WasteNot Consulting

Update of National Average Waste Composition for Class 1 Landfills

CONFIDENTIAL - INCLUDES COMMERCIALLY SENSITIVE ONLINE WASTE LEVY SYSTEM DATA

Prepared for
Ministry for the Environment

August 2020

Document quality control

Status	Date	Written by	Approved by	Distributed to
Confidential Final 1.0	14 September 2020	BM	Duncan Wilson - Eunomia	CB - MfE
Confidential Draft 0.4	27 August 2020	BM	Duncan Wilson - Eunomia	CB - MfE
Confidential Draft 0.3	11 August 2020	BM	Duncan Wilson - Eunomia	CB - MfE
Confidential Draft 0.2	10 August 2020	BM	Duncan Wilson - Eunomia	CB - MfE
Confidential Draft 0.1	15 June 2020	BM	Duncan Wilson - Eunomia	CB - MfE

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Contents

1 Introduction

In line with New Zealand's commitments to the United Nations Framework Convention on Climate Change, the Ministry for the Environment (MfE) produces an annual inventory of greenhouse gas emissions. The inventory includes estimates of greenhouse gas emissions from solid waste disposal to land. To improve the accuracy of the inventory, MfE engaged Waste Not Consulting Ltd to produce the updated estimate of a national average solid waste composition for 2018 presented in this document.

1.1 Background

The United Nations Framework Convention on Climate Change (UNFCCC), to which New Zealand is a signatory, took effect in 1994. Ratification of the Convention requires signatories to address the climate change issue through various means, including the production of an annual inventory of greenhouse gas emissions.

The UNFCCC invited the Intergovernmental Panel on Climate Change (IPCC) to produce internationally-agreed methodologies to ensure consistent monitoring and reporting of national greenhouse gas inventories. These guidelines have been published as *The 2006 IPCC Guidelines for National Greenhouse Gas Inventories* (*2006 Guidelines*). The *2006 Guidelines* are accompanied by *IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories* (*Good Practice Guidance*).

Estimates of greenhouse gas emissions from solid waste disposal to land form part of the New Zealand greenhouse gas inventory. Refinements to the *2006 Guidelines* for waste generation, composition, and management data were published in 2019.[1] The 2019 refinements included updates of default national waste compositions, which are not relevant to this research, and a change to the definition of 'sludge'.

New Zealand uses the first-order decay model for estimating methane emissions from solid waste disposal sites. The *2006 Guidelines* provide guidance for determining each of the parameters used when applying the first-order decay model. The degradable organic carbon component of solid waste is one of these parameters, and this is based on the composition of waste.

The IPCC encourages the use of country-specific (rather than default) values for waste composition, and advises these can be obtained by performing waste generation studies and sampling of different solid waste disposal sites within a country.

The MfE has produced several estimates of the national composition of solid waste for modelling methane emissions. Solid waste composition was estimated using the results of a large-scale national survey that took place in 1995 and estimates for 2004 and 2008 were made using smaller national surveys and combining those results with other solid waste composition studies. In 2013, MfE engaged Waste Not Consulting Ltd to verify or amend the MfE's 2008 national waste composition estimate and to produce a 2012 estimate. Previous estimates are described in greater detail in section 2.1.

[1] 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories

2 Methodology for estimating national waste composition

2.1 Background

To facilitate the collection of consistent and reliable data on solid waste in New Zealand, in 1992 MfE developed the *New Zealand Waste Analysis Protocol* (WAP). The protocol was updated in 2002 and released as the *Solid Waste Analysis Protocol* (SWAP).

Over the last twenty years, these protocols have been used by both local and national government to determine the composition of solid waste being disposed of to land. On several occasions, the composition data on individual facilities has been collated by MfE and used to produce national waste composition estimates. These estimates have been used for MfE's greenhouse gas inventory reporting of estimates of methane emissions from solid waste. A brief history of this process is presented in this section, with a summary table provided at the end.

In 1993-1995, an estimate of national waste composition was produced using WAP studies of the ten largest landfills in the country. These landfills accounted for 40% of all waste disposed of in landfills at the time and the results of the surveys were used to produce the estimate of waste composition in the 1997 *National Waste Data Report*. This estimate of waste composition was also used for an estimate of New Zealand's emissions from solid waste.[2]

In 2004 and 2008, the MfE again commissioned a series of SWAP surveys (the SWAP Baseline Programme) to determine the national waste composition. These series of four quarterly surveys took place at four disposal facilities, which accounted for 6% of all waste disposed of to landfill. The results of these SWAP surveys were combined with other SWAP surveys, independently commissioned by landfill operators, and used to produce the 2004 and 2008 national waste composition estimates described below.

In 2005, MfE commissioned Waste Not Consulting to produce an estimate of national waste composition for the year 2004. For that study, the composition was estimated by aggregating waste composition data from SWAP surveys of 16 disposal facilities. The tonnage disposed of at those facilities represented over 50% of waste to landfill in New Zealand. The primary compositions from each of the 16 facility surveys were averaged, with a weighting based on the annual tonnage of each facility, to give an estimate of primary waste composition on a national level.[3]

The 2004 composition estimate was used in the MfE's state of the environment report, *Environment New Zealand 2007,* and was used in New Zealand's waste emissions estimates. The 2004 composition estimate also became the default waste composition for disposal facility operators to use to calculate greenhouse gas emissions under the Climate Change (Unique Emissions Factors) Regulations 2009.

