



**SID 5** **Research Project Final Report**

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**Project identification**

1. Defra Project code	<input type="text" value="WR0119"/>
2. Project title	<input type="text" value="Municipal Waste Composition:&lt;br/&gt;A Review of Municipal Waste Component Analyses"/>
3. Contractor organisation(s)	<input type="text" value="Resource Futures"/>
4. Total Defra project costs (agreed fixed price)	<input type="text" value="£ 52,260"/>
5. Project: start date .....	<input type="text" value="01 April 2008"/>
end date .....	<input type="text" value="31 March 2009"/>

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## Executive Summary

7. The executive summary must not exceed 2 sides in total of A4 and should be understandable to the intelligent non-scientist. It should cover the main objectives, methods and findings of the research, together with any other significant events and options for new work.

The principal aims of this study have been to:

- collate municipal waste compositional evidence for the UK
- assess the robustness of the collated data in terms of determining the national composition of municipal waste and its biodegradable content
- consider the relative merits of the methodologies employed in the collated studies
- identify gaps in UK municipal waste compositional evidence
- recommend further work required to fill these data gaps.

A significant amount of compositional data was already held by Resource Futures, from waste auditing work carried out by Resource Futures and from previous national municipal waste composition reviews carried out by Dr Julian Parfitt. Additional compositional studies were obtained through:

- Defra Local Authority Support Unit and the Waste Information Network
- requests to local authorities (via LARAC, NAWDO and other fora)
- requests to other contractors who provide waste auditing services to local authorities.

In general the contacted parties responded positively and a considerable body of municipal waste compositional evidence was collated. Where possible, collated studies were subdivided into datasets, with county council level kerbside studies subdivided into district levels datasets; and studies of more than one waste stream subdivided into separate datasets for each municipal waste stream (i.e. kerbside, HWRC, etc).

In total 535 datasets were collated. The majority of these related to audits of kerbside waste in England, with a reasonably large number of HWRC datasets also for England. A smaller number of datasets were obtained for the Devolved Administrations and for other municipal waste streams (municipally collected commercial waste, bulky waste collections, etc).

Evaluation criteria were developed for assessing the collated datasets and their suitability for inclusion in subsequent analyses for estimating national municipal waste composition. These selection criteria were applied to the kerbside datasets. Those kerbside datasets selected for inclusion in further analyses were required to meet the following criteria:

- waste audit carried out in 2005 or more recently (particularly important given the need to gross-up estimates to a single WasteDataFlow reporting year)
- 2 or more phases (i.e. some attempt to account for seasonal variations in composition)
- ACORN, Council Tax band, or other socio-demographic stratification (i.e. some attempt to control for area types when generalising results for a district).

Applying these criteria resulted in over half of the collated kerbside datasets being excluded. Nonetheless 120 datasets kerbside residual datasets for England met the selection criteria and these datasets represented a good coverage of England in terms of level of deprivation and region.

These selection criteria were not applied to non-kerbside waste streams, due to the relative paucity of data collated. However reasonable coverage was obtained for HWRC residual waste in England, though these datasets showed a slight bias towards more affluent local authorities.

The selected compositional data were then analysed in conjunction with WasteDataFlow tonnages for 2006/07 to arrive at overall estimates of municipal waste composition. However, due to lack of collated data for the Devolved Administrations, the analysis of overall municipal waste composition focussed only on England. Due to the quantity and quality of data collated by this project, and the separate consideration of all municipal waste streams included in WasteDataFlow, the national estimates of municipal composition for England are the most robust to be produced to date.

The estimated composition of municipal waste in England during 2006/07 is summarised in the following table, which includes 95% confidence intervals.

**Table E1: Confidence intervals for compositional estimates for all municipal waste**

ENGLAND 2006/07 ALL MUNICIPAL WASTE	TONNES		PERCENTAGE ARISING			
	Estimated total tonnes in municipal waste	95% confidence interval, +/-	Estimated composition	95% confidence interval, +/-	95% confidence interval: LOWER BOUND	95% confidence interval: UPPER BOUND
Food waste	5,056,259	244,230	17.84%	0.86%	16.98%	18.70%
Garden waste	3,989,782	611,804	14.08%	2.16%	11.92%	16.24%
Other organic	490,352	96,391	1.73%	0.34%	1.39%	2.07%
Paper	4,718,113	225,071	16.65%	0.79%	15.85%	17.44%
Card	1,711,499	162,571	6.04%	0.57%	5.47%	6.61%
Glass	1,881,799	159,664	6.64%	0.56%	6.08%	7.20%
Metals	1,217,335	125,653	4.30%	0.44%	3.85%	4.74%
Plastics	2,831,585	175,355	9.99%	0.62%	9.37%	10.61%
Textiles	802,816	63,683	2.83%	0.22%	2.61%	3.06%
Wood	1,056,748	169,492	3.73%	0.60%	3.13%	4.33%
WEEE	620,566	96,254	2.19%	0.34%	1.85%	2.53%
Hazardous	149,396	26,287	0.53%	0.09%	0.43%	0.62%
Sanitary	712,015	75,919	2.51%	0.27%	2.24%	2.78%
Furniture	379,783	95,213	1.34%	0.34%	1.00%	1.68%
Mattresses	72,162	28,173	0.25%	0.10%	0.16%	0.35%
Misc combustible	671,666	140,393	2.37%	0.50%	1.87%	2.87%
Misc non-combustible	798,836	182,318	2.82%	0.64%	2.18%	3.46%
Soil	52,144	26,691	0.18%	0.09%	0.09%	0.28%
Other wastes	658,130	223,591	2.32%	0.79%	1.53%	3.11%
Fines	469,127	141,261	1.66%	0.50%	1.16%	2.15%
<b>TOTAL</b>	<b>28,340,112</b>	<b>na</b>	<b>100%</b>	<b>na</b>	<b>na</b>	<b>na</b>

Applying the Environment Agency's assumptions regarding the biodegradable content of various municipal waste components, the biodegradable content of municipal waste in England was estimated to be 66.71%, with a 95% confidence interval of +/- 6.68%; lower bound 60.03% and upper bound 73.39% at the 95% confidence level.

However, the categorisation of recycling tonnages in WasteDataFlow gave rise to significant uncertainties in these estimates. For example, WasteDataFlow includes a 'co-mingled materials' category for kerbside recycling; and for this study we have estimated the breakdown of these tonnages into specific materials (paper, glass, etc) on the basis of the best reference data available. Therefore it is important to note that the 95% confidence intervals stated above cannot account for the uncertainties introduced by WasteDataFlow material categorisation. Furthermore, the poorer coverage of non-kerbside and non-HWRC streams means that compositional estimates for these streams have been based on limited sets of data.

The municipal waste composition estimates for England have been considered alongside compositional estimates from previous national reviews for England, Wales and Northern Ireland (refer to Appendix 4, Section 4.5). The methods for grossing up compositional estimates were found to be inconsistent across these reviews, which made direct comparison between national estimates problematic.

The most significant data gaps identified related to kerbside and HWRC wastes in the Devolved Administrations; and to non-household waste, street sweepings, litter and bulky waste collections.

