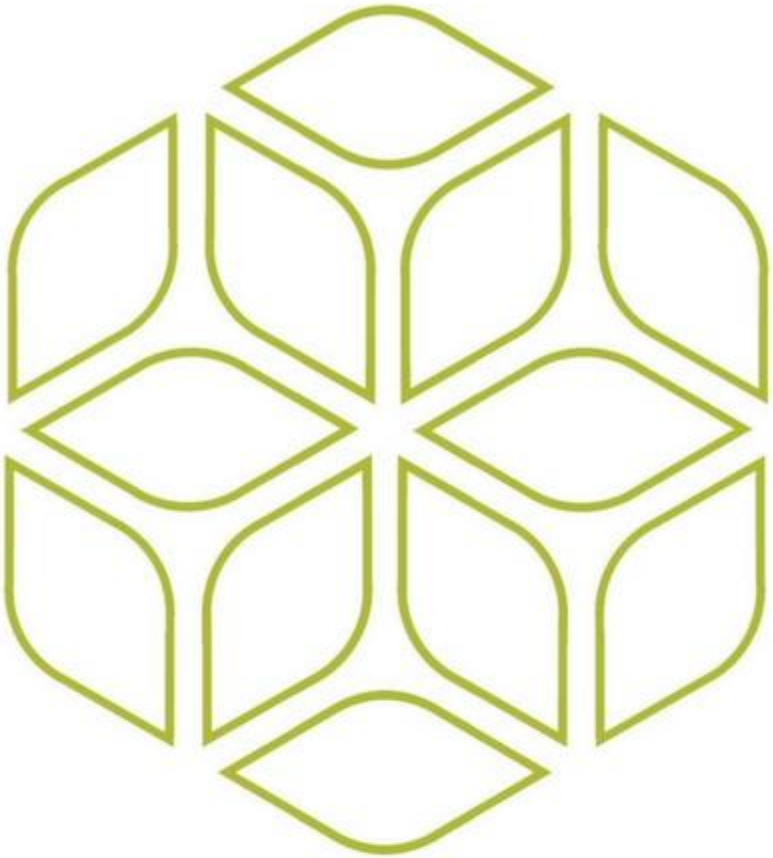

Gloucestershire County Council Four Season Waste Composition Analysis Study

Gloucestershire County Council

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resourcefutures

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Commercial confidentiality

We regard the ideas we are submitting to be commercially confidential and we ask you to respect this and not to share this document with any individuals or agencies who would have an interest in tendering for any of these work packages or to use the information and ideas in the drawing up of tender specifications.

Contents

1 Introduction

1.1 Background

In 2018 Resource Futures was commissioned by Gloucestershire County Council (GCC) as an independent analyst to conduct a composition analysis study of residual wastes. The work was to determine the baseline calorific value (CV) of the residual waste sent under contract to a new energy from waste (EfW) facility. Urbaser Balfour Beatty (UBB) designed and are constructing the new Javelin Park facility which will come into service in summer 2019. UBB will also operate the facility treating residual waste currently sent to landfill.

To account for any seasonal variation, fieldwork took place over four repeat analysis 'phases' beginning in summer 2018 ahead of the school summer holidays. Following phases were scheduled to avoid key school holidays, half terms and bank holidays so far as practicably possible. This report provides findings and the analysis approach to combining the datasets from all four phases between June 2018 to May 2019.

Gloucestershire County Council is the waste disposal authority (WDA) responsible for managing the waste collected by the six district councils (waste collection authority, WCAs):

- Cheltenham Borough Council
- Cotswold District Council
- Forest of Dean District Council
- Gloucester City Council
- Stroud District Council and;
- Tewkesbury Borough Council

The residual waste streams which were sampled and analysed each phase are listed below. Table 1 gives the proportion of each stream received over one year across four phases.

- Kerbside collected household waste (from each of the six districts)
- Residual household recycling centre (HRC) waste (HRC waste)
- Non-recyclable, collected bulky waste (bulky waste)
- Litter waste
- Street sweepings from mechanical sweepers, and;
- Residual commercial waste collected by the WCAs (where applicable)

Animal and clinical wastes were proportionally small and were not included in the analyses

Table 1: Residual waste streams, June 2018 to May 2019

Waste stream	Tonnes, Jun 18 to May 19	% Total tonnage
Kerbside household waste (Exc Fly Tipped & Trade)	95,678	76.7%
HRC residual waste	17,655	14.2%
Street Sweepings	6,219	5.0%
Litter Waste	3,392	2.7%
Bulky Waste	1,745	1.4%
Clinical Waste	10	0.0%
Animal Waste	1	0.0%
All	**124,700**	**100.0 %**

1.2 Aims and objectives

The aim of this project was to determine the average baseline CV of all of the residual wastes generated from within the county of Gloucestershire which will be treated at the new energy from waste facility.

The objectives of the work were:

- To carry out a waste composition analysis study of the residual waste within the county over four seasons
- To apply the composition analysis findings to reported waste tonnages to calculate the average baseline CV of the county's residual waste.

1.3 Outline of approaches to sampling waste streams

The following section outlines the proposed approach to sampling each of the identified residual waste streams. In each case, industry recognised good practice guidance informs the approach. Detailed information on sample sizes and the analysis approach is provided in the analysis methodology (Section 3).

1.3.1 Kerbside household waste Sample size

Kerbside household waste makes up three quarters of the residual waste handled by GCC at 95,678 tonnes over 2018/19. It is therefore important to choose a sample size that is likely to result in composition data that achieves an adequate level of validity which can be relied upon to give insight about the population. Confidence intervals decrease (improve) as sample sizes increase. The smaller the confidence interval for a waste fraction, the more accurate the sample mean is as an estimate of the population mean. A well-designed waste analysis study will balance the budgetary constraints with the need to sample and categorise a sufficient amount of waste.

Kerbside household waste can be sorted at an individual household level, although this provides very reliable data which can analysed in detail at a statistical level, this type of study is both time consuming and expensive. A more common and widely approved approach is to collect and analyse waste from demographically alike household groups or 'batches' which provide a wider representation of the demographic profile of an area.

Well-designed samples of 150 to 200 households (HH) are known to produce robust and reliable data. Statistical interpretation of past studies indicates that a sample of 150hh will achieve a 95% confidence interval of around 12%. The final chosen sample size is a balance between the financial cost of the project, and the robustness of the results.

Given the primary aim of this project to establish a baseline calorific value for the waste prior to Javelin Park EfW facility becoming operational, a sample size of 150 households per WCA (900hh in total across the county) was agreed for the work. The overall results will give a robust assessment of the composition in the county (CI around +/-5%) and a reasonable level for each of the WCAs.

1.3.2 Household Sample design

In line with best practice guidance from WRAP, sociodemographic profiling systems should be used to identify different, but most common groups within each waste collection authority. For this project a socio demographic system was used; the overall 'profile' for each of the districts in Gloucestershire determined the sample makeup used in each district. Samples of 150 households were proportionally stratified, so that

greater numbers of households were included in each sample according to the prominence of these groups in the overall profile. Each authority provided regular waste collection rounds and lists of suitable 'target' streets were identified.

When constructing the samples, each demographic group included more than one street, since behaviour can vary on a street by street basis independently of demographics. Resource Futures then visited these streets on the usual collection day and gathered waste samples for sorting and analysis. A detailed breakdown of each authority demographic profile is given in the analysis methodology (Section 3).

1.3.3 HRC waste

GCC manages residual waste from five recycling centres which are run by their contractor Ubico. Residual waste is usually gathered in 40 cubic yard, roll-on-roll-off (roro) containers and this is the case at each of the Gloucestershire sites. When analysing material from these skips it is standard practice to allow waste to gather in the normal way, so as not to interfere with normal behaviour and practices of site staff and the general public. The whole residual skip is then isolated when partly full and its contents is taken for analysis. Skips should not be compacted as the waste is both difficult to separate into materials and individual items.

It is good practice when analysing this waste stream to look at both a weekend and weekday sample from each site in case of any significant differences in how the sites are used at different times[1]. HRC waste can be quite variable in its composition; and skips tend to be made up of a mixture of larger 'bulky' items, bagged waste and uncontained 'loose' waste. To account for both variability and separation between these proportions, whilst still returning a reliable composition, a three sort stage method is used. This approach separates each 'stage' into representative subsamples of 'bulky', 'bagged' and 'loose' waste to provide an overall composition. The key advantage of this approach is that if large quantities of similar wastes are found, they are not sorted unnecessarily.

Using the three-stage methodology bulky items were first separated and classified and weighed. Any domestic type bags of waste were opened and a minimum of 150kg of these bags were sorted. A representative sample of a minimum 150kg of the 'loose', fine material left on the floor was then analysed. This approach ensured that the different fractions (stages) were included in the analysis and detailed composition has been calculated for the different types of waste found in the HRC waste stream. The total weight of each of the fractions was recorded and extrapolated to the total sample weight.

1.3.4 Street sweepings

Mechanical street sweepings tend to be made up of a mixture of fine grit, other detritus and added water. Although in autumn there is likely to be a higher proportion of organic matter present due to fallen leaves, it is likely that this waste stream will still have a low calorific value and high moisture content. Sorting this material to the same methodology as the rest of the composition analysis would lead to most of the material being classified as 'fines' as they would pass through the 10mm screen used in the sort. As fines from most waste streams are usually a mixture of organic and inert material, laboratory testing provides a

[1] *WRAP Monitoring and Evaluation guidance* *http://www.wrap.org.uk/content/monitoring-and-evaluation-guidance*

more robust means of applying a calorific value to this waste stream. The testing also returns the moisture content of this material which is also important in relation to calorific value.

In each authority a sample or 20kg of sweepings was taken from a mechanical sweeper at the point its load was tipped off. Samples were gathered by a Resource Futures operative using polyethene bags which were sealed to retain the original moisture content. The samples from all districts were collected over two days and sent via courier directly to the laboratory.