[2]Ministry for the Environment (1997) *National Waste Data Report*
[3]Waste Not Consulting Ltd (2006) *Waste Composition and Construction Waste Data*, prepared for Ministry for the Environment

To fulfil the government's reporting requirements under the UNFCCC, an estimate for the 2008 composition of waste to landfill was subsequently produced by MfE. MfE's 2008 estimate of the national composition of solid waste was produced by aggregating landfill waste composition data from a number of sources, all of which used survey methodologies based on the SWAP. The estimate was based on composition data for 15 disposal facilities, which represented 25% of waste landfilled in 2008. MfE's 2008 estimate for national waste composition was included in *New Zealand's Greenhouse Gas Inventory 1990-2011*.

While the SWAP recommends the use of 12 primary classifications for waste, New Zealand's inventory reporting has adopted the IPCC protocol for calculating greenhouse gas emissions based on eight waste components: food, garden, paper, wood, textile, nappies, sewage sludge, and other. The rationale for these classifications is to identify wastes with different levels of degradable organic carbon.

While these components roughly align with the classifications of the SWAP, the SWAP, at the primary level of classification, combines 'food' and 'garden' waste in a single 'Putrescibles' classification and sewage sludge is combined with other hazardous materials in a 'Potentially hazardous' classification. The MfE estimate was based on the SWAP primary classifications, as presented in the available data sources, so the results did not align with the IPCC protocol.

In 2013, MfE engaged Waste Not Consulting to produce an estimate of national waste composition for the year 2012 and amend the 2008 estimate to better align it with the IPCC protocol. For the amended 2008 and the 2012 estimates, the SWAP primary classification 'Putrescibles' was broken down into food and garden waste and sewage sludge was included as a separate secondary classification of the 'Potentially hazardous' classification.

The development and use of estimates of national waste composition are summarised in the table below.

Table 2.1 - Estimates of national composition of solid waste

Year to which estimate applies	Source of composition data	Applications for data
1997	MfE national WAP programme	*National Waste Data Report* NZ waste emission estimates
2004	MfE SWAP Baseline Programme2004 and independently-commissioned SWAP surveys	*Environment New Zealand 2007* NZ waste emission estimates Climate Change (Unique Emissions Factors) Regulations 2009
2008	MfE SWAP Baseline Programme 2008 and independently-commissioned SWAP surveys	Initially used in *New Zealand's Greenhouse Gas Inventory 1990-2011*
2012	Independently-commissioned SWAP surveys	Previously applied to all greenhouse gas inventory data years from 2012 onward, and as of the 2021 greenhouse gas inventory will apply for 2012
2018	Independently-commissioned SWAP and UEFwc surveys	Greenhouse gas inventory data years from 2018 onwards in the upcoming 2021 greenhouse gas inventory

2.2 Methodology for estimate of 2018 national waste composition

2.2.1 Types of facilities included in estimate

In New Zealand, solid waste is disposed of to land at a number of different types of facilities. What are commonly referred to as 'municipal waste landfills' are classified as 'Class 1 landfills' by the WasteMINZ *Technical Guidelines for Disposal to Land* [4]and 'disposal facilities' by the Waste Minimisation Act 2008. The WMA defines 'disposal facilities' as:

> (a) a facility, including a landfill,—
> (i) at which waste is disposed of; and
> (ii) at which the waste disposed of includes household waste; and
> (iii) that operates, at least in part, as a business to dispose of waste; and
> (b) any other facility or class of facility at which waste is disposed of that is prescribed as a disposal facility.
>
> (2) In subsection (1)(a)(ii), **household waste** means waste from a household that is not entirely from construction, renovation, or demolition of the house.

Other types of facilities include single-purpose 'monofills', which may accept only a single type of waste from an industrial activity (Class 2 landfills) and 'cleanfills' (Class 3-5 landfills), which may or may not only accept inert materials and which may or may not require a consent under the Resource Management Act 1992 to operate.

For the purposes of this research, only solid waste disposed of at 'disposal facilities' - Class 1 landfills - is included in the composition estimates.

2.2.2 Tonnages of waste used for estimate

All waste disposed of at Class 1 landfills that are 'disposal facilities', in terms of the WMA, is potentially subject to the waste levy imposed by the WMA. The waste levy is not imposed on waste materials that are recovered or removed from the landfill. Operators of disposal facilities are required to regularly report tonnages of waste and diverted materials to MfE. This reporting is done through the Online Waste Levy System (OWLS).

For previous estimates, the composition estimates in individual SWAP surveys were applied to an annual tonnage of waste to landfill that was either presented in the SWAP report or was extrapolated to an annual basis from data in the report. For the estimate of 2018 national waste composition, in those instances where the waste stream measured in a SWAP survey includes all waste disposed of to a disposal facility, the composition has been applied to the OWLS tonnage of levied waste for 2018.

Several of the SWAP surveys assessed for this research were conducted for territorial authorities to determine the composition and quantity of waste disposed of from the TA area. In some instances, the waste from the TA area was disposed of at a regional landfill for which there was no other available data. For instance, Tirohia Landfill, in Waikato, accepts waste from approximately ten TA areas.

While no data on the composition of all waste entering Tirohia Landfill was made available for this project, data from three TA areas, Tauranga City, Western Bay of Plenty District and

[4] https://www.wasteminz.org.nz/wp-content/uploads/2016/04/Technical-Guidelines-for-Disposal-to-Land-9Aug18-FINAL.pdf

Gisborne District, was available. In such instances, tonnage data on the complete waste stream from those TA areas was used in the calculation of the national waste composition.