Auditing methodologies applied in the collated studies have been reviewed (refer to Appendix 5) and in general these were found to be broadly suited to meeting the needs of local waste analysis campaigns. Nevertheless there is a requirement for standardisation of waste auditing methodologies, most urgently in terms of consistent categorisation of municipal waste components.

It is considered that the large amount of kerbside and HWRC data collated for England obviates the requirement for a dedicated national waste analysis programme. In view of challenging recycling targets, local authorities are likely to continue to fund campaigns at a local level. The standardisation of any such locally conducted work should be pursued through producing practicable guidance on waste auditing protocols.

It is recommended that specific research projects are required to underpin the assumptions of this guidance, mainly focussing on the variability in composition of municipal waste. For example, it is recommended that further research is required to ascertain whether the use of ACORN groups to stratify kerbside samples (which is currently common practice in the UK) is the most suitable sampling strategy.

Locally conducted campaigns are unlikely to address all data gaps and it is recommended that central government funding support is provided to encourage local authorities to carry out studies that fill these gaps, notably in relation to the Devolved Administrations, and all waste streams apart from kerbside and HWRC.

It is recommended that some recycling categories in WasteDataFlow should be reviewed with a view to introducing a breakdown of materials where possible, for example in relation to the '*co-mingled materials*' category for kerbside recycling tonnages.

Finally, the collated datasets could be further analysed to provide additional useful compositional evidence, particularly in terms of the analysis of municipal waste composition at a more detailed level than the primary categories applied in this study. This is likely to provide overall estimates of the municipal waste packaging fraction and quantities of recyclables that remain within residual waste streams.

## Project Report to Defra

8. As a guide this report should be no longer than 20 sides of A4. This report is to provide Defra with details of the outputs of the research project for internal purposes; to meet the terms of the contract; and to allow Defra to publish details of the outputs to meet Environmental Information Regulation or Freedom of Information obligations. This short report to Defra does not preclude contractors from also seeking to publish a full, formal scientific report/paper in an appropriate scientific or other journal/publication. Indeed, Defra actively encourages such publications as part of the contract terms. The report to Defra should include:
- the scientific objectives as set out in the contract;
  - the extent to which the objectives set out in the contract have been met;
  - details of methods used and the results obtained, including statistical analysis (if appropriate);
  - a discussion of the results and their reliability;
  - the main implications of the findings;
  - possible future work; and
  - any action resulting from the research (e.g. IP, Knowledge Transfer).

## 1. Introduction

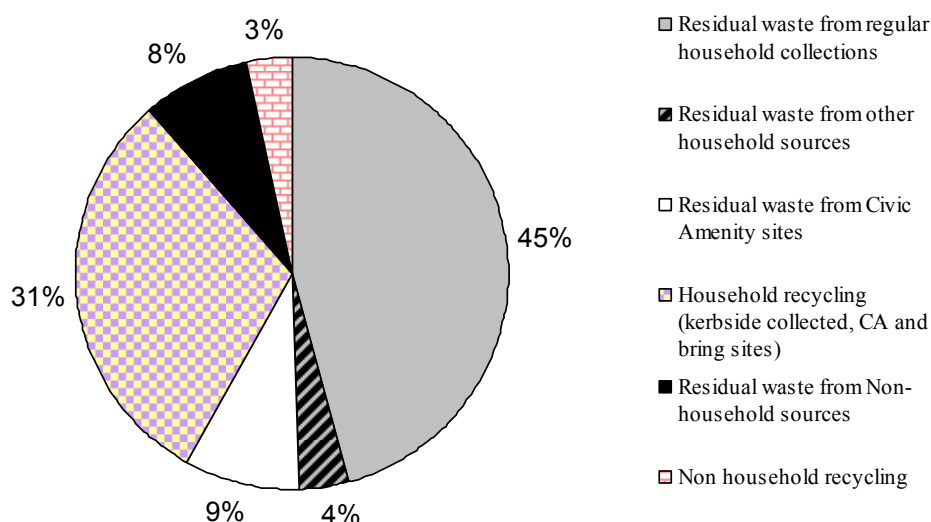
### 1.1 The national context of this project

The informed development, implementation and monitoring of national municipal waste strategies requires robust data relating to the quantities arising and their composition. National waste analysis programmes in the UK have been implemented at different times since the early 1990s. They have been costly to undertake and limited in terms of geographical, seasonal and socio-economic coverage (Parfitt and Flowerdew 1997, Burnley 2007). The types of municipal waste sampled has been mostly limited to household waste collected at the kerbside.

In recent years many municipal authorities across the UK have commissioned their own compositional analyses, mainly in order to assess the quality and effectiveness of local recycling and composting schemes. The collation of such local data has the potential to provide national estimates without the need to develop purpose-built national waste analysis programmes. For this approach to provide robust estimates, differences between collated local authority studies must be reconciled in terms of sampling strategies, the compatibility of material category lists used in waste sorting and a range of issues relating to data coverage (geography, seasonality and waste stream type).

With a higher proportion of UK municipal waste now being segregated for recycling and composting, it is also necessary to consider how data derived from compositional studies for residual waste and waste diverted into recycling/composting, might be combined with operational statistics and used to estimate municipal waste composition at a national level. In the UK, detailed operational data are available on the quantities of municipal waste arising, based on quarterly returns from municipal authorities to a web-based data collection system (WasteDataFlow 2009). The most recently published WasteDataFlow (WDF) statistics for England (Figure 1) show that nearly 90% of the 28.5 million tonnes collected in 2007/08 was from household sources, with 34% of municipal waste diverted into recycling and composting schemes. As the responsibility for municipal waste management is a devolved function within the UK, the reporting of overall waste arisings is handled separately in England, Wales, Scotland and Northern Ireland.

**Figure 1: Municipal waste arisings in England by waste stream, 2007/08 (source: WDF, Defra 2009)**



## **1.2 Aims and scope of this project**

*For further details regarding the aims and scope of the project, refer to Appendix 1.*

The principal aims of this study have been to:

- collate municipal waste compositional evidence for the UK
- assess the robustness of the collated data in terms of determining the national composition of municipal waste and its biodegradable content
- consider the relative merits of the methodologies employed in the collated studies
- identify gaps in UK municipal waste compositional evidence
- recommend further work required to fill these data gaps.

## **2. Data collation methods**

*For further details regarding data collection methods, refer to Appendix 2.*

A significant amount of compositional data was already held by Resource Futures, from waste auditing work carried out by Resource Futures and from previous national municipal waste composition reviews carried out by Dr Julian Parfitt. Additional compositional studies were obtained through:

- Defra Local Authority Support Unit and the Waste Information Network
- requests to local authorities (via LARAC, NAWDO and other fora)
- requests to other contractors who provide waste auditing services to local authorities.

In general the contacted parties responded positively and a considerable body of municipal waste compositional data was collated. Where possible, collated studies were subdivided into datasets, with county council level kerbside studies subdivided into district levels datasets; and studies of more than one waste stream subdivided into separate datasets for each municipal waste stream (i.e. kerbside, HWRC, etc).