1.3.5 Litter

For each of the authorities one sample of around 250kg of litter waste was analysed in this phase. Litter waste is likely to be less variable than the HRC waste stream and makes up less than 2% of the residual waste handled. Each authority was asked to provide a sample from a regular collection which would provide a good representation of the type of material which they commonly collect. It was arranged that each authority delivered a sample directly to the sort location.

1.3.6 Bulky waste

Carrying out a conventional composition analysis study on kerbside collected bulky waste is not practical due to the nature of collections, the larger size of items and the fact that many items often tend to be made up of a mixture of materials and component assemblies. Work has been carried out by WRAP to investigate the composition of the bulky waste stream; part of a national study, *Composition and reuse potential of household bulky waste items in the UK* looked at waste generated through kerbside bulky waste collections[2]. Local authority held call logs of kerbside collected bulky waste items from several months were assessed, average item weights were then applied based on previous project experience and the same methodology used in this study. This analysis produced an estimated national composition of kerbside collected bulky waste. The same approach was used in this study to produce a composition to which calorific value could be applied. Each of the six districts was asked to provide six months of call logs from booked, kerbside bulky waste collections. Six months of data was chosen as it was felt this would allow for some seasonal variation to be incorporated without the task becoming unnecessary in proportion to the amount of waste generated. An average item weight and an WRATE value was applied based on the likely item composition (Appendix C). Due to the detail held in the call logs it was necessary to make certain assumptions about items, further detail is provided in section 3.6 of the analysis methodology.

1.3.7 Cheltenham commercial waste

Cheltenham Borough Council is the only authority who have a commercial residual waste collection in which some commercial waste is co-collected in collection vehicles with kerbside household waste. Businesses buy rolls of orange, authority labelled sacks which are collected by the kerbside household crews when they are presented on street. Data from Cheltenham suggested that only around 3 tonnes per month (40 tonnes per year) of this waste is collected. Ahead of the phase 1 work GCC agreed that this waste should still be sampled as part of the work.

[2] WRAP: Composition and reuse potential of household bulky waste items in the UK
http://www.wrap.org.uk/sites/files/wrap/UK%20bulky%20waste%20summary.pdf

Very little of this waste was collected and sampled during the first phase of the analysis, GCC agreed that this waste stream would not be included within the analysis for the second, third and fourth phases of the analysis study.

Despite visiting the target areas and streets during the first phase, only around four sacks of co-collected commercial waste were found by Resource Futures collection crews. The material was analysed and was less than 30kg in weight. GCC agreed that this information would not be included within the analysis and that this waste stream would be omitted from analysis in the remaining phases.

1.4 Composition analysis sorting protocol

Samples of kerbside household waste, HRC waste and litter waste were each hand sorted and categorised according to industry best practice outlined in WRAPs monitoring and evaluation guidance document.[3] An experienced Resource Futures site manager gathered the waste samples and then once back at the sort site managed the sort process and the quality of material separation. All bags and sacks were first opened on the sort table on top of a 10 mm mesh screen. Items passing through the screen were then classified as 'sub 10 mm fines'. Each material and type of item was type then separated into containers.

The site manager regularly checked the classification of materials to ensure quality. Where materials were made up of multiple components, they were separated where possible or if they were inseparable, they were classified according to the predominant weight. Where possible liquid or food remaining within its packaging was classified separately, unless the weight was deemed negligible or the liquid was hazardous.

Each category of sorted waste was weighed using digital scales. The site manager was responsible for weighing materials, recording the data on pre-prepared recording sheets and monitoring the quality of the sort. Recyclable materials which were separated in the sort process were kept aside for recycling.

1.4.1 Material categorisation

Waste was sorted according to the classifications developed with GCC following the project inception meeting. The same categorisation will be used in all study phases. The sorting team were provided with laminated copies of the category classification list including item level descriptions. A full categorisation list is included in Appendix A.

[3] *WRAP Monitoring and Evaluation guidance* *http://www.wrap.org.uk/content/monitoring-and-evaluation-guidance*

2 Sampling plan

2.1 Fieldwork timetable

The following section outlines the proposed sample plan ahead of the composition fieldwork. Any deviations or changes which took place during the fieldwork are summarised at the beginning of the results section with commentary on any implications for the analysis.

The residual waste composition analysis study took place in each season, beginning in summer 2018/19. The fourth and final phase of work took place in spring 2019.

2.2 All residual waste streams and sample summary

The residual waste composition study for Gloucestershire County Council in 2018/19 includes analysis of all municipal residual waste streams which will be treated by the new energy from waste (EfW) facility at Javelin Park. The table below lists each of the included waste streams the facility will receive; collectively these are referred to as residual waste. The table shows each of the waste streams and the proposed number of samples or weight of material which will be sorted or collected within the analysis.

Table 2: Residual waste streams included in each of the four phases of the waste composition analysis

District	Waste stream and sample details				
	Kerbside household waste (households)	HRC (skips of around 2000kg)	Litter (sample of 250 kg)	Street sweepings (sample of around 20 kg)	Bulky waste collections (Call/ collections logs)
Cheltenham	150	N/a	1	1	6 months
Cotswold	150	2	1	1	6 months
Forest of Dean (FoD)	150	2	1	1	6 months
Gloucester	150	2	1	1	6 months
Stroud	150	2	1	1	6 months
Tewkesbury	150	2	1	1	6 months
All	**900**	**10**	**6**	**6**	**N/a**

Kerbside household waste was collected from 150 households from each of the six districts. Litter and street sweepings from each district were collected and analysed. The Cheltenham, Swindon Road HRC site is managed outside of the residual waste contract so has not been included for analysis.

The following summary table indicates the planned fieldwork weeks for analysis during each phase of fieldwork.

Table 3: fieldwork dates for waste stream analysis during phase 3

Fieldwork phase	Weeks of fieldwork
Phase 1	Weeks commencing 18/06/2018 to 23/07/2018
Phase 2	Weeks commencing 05/11/2018 to 26/11/2018
Phase 3	Weeks commencing 21/01/2019 to 11/02/2019
Phase 4	Weeks commencing 29/04/2019 to 27/05/2019

The following sections present the sample collection and sorting plan for each waste stream identified in the tables above.

2.3 Summary of fieldwork across four phases

Composition fieldwork was conducted in four phases spread across the year between June 2018 and May 2019 as shown in Table 4 and Table 5. The detailed weekly sample collection and sorting plan for each waste stream in each phase of fieldwork are presented in Appendix B.

Table 4: Fieldwork schedule for Phase 1 and 2

Season	Summer 2018			Autumn 2018		
Phase/Month	**June**	**July**	**August**	**September**	**October**	**November**
Phase 1	**2 weeks**	**2 weeks**				
Phase 2						**4 weeks**

Table 5: Fieldwork schedule for Phase 3 and 4

Season	Winter 2018 - 19			Spring 2019		
Phase/Month	**December**	**January**	**February**	**March**	**April**	**May**
Phase 3		**2 weeks**	**2 weeks**			
Phase 4					**1 week**	**4 weeks**

2.3.1 Demographic stratification of kerbside household waste samples

All kerbside household waste samples were collected and sorted on the same day. A total of 150 households made up each overall kerbside household sample in each district for each phase. In practice, three daily subsamples (or strata) of waste were collected in each district, each subsample consists of waste from 50 households with three days spent in each authority.

To provide overall representation for each of the districts, each of the kerbside household waste samples of 150 households are demographically stratified using a sociodemographic profiling system, data was provided by GCC. The approach to sample size, stratification and the use of recognised sociodemographic systems is guided by extensive experience in this field and industry good practice outlined in the WRAP monitoring and evaluation guide[4]. The demographic profiles give an indication of levels of affluence and common behavioural patterns, these are then grouped into five key sociodemographic categories. Broadly group tends to be most affluent to group 5 which is least affluent. When matched with postcode information this gives the percentage makeup of residents in each district by each of the headline demographic categories. The data provides a sociodemographic 'profile' for each district; this is the proportional split of the headline groups within each district. Table 6 shows the profiles of each district.

Table 6: The sociodemographic demographic profile in each district

Group	Cotswold	Gloucester City	Stroud	Forest of Dean	Cheltenham	Tewkesbury
1	51.7%	14.9%	37.2%	22.8%	31.9%	33.1%
2	3.4%	6.1%	5.2%	0.7%	15.0%	8.0%
3	22.2%	35.3%	30.6%	46.5%	24.2%	33.3%
4	18.3%	21.6%	20.7%	25.0%	15.3%	18.0%
5	3.8%	21.2%	5.6%	4.3%	12.8%	6.8%
6	0.6%	1.0%	0.7%	0.8%	0.8%	0.8%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

The above proportions of each demographic category were applied to the sample size of 150 households as a percentage, to proportionally split, or 'stratify' the sample within each district. Table 7 to Table 13 show the number of 'target' households to include from each category using the percentage split of the district profiles to make up the total sample of 150 households per district. Each of the districts provided a number of kerbside household waste collection rounds which included street names household postcodes. The data was applied to these postcodes and suitable 'target' streets for each category were selected.

The following tables for the 6 districts provide a revised percentage split based on the profiles in Table 6. Categories which accounted for a very small proportion of the population, for instance, less than 5% in each district have not been included within the samples as this would be equivalent to sampling waste from only five or six properties. This approach allows additional households to be included in the groups representing the great majority of the populations and avoids skewing the data with potentially spurious results from

[4] *WRAP Monitoring and Evaluation guidance* *http://www.wrap.org.uk/content/monitoring-and-evaluation-guidance*

only a handful of proportions. Where individual groups were discounted for this reason additional households were either added to the closest demographic groups. The demographic split in Cheltenham is shown in the table below.