2.2.3 Composition data used for estimate

The estimate of 2018 national waste composition has been based on the same primary sources of data that was used by Waste Not Consulting for the estimates of composition in 2004, 2008, and 2012. These estimates have all been based, in the first instance, on SWAP surveys undertaken by Waste Not Consulting at Class 1 landfills and transfer stations. For the regions in which Waste Not had not measured waste composition, other data sources were sought, including:

- SWAP reports prepared by other organisations
- composition data included in territorial authority waste assessments
- SWAP reports prepared by private landfill operators and submitted to local government as a condition of resource consents
- SWAP reports used for UEFwc applications to the Environmental Protection Authority - These applications for unique emissions factors based on waste composition (UEFwc) are made under section 23D of the Climate Change (Unique Emissions Factors) Regulations 2009 (the Regulations). As the Regulations require that a survey for a UEFwc be based on the SWAP, the results are compatible with those from other SWAP surveys.

For the 2018 estimate, the same process was employed as for the previous estimates of national waste composition. All available SWAP surveys undertaken within a suitable timeframe have been collated and assessed and the individual annual tonnages from each survey aggregated. The aggregated total (broken down by SWAP classification) is then used to calculate the percentage composition of the aggregated waste stream.

2.2.3.1 Assessment of suitability of composition data

The suitability of each of the collated surveys was assessed to determine the suitability of the survey for inclusion in the national composition estimate and the subsequent manipulation of the available data. The criteria used for assessing the surveys, and the assessments themselves, are described below.

- The SWAP surveys that are used would include those from, roughly, a three-year period bracketing the target year (i.e. 2017-2019).
    - For the 2018 estimate, data primarily from 2017-2019 has been used. The exception to this was one landfill for which data from late 2016 and early 2020 was available. As these two surveys tightly bracketed the 2017-2019 parameters, the compositions from these two SWAP surveys was averaged and applied to the 2018 OWLS data for the facility.
- In the event of a one-off event affecting a survey's results, such as waste from a natural disaster, the inclusion of the SWAP survey results may not be appropriate.
    - None of the SWAP surveys included significant quantities of disaster, or similar, waste.

- Only survey results based on estimates of weight, rather than volume, would be included. The conversion of volume composition to weight composition is not considered a sufficiently accurate method for measuring composition.
    - One of the SWAP surveys assessed for inclusion was based on volume measurements. This survey was not included in the 2018 estimate.
- The annual tonnage of waste into a disposal facility should be taken from OWLS data wherever possible. If this is not possible, weight data based on annual weighbridge records is preferable to annualising the weight from shorter periods, such as a weekly or monthly tonnage.
    - Only one of the SWAP annual tonnages was based on extrapolation from a shorter time period. The majority of annual tonnages were taken directly from OWLS data. The remainder of annual tonnages were taken from either TA waste assessments or weighbridge records for a 12-month period.
- Whether composition data requires adjustment to exclude materials that were used for cover material or engineering purposes at the disposal facility and are not, as a result, subject to the waste levy as they are diverted materials. This would need to be done to align the composition data more accurately with OWLS data.
    - Two SWAP surveys were excluded from the estimate of 2018 waste composition as the results could not be accurately aligned with the OWLS data for the facility. It was assumed that non-levied waste had been included in the survey results.
- A SWAP survey would only be considered suitable if the waste stream that has been surveyed represents all waste to a landfill or a significant proportion of all waste from a TA area that is considered to be sufficiently representative of a community's overall waste output.
    - All of the SWAP surveys used for the 2018 composition estimate met one of these criteria. Of the 18 SWAP surveys used for the estimate, 11 surveys were for all waste being disposed of at a landfill and seven were for transfer stations where no data was available for the landfill to which the waste was disposed. Care was taken to ensure that there was no double-counting of waste between transfer stations and Class 1 landfills.

2.2.4 Datasets used for 2018 solid waste composition estimate

Table 2.2 on the next page summarises the data used for Waste Not's 2018 estimate of waste composition at Class 1 landfills. Data from the 2012 estimate is also shown in the table.

For six of the landfills listed, SWAP data was not available for all waste being disposed of at the facility. In these instances, SWAP composition data has been used for transfer stations from which waste was disposed of at the landfill. This data is shown in red.

Table 2.2 - Data used for estimating national solid waste composition - 2018 and 2012

s 9(2)(b)(ii)

[redacted]

2.2.5 Sewage sludge

Greenhouse gas emissions from sewage sludge disposed of to Class 1 landfills are calculated differently by MfE and the Environmental Protection Authority (EPA), which manages the Emissions Trading Scheme (ETS). MfE's greenhouse gas inventories and calculations of emissions do not include a separate classification for sewage sludge for landfill sites with landfill gas capture systems, with these materials being classified as 'inert', and is instead estimated separately and calculated as part of managed landfill sites without landfill gas capture. In contrast, there a specific and separate waste type category for sewages sludge is used by the EPA for ETS calculations.

The difference between the two methods is described by the *2020 Inventory* as:[5]

> The main difference between the inventory and the ETS is that generated emissions in the NZ ETS are modelled using a per-waste-type, multi-phase decay model with default k-values. This is compared to the inventory, which uses a single-phase bulk waste model with non-default k-values as per table 7.2.5. The NZ ETS also includes 3.9 per cent sludge in the composition for these sites whereas the inventory accounts for sludge in sites without LFG collection.

As many of the SWAP surveys collated for the 2018 estimate of national waste composition include sewage sludge, a separate classification has been included in the estimate. A working definition for 'sludges' has been taken from the *2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories*.