## **3. Mapping and evaluation of collated data**

*For further details regarding mapping and evaluation of collated data, refer to Appendix 3.*

In total 535 datasets were collated. The majority of these related to audits of kerbside waste in England, with a reasonably large number of HWRC datasets also for England. A smaller number of kerbside datasets were obtained from the Devolved Administrations and for other waste streams (municipally collected commercial waste, bulky waste collections, etc). Many of these datasets included data for more than one kerbside stream (i.e. residual, dry recycling, garden waste and/or organics). Where appropriate, collated datasets were split into individual kerbside streams. This resulted in a total of 873 datasets by individual municipal waste stream, as summarised in Table 1 below.

**Table 1: Number of municipal waste streams covered by the 535 collated UK compositional datasets**

Waste stream	Total	2008	2007	2006	2005	2004	earlier
Kerbside residual	342	39	115	72	56	26	12
Kerbside dry recycling	229	35	83	53	32	9	2
Kerbside garden waste	114	21	36	34	14	1	2
Kerbside organics	21	7	8	4	1	1	0
Communal residual	19	0	6	3	2	7	0
Communal dry recycling	10	0	6	2	1	0	0
HWRC residual	53	4	13	15	5	11	2
HWRC other	9	1	1	5	5	2	2
Bulky waste collections	23	1	2	1	4	6	2
Commercial residual	17	0	4	5	4	3	2
Street sweepings & litter	13	0	4	1	5	3	1
Street recycling bins	3	0	2	0	0	1	0
Council office residual	8	0	3	0	3	2	0
Schools residual	6	0	2	0	3	0	1
Beach & caravan residual	2	0	1	0	0	1	0
Flytipping	2	0	0	0	1	1	0
Community skips	1	0	0	0	1	0	0
Bring site dry recycling	71	0	0	0	0	1	0
<b>Total</b>	<b>873</b>	<b>108</b>	<b>260</b>	<b>190</b>	<b>161</b>	<b>71</b>	<b>24</b>

Note: includes district level data sets and some non-disaggregated county level datasets.

Few studies addressed other municipal waste streams, such as non-household municipal waste or other household waste collections, such as bulky waste collections or litter. Over 80% of the studies related to fieldwork started in 2005, or more recently.

Selection criteria were developed for assessing the collated datasets and their suitability for inclusion in subsequent analyses for estimating national municipal waste composition. These simple criteria were designed to reflect aspects of the datasets that were most likely to influence how representative samples were of district arisings and how recently the fieldwork was undertaken:

- **timeliness:** that the waste audit fieldwork commenced in 2005 or more recently, in order to be as contemporary as possible with other datasets and with a chosen WDF reference year to be adopted for grossing-up results to produce national estimates;
- **seasonality:** studies were selected if they contained two or more seasons, so that some attempt had been made to account for seasonal variations in composition; a sub-analysis of single season and multi-season studies was carried out for garden waste in residual kerbside collections and statistically significant differences were found between mean residual garden waste in single season versus multiseason studies;
- **sampling strategy:** samples stratified by ACORN group ('A Classification of Residential Neighbourhoods' - a general purpose geo-demographic package often used by waste auditors to characterise different neighbourhood types), Council Tax banding, or some other geo-demographic stratification methodology was applied (i.e. some attempt had been made to control for area types when generalising compositional results for a district).

For a summary of the issued considered in developing the evaluation criteria, refer to Appendix 8.

**Table 2: Number of municipal waste streams covered by the 535 collated UK compositional datasets by year**

Waste stream	Total	2008	2007	2006	2005	2004	earlier
Kerbside residual waste from household collections	342	39	115	72	56	26	12
Kerbside dry recycling from household collections	229	35	83	53	32	9	2
Kerbside garden waste from household collections	114	21	36	34	14	1	2
Kerbside food waste/ mixed garden and food waste from household collections	21	7	8	4	1	1	0
Communal bins: residual waste	19	0	6	3	2	7	0
Communal bins: dry recycling	10	0	6	2	1	0	0
Civic Amenity site /HWRC residual waste	53	4	13	15	5	11	2
Civic Amenity site /HWRC other waste	9	1	1	5	5	2	2
Bulky waste: Municipally contracted services collecting from householders	23	1	2	1	4	6	2
Commercial residual waste collected by Municipally contracted services	17	0	4	5	4	3	2
Street sweepings and litter	13	0	4	1	5	3	1
Street recycling bins	3	0	2	0	0	1	0
Council office residual waste	8	0	3	0	3	2	0
Schools residual waste	6	0	2	0	3	0	1
Beach & caravan residual waste	2	0	1	0	0	1	0
Flytipping	2	0	0	0	1	1	0
Community skips	1	0	0	0	1	0	0
Bring site dry recycling	71	0	0	0	0	1	0
<b>Total</b>	<b>873</b>	<b>108</b>	<b>260</b>	<b>190</b>	<b>161</b>	<b>71</b>	<b>24</b>

Application of the three selection criteria to the large number of kerbside datasets resulted in over half of the collated kerbside datasets being excluded, with lack of seasonal coverage accounting for nearly half of the rejections. Nonetheless, 120 kerbside residual datasets for England fulfilled the selection criteria. These datasets represented good coverage of England in terms of level of deprivation and region.

Although reasonable coverage was obtained for HWRC residual waste in England, selection criteria similar to those applied to kerbside datasets were not applied. A number of the collated HWRC studies shown in Table 2 were rejected due to limitations with waste categorisation or a failure to fully sort the 'black bag' residual waste sampled from HWRC sites. Of the 56 collated studies, 34 residual waste datasets were included in the analyses for assessing national HWRC waste composition.

In common with previous compositional reviews, compositional studies for other municipal waste streams achieved fairly poor coverage. In total 106 datasets were collated for these waste streams, which mostly related to street sweeping, litter or bulky waste collections, with commercial municipal collections represented by only 25 studies.

#### **4. Analysis of collated studies and updated estimates of national municipal waste composition**

*For further details regarding analysis of collated studies and updated estimates of national municipal waste composition, refer to Appendix 4.*

The combined datasets were analysed in conjunction with operational data from WDF to produce updated national estimates of municipal waste composition. Due to the quantity and quality of data collated by the review, and the separate consideration of all municipal waste streams included in WDF, the national estimates of municipal composition for England obtained are considered to be the most robust produced to date. However significant data gaps were also identified. The first task in compiling national estimates was to reconcile differences between the compositional categories used by different studies.

##### **4.1 Reconciliation of compositional categories**

Variation in the component categories across different datasets made the task of compiling national estimates from the assembled datasets more challenging. These inconsistencies reflected differing local information priorities and variation in the practices of different waste analysis contractors. In view of this, a simple primary category list, set out in Table 3, was adopted for the purpose of producing national municipal waste composition estimates. Table 3 also indicates the assumed biodegradable percentage for each of the primary categories, in line with guidance provided by the Environment Agency.

The 'other wastes' category included materials that could not be readily placed in either the 'combustible' or 'non-combustible' categories. In general, materials in this category were likely to constitute a mixture of combustible and non-combustible elements. The category list was designed so as to minimise the types of materials placed in the 'other wastes' category. Whilst most categories were, in theory, applicable across all municipal waste streams, the primary categories created for 'furniture', 'mattresses' and 'soil' were more specifically related to wastes arising at HWRCs or to bulky waste collections.