Table 7: The demographic profile for Cheltenham and revised sample strata split

Cheltenham				
Group	Proportion of population (%)	Revised	New split for Households	Household target
1	31.9%	31.9%	32.0%	48
2	15.0%	15.0%	15.3%	23
3	24.2%	24.2%	24.0%	36
4	15.3%	15.3%	15.3%	23
5	12.8%	12.8%	13.3%	20
6	0.8%	-	-	-
Total	**100%**	**99.2%**	**100%**	**150**

Flatted properties make up 28% of the total residential dwellings in Cheltenham according to Council tax valuation office figures (Table 8). Assessment of the council tax bands and designated flats collection rounds in Cheltenham indicated that the majority of these properties would fall into demographic categories two and four. Therefore, groups two and four will be represented by flats properties in the district level sample.

Table 8: Household types within Cheltenham from the Council tax Valuation Office Agency (VOA)

HH Type	Total hh	% split
Bungalow	3,930	7.2%
Flats	15,390	28.1%
Terraced	12,880	23.6%
Semis	13,980	25.6%
Detached	7,530	13.8%
Annex	40	0.1%
Other	380	0.7%
Unknown	550	1.0%
All	**54,680**	**100.0%**

The demographic split in the Cotswolds is shown in the table below.

Table 9: The demographic profile for Cotswold and revised sample strata split

Cotswold				
Group	Proportion of population (%)	Revised	New split for Households	Household target
1	51.7%	51.7%	56%	84
2	3.4%	-	-	-
3	22.2%	22.2%	24%	36
4	18.3%	18.3%	20%	30
5	3.8%	-	-	-
6	0.6%	-	-	-
Total	**100%**	**92.2%**	**100%**	**150**

The demographic split in the Forest of Dean is shown in the table below.

Table 10: The demographic profile for Forest of Dean and sample strata split

Forest of Dean				
Group	Proportion of population (%)	Revised	New split for Households	Household target
1	22.8%	22.8%	24%	36
2	0.7%	-	-	-
3	46.5%	46.5%	49.3%	74
4	25.0%	25.0%	26.7%	40
5	4.3%	-	-	-
6	0.8%	-	-	-
Total	**100%**	**94.3%**	**100%**	**150**

The demographic split in Gloucester is shown in the table below.

Table 11: The demographic makeup for Gloucester and sample strata split

Gloucester				
Group	Proportion of population (%)	Revised	New split for Households	Household target
1	14.9%	14.9%	15.0%	23
2	6.1%	6.1%	6.1%	9
3	35.3%	35.3%	35.7%	54
4	21.6%	21.6%	21.8%	33
5	21.2%	21.2%	21.4%	32
6	1.0%	-	-	-
Total	**100%**	**99.0%**	**100.0%**	**150**

The demographic split in Stroud is shown in the table below.

Table 12: The demographic makeup for Stroud and sample strata split

Stroud				
Group	Proportion of population (%)	Revised	New split for Households	Household target
1	14.9%	37.2%	37.2%	42%
2	6.1%	5.2%	-	-
3	35.3%	30.6%	30.6%	35%
4	21.6%	20.7%	20.7%	23%
5	21.2%	5.6%	-	-
6	1.0%	0.7%	-	-
Total	**100%**	**100%**	**88.6%**	**100.0%**

The demographic split in Tewkesbury is shown in the table below.

Table 13: The demographic makeup for Tewkesbury and sample strata split.

Tewkesbury				
Group	Proportion of population (%)	Revised	New split for Households	Household target
1	33.1%	33.1%	33%	50
2	8.0%	8.0%	8%	12
3	33.3%	33.3%	34%	50
4	18.0%	18.0%	18%	27
5	6.8%	6.8%	7%	10
6	0.80%	-	-	-
Total	**100%**	**99.2%**	**100.0%**	**150**

2.3.2 Kerbside household waste collections plan by district

During each phase, kerbside household waste collections were scheduled throughout Gloucestershire over four weeks, it was planned that Resource Futures teams would spend three days in each WCA, sampling kerbside household waste from around 50 households each day. Over the course of three days, subsamples from different groups make up the full sample of 150 households in each district.

For each of the demographically representative district sample frames identified above, the full sample of target households was devised using actual residual waste collection round information. Postcode level information was matched with the database to identify streets, and sections of streets which included the right mixture of demographic types to include to make up the desired sample profile. The collection round information allows households on specific streets to be targeted on their regular waste collection day.

2.3.3 HRC waste sample plan

Composition analysis was scheduled for residual waste from each of the five HRCs in all districts other than Cheltenham whose HRC site is operated outside of the contract. The gathering and delivery of samples waste scheduled over either a two or three-week period in each phase. To follow best practice and to gain waste samples across a range of days of site use, a waste sample gathered over a weekend and weekday were included.

The contractor, Ubico, and Gloucestershire County Council oversaw gathering and delivery of all samples. Gathering of samples took place at each HRC where waste was deposited into skips by site users as usual. Skips were not compacted as might be the case under normal operations. On the day the sample was being gathered, site staff were instructed to isolate the residual waste sample skips once half to three quarters full; typically, around 1.5 to 2 tonnes in weight. Skips were then delivered to the sort site by a designated vehicle. For samples gathered on weekend days, some skips may have sat for several days before sorting, the contractor made arrangements to cover these skips to stop the contents becoming wet in case of rain.

2.3.4 Litter waste sample plan

A single litter waste sample was scheduled from each district in each phase. Litter rounds were selected to represent the overall mix of rural and urban areas from each district following liaison with street cleansing supervisors. These 250kg samples were tipped at the sort site ready for sorting on the same day.

2.3.5 Street sweepings samples

A single sample of street sweepings (from mechanical sweepers) was scheduled in each district in each phase. As this material is fine and homogenous in nature, a sub sample of around 20kg from each district was sent for lab testing to determine a calorific value rather than hand sorting to categorise the material. Street sweeper rounds were selected to represent the overall mix of rural and urban areas of each WCA following liaison with street cleansing supervisors. Waste was tipped at pre-arranged sites on the dates indicated. A Resource Futures technician collected samples and prepared these for laboratory analysis.

2.3.6 Bulky waste data

Ahead of the phase 1 summer fieldwork in 2018, it was agreed by GCC that rather than collecting a sample of bulky items from each district, an alternative method using bulky waste collection call logs would be used to determine a robust approximation of the calorific value and composition of this waste stream.

Bulky waste collection records and call logs were provided by each district. An estimated composition and CV have been calculated and included in the analysis.

2.3.7 Commercial waste – Cheltenham only

Due to small arisings in Phase 1, it was decided by GCC that commercial waste sampling and analysis would not be carried out in the following three phases.

3 Analysis methodology

3.1 Application of WRATE calorific value to composition findings

The composition study analysis calculates the material split and calorific value (CV) of each of the residual waste streams which will be received at the new facility. All waste is sorted to the agreed category list to produce the composition by percentage weight of the total waste sample. To calculate the calorific value of the materials making up each waste stream, each sort category has been assigned a calorific value based on the WRATE (Waste and Resources Assessment Tool for the Environment). The CV is expressed as the potential energy content in mega joules per kilogram (Mj/Kg). The CV by material was applied to the total weight of material in each category to produce the average energy content across each waste stream. A list of the WRATE values applied to each of the sort categories is included in Appendix C.

3.2 Kerbside household waste analysis

Weight data was manually recorded onto prepopulated recording sheets during the fieldwork. The data was entered into an Excel spreadsheet for analysis. A data entry and sense check was carried out by an experienced consultant to ensure accuracy.

In addition to calculating a household composition profile by percentage weight, average arisings are calculated based on the total waste collected per kilogram per household per week (kg/hh/wk). A weighted average was used for the arisings from the flats sampled in Cheltenham, considering the proportion of houses and flats within Cheltenham.

The total material collected per group was summed to give an overall composition by percentage weight per material category and for each local authority. Weighted average arisings per waste category for the whole of Gloucestershire were then calculated from the percentage composition in each local authority and multiplied by a weighting factor. This weighting factor was based upon data provided by each authority on their kerbside household waste arising tonnages per quarter. From this, an average composition of all samples from all local authorities was derived. The average percentage composition was multiplied by the quarterly waste arising figures to give total arisings by category, per quarter in tonnes rather than by kilograms per household. The calorific value (CV) figures provided in the WRATE tool were then multiplied by the estimated total tonnes of each material produced in each district to produce an average CV by material type and district.

Figures stated are either in kilograms per household per week (kg/hh/wk), tonnes per quarter or as composition by percentage weight. Calorific values are presented as Megajoule per kilogram (Mj/kg).

Whilst sorting kerbside household waste, it is relatively common to find hypodermic needles or diabetic test needles, where multiple items were found on the sort tables the surrounding waste material was not sorted for safety reasons. For any hazardous waste which was not sorted, then the compositional breakdown of that demographic group was also applied to the unsorted waste to give the full waste arisings per group.

3.3 HRC waste analysis

The same sorting and analytical process was applied to the HRC data as that of the kerbside data. For any waste which was not sorted, the returned compositional breakdown was proportionally applied to return the overall composition. HRC waste tends to be more variable then the kerbside household waste stream and so is sorted in three distinct stages; 'bulky', 'loose' and 'bagged'. Usually all larger items of 'bulky' waste are sorted and categorised as they make up relatively few individual items. Bagged and loose waste usually account for varying proportions of a sample. Sorting a minimum of 150kg of this material allows a robust composition to be returned with a reasonable level of resource.

Once the proportions of waste have been sorted and recorded, the weight of any unsorted material is also recorded. In the analysis this is proportionally applied to the main sample composition to produce an overall weight based composition for the whole skip of material.

3.4 Litter waste analysis

The litter was analysed using the same methodology as the kerbside collected residual waste.

3.5 Sweepings waste analysis

The analysis for the street sweepings was conducted externally by a specialist laboratory. The analysis method was used to return the calorific value (CV) and moisture content of the waste.

A weighted average across the county was calculated using the CV value returned for each district which was applied to the residual waste tonnage of the material produced by each district in the quarter.