> In this refinement, definition of sludge is addressed. Sludge is a mixture of liquid and solid components and can be produced as sewage sludge from wastewater treatment processes or as a settled suspension obtained from conventional drinking water treatment or from numerous other industrial processes. Sludge from industrial processes is usually process-specific and it is good practice to obtain sludge composition data from producers.

Based on the *2019 Refinement*, materials that can be identified as either sludge or milliscreenings from wastewater treatment plants or milliscreenings from water treatment plants have been included as a separate classification in the 2018 estimate of national waste composition.

In the course of collating the primary data sources for the 2018 composition estimate, it was determined that many of the SWAP reports contained information regarding the disposal of sewage sludge or milliscreenings from water and wastewater treatment plants. In some instances, while the report did not specific data, suitable data was included in the weighbridge records used for the SWAP data analysis.

For landfills for which sewage sludge disposal data was not available, territorial waste assessments and other internet sources were checked for relevant information.

To validate the sludge data from the SWAP-based estimate of composition, the author of a 2019 report on the nationwide disposal of sewage sludge was consulted.[6] The background data used for the report was provided by the researcher, and this data was used to cross-check the SWAP-based estimate.

[5] Ministry for the Environment (2020) *New Zealand's Greenhouse Gas Inventory 1990-2018*
[6] Tinholt, R (2019) *The Value of Biosolids in New Zealand - An Industry Assessment*, viewed on 30/06/2020 <https://www.wasteminz.org.nz/pubs/wasteminz-2019-potential-value-of-biosolids-in-nz-an-industry-assessment/>

3 Composition estimate for 2018

The national composition of levied waste disposed of to Class 1 landfills in 2018 was estimated by aggregating annualised composition data from SWAP surveys at 18 disposal facilities and transfer stations. The waste tonnage disposed of at these facilities represents 66.0% of all waste disposed of in 2018 (based on waste levy tonnage for 2018). The estimate of waste composition at Class 1 landfills in 2018 is presented in Table 3.1. In the table, the estimated composition has been applied to the total OWLS tonnage of all levied waste in 2018.

Table 3.1 - Estimate of 2018 national composition of solid waste to Class 1 landfills

Composition of waste to Class 1 landfills in 2018	% of total	Tonnes/annum - 2018
Paper	5.9%	218,211
Plastic	8.3%	308,169
Putrescibles - Kitchen & other	*9.0%*	*333,881*
Putrescibles - Garden waste	*5.7%*	*212,747*
Subtotal - Putrescibles	**14.8%**	**546,627**
Ferrous metal	2.7%	99,708
Non-ferrous metal	0.8%	30,438
Glass	1.8%	65,150
Textiles	5.0%	186,035
Sanitary paper	2.5%	91,551
Rubble & concrete	20.1%	744,092
Timber	12.6%	467,664
Rubber	2.1%	77,690
Potentially hazardous - Sewage sludge	*1.9%*	*71,222*
Potentially hazardous - Other	*21.5%*	*798,271*
Subtotal - Potentially hazardous	**23.5%**	**869,493**
TOTAL	**100.0%**	**3,704,828**

Potentially hazardous material was the largest primary classification of waste being disposed of to disposal facilities in 2018, representing 23.5% of all levied waste. A significant proportion of the Potentially hazardous material was likely to have been contaminated fill. Rubble & concrete was the second largest primary classification, representing 20.1% of all waste, and Timber, 12.6% of all waste, was the third largest primary classification.

3.1 Assessment of reliability of estimate of sewage sludge

The national composition of levied waste disposed of to Class 1 landfills in 2018 was estimated by aggregating annualised composition data from SWAP surveys at 18 disposal facilities and transfer stations. The tonnage disposed of at these facilities represented 66.0% of all waste disposed of in 2018 (based on OWL data for 2018). Sewage sludge and milliscreenings from water and wastewater treatment plants (refer to section 2.2.5) comprised 1.9% of levied waste disposed of at the facilities included in the estimate. When this estimate of 1.9% is applied to the OWLS data for 2018 of 3,704,828 tonnes, the result is 71,222 tonnes of sewage sludge and milliscreenings, as shown in Table 3.1.

To validate the sludge data from the SWAP-based estimate of composition, the author of a 2019 report on the nationwide disposal of sewage sludge was consulted.[7] The research was based on the results of a survey of the 23 largest wastewater treatment plants in New Zealand. Sewage sludge from 10 of the 23 plants was disposed of to Class 1 landfills. Precise timeframes for the survey data were not provided. The data included figures for the production of both dry solids and wet solids. Analysis of this data showed the wet solids disposed of to Class 1 landfills constituted, on average, 26% dry matter.

Based on the background data provided by the author, 72,002 tonnes per annum of wet solids were disposed of to Class 1 landfills. This figure is 1.1% greater than the estimate from SWAP surveys of 71,222 tonnes. The background data has only been used to assess the reliability of the estimate from the SWAP surveys. No adjustment has been made on the basis of the background data.

4 Changes in composition over time

In Table 4.1, the four most recent estimates of national waste composition are compared in terms of percentages. The 2012 and 2018 estimates, in terms of tonnes per annum, are compared in Appendix 1.