**Table 3: Primary category list applied for producing national compositional estimates**

<b>PRIMARY CATEGORY</b>	<b>ASSUMED % biodegradable</b>
Food waste	100%
Garden waste	100%
Other organic (includes pet bedding & excrement, unidentified putrescibles)	100%
Paper	100%
Card	100%
Glass	0%
Metals	0%
Plastics	0%
Textiles (includes clothing, shoes, bed linen / duvets / pillows, handbags, soft toys)	50%
Wood	100%
Waste Electrical & Electronic Equipment (WEEE)	0%
Hazardous (excluding WEEE)	0%
Sanitary (including nappies)	50%
Furniture (likely to include a mixture of combustible and non-combustible components)	50%
Mattresses (likely to include a mixture of combustible and non-combustible components)	50%
Miscellaneous combustible (includes carpets & underlay, rubber, unclassified combustibles)	50%
Miscellaneous non-combustible (includes rubble, ash, ceramics, DIY/renovation wastes, unclassified non-combustibles)	0%
Soil (primarily soil from gardens which has been separately identified in audits of HWRC wastes)	0%
Other wastes (typically a mixture of combustible & non-combustible components; includes bric-a-brac & other re-usable items, floor tiles, composite packaging; in rare cases, some datasets also include a small element of unsorted bagged residual waste)	50%
Fines (typically <10mm or <20mm)	50%

Due to the different approaches to categorisation employed across the compositional studies included in the review, it is likely that some categories did not map consistently between all studies. For example, some studies included a separate category for 'sanitary waste', whilst others did not and were likely to have included these materials with the 'miscellaneous combustibles' category. Furthermore, material specific categories for recycling used within WDF were sometimes found to be insufficiently detailed. For example, WDF included a 'mixed paper and card' category for several municipal recycling streams. In these instances, reference data from the collated compositional studies were used to split out WDF tonnages in terms of the primary category list; in this particular example, splitting out 'paper' and 'card' separately.

#### 4.2 Analysis of variability and assessing benefits of weighting compositional data

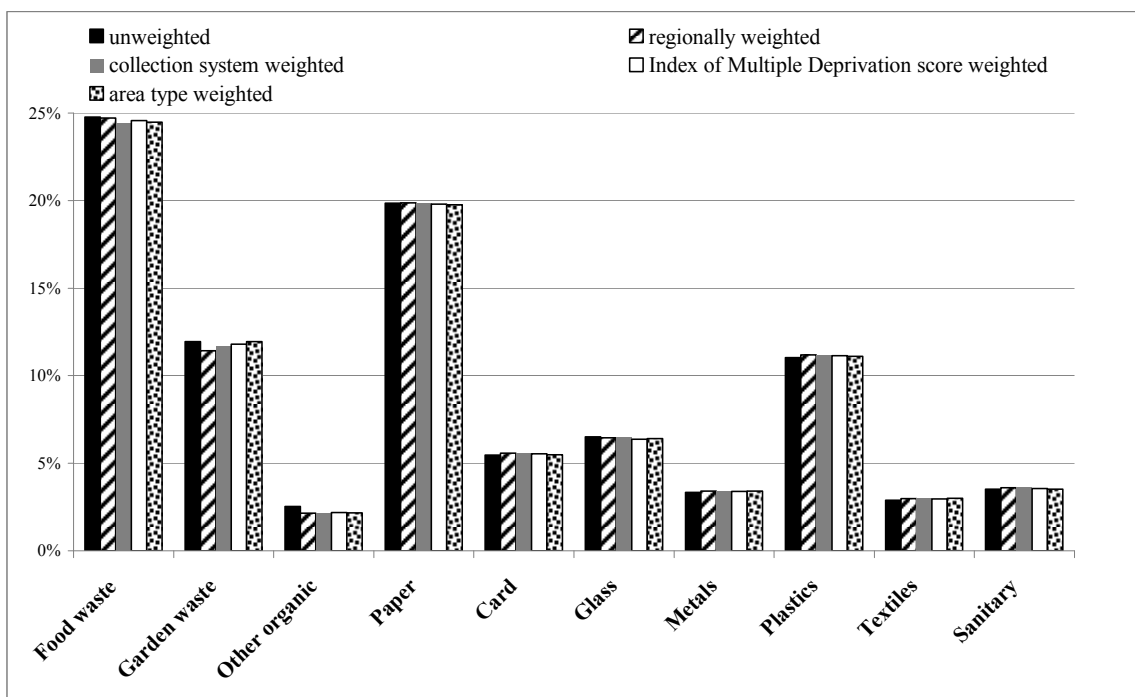
Factors influencing the variability of composition were explored for the selected kerbside residual and recycling waste streams. The results were then used to inform the decision on whether or not to weight the data as part of the procedure for calculating national estimates.

The data on kerbside residual waste composition from 120 English authorities were combined with WDF estimates of materials source-separated at kerbside for recycling and composting. Using the combined kerbside data, different methods of weighting the district-level datasets were applied to assess the impact on national estimates. The factors looked at included:

- regional coverage,
- kerbside collection system type (different methods of waste containment, frequency of residual waste collection and recycling systems),
- district authority area type (using National Statistics 2001 Area Classification for local authorities: ONS 2009),
- level of deprivation (Index of Multiple Deprivation, ‘IMD’ scores: the Government’s official measure of local deprivation, Department of Communities and Local Government 2009).

The compositional profiles derived from this analysis were then compared with the unweighted results. The results for the main compositional categories (those primary categories above 2% of total kerbside weight) are shown in Figure 2.

**Figure 2: Kerbside compositional profiles for primary waste categories for England, comparison of unweighted and weighted data, using four different weighting methodologies**



Overall the weighted kerbside compositions did not vary significantly between weighted and unweighted estimates. Minor differences across the main primary categories were found for garden, food and other organic waste categories. These results suggested that weighting the data by a particular factor would have had limited benefit in correcting biases in the national estimates for the following reasons:

- the variations generated by each weighting system were likely to be well within the confidence intervals associated with the unweighted data,

- the weighted data could not be used to examine variability and confidence intervals in the same way as unweighted data,
- there was no clear choice as to which weighting system to adopt, with the possibility that one system might reduce potential biases in relation to one category whilst increasing the biases in others.

In view of the above considerations, unweighted estimates were used for collated datasets, across all municipal waste streams.

For further discussion on these issues, refer to Appendices 4 and 10.