3.6 Bulky waste analysis

Across all four study phases bulky waste accounted for 1.4% of all residual waste streams.
A key aim of the composition analysis study is to calculate the calorific value (CV) for all of the waste streams. Due to the variability of bulky waste items, the likelihood that items are made of multiple materials and assemblies of parts, conventional composition analysis across six districts would not be a practical approach. It would be necessary to collect and sort a high number of samples to determine a robust composition from which to then calculate CV. An alternative approach to calculating the CV of this waste stream in relation to the proportion of total waste it accounts for was proposed and implemented; this is summarised in the following section.

3.6.1 Alternative approach to calculating the calorific value of bulky waste

An alternative approach was put forward whereby bulky waste call logs or collection record sheets held by each authority would be gathered as part of a desk based review and CV calculation exercise. To manage bulky waste collections each local authority keeps a record of telephone and or email requests made by householders for collections of bulky waste items. Six months of call data was submitted by each authority apart from Gloucester City Council who were able to provide one month of data. Comparison of this data with the figures returned by the other authorities was similar so the month of data was extrapolated for the six month period.

Resource Futures categorised all items listed within the call logs, applying an average weight to all items based on the method used in previous work by Wrap. WRATE calorific values were then applied to this list

to create an estimated composition and calorific value for this waste stream which is then extrapolated across the year. (Appendix C)

3.6.2 CV application method for bulky waste

The level of detail in the authority bulky item lists varied. In some cases, the call lists gave a relatively detailed description of every single item which was collected, others gave just a count of how many of each broad item type was collected each month (for example 'chair'). Other authorities listed grouped bulky collections from individual properties, sometimes including up to five different items. The following process was used to combine the data to produce a uniform data set as far as practicably possible.

- As part of the first step, where item descriptions were vague, an assumption was made based on how common the item type was. Groups of items were separated out, for example; *'metal double bed frame, with double mattress and fabric headboard'*. These items were separated to be attributed with an individual weight and an estimated CV. Variability in the names of items between lists were then normalised, for example 'large sofa' and '3-seater sofa' were assumed to be the same thing.
- In total the lists included 4,872 individual items
- Once the list was unified, estimated item weights were added for every individual item. An average item weight list was used as a base, these were applied to common items where possible. For uncommon and unusual items, several similar products were looked up online and an estimated weight was applied.
- The material type was also applied to unusual or ambiguous items where possible; as materials made from plastic, metal or wood will all have a different CV and weight. In each case, if it was not possible to apply a material type an assumption was made or an average weight and CV was applied.
- CV per kg was then added to every item using the values in the WRATE materials categorisation list used for the other waste stream and materials analysed through the composition sort process.
- The overall average CV for all of the items collected by each authority was calculated and applied to the estimated total weight of all items collected for the same six month period.
- This produced a weighted average CV for the county which was then applied to the quarterly tonnage of items actually collected each quarter by each district.

Given the level of detail to which this desk based analysis was carried out and given the very small proportion of the waste stream which bulky items make up (1.61%), it was agreed by GCC that applying these average figures to the total bulky waste collected in each quarter, would provide a good indication of the total calorific value of this waste stream.

3.7 Combining all quarterly results to calculate total annual waste calorific value

The calculated results from data collected and analysed in each of the individual four phases was combined as explained in Figure 1. This provided the total estimated annual tonnages of each material category by waste stream and the estimated calorific value of each type of waste.

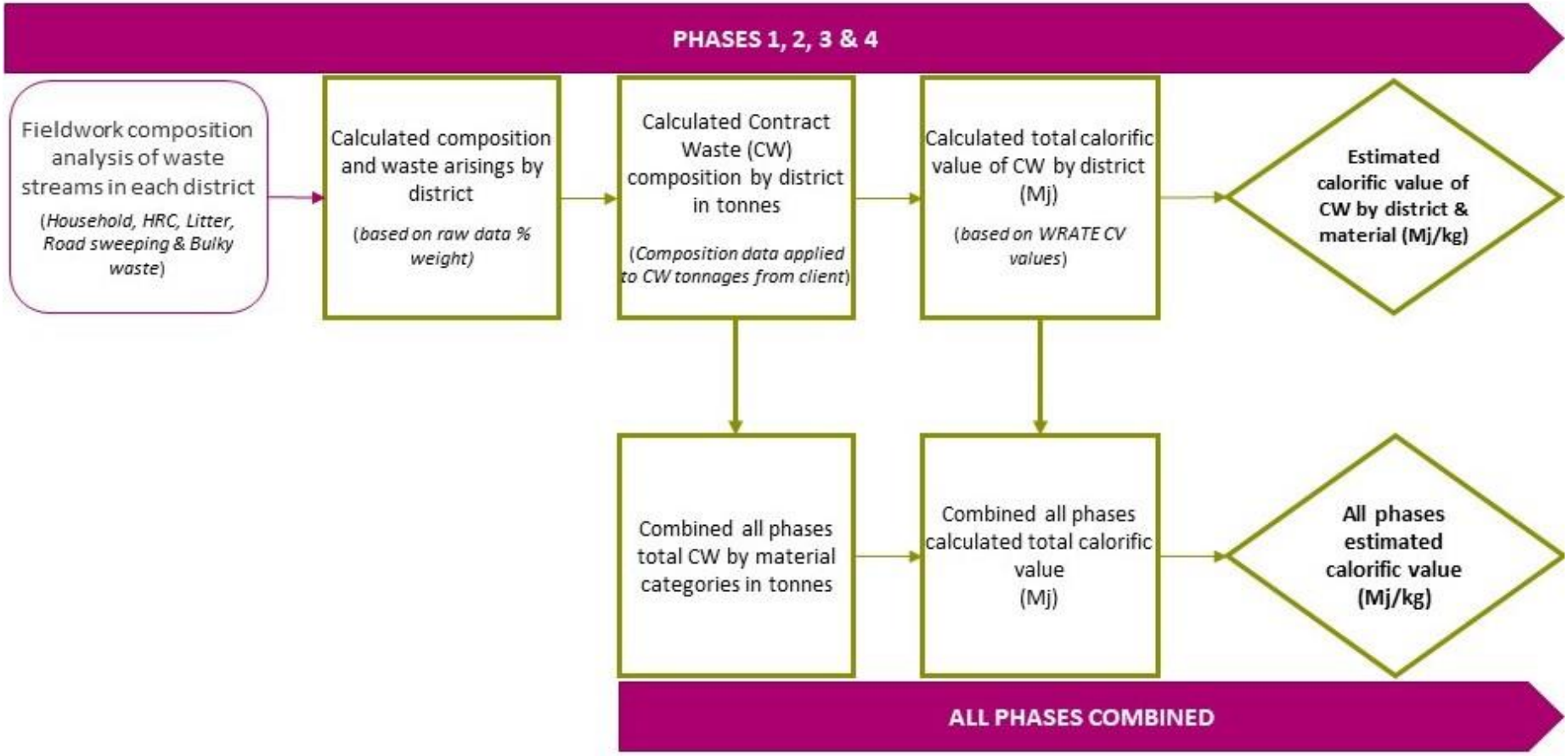

Figure 1: Data collation and analysis for all four phases to calculate estimated overall residual waste

The combined residual waste (RW) in tonnes for each material category from all districts was converted into total kilograms per quarter. A total calorific value in megajoules (Mj) was then calculated by applying the average WRATE figures for each material type to the total material. The estimated average calorific value per kilogram of material (Mj/kg) was then calculated by dividing the total calorific value by the total weight of each material.

Table 14: Approach to calculation of total annual composition and calorific value

Waste stream	Calculation of total residual waste tonnage	Calculation of estimated CV of overall residual waste
Kerbside household	Sum of quarterly calculated residual waste tonnage based on calculated % composition and actual RW data provided by client	From sum of quarterly calculated total CV (based on WRATE categorisation) and calculated residual waste tonnage
HRC	Sum of quarterly calculated County HRC tonnage based on calculated % composition of sample collected, and actual residual waste data provided by client	From sum of quarterly calculated total CV (based on WRATE categorisation) and County HRC tonnage
Litter	Sum of quarterly calculated County litter tonnage based on calculated % composition of sample collected, and actual residual waste data provided by client	From sum of quarterly calculated total CV (based on WRATE categorisation) and County litter tonnage
Road sweepings	n/a	Average of quarterly estimated calorific value of each district sample (based on laboratory analyses) and actual residual waste data provided by client
Bulky	Sum of quarterly calculated County bulky tonnage based on extrapolated raw data and actual residual waste data provided by client	From sum of quarterly calculated total CV (based on WRATE categorisation) and County bulky tonnage

4 Results

Findings form the composition analysis are presented separately for each of the residual waste streams. Results are presented at primary category level by key materials, detailed results at subcategory level are presented in full in the accompanying excel file.

Subcategory level findings for the kerbside household waste stream in each district and as an average across the county are presented in Appendix D.

4.1 Results – Kerbside household waste

4.1.1 Annual estimated arising of kerbside household waste in tonnes

The calculated annual arising of kerbside household waste in each Gloucestershire local authority is shown in Table 15 and Figure 2 below. The figures were produced by applying the composition returned by the waste sort applied to the total tonnages of material collected by each district during each quarter of the year.

Table 15: Calculated material arisings (tonnes) of kerbside household waste in each Gloucestershire local authority per quarter.