Table 4.1 - Comparison of estimates of national composition of solid waste

Comparison of national waste composition estimates - 2004, 2008, 2012, and 2018	2004 estimate	2008 estimate (amended in 2013)	2012 estimate	2018 estimate
Paper	14.9%	9.0%	10.7%	5.9%
Plastic	9.1%	8.4%	14.8%	8.3%
Putrescibles - Food waste	*14.1%*	*17.1%*	*16.8%*	*9.0%*
Putrescibles – Garden waste	*9.2%*	*9.4%*	*8.3%*	*5.7%*
Subtotal - Putrescibles	**23.3%**	**26.5%**	**25.1%**	**14.8%**
Ferrous metal	5.1%	3.8%	2.2%	2.7%
Non-ferrous metal	0.9%	0.6%	1.0%	0.8%
Glass	2.5%	2.9%	3.2%	1.8%
Textiles	3.9%	3.8%	5.6%	5.0%
Sanitary paper	2.7%	3.3%	3.0%	2.5%
Rubble & concrete	12.2%	9.0%	9.6%	20.1%
Timber	13.9%	12.0%	11.9%	12.6%
Rubber	1.0%	0.7%	2.2%	2.1%
Potentially hazardous - Sewage sludge	-	*2.9%*	*3.9%*	*1.9%*
Potentially hazardous - Other	-	*16.9%*	*6.9%*	*21.5%*
Subtotal - Potentially hazardous	**10.5%**	**19.8%**	**10.8%**	**23.5%**
TOTAL	**100.0%**	**100.0%**	**100.0%**	**100.0%**

[7] Tinholt, R (2019) *The Value of Biosolids in New Zealand - An Industry Assessment*, viewed on 30/06/2020 <https://www.wasteminz.org.nz/pubs/wasteminz-2019-potential-value-of-biosolids-in-nz-an-industry-assessment/>

The most significant variance in the composition estimates relates to the variability of the proportion of potentially hazardous materials, which nearly doubled between 2004 and 2008, halved between 2008 and 2012, then more than doubled again in 2018. A very high proportion of materials that are classified as 'Potentially hazardous' are contaminated soils and fills. The quantity of these materials disposed of to landfill tends to vary more than other materials, as the generation of materials such as asbestos-contaminated fill is often project-based. The construction of the Victoria Park Tunnel in Auckland, for example, generated over 100,000 tonnes of contaminated soil.

The other significant difference between the compositions in 2012 and 2018 is the proportion of Rubble & concrete, which increased from 9.6% in 2012 to 20.1% in 2018. A substantial proportion of the increase is associated with the increase in the proportion of Rubble & concrete at Redvale Landfill, the second largest landfill in the country in 2018. In 2018, Rubble & concrete disposed of at Redvale Landfill represented over half of the rubble & concrete in all of the SWAP reports included in the estimate.

The changes in waste composition at Redvale Landfill from 2003 to 2018 are shown in Table 4.2 below, taken directly from the 2018 SWAP report. SWAP composition at Redvale Landfill is reported to Auckland Council every five years as a resource consent condition. These reports are in the public domain.

Table 4.2 - Composition of waste to Redvale Landfill - 2003-2018 [8]

Overall waste stream		2003	2006	2009	2012	2015	2018
Paper	1	10.4%	8.3%	6.8%	11.4%	7.3%	5.1%
Plastic	2	6.7%	7.1%	6.8%	18.0%	10.2%	6.2%
Putrescibles (food)	3a	12.5%	10.7%	11.2%	8.6%	9.0%	4.6%
Putrescibles (garden)	3b	6.6%	5.4%	8.3%	8.0%	5.4%	4.5%
Putrescibles (other)	3c	0.9%	1.4%	1.5%	4.8%	1.0%	1.5%
Metals (ferrous)	4	6.5%	3.6%	3.7%	1.8%	2.2%	1.7%
Metals (non-ferrous)	5	0.5%	0.7%	0.7%	1.3%	1.2%	1.2%
Glass	6	2.1%	1.9%	1.8%	3.0%	1.2%	1.5%
Textiles	7	3.3%	2.7%	3.5%	6.0%	2.6%	2.3%
Nappies	8	3.1%	2.7%	3.6%	2.2%	1.8%	2.0%
Rubble/concrete	9	9.1%	9.2%	8.2%	9.4%	24.4%	32.9%
Timber/wood	10	14.4%	13.1%	11.9%	9.6%	8.1%	7.7%
Rubber	11	0.6%	1.4%	0.8%	4.4%	2.4%	4.1%
Potentially hazardous	12	23.3%	31.8%	31.2%	11.4%	22.9%	24.7%
Total		100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

The comparison of tonnages over time, rather than percentages over time, is a more meaningful way of assessing changes in waste composition. The tonnages associated with all four estimates are compared in Appendix 2.

In general terms, the estimated tonnages in Appendix 2 are not sufficiently robust to be relied upon for comparing individual materials across the four national estimates or for speculating on drivers for any changes. The gradual decrease in the tonnages of paper across the four national estimates, for example, could be taken as evidence of both decreasing paper usage

[8] Waste Management NZ Ltd (2018) *Redvale Landfill - Analysis of Waste Composition 2018*, unpublished

and increasing recovery activity, but such consistent changes are not shown for most of the other materials.

For example, there are no such obvious drivers for the changes in the estimated tonnages of plastics. In the four national estimates, the estimated tonnage of plastics increases 38% between 2008 and 2012, then decreases 17% to 2018. The magnitude of these apparent changes are more likely to be a function of the process used to calculate the estimates than of actual changes in the disposal of plastics (see section 5.1), although this cannot be said with certainty.

The substantial differences in the tonnages of materials, particularly inert materials, between the four national composition estimates is also of relevance to MfE's reporting of greenhouse gas emissions. It is understood that MfE reports annually on greenhouse gas emissions, and that the annual emissions estimates for a given year are calculated by applying the most recent national waste composition estimate to the OWLS tonnage for that year.