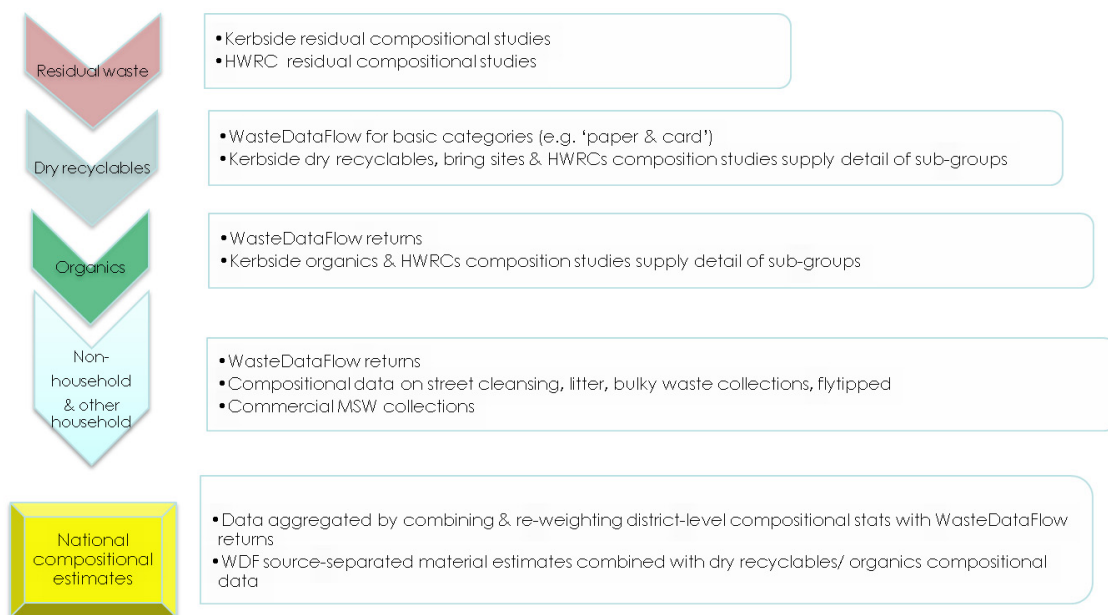
### 4.3 Methodology for producing national municipal waste composition estimates

Updated national municipal waste compositional estimates have been produced broadly according to the methodology developed in 2002 for work undertaken for the Prime Minister’s Strategy Unit (Parfitt, 2002). This approach is demonstrated here for producing estimates for England.

The methodology, illustrated in Figure 3 below, involves the integration of WDF operational data for the relevant district authority with supporting compositional data, in particular, kerbside residual waste data and – where available, HWRC residual waste data.

WDF tonnages from the 2006/07 reference year have been used by the review to produce updated compositional estimates for England, since this was the period with the best overall fit with the compositional datasets meeting the selection criteria (Table 2). An overview of English municipal waste tonnages reported to WDF for 2006/07 is provided in Table 4, which illustrates the proportion of each waste stream in relation to overall municipal waste arisings. Furthermore, Table 4 distinguishes between those waste streams for which material specific recycling tonnages have been reported to WDF (left-hand column with percentages) and the remaining waste streams which constitute either residual waste or recycling tonnages with no material specific tonnages reported (right-hand column with percentages). As Table 4 shows, 26% of England’s municipal waste during the reference year of 2006/07 was reported by local authorities to WDF in terms of material specific tonnages. For several waste streams and material types, the level of detail provided by WDF was not sufficient to fit with the primary categories (Table 3) and it was necessary to estimate the breakdown of particular materials using the appropriate compositional datasets collated by the review.

**Figure 3: Methodology for the construction of national municipal waste compositional estimates**



**Table 4: Summary of municipal waste streams reported in WDF for England 2006/07**

<b>ENGLAND 2006/07</b>	<b>Tonnes</b>	<b>Material specific tonnages reported</b>	<b>No material specific tonnages reported</b>
Kerbside household residual	14,050,000		48.21%
Kerbside household recycling	4,656,625	15.98%	
HWRC household residual	2,576,000		8.84%
HWRC non-household residual	270,006		0.93%
HWRC recycling, excluding rubble	2,556,704	8.77%	
Other household residual	1,173,000		4.02%
Household recycling, bring sites	665,856	2.28%	
Household recycling, street recycling bins	19,165	0.07%	
Other household recycling	77,649		0.27%
Non-household residual (excluding HWRC)	2,137,994		7.34%
Non-household recycling	961,000		3.30%
<b>TOTAL</b>	<b>29,144,000</b>	<b>27.10%</b>	<b>72.90%</b>

#### **4.4 Results of Compositional Estimates for England**

Compositional estimates were produced using the methodology described that combined WDF returns with compositional data from the collated studies. This process was applied to each of the municipal waste streams: the results for the kerbside and HWRC elements are described here.

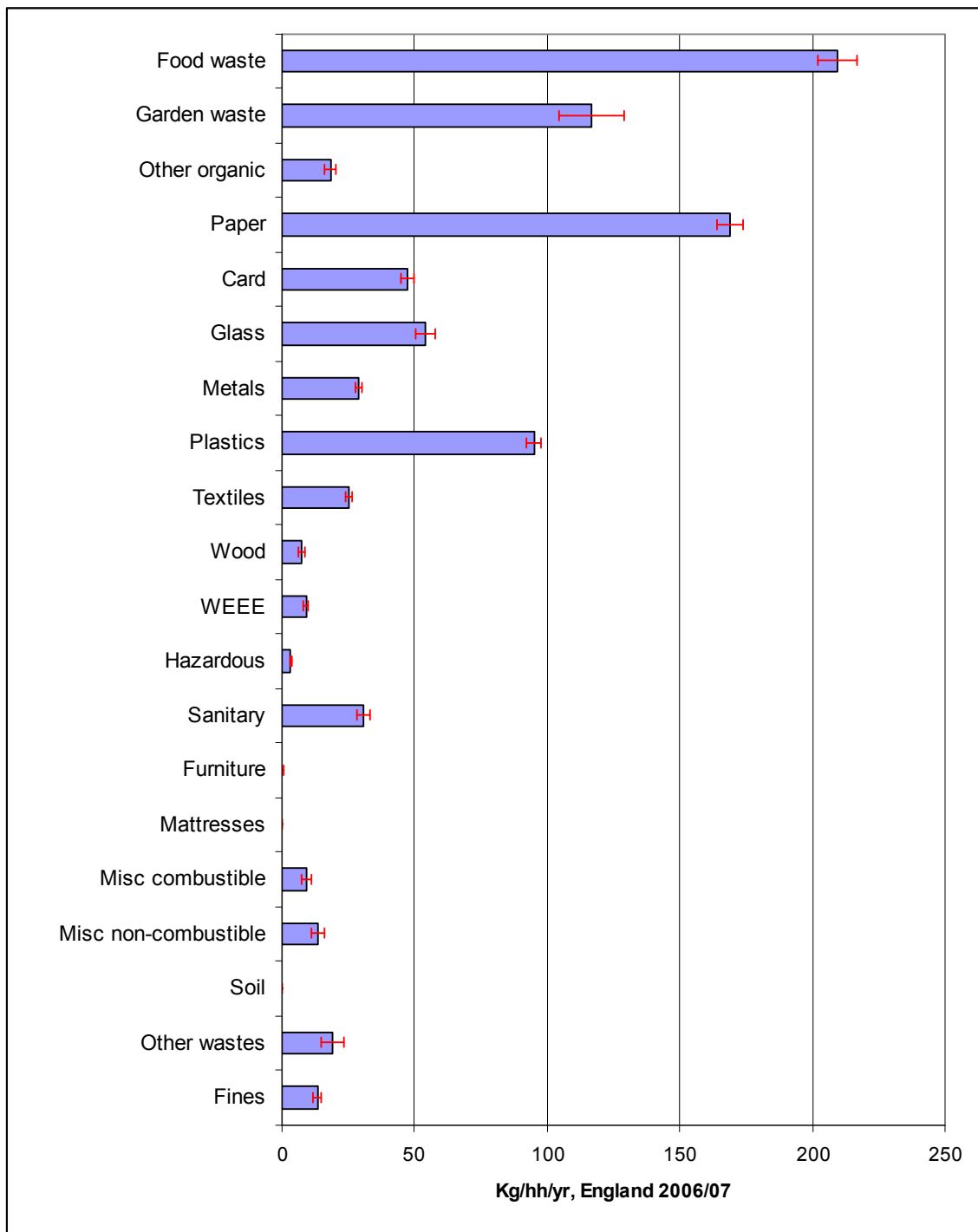
##### **4.4.1 Composition of Kerbside Wastes in England**