Category	Cheltenham (Tonnes)	Cotswolds (Tonnes)	Forest of Dean (Tonnes)	Gloucester (Tonnes)	Stroud (Tonnes)	Tewkesbury (Tonnes)	County total RW (tonnes)
Paper	2,243	1,693	1,467	2,398	1,551	1,126	10,477
Card	835	444	550	1,017	418	391	3,655
Plastic film	1,525	1,484	1,481	2,150	1,516	1,204	9,359
Dense plastics	1,499	813	1,418	2,011	817	938	7,495
Textiles	835	570	610	1,089	689	640	4,432
Sanitary	1,664	634	1,148	1,750	697	1,398	7,292
Combustibles	1,513	943	664	1,321	705	658	5,805
Non combustibles	1,499	1,195	750	1,560	601	948	6,553
Glass	646	279	355	644	209	246	2,380
Ferrous	474	228	281	425	171	254	1,832
Non ferrous	234	192	181	307	106	144	1,164
Food	4,309	3,250	3,561	6,661	2,467	3,749	23,997
Garden and other organic	1,215	927	1,171	1,641	1,150	1,664	7,768
WEEE	401	174	151	281	142	252	1,401
HHW	219	137	143	165	193	134	991
Fines	171	161	183	266	156	139	1,077
Total	**19,282**	**13,122**	**14,114**	**23,687**	**11,589**	**13,885**	**95,678**

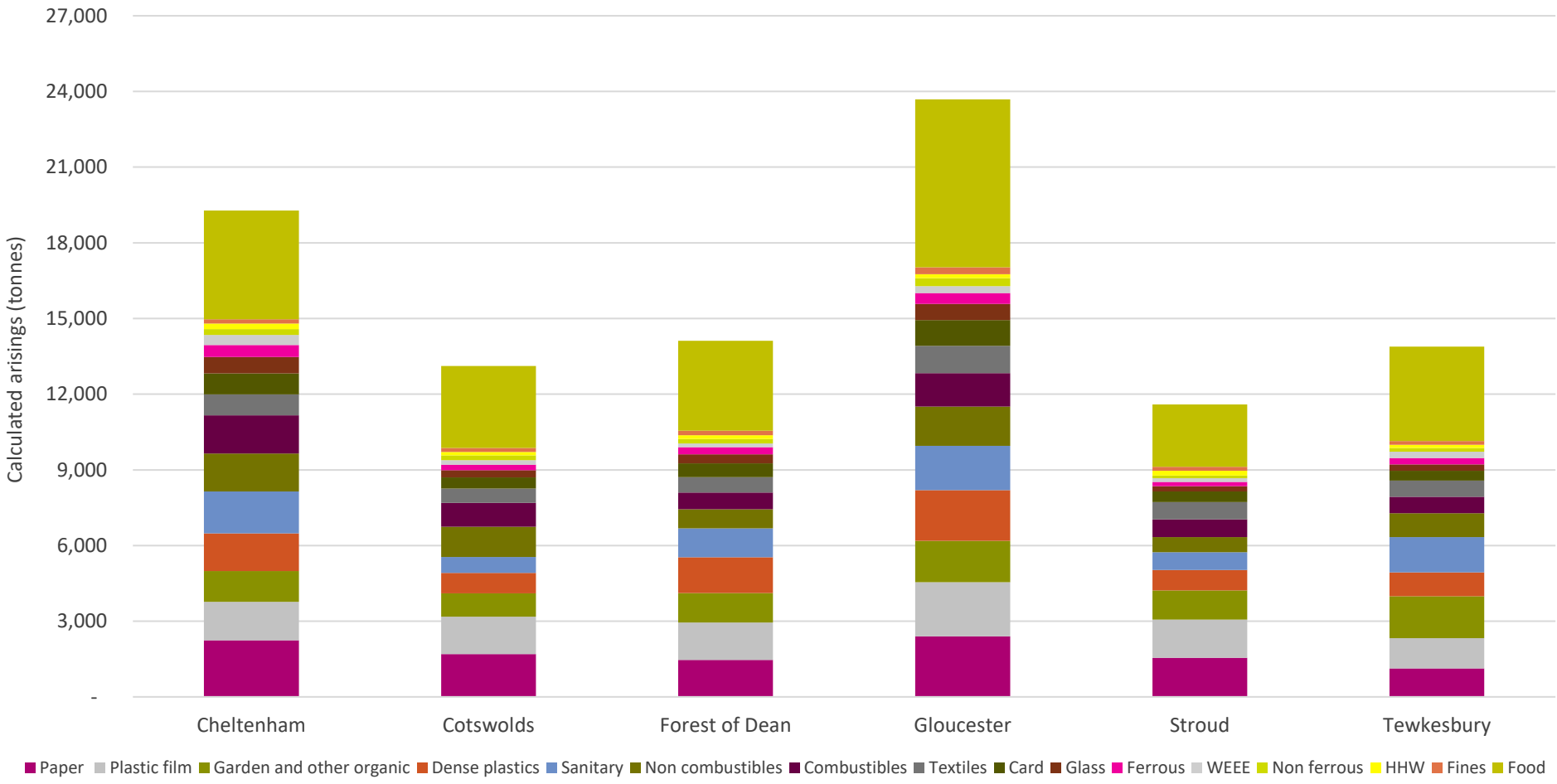

Figure 2: Composition and arising of kerbside household waste per quarter in Gloucestershire by local authority.

4.1.2 Headline composition of kerbside household waste over all four phases

Table 16: Calculated material composition of kerbside household waste in each Gloucestershire local authority (% of calculated annual tonnes)

Category	Cheltenham	Cotswolds	Forest of Dean	Gloucester	Stroud	Tewkesbury	County Average
Paper	11.6%	12.9%	10.4%	10.1%	13.4%	8.1%	11.0%
Card	4.3%	3.4%	3.9%	4.3%	3.6%	2.8%	3.8%
Plastic film	7.9%	11.3%	10.5%	9.1%	13.1%	8.7%	9.8%
Dense plastics	7.8%	6.2%	10.0%	8.5%	7.1%	6.8%	7.8%
Textiles	4.3%	4.3%	4.3%	4.6%	5.9%	4.6%	4.6%
Sanitary	8.6%	4.8%	8.1%	7.4%	6.0%	10.1%	7.6%
Combustibles	7.8%	7.2%	4.7%	5.6%	6.1%	4.7%	6.1%
Non combustibles	7.8%	9.1%	5.3%	6.6%	5.2%	6.8%	6.8%
Glass	3.4%	2.1%	2.5%	2.7%	1.8%	1.8%	2.5%
Ferrous	2.5%	1.7%	2.0%	1.8%	1.5%	1.8%	1.9%
Nonferrous	1.2%	1.5%	1.3%	1.3%	0.9%	1.0%	1.2%
Food waste	22.3%	24.8%	25.2%	28.1%	21.3%	27.0%	25.1%
Garden and other Organic	6.3%	7.1%	8.3%	6.9%	9.9%	12.0%	8.1%
WEEE	2.1%	1.3%	1.1%	1.2%	1.2%	1.8%	1.5%
HHW	1.1%	1.0%	1.0%	0.7%	1.7%	1.0%	1.0%
Fines	0.9%	1.2%	1.3%	1.1%	1.3%	1.0%	1.1%
Total	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**

The composition of kerbside household waste in each Gloucestershire local authority is shown in Table 16 above.

The overall average composition of residual waste in Gloucestershire, based on the weighted combined results for each district, is shown in the figure below.

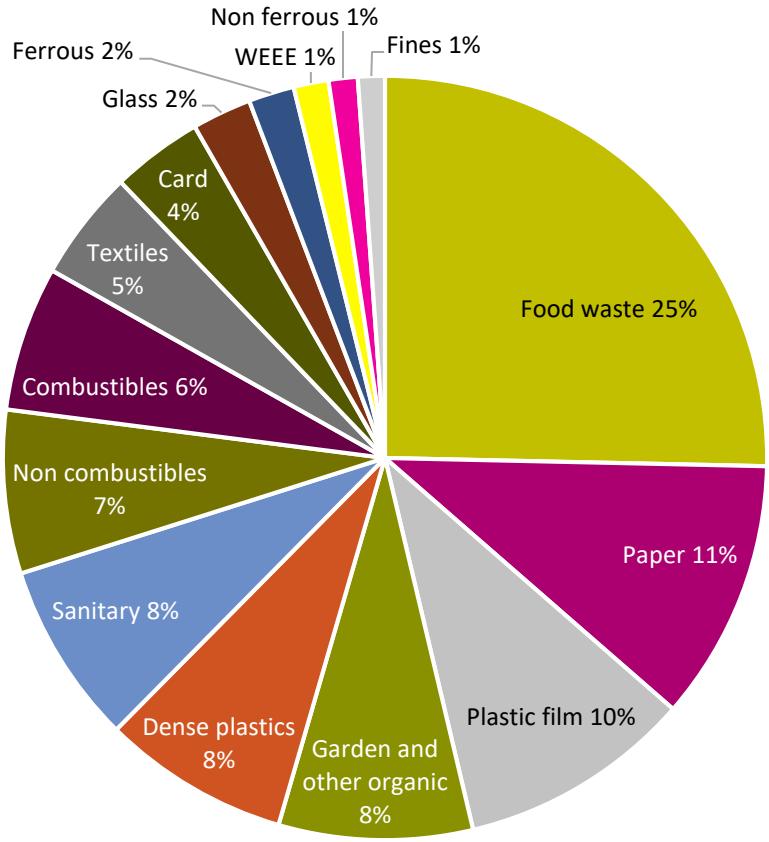

Figure 3: Average percentage composition of kerbside household waste in Gloucestershire

Food waste made up the highest proportion of the kerbside household waste, averaging 25% countywide. A large percentage of this organic waste was avoidable food waste (17%). Paper made up the next highest proportion at 11%, followed by plastic film at 10% and garden and other organic waste at 8%. Dense plastics also made up 8% as did sanitary waste which included nappies.