As Table 4.2 shows that the proportion of inert materials (Rubble/concrete, Potentially hazardous) can change substantially from one year to the next, it is not likely that the emissions from non-inert materials are changing to the same extent as the tonnage of non-inert materials is changing at a different rate.

An alternative means of calculating annual emissions would be to base emissions calculations on the tonnage of non-inert materials (i.e. those responsible for producing greenhouse gases) in the year in which a national waste composition estimate has been made. In subsequent years, the tonnage of inert materials could be adjusted according to a variable (such as gross domestic product) that is known to have an association with waste generation.

5 Uncertainties in estimate

The *2006 Guidelines* identify uncertainty estimates as 'an essential element of a complete emissions inventory' and describe the objective of an uncertainty analysis as '…first and foremost, a means to help prioritise national efforts to reduce the uncertainty of inventories in the future, and guide decisions on methodological choice'.

In the following sections, the approach taken in assessing the uncertainty of the estimate of national waste composition has been to:

1) identify uncertainties with the methodology used to make the estimate and to qualitatively assess these uncertainties, using expert judgement
2) calculate the 95% confidence intervals for the results of the 2018 estimate, based on statistical analysis of the percentage results of the SWAP surveys used for the estimates.

5.1 Identification and assessment of uncertainties in estimate

With regards to the procedure used for estimating the national composition of solid waste disposed of to Class 1 landfills in New Zealand, the following uncertainties have been identified and assessed:

1. ***The range of SWAP survey results that have been aggregated to estimate national waste composition may not necessarily be representative of waste generated by the New Zealand population as a whole.***

   As the surveys include Class 1 landfills in major urban centres, provincial centres, and rural districts from both the North and South Island, the range of population demographics and economic activities are considered to be sufficiently representative of all disposal facilities in the country.

2. ***The range of SWAP survey results that have been aggregated to estimate national waste composition may not necessarily be representative of all Class 1 landfills.***

   While no research is available on factors that may affect the composition of waste at different Class 1 landfills, the annual tonnage of waste received at a landfill can be assessed as one such factor.

   Small landfills, defined for this analysis to be those that receive less than 50,000 tonnes of levied waste per annum, are usually associated with small, isolated rural centres. In such centres, economic activity is often centred on primary industries, rather than industrial and commercial activity. Rural areas tend towards lower per capita rates of disposal of domestic waste as many rural properties dispose of waste on-site.[9]

   Medium-sized Class 1 landfills, defined for this analysis to be those that receive between 50,000-250,000 tonnes of levied waste per annum, tend to receive waste from the smaller urban centres and provincial centres and surrounding districts. In these centres, industrial and commercial activity tends to be higher than in rural areas.

[9] Environment Canterbury (2013) *Non-natural rural wastes - Site survey data analysis*

Large Class 1 landfills, defined for this analysis to be those that receive over 250,000 tonnes of levied waste per annum, are, for the most part, associated with the large urban centres. The large urban centres are associated with high levels of industrial and commercial activity and the higher levels of waste generated by these activities.

In Table 5.1, the OWLS data for all Class 1 facilities is broken down into the three sizes of landfills and compared to the same breakdown of the data from the SWAP surveys used to calculate the estimate of national waste composition.

Table 5.1 - Comparison of OWLS data and SWAP data by size of landfill

Comparison of OWLS data and SWAP data by size of landfill	Number of Class 1 landfills		Tonnes/annum		Tonnes as % of total tonnage	
	OWLS DATA	SWAP DATA	OWLS DATA	SWAP DATA	OWLS DATA	SWAP DATA
<50,000 TPA	20	8	s 9(2)(b)(ii) [redacted]		s 9(2)(b)(ii) [redacted]	
50-250,000 TPA	12	7				
>250,000 TPA	4	2				
TOTAL	36	17				

s 9(2)(b)(ii)

[redacted]

While there may be other factors that affect the composition of waste at different landfills, the sizes of landfills included in the SWAP surveys used to calculate the estimate of national waste composition are reasonably representative of the sizes of all Class 1 landfills.

3. Seasonal variations in waste composition may not be adequately accounted for by the SWAP survey results that have been used.

Generally, SWAP surveys undertaken for territorial authorities are undertaken at what are considered to be 'representative' times of the year. Usually this means avoiding the early summer peak waste generation period and the following holiday season, generally December through January, and the low waste generation period in mid-winter. As a result, any differences in the composition of solid waste at these 'non-representative' times have not been captured by the available data.

Approximately 28% of the tonnage of waste included in the SWAP surveys used to calculate the estimate of national waste composition was from SWAP surveys undertaken for territorial authorities. In several instances, the SWAP comprised two surveys, undertaken in opposing seasons. Any effects relating to the exclusion of SWAPS undertaken for territorial authorities in 'non-representative' seasons are, therefore, assumed to be minor.

The SWAP surveys representing the other 72% of the tonnage of waste were undertaken for UEFwc applications and extrapolated to an annual basis using annual weighbridge records. SWAP surveys undertaken for UEFwc purposes are required to be conducted twice, at least three months apart. While this could, conceivably, result in a composition being 'non-representative' of all seasons, the application of the survey results to verifiable annual data would mitigate any such effects on the composition.

4. Uncertainty in scaling composition results from a specific week to an annual basis

All of the results of SWAP surveys undertaken for territorial authorities have been extrapolated from the results of one or two surveys conducted over a three to six-day period. The composition results from the surveys were then extrapolated to average weekly figures based on the analysis of weighbridge records from a six or eight-week period.

For SWAP surveys undertaken for UEFwc purposes, the SWAP survey results were extrapolated based on analysis of annual weighbridge records.