Whilst compositional estimates for kerbside recycling were available from WDF for all 354 English collection authorities (within the reporting limitations posed by WDF reporting categories), kerbside residual compositional estimates were only available for the 120 local authorities with data that met the selection criteria. The overall composition of kerbside collected waste was estimated for these authorities by combining the compositional estimates for kerbside residual waste tonnages with the relevant kerbside recycling tonnages for each authority.

It was assumed, based on the analysis of the coverage of qualifying studies, that these local authorities were representative of residual waste collected by all English waste collection authorities (354 local authorities in total, pre-April 2009 reorganisation). The composition of all kerbside waste in England was then estimated by taking a simple average of compositional data (residual and recycling) across all 120 local authorities for which residual waste composition estimates were available. Compositional estimates for all kerbside waste in England (combined for residual and recycling), calculated on this basis, are shown in Figure 4.

Food waste accounted for a quarter of kerbside waste arisings, with paper and card categories together comprising a further quarter. Garden waste and plastics were the next most important contributors to total weight (12 % and 11% respectively). Comparison of kerbside residual estimates with quantities diverted into recycling and composting schemes revealed considerable variation in national kerbside material capture rates, ranging from 75% for garden waste to 1% for food waste collections (Table 5). Although this variation partly reflected differences in the level of development of kerbside recycling infra-structure, it was also a function of the extent to which primary categories contained materials that were targeted for recycling. For instance, further work on the kerbside compositional datasets suggested that plastic bottles, which are more widely targeted for recycling than other plastics, accounted for only about 17% of the primary plastics category by weight. The estimated capture rate for plastic bottles was approximately 40%. A case study analysing plastics at a secondary category level is presented in Appendix 9, providing an indication of the potential benefits of consolidating the datasets at a secondary level of sort category.

**Figure 4: Compositional estimates for all kerbside waste in England, kg/hh/yr in 2006/07**



*Note: The red “error bars” indicate 95% confidence intervals. There are several issues to be considered in relation to these confidence intervals; for example, confidence intervals derived from residual waste data have been combined with WasteDataFlow operational tonnages. Please refer to Appendix 4 for further discussion of these issues.*

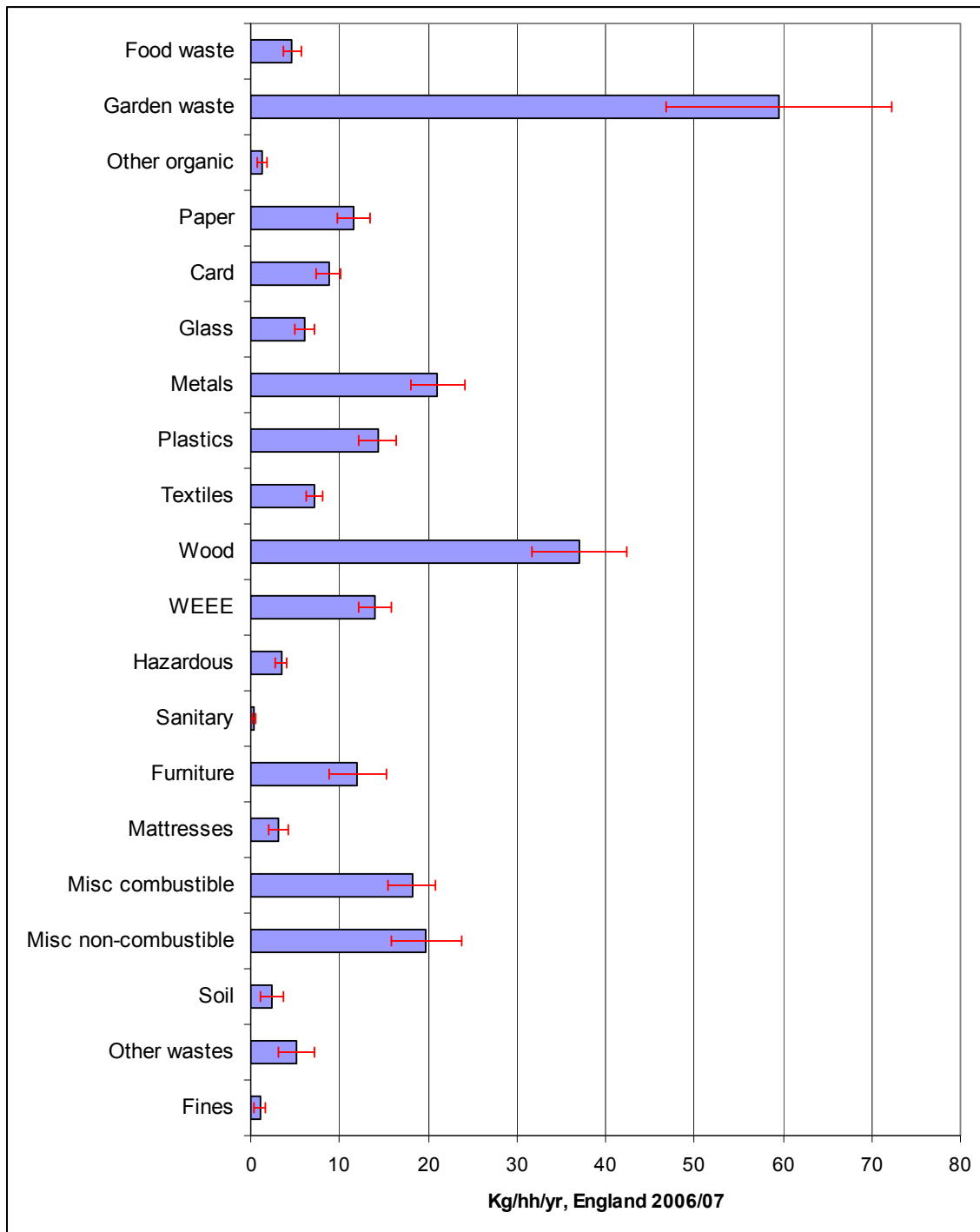
**Table 5: Kerbside capture rates for selected primary categories in England for 2006/07**

Primary category	Kerbside capture rate
Garden waste	75%
Paper	50%
Glass	40%
Card	28%
Metals	23%
Plastics	7%
Textiles	6%
Wood	3%
Other organics	3%
Food waste	1%
Overall	25%

#### **4.4.2 Composition of HWRC wastes in England**

Whilst HWRC recycling compositional estimates were also available for all English local authorities that reported HWRC recycling tonnages in WDF, HWRC residual waste compositional estimates were only available for 34 local authorities. The overall composition of HWRC collected waste for these authorities was estimated by combining the HWRC residual waste tonnages for the primary categories with the relevant WDF derived HWRC recycling tonnages for each authority. The results, shown in Figure 5, indicate that garden and wood waste accounted for the highest share of HWRC tonnages (23.5% and 15% by weight). The extent to which materials were segregated for recycling and composting was approaching 50% in 2006/07, with high capture rates for garden waste, metals and waste electronic and electrical equipment (Table 6).

