based in Waihi, but there are believed to be 2 other companies operating in Wellington and Christchurch.

Secondary steel production is carried out at the Pacific Steel plant in Otahuhu, Auckland, in conjunction with an adjoining scrap metal processing operation run by Sims Pacific. Pacific Steel is part of the Fletcher Building organisation and Sims Pacific is a joint venture between Pacific Steel and Sims Metal Management. Sims Pacific collects scrap metal through 8 branches around the country, and there are also numerous other scrap metal dealers. The total amount of scrap ferrous metal collected in New Zealand is approximately 500,000 tonnes/year, and about half of this processed by Pacific Steel, with the remainder being exported. The scrap metal industry also processes about 60,000 tonnes per year of non-ferrous metals, much of which is exported (K Kirk, Scrap Metal Recycling Association, pers comm, 2013).

In 2002, a survey of secondary metal production plants in New Zealand (MfE, 2004) identified 82 processing operations, with the following distribution across different metals[33]: ferrous metals, 27, aluminium, 48, copper, 45, and other non-ferrous metals, 20. Only 8 of these were classed as large operations, because they processed more than 5000 tonnes per year. In 2009 it was noted that some of these plants had been shut down, including two of the large ones, but the exact number of remaining operations was not determined (MfE, 2011a).

At a national level the ferrous and non-ferrous metal processing industries are represented by the Scrap Metal Recycling Association of New Zealand and the Metal Casting Industry Association of New Zealand (now known as Casting Technology New Zealand).

15.7 Incineration

The individual incinerators identified in sections 10.2 to 10.6 are operated by Dow AgroSciences in New Plymouth, the Grey Hospital in Greymouth, Dunedin City Council, and the New Zealand Air Force (Ohakea). In addition, there are 71 school incinerators, which are mainly found in rural areas, and 13 pet cremators, which are distributed around the main urban centres.

15.8 Waste treatment and disposal

Most of the municipal solid waste generated in New Zealand is disposed at the more than 50 waste disposal facilities covered by the Waste Disposal Levy scheme. These facilities are owned and operated by a mixture of territorial local authorities and commercial operators, and the total quantity of wastes disposed in 2012 was about 2.5 million tonnes. There are also about 176 consented landfills and cleanfills that are not covered by the Waste Levy scheme (MfE, 2011b). However, the total volume of waste disposed at these latter facilities is unknown.

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33 Some plants process multiple types of metals.

There are about 320 wastewater treatment plants in New Zealand, which are mainly owned and operated by territorial local authorities.

In the case of liquid and solid hazardous wastes, specialist treatment and disposal services are provided by a number of companies, with the main providers being TransPacific Technical Services, Envirowaste and Interwaste.

15.9 Crematoria and cemeteries

There are 50 cremation facilities in New Zealand, of which 33 are privately owned and the remainder operated by territorial local authorities (R Grooby, New Zealand Funeral Directors Association, pers comm, 2013)). The exact number of cemeteries is unknown.

The majority of burials and cremations are organised through funeral directors, who are represented by the New Zealand Funeral Directors Association. The association's website indicates that its members arrange and direct about 80% of all funerals in this country.

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