One-off events, such as floods or major demolition projects, can change the composition of waste considerably from week to week, particularly at small facilities. As a high proportion of the tonnage of waste included in the SWAP surveys used to calculate the estimate of national waste composition was based on the analysis of annual weighbridge records, the effects of annualising SWAP surveys of short duration are considered to be minor. While one-off events can significantly change the composition of waste at a small facility, they rarely have the same effect at larger facilities.

5. Difference in surveying techniques and data analysis leading to possible inaccuracies

Although the SWAP provides a recommended methodology for measuring the composition of solid waste, each of the three organisations that have produced the SWAP surveys used for the estimate has interpreted the recommendations differently. SWAP surveys undertaken by Waste Not Consulting represented 64% of the total tonnage from SWAP surveys, and there is a high degree of confidence in the accuracy of these results.

SWAP surveys undertaken to determine the composition of the other 36% of the tonnage were undertaken by organisations with over a decade of experience conducting SWAP surveys. While the quality of the data-gathering and data analysis cannot be assessed accurately from the reports provided, assessment of the reports provides no reason to question the accuracy of the results.

6. Uncertainty relating to classification of managed fill site at Redvale Landfill

The Redvale Landfill site contains both a Class 1 landfill and a separate managed fill site. s 9(2)(b)(ii) s 9(2)(b)(ii) [redacted]

However, the 2018 Redvale SWAP report does not state whether the composition estimate includes material disposed of at the managed fill site. s 9(2)(b)(ii) [redacted] For the purposes of the estimate, it has been assumed that the Redvale SWAP data can be applied to the OWLS tonnage data.

7. Uncertainty relating to accuracy of results of individual SWAP surveys

The SWAP sort-and-weigh methodology for determining the composition of solid waste disposed of at landfills and transfer stations was originally developed in 1992, with minor changes being introduced in 2002. s 9(2)(b)(ii) [redacted]

The SWAP methodology is based on the sorting-and-weighing of samples of waste over a one-week period. A one-week landfill SWAP survey will typically involve approximately 50-60 samples, weighing a total of 8-12 tonnes. While the sorting-and-weighing of individual samples produces reasonably accurate composition results for that sample, the aggregated results lack precision due to the high degree of variance between individual samples. As a result, the accuracy of the overall composition estimate, that is, the difference between the calculated composition and the 'true' composition, is uncertain.

5.2 Calculating confidence intervals for national waste composition estimates

The *2006 Guidelines* recommend that good practice 'requires the use of a 95 percent confidence interval for quantification of random errors' for random errors 'that are based on the inherent variability of a system and the finite sample size of available data'.

For the purpose of greenhouse gas inventories, the concept of a 'confidence interval' is described as follows:

> The true value of the quantity for which the interval is to be estimated is a fixed but unknown constant, such as the annual total emissions in a given year for a given country. The confidence interval is a range that encloses the true value of this unknown fixed quantity with a specified confidence (probability). Typically, a 95 percent confidence interval is used in greenhouse gas inventories. From a traditional statistical perspective, the 95 percent confidence interval has a 95 percent probability of enclosing the true but unknown value of the quantity.

The *2006 Guidelines* also state that 'If the data are a random, representative sample, then the distribution can be established directly using classical statistical techniques, even if the sample size is small'.

To quantify the uncertainty relating to random error in the data used for the 2018 estimate of waste composition, the 95% confidence intervals for the waste classifications have been calculated by statistical analysis of the SWAP survey results, in terms of percentage composition, for the 2018 estimate. The mean, standard deviation, and coefficient of variation were calculated.

The reliability of this method for accurately determining confidence intervals is dependent on the data points for each waste classification meeting the criteria for being a 'normal distribution'. The *2006 Guidelines* indicate that 'In situations where the coefficient of variation (standard deviation divided by the mean) is less than approximately 0.3 and is known with reasonable confidence, a normal distribution may be a reasonable assumption'

In those instances in which the coefficient of variation for an individual material type are considerably larger than 0.3, an assessment of the confidence interval, based on expert judgement, has been made.

The assessments of the statistical outliers in these cases have been largely based on the relative annual tonnages of the disposal facilities in question. For example, the proportion of greenwaste was markedly higher in several small-medium landfills than in the large landfills. As a result, the coefficient of variation was 0.445, so was not likely to be a normal distribution, based on the IPCC Guidelines. However, as the tonnages at the large landfills comprised 69% of all waste in the SWAP surveys (see Table 5.1), the actual proportion of greenwaste nationally is not likely to be markedly different than that calculated from the aggregated tonnages.

The confidence interval for sewage sludge was assessed separately, based on the analysis in section 2.2.5. As the two methods outlined for estimating the annual tonnage of sewage sludge produced estimates that were within 1.1%, it was not considered likely that the actual tonnage would vary considerably from the tonnage shown in Table 3.1.

The confidence intervals for the individual waste classifications in the estimate of the 2018 national waste composition are provided in Table 5.2 on the next page. It should be noted that the 'Mean of results as %' columns in Table 5.2 differs from the estimated percentages for the individual waste classifications in Table 4.1. This is due to the means having been calculated from the percentage composition from each SWAP survey used while the estimated percentages have been based on the aggregated annual tonnages. That is, Table 4.1 presents weighted averages based on annual tonnages disposed of at each facility while Table 5.2 does not.

5.3 Total uncertainty of waste composition

The *Good Practice Guidance* presents an uncertainty range for the total uncertainty of waste composition of ±10% for countries with high quality data (e.g. regular sampling at representative solid waste disposal sites) to ±30% for countries with data based on studies that include periodic sampling. The New Zealand sampling regime includes some regular sampling and some periodic sampling at a range of sites that Waste Not has considered to be representative of those throughout the country. As a result of these factors, the total uncertainty of the waste composition (when expressed in terms of a value for degradable organic carbon) is assessed as being +/-20%.