**Figure 4.14: Compositional estimates for all HWRC waste in England, kg/hh/yr in 2006/07**



Notes: (1) The red “error bars” indicate 95% confidence intervals. There are several issues to be considered in relation to these confidence intervals; for example, confidence intervals derived from residual waste data have been combined with WasteDataFlow operational tonnages. Please refer to Appendix 4 for further discussion of these issues. (2) Includes non-household residual waste collected at HWRCs, but excludes rubble separated for recycling.

**Table 6: HWRC capture rates for selected primary categories, England for 2006/07**

Primary category	HWRC capture rate
Garden waste	89%
Metals	79%
WEEE	74%
Other wastes	57%
Card	56%
Glass	47%
Wood	46%
Paper	44%
Hazardous	42%
Textiles	17%
Furniture	9%
Plastics	4%
Mattresses	0%
Overall	47%

#### **4.4.3 Compositional estimates for All Municipal Waste Streams in England**

Fewer compositional datasets were available for the remaining municipal waste (and recycling) streams in England (i.e. excluding kerbside and HWRC wastes). Nonetheless it was possible to produce compositional estimates for each of the remaining waste streams, albeit on the basis of compositional evidence with poorer coverage in comparison to kerbside and HWRC wastes. Compositional estimates for all the main municipal waste streams in England are presented in Table 7, expressed in terms of estimated tonnage arisings during 2006/07.

**Table 7: Estimated tonnage arisings of materials in municipal waste in England, 2006/07**

<b>ENGLAND 2006/07</b>	<b>Kerbside total</b>	<b>HWRC total excl rubble</b>	<b>Other hhold residual</b>	<b>Bring recycling</b>	<b>Street recycling bins</b>	<b>Other hhold recycling</b>	<b>Non-hhold residual</b>	<b>Non-hhold recycling excl rubble</b>	<b>All municipal waste</b>	<b>Estimated composition, all municipal waste (%)</b>
Food waste	4,508,285	101,094	110,107	2,071	0	0	334,702	0	<b>5,056,259</b>	<b>17.84%</b>
Garden waste	2,516,371	1,280,695	84,586	10,607	0	42,436	55,086	0	<b>3,989,782</b>	<b>14.08%</b>
Other organic	391,327	27,296	63,784	480	0	0	7,465	0	<b>490,352</b>	<b>1.73%</b>
Paper	3,635,357	249,930	117,645	165,693	6,041	104	452,241	91,102	<b>4,718,113</b>	<b>16.65%</b>
Card	1,013,142	188,623	46,079	62,647	1,708	84	387,801	11,414	<b>1,711,499</b>	<b>6.04%</b>
Glass	1,164,881	130,565	62,357	347,443	8,394	82	126,711	41,366	<b>1,881,799</b>	<b>6.64%</b>
Metals	617,743	452,419	40,531	11,604	955	288	86,158	7,636	<b>1,217,335</b>	<b>4.30%</b>
Plastics	2,042,743	308,304	150,020	15,394	2,067	417	307,045	5,594	<b>2,831,585</b>	<b>9.99%</b>
Textiles	547,274	154,232	13,984	44,003	0	210	43,113	0	<b>802,816</b>	<b>2.83%</b>
Wood	157,092	797,561	15,388	3,315	0	1,830	81,562	0	<b>1,056,748</b>	<b>3.73%</b>
WEEE	192,535	300,787	99,174	1,415	0	16,039	10,615	0	<b>620,566</b>	<b>2.19%</b>
Hazardous	71,281	73,380	1,489	271	0	0	2,975	0	<b>149,396</b>	<b>0.53%</b>
Sanitary	662,259	7,536	8,208	13	0	0	33,998	0	<b>712,015</b>	<b>2.51%</b>
Furniture	3,813	259,471	98,199	202	0	16,159	1,939	0	<b>379,783</b>	<b>1.34%</b>
Mattresses	0	68,120	4,042	0	0	0	0	0	<b>72,162</b>	<b>0.25%</b>
Misc combustible	198,750	391,397	25,668	24	0	0	55,827	0	<b>671,666</b>	<b>2.37%</b>
Misc non-combustible	289,643	425,247	19,578	6	0	0	64,361	0	<b>798,836</b>	<b>2.82%</b>
Soil	0	51,998	0	0	0	0	147	0	<b>52,144</b>	<b>0.18%</b>
Other wastes	406,668	111,471	91,380	654	0	0	47,957	0	<b>658,130</b>	<b>2.32%</b>
Fines	287,459	22,583	120,781	14	0	0	38,289	0	<b>469,127</b>	<b>1.66%</b>
<b>TOTAL</b>	<b>18,706,625</b>	<b>5,402,709</b>	<b>1,173,000</b>	<b>665,856</b>	<b>19,165</b>	<b>77,649</b>	<b>2,137,994</b>	<b>157,112</b>	<b>28,340,112</b>	<b>100.00%</b>

*Note: excludes rubble separated for recycling*

Estimated tonnages for all municipal waste in England are detailed in Table 8, with confidence intervals (deriving from analyses of residual waste audit datasets) expressed in terms of tonnage; compositional estimates and 95% confidence intervals for each waste type are also expressed in terms of percentage of total arisings of municipal waste.