4.1.3 Kerbside household waste average annual calorific values by material

Table 17: Calculated average calorific value of kerbside household waste by district and material in Megajoules per kilogram (Mj/kg)

Category	Cheltenham	Cotswolds	Forest of Dean	Gloucester	Stroud	Tewkesbury	County CV (Mj/kg)
Paper	9.9	9.8	9.9	9.9	9.9	9.9	9.9
Card	11.4	11.5	11.4	11.3	11.3	11.3	11.4
Plastic film	20.8	20.8	20.9	20.8	20.8	20.9	20.8
Dense plastics	23.8	24.1	23.6	23.8	24.0	23.8	23.8
Textiles	14.3	14.2	14.3	14.3	14.3	14.3	14.3
Sanitary	5.5	5.5	5.5	5.5	5.5	5.5	5.5
Combustibles	15.3	14.6	14.5	14.7	14.5	14.7	14.8
Non combustibles	2.6	2.6	2.6	2.6	2.6	2.6	2.6
Glass	1.4	1.5	1.5	1.6	1.5	1.5	1.5
Ferrous	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Non ferrous	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Food waste	3.5	3.5	3.5	3.5	3.5	3.5	3.5
Garden and other organic	4.0	3.7	3.8	3.9	3.9	3.9	3.9
WEEE	7.1	7.1	7.1	7.1	7.1	7.1	7.1
HHW	7.7	9.8	10.9	10.5	5.1	11.9	9.0
Fines	3.5	3.5	3.5	3.5	3.5	3.5	3.5
Total	**9.0**	**9.1**	**9.4**	**8.9**	**9.7**	**8.3**	**9.0**

The figures in Table 17 provide a summary of the average calorific values for the range of materials making up the headline categories. Average calorific values varied slightly in each district depending on the calorific value of the specific items recorded, for example, combustible items and items of household hazardous waste (HHW) had a greater range of individual calorific values compared to items of food waste.

4.1.4 Summary for annual kerbside household waste, total tonnes, total and average calorific value

The calculated arisings and calorific value of kerbside household waste across Gloucestershire are summarised below.

Table 18: Calculated split of kerbside household waste and CV of household waste in Gloucestershire

Category	County kerbside household waste (tonnes)	County kerbside household waste Net CV per quarter (Total Mj per quarter)	County average kerbside household waste, Net CV for quarter (Mj/kg)
Paper	10,477	103,539,942	9.9
Card	3,655	41,538,131	11.4
Plastic film	9,359	195,001,531	20.8
Dense plastics	7,495	178,691,953	23.8
Textiles	4,432	63,209,194	14.3
Sanitary	7,292	40,325,351	5.5
Combustibles	5,805	85,790,527	14.8
Non combustibles	6,553	16,840,096	2.6
Glass	2,380	3,542,309	1.5
Ferrous	1,832	-	0.0
Nonferrous	1,164	-	0.0
Food waste	23,997	83,029,727	3.5
Garden and other organic	7,768	30,135,350	3.9
WEEE	1,401	9,890,795	7.1
HHW	991	8,912,716	9.0
Fines	1,077	3,747,783	3.5
Total	**95,678**	**864,195,402**	**9.0**

4.2 HRC waste

4.2.1 HRC Composition and total annual arisings

Table 19 and Figure 4 below show the percentage composition of HRC waste in Gloucestershire and total annual tonnages of material.

Table 19: Composition and quarterly arising of HRC waste in Gloucestershire

Category	County HRC waste (tonnes)	Composition
Paper	817	5%
Card	521	3%
Plastic film	578	3%
Dense plastics	2,689	15%
Textiles	1,279	7%
Sanitary	136	1%
Combustibles	6,612	37%
Non combustibles	1,638	9%
Glass	544	3%
Ferrous	499	3%
Non ferrous	61	0%
Organic	1,027	6%
WEEE	414	2%
HHW	578	3%
Fines	264	1%
Total	**17,655**	**100%**

The greatest proportion of the HRC waste was combustible material which makes up 37%. Carpet and underlay were the most significant items in this category, making up 12% of the overall composition followed by soft furniture at 6% of the composition. At headline level, dense plastics were next most common making up 15% of the composition. Other materials categories of note were non-combustibles (9%), textiles (7%), organic waste (6%), paper (5%) and card and plastic film each at 3%.

The composition is presented graphically in Figure 4 below.

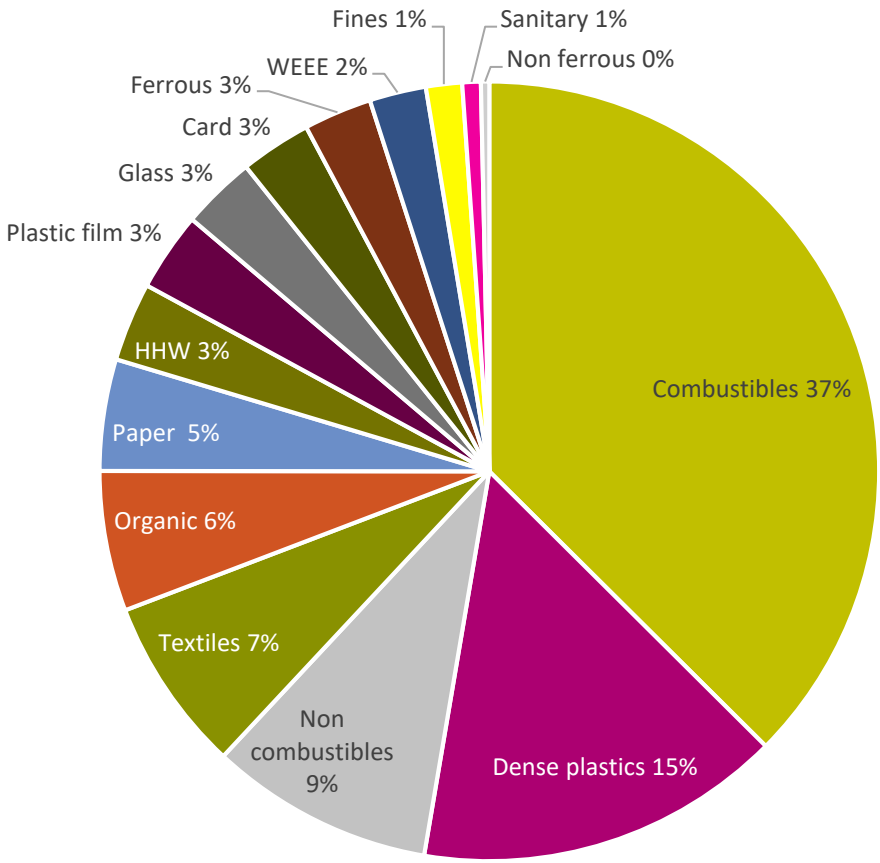

Figure 4: Average annual percentage composition of HRC waste in Gloucestershire.

4.2.2 HRC waste calorific value

The calorific value of HRC waste in Gloucestershire is shown in Table 20 below.

Table 20: Annual tonnes and Net CV of HRC waste in Gloucestershire

Category	County HRC waste (tonnes)	County HRC waste, annual Net CV (Total Mj per quarter)	County HRC waste Net CV for quarter (Mj/kg)
Paper	817	8,041,124	9.8
Card	521	5,842,017	11.2
Plastic film	578	12,188,227	21.1
Dense plastics	2,689	69,579,316	25.9
Textiles	1,279	18,256,033	14.3
Sanitary	136	749,473	5.5
Combustibles	6,612	97,055,502	14.7
Non combustibles	1,638	4,209,741	2.6
Glass	544	874,107	1.6
Ferrous	499	-	0.0
Non ferrous	61	-	0.0
Organic	1,027	3,808,993	3.7
WEEE	414	2,925,950	7.1
HHW	578	7,795,696	13.5
Fines	264	919,141	3.5
Total	**17,655**	**232,245,320**	**13.2**

The average net CV of HRC waste in Gloucestershire across all materials was 13.2 Mj/kg.

4.3 Litter waste

4.3.1 Annual arising and calorific value of litter waste

The annual arising based on waste tonnages and CV value of the waste is shown in Table 21 Figure 5 below.

Table 21: Annual arising and CV of litter waste

Category	County litter waste (tonnes)	Composition	County Litter waste Net CV for quarter (Mj/kg)
Paper	252	7%	10.1
Card	180	5%	11.4
Plastic film	205	6%	21.0
Dense plastics	216	6%	22.7
Textiles	65	2%	14.2
Sanitary	93	3%	5.5
Combustibles	61	2%	14.5
Non combustibles	45	1%	2.6
Glass	399	12%	1.3
Ferrous	39	1%	0.0
Non ferrous	68	2%	0.0
Organic	1,716	51%	3.5
WEEE	17	1%	7.1
HHW	14	0%	12.5
Fines	22	1%	3.5
Total	**3,392**	**100%**	**6.8**

The average annual net CV of litter waste in Gloucestershire across all materials was 6.8 Mj/kg.

4.3.2 Composition of litter

The composition of litter waste in Gloucestershire overall is shown in Figure 5 below.

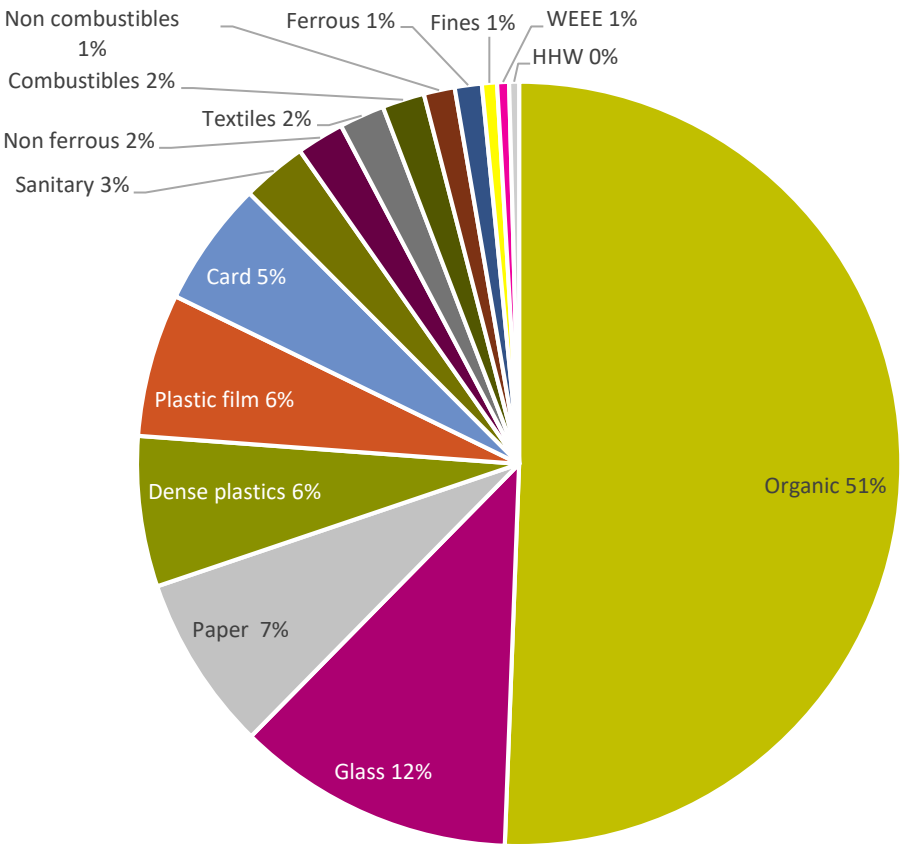

Figure 5: Average percentage composition of litter waste in Gloucestershire.