Table 5.2 – Confidence intervals for 2018 national waste composition estimate

Waste classifications (assessed confidence intervals shown *in red*)	**Mean of results as %**	**St. Dev.**	**Coefficient of variation**	**95% confidence interval**
Paper	7.9%	2.4%	0.303	±1.1%
Plastic	11.2%	3.4%	0.302	±1.6%
Putrescibles - Food waste	*15.0%*	*5.2%*	*0.345*	*±2.4%*
Putrescibles – Garden waste	*9.6%*	*4.3%*	*0.445*	*±1.0%*
Putrescibles - Subtotal	**24.6%**	**7.5%**	**0.306**	**±3.5%**
Ferrous metal	2.7%	0.8%	0.282	±0.3%
Non-ferrous metal	0.7%	0.2%	0.340	±0.1%
Glass	3.0%	1.8%	0.599	±0.5%
Textiles	5.7%	1.5%	0.267	±0.7%
Sanitary paper	4.6%	2.0%	0.441	±0.9%
Rubble & concrete	15.2%	13.8%	0.909	±3.4%
Timber	13.9%	5.0%	0.356	±2.3%
Rubber	1.3%	1.0%	0.810	±0.5%
Potentially hazardous - Sewage sludge	*1.6%*	*3.5%*	*2.163*	*±0.2%*
Potentially hazardous - Other	*7.6%*	*9.4%*	*1.232*	*±1.0%*
Potentially hazardous - Subtotal	**9.3%**	**11.6%**	**1.257**	**±5.4%**
TOTAL	**100%**	**-**	**-**	**-**

5.4 Total uncertainty of waste composition

The *Good Practice Guidance* presents an uncertainty range for the total uncertainty of waste composition of ±10% for countries with high quality data (e.g. regular sampling at representative solid waste disposal sites) to ±30% for countries with data based on studies that include periodic sampling. The New Zealand sampling regime includes some regular sampling and some periodic sampling at a range of sites that Waste Not has considered to be representative of those throughout the country. As a result of these factors, the total uncertainty of the waste composition (when expressed in terms of a value for degradable organic carbon) is assessed as being +/-20%.

Appendix 1 - Changes in composition - 2012-2018

Comparison of national waste composition estimates - 2012, and 2018	2012 estimate	2018 estimate	2012 estimate - Tonnes/ annum	2018 estimate - Tonnes/ annum	% change
Paper	10.7%	5.9%	268,563	218,211	-19%
Plastic	14.8%	8.3%	373,313	308,169	-17%
Putrescibles - Food waste	*16.8%*	*9.0%*	*421,560*	*333,881*	*-21%*
Putrescibles – Garden waste	*8.3%*	*5.7%*	*209,400*	*212,747*	*2%*
Subtotal - Putrescibles	**25.1%**	**14.8%**	**630,967**	**546,627**	**-13%**
Ferrous metal	2.2%	2.7%	56,469	99,708	77%
Non-ferrous metal	1.0%	0.8%	24,145	30,438	26%
Glass	3.2%	1.8%	79,935	65,150	-18%
Textiles	5.6%	5.0%	141,222	186,035	32%
Sanitary paper	3.0%	2.5%	74,618	91,551	23%
Rubble & concrete	9.6%	20.1%	241,158	744,092	209%
Timber	11.9%	12.6%	298,436	467,664	57%
Rubber	2.2%	2.1%	54,520	77,690	42%
Potentially hazardous - Sewage sludge	*3.9%*	*1.9%*	*98,222*	*71,222*	*-27%*
Potentially hazardous - Other	*6.9%*	*21.5%*	*172,582*	*798,271*	*363%*
Subtotal - Potentially hazardous	**10.8%**	**23.5%**	**270,805**	**869,493**	**221%**
TOTAL	**100.0%**	**100.0%**	**2,514,151**	**3,704,828**	**47%**

Appendix 2 - Changes in composition (by tonnes) - 2004-2018

Comparison of national waste composition estimates - 2004-2018	**2004 estimate**	**2008 estimate (amended in 2013)**	**2012 estimate - Tonnes/ annum**	**2018 estimate - Tonnes/ annum**
Paper	474,713	289,485	268,563	218,211
Plastic	289,926	271,027	373,313	308,169
Putrescibles - Food waste	*449,225*	*550,781*	*421,560*	*333,881*
Putrescibles – Garden waste	*293,112*	*301,740*	*209,400*	*212,747*
Subtotal - Putrescibles	**742,337**	**852,038**	**630,967**	**546,627**
Ferrous metal	162,486	122,421	56,469	99,708
Non-ferrous metal	28,674	20,441	24,145	30,438
Glass	79,650	92,857	79,935	65,150
Textiles	124,254	123,392	141,222	186,035
Sanitary paper	86,022	107,473	74,618	91,551
Rubble & concrete	388,691	290,550	241,158	744,092
Timber	442,853	385,941	298,436	467,664
Rubber	31,860	22,254	54,520	77,690
Potentially hazardous - Sewage sludge		*94,535*	*98,222*	*71,222*
Potentially hazardous - Other		*542,687*	*172,582*	*798,271*
Subtotal - Potentially hazardous	**334,529**	**637,222**	**270,805**	**869,493**
TOTAL	**3,185,995**	**3,215,583**	**2,514,151**	**3,704,828**