**Table 8: Confidence intervals for compositional estimates for all municipal waste**

<b>ENGLAND 2006/07 ALL MUNICIPAL WASTE</b>	<b>TONNES</b>		<b>PERCENTAGE ARISING</b>			
	Estimated total tonnes in municipal waste	95% confidence interval, +/-	Estimated composition	95% confidence interval, +/-	95% confidence interval: LOWER BOUND	95% confidence interval: UPPER BOUND
Food waste	5,056,259	244,230	17.84%	0.86%	16.98%	18.70%
Garden waste	3,989,782	611,804	14.08%	2.16%	11.92%	16.24%
Other organic	490,352	96,391	1.73%	0.34%	1.39%	2.07%
Paper	4,718,113	225,071	16.65%	0.79%	15.85%	17.44%
Card	1,711,499	162,571	6.04%	0.57%	5.47%	6.61%
Glass	1,881,799	159,664	6.64%	0.56%	6.08%	7.20%
Metals	1,217,335	125,653	4.30%	0.44%	3.85%	4.74%
Plastics	2,831,585	175,355	9.99%	0.62%	9.37%	10.61%
Textiles	802,816	63,683	2.83%	0.22%	2.61%	3.06%
Wood	1,056,748	169,492	3.73%	0.60%	3.13%	4.33%
WEEE	620,566	96,254	2.19%	0.34%	1.85%	2.53%
Hazardous	149,396	26,287	0.53%	0.09%	0.43%	0.62%
Sanitary	712,015	75,919	2.51%	0.27%	2.24%	2.78%
Furniture	379,783	95,213	1.34%	0.34%	1.00%	1.68%
Mattresses	72,162	28,173	0.25%	0.10%	0.16%	0.35%
Misc combustible	671,666	140,393	2.37%	0.50%	1.87%	2.87%
Misc non-combustible	798,836	182,318	2.82%	0.64%	2.18%	3.46%
Soil	52,144	26,691	0.18%	0.09%	0.09%	0.28%
Other wastes	658,130	223,591	2.32%	0.79%	1.53%	3.11%
Fines	469,127	141,261	1.66%	0.50%	1.16%	2.15%
<b>TOTAL</b>	<b>28,340,112</b>	na	<b>100%</b>	na	na	na

Table 9 summarises estimated total municipal waste composition for England in 2006/07, with 95% confidence intervals, expressed in terms of tonnage arisings. The assumed BMW (biodegradable municipal waste) content for each category of material is applied to these tonnages to arrive at, respectively, estimated arisings of BMW in 2006/07 and confidence intervals, both expressed in terms of tonnages.

**Table 9: Estimated tonnage arisings of BMW for England, 2006/07**

ENGLAND 2006/07	ALL MUNICIPAL WASTE		BMW IN MUNICIPAL WASTE		
	Estimated total tonnes in municipal waste	95% confidence interval, +/- tonnes	Assumed BMW content	Estimated tonnes BMW in municipal waste	95% confidence interval, +/- tonnes
Food waste	5,056,259	244,230	100%	5,056,259	244,230
Garden waste	3,989,782	611,804	100%	3,989,782	611,804
Other organic	490,352	96,391	100%	490,352	96,391
Paper	4,718,113	225,071	100%	4,718,113	225,071
Card	1,711,499	162,571	100%	1,711,499	162,571
Glass	1,881,799	159,664	0%	0	0
Metals	1,217,335	125,653	0%	0	0
Plastics	2,831,585	175,355	0%	0	0
Textiles	802,816	63,683	50%	401,408	31,841
Wood	1,056,748	169,492	100%	1,056,748	169,492
WEEE	620,566	96,254	0%	0	0
Hazardous	149,396	26,287	0%	0	0
Sanitary	712,015	75,919	50%	356,007	37,959
Furniture	379,783	95,213	50%	189,891	47,606
Mattresses	72,162	28,173	50%	36,081	14,087
Misc combustible	671,666	140,393	50%	335,833	70,196
Misc non-combustible	798,836	182,318	0%	0	0
Soil	52,144	26,691	0%	0	0
Other wastes	658,130	223,591	50%	329,065	111,795
Fines	469,127	141,261	50%	234,564	70,630
<b>TOTAL</b>	<b>28,340,112</b>	<b>na</b>		<b>18,905,601</b>	<b>1,893,676</b>

The estimated proportion of BMW in municipal waste in England is presented in Table 10, with confidence intervals, expressed in terms of tonnage arisings and overall percentage BMW in municipal waste.

**Table 10: Estimated proportion of BMW in municipal waste, England 2006/07**

ENGLAND 2006/07	Estimated tonnes total municipal waste	Estimated tonnes BMW in municipal waste	95% confidence interval lower bound	95% confidence interval upper bound
<b>Tonnes</b>	28,340,112	<b>18,905,601</b>	<b>17,011,925</b>	<b>20,799,277</b>
<b>% in municipal waste</b>	na	<b>66.71%</b>	<b>60.03%</b>	<b>73.39%</b>

According to the compositional estimates presented here, the BMW content of municipal waste in England is estimated to be 66.71%, with a 95% confidence interval of +/- 6.68%, resulting in a lower bound of 60.03% and an upper bound of 73.39% at the 95% confidence level<sup>1</sup>.

<sup>1</sup> Variation in kerbside composition datasets only has a limited contribution to the magnitude of this confidence interval. Hypothetically, if confidence intervals for the kerbside element of England’s municipal waste were zero the resultant confidence interval for BMW content of municipal waste in England would be 66.71% +/- 3.94%, at the 95% confidence level. For further discussion of these issues, refer to Appendix 4.

## **5. Conclusions**

A large number of compositional studies were collated for kerbside compositional analysis studies carried out between 2004 and 2008, mostly for local authorities in England. A reasonable coverage of HWRC studies was also obtained. For other municipal waste streams coverage was more limited.

For the more extensive datasets, a grossing-up methodology was demonstrated that combined data from operational sources (WDF statistics) with compositional studies of residual waste. This approach has also been used to augment the compositional breakdown of materials reported in WDF operational statistics from materials separated for recycling and composting.

In terms of kerbside wastes, it is questionable whether a dedicated waste analysis programme in England would contribute significantly to the robustness and statistical confidence surrounding the estimates included in this study, particularly in relation to the resource that would be required in order to undertake such a programme. Further compositional analysis work is currently being undertaken in Scotland and Wales.

The review has also identified significant data gaps and many areas where future work will be required in order to meet these data gaps. In the first instance, although coverage of kerbside residual compositional data is currently good, it relates to the period 2005 to the present, and in due course it will obviously become dated. In recent years there has been sufficient demand in the municipal waste auditing market – driven in part by support from central government - for a large number of local kerbside residual auditing studies to be conducted locally in England. If this trend continues, then the priority should be to find a suitable mechanism for encouraging or enforcing standardisation of the waste auditing methodologies employed by the various contractors who carry out waste composition primary data gathering. This applies to municipal waste auditing in general, and not only to the auditing of kerbside residual wastes.

Attempts to introduce a degree of standardisation to waste auditing protocols have been made previously, for example with the publication of national guidance for carrying out compositional analysis (e.g. Defra, 2004). However the range of waste auditing protocols employed by contractors in the collated studies illustrates that this guidance has had limited influence in the industry. Therefore a key recommendation from the review was that measures should be taken to encourage the standardisation of waste auditing protocols, particularly with a view to ensuring that local studies can support future reviews of UK municipal waste compositional evidence.

Finally, the datasets collated during this review could be further analysed to provide additional insights into variation in waste composition. For example, due to the large quantity of data collated it was not possible to analyse waste components a more detailed level of categorisation than the primary categories used. Much could also be learnt about socio-economic variability from the analysis of the kerbside data at the level of the sub-district ACORN strata.

*For further discussion of these issues refer to these appendices as appropriate:*

*Appendix 5: Review of Waste Auditing Methodologies*

*Appendix 6: Gap Analysis of Municipal Waste Compositional Evidence*

*Appendix 7: Conclusions and Recommendations for Future Work*

## **Acknowledgements**

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## References to published material ---

9. This section should be used to record links (hypertext links where possible) or references to other published material generated by, or relating to this project.

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