Just over half of all countywide litter waste was organic material (51%). This consisted of garden waste (1%), food waste (13%) and other organic waste (33%, the majority of which was pet excrement and dead animals). Glass was the next highest constituent at 12% followed by paper (7%) and dense plastics (6%).

4.4 Sweepings waste

Laboratory analysis was carried out to determine the calorific value of the sweeping samples collected across Gloucestershire in each quarter.

The results are shown in **Error! Reference source not found.** below.

Table 22: Calorific value of sweepings in Gloucestershire

Stream	Cheltenham Borough Council	Cotswold District Council	Forest of Dean District Council	Gloucester City Council	Stroud District Council	Tewkesbury Borough Council	Total
Street Sweepings in quarter (tonnes)	787	1,863	364	1,217	1,245	742	**6,219**
Street Sweepings in quarter (kg)	787,340	1,862,520	364,380	1,216,880	1,245,340	742,440	**6,218,900**
Net CV for total tonnage per quarter (Mj)	2,301,985	2,804,024	606,875	3,517,696	1,318,815	288,067	**10,837,462**
Average Net CV for total tonnage per quarter (Mj/kg)	2.9	1.5	1.7	2.9	1.1	0.4	**1.7**

The average net CV of sweepings in Gloucestershire was 1.7 Mj/kg.

4.5 Bulky waste

The calculated quarterly arisings by material and estimated calorific value of bulky waste in Gloucestershire is shown in Table 23 below.

Table 23: Tonnage and CV of bulky waste in Gloucestershire

Category	Total bulky waste (tonnes) INC Gloucester City	Total bulky waste - exc Gloucester City (tonnes)	County bulky total CV (Mj) INC Gloucester City	County bulky total CV- exc Gloucester (Mj)	Average CV by material group Mj/kg INC Gloucester City	Average CV by material group Mj/kg EXC Gloucester City (Mj)
Paper	-	-	-	-	-	-
Card	0	0	913	1,646	11.2	11.2
Plastic film	-	-	-	-	-	-
Dense plastics	15	9	402,283	238,397	26.1	26.1
Textiles	0	0	2,978	2,666	14.3	14.3
Sanitary	-	-	-	-	-	-
Combustibles	1,471	1,048	22,198,012	15,869,592	15.1	15.1
Non combustibles	5	3	13,864	7,637	2.6	2.6
Glass	1	0	895	694	1.6	1.6
Ferrous	26	16	-	-	-	-
Non ferrous	0	0	-	-	-	-
Organic	-	-	-	-	-	-
WEEE	226	134	1,597,120	945,821	7.1	7.1
HHW	-	-	-	-	-	-
Fines	-	-	-	-	-	-
Total	**1,745**	**1,211**	**24,216,065**	**17,066,452**	**13.9**	**14.1**

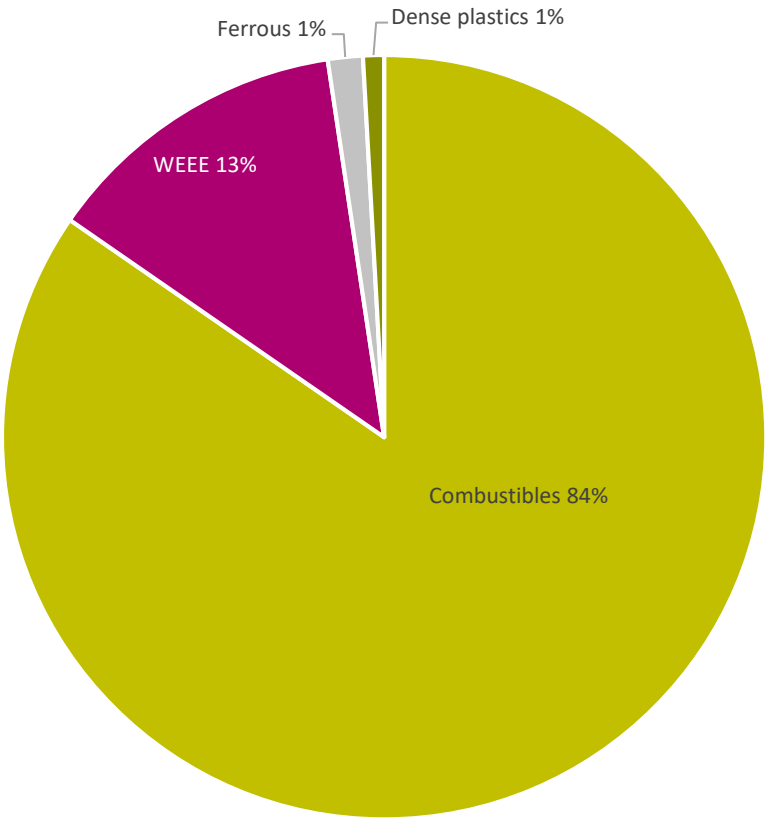

Figure 6: Average composition of bulky waste in Gloucestershire, by percentage weight

Countywide bulky waste was almost solely composed of combustible material (84%) and WEEE (13%). Ferrous metals made up 1% and dense plastics made up 1%.

4.6 Commercial waste

Following the decision from Phase 1 analysis, commercial waste sampling and analysis was not carried out in the following three phases due to small arisings. In the first phase this work was only undertaken in Cheltenham which has a commercial waste service.

4.7 Combined residual waste streams over all phases

The calorific value of all residual wastes was calculated for the whole county for the four analysis quarters. The split of residual waste and estimated total calorific value were calculated by material type. The combined estimated calorific values of the materials making up the waste streams which will be treated at the new Javelin Park energy from waste facility are given below in Table 24.

The figures include those calculated for Gloucester City's bulky waste; the total calorific value would be around 7 million mega joules less if excluded.

Sweepings waste gathered by mechanical sweepers in each district was not sorted into material categories and so is presented as a separate category.

Table 24: Combined waste quarterly arising and CV

Category	Total residual waste (tonnes)	County residual waste composition % weight	Calorific value (Total Mj per quarter)	Average Calorific value (Mj/kg)
Paper	11,546	9%	114,127,725	9.9
Card	4,355	3%	49,436,324	11.4
Plastic film	10,142	8%	211,501,867	20.9
Dense plastics	10,415	8%	253,563,657	24.3
Textiles	5,776	5%	82,390,818	14.3
Sanitary	7,521	6%	41,590,549	5.5
Combustibles	13,949	11%	205,920,217	14.8
Non combustibles	8,241	7%	21,178,092	2.6
Glass	3,324	3%	4,955,945	1.5
Ferrous	2,395	2%	-	-
Non ferrous	1,293	1%	-	-
Organic	34,509	28%	122,947,933	3.6
WEEE	2,059	2%	14,534,755	7.1
HHW	1,583	1%	16,886,656	10.7
Fines	1,363	1%	4,742,006	3.5
Sweepings (mechanical)	6,219	5%	10,837,462	1.7
Total	**124,689**	**100%**	**1,154,614,005**	**9.3**

The calculated average calorific value of all residual waste streams across Gloucestershire was 9.3 mj/kg.

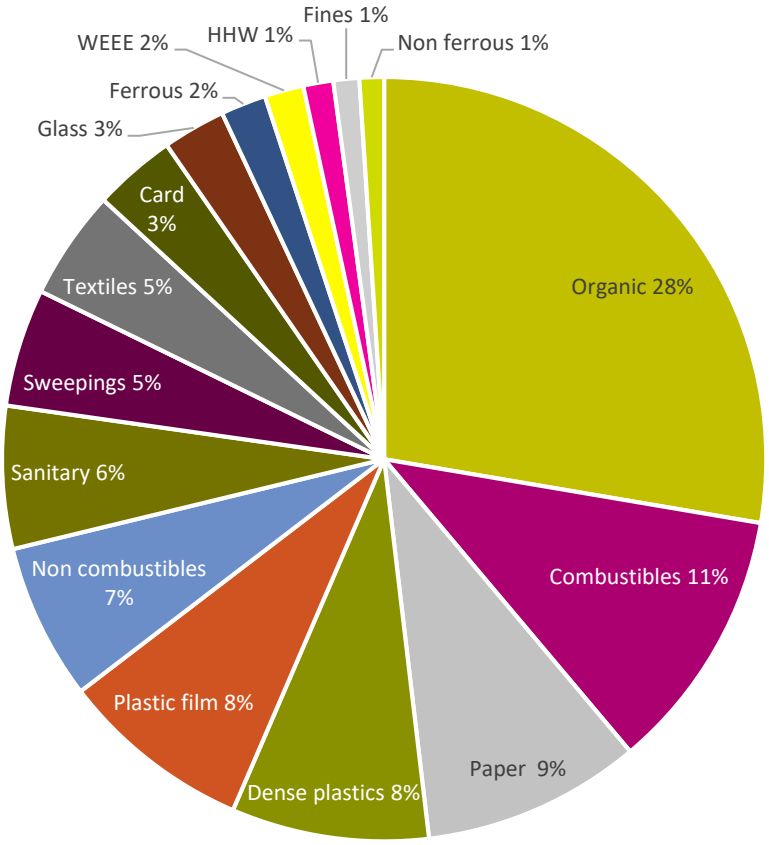

Figure 7: Average composition of total residual waste from all waste streams in Gloucestershire, by percentage weight

Organic material made up 28% of the countywide residual waste from the different streams in all four phases analysed in this study. Organic waste included avoidable food waste (14%), other food waste (6%) and other organic waste (4%, the majority of which was pet excrement and dead animals) and garden waste (3%). Combustibles were the next highest constituent at 11% followed by paper (9%) and dense plastics and plastic films each at 8%.

Appendix A

A.1 Waste sort categorisation and descriptions

Category	Description	
Paper	Newspapers	all newspapers
	Magazines	magazines, pamphlets, glossy junk mail
	Other recyclable paper	household/office paper, envelopes, books, catalogues, directories
	Non-recyclable paper	tissues and wipes, wallpaper, photo paper
Card	Corrugated Card	large boxes and cardboard sheets
	Thin card	cereal boxes, tea boxes, greeting cards
	Tetra packs	juice boxes, UHT milk
	Non-recyclable card	coffee cups, takeaway trays, lids
Plastic film	Carrier bags	
	Refuse/recycling sacks	
	wet wipes (plastic based)	
	Other film	bubble wrap, bread bags, crisp packets
Dense plastics	Plastic bottles	all types
	Plastic tubs, trays and pots	all types
	Other dense plastics	toys, pipes. Pvc, plastic furniture
Textiles	Reusable textiles	undamaged, unsoiled
	Non reusable textiles, inc rags	damaged or soiled items
	Filled textiles	duvets, pillows, cuddly toys etc
	Shoes and accessories	
Sanitary	Disposable nappies	
	Other sanitary	puppy pads, feminine absorption products
Combustibles	Furniture (wooden)	tables, chairs, shelves
	Mattresses	all sizes and constructions
	Soft furniture	sofas armchairs
	Other wood	wood packaging, fencing,
	Carpet and Underlay	
	DIY waste	combustible only e.g. lagging, roof felt
	Other combustibles	
Non combustibles	Rubble, ceramics, plaster, bricks,	
	Soil	
	Inorganic pet litter	clay cat litter
Glass	Green bottles	
	Clear bottles	
	Brown bottles	
	Jars	
	Non packaging glass	pane glass, drinking glasses
Ferrous	Food and drink cans	
	Aerosols	
	Other ferrous	pans, tools, cutlery, pipes, metal furniture
Nonferrous	Drinks cans	
	Aerosols	
	Alu foil	
	Other non-ferrous	pans, tools, cutlery, pipes, nonferrous furniture
Organic	Garden waste	
	Avoidable food waste	cooked and prepared meals, whole fruit, veg, fruit&veg flesh, whole coffee products, unused teabags, cakes, bread slices, whole loafs, rolls, unused oils, marge/butter, confectionary, condiments, meat & fish cooked and raw.

Category	Description	
	Possible avoidable food waste	bread crusts and end slices, fat from meat, fish skin; apply, citrus, plum, peach peel; carrot, potato, courgette, tomato peel; mushroom caullie, broccoli stalks; herb stalks, used cooking oil; pie, pizza, sandwich crusts.
	Unavoidable food waste	bones, gristle, cheese wax, nut shells, fruit stones; pineapple, banana, avocado, melon skin, fruit cores, fruit stalks, tops and stalks of veg except broccoli, caullie, mushrooms, garlic/ginger/onion peel, teabags, coffee grounds, eggshells, sprouting potato
	Pet bedding (organic)	straw and bedding from herbivorous pets
	Other organic	dead animals, excrement
	Liquid food and drink	
WEEE	White goods	
	Large electronic goods (exc CRT	
	CRT TVs and monitors	
	Mobile phones	
	Other WEEE	
HHW	Batteries	
	Clinical waste	
	Paint/varnish, oil, household	
Fines	Fines <10mm	

Appendix B

B.1 Phase 1 daily summary of samples by residual waste stream

Table 25: Kerbside household waste and litter waste samples which were collected and sorted during the first two weeks of phase 1 fieldwork

		Week 1						Week 2				
Day	Waste stream	Mon	Tue	Wed	Thur	Fri		Mon	Tue	Wed	Thur	Fri
Date		18/06/18	19/06/18	20/06/18	21/06/18	22/06/18		25/06/18	26/06/18	27/06/18	28/06/18	29/06/18
Cheltenham	**Kerbside household waste samples collected**								50	50	50	
Cotswold												
Forest of Dean (FoD)				50	50	50						
Gloucester												
Stroud												
Tewkesbury		50	50					50				
Cheltenham	**Litter samples collected**								1			
Cotswold										1		
Forest of Dean (FoD)		1										
Gloucester												1
Stroud												1
Tewkesbury				1								

Table 26: Kerbside household waste and HRC waste samples collected and sorted during the final weeks of phase 1 fieldwork

		Week 3						Week 4				
Day		Mon	Tue	Wed	Thur	Fri		Mon	Tue	Wed	Thur	Fri
Date		16/07/18	17/07/18	18/07/18	19/07/18	20/07/18		23/07/18	24/07/18	25/07/18	26/07/18	27/07/18
Cheltenham	**Kerbside household waste samples collected**											
Cotswold										50	50	50
Forest of Dean (FoD)												
Gloucester						50		50	50			
Stroud			50	50	50							
Tewkesbury												
		HRC samples delivered						**HRC samples delivered**				
Cheltenham	**Litter samples collected**											
Cotswold												
Forest of Dean (FoD)												
Gloucester												
Stroud												

		Week 3						Week 4				
Day		Mon	Tue	Wed	Thur	Fri		Mon	Tue	Wed	Thur	Fri
Date		16/07/18	17/07/18	18/07/18	19/07/18	20/07/18		23/07/18	24/07/18	25/07/18	26/07/18	27/07/18
Tewkesbury												

Table 27: Street sweepings samples in phase 1

Week 5					
Day	Mon	Tue	Wed	Thur	Fri
Date	30/07/18	31/07/18	01/08/18	02/08/18	03/08/18
WCA	**Street sweeping samples collected**				
Cheltenham			1		
Cotswold		1			
Forest of Dean	1				
Gloucester				1	
Stroud				1	
Tewkesbury			1		

B.2 Phase 2 daily summary of samples by residual waste stream

Table 28: Kerbside household waste and litter waste samples collected and sorted during the first two weeks of phase 2 fieldwork

	Week 1						Week 2				
Day	Mon	Tue	Wed	Thur	Fri		Mon	Tue	Wed	Thur	Fri
Date	05/11/18	06/11/18	07/11/18	08/11/18	09/11/018		12/11/18	13/11/18	14/11/18	15/11/18	16/11/18
District	**Kerbside household waste collected**						**Kerbside household waste collected**				
Cheltenham								**50**	**50**	**50**	
Cotswold									**50**	**50**	**50**
Forest of Dean (FoD)			**50**	**50**	**50**						
Gloucester					**50**		**50**	**50**			
Stroud		**50**	**50**	**50**							
Tewkesbury	**50**	**50**					**50**				
	Litter samples collected						**Litter samples collected**				
Cheltenham			**1**								
Cotswold											**1**
Forest of Dean (FoD)	**1**										
Gloucester									**1**		
Stroud							**1**				
Tewkesbury		1									

Table 29: HRC waste samples collected and sorted during the third and fourth week of phase 2 fieldwork

	Week 3						Week 4				
Day	Mon	Tue	Wed	Thur	Fri		Mon	Tue	Wed	Thur	Fri
Date	19/11/18	20/11/18	21/11/18	22/11/18	23/11/018		26/11/18	27/11/18	28/11/18	29/11/18	30/11/18
District	**HRC samples delivered**						**HRC samples delivered**				
Cheltenham											
Cotswold											
Forest of Dean (FoD)											
Gloucester											
Stroud											
Tewkesbury											

Table 30: Street sweepings samples collected during phase 2

Week 5					
Day	Mon	Tue	Wed	Thur	Fri
Date	19/11/18	20/11/18	21/11/18	22/11/18	23/11/18
WCA	**Street sweeping samples collected**				
Cheltenham			1		
Cotswold		1			
Forest of Dean			1		
Gloucester		1			
Stroud		1			
Tewkesbury			1		

B.3 Phase 3 daily summary of samples by residual waste stream

Table 31: Kerbside household waste and litter waste samples collected and sorted during the second and third week of phase 3 fieldwork

	Week 2						Week 3				
Day	Mon	Tue	Wed	Thur	Fri		Mon	Tue	Wed	Thur	Fri
Date	28/01/2019	29/01/2019	30/01/2019	31/01/2019	01/02/2019		04/02/2019	05/02/2019	06/02/2019	07/02/2019	08/02/2019
District	**Kerbside household waste collected**						**Kerbside household waste collected**				
Cheltenham								**50**	**50**	**50**	
Cotswold									**50**	**50**	**50**
Forest of Dean (FoD)			**50**	**50**	**50**						
Gloucester					**50**		**50**	**50**			
Stroud		**50**	**50**	**50**							
Tewkesbury	**50**	**50**					**50**				
	Litter samples collected						**Litter samples collected**				
Cheltenham			**1**								
Cotswold									**1**		
Forest of Dean (FoD)	**1**										
Gloucester									**1**		
Stroud							**1**				
Tewkesbury		1									

Table 32: HRC waste samples collected and sorted during the first and fourth week of phase 3 fieldwork

	Week 1						Week 4				
Day	Mon	Tue	Wed	Thur	Fri		Mon	Tue	Wed	Thur	Fri
Date	21/01/2019	22/01/2019	23/01/2019	24/01/2019	25/01/2019		11/02/2019	12/02/2019	13/02/2019	14/02/2019	15/02/2019
District	**HRC samples delivered**						**HRC samples delivered**				
Cheltenham											
Cotswold											
Forest of Dean (FoD)											
Gloucester											
Stroud											
Tewkesbury											

Table 33: Street sweepings samples collected in phase 3

Week 5					
Day	**Mon**	**Tue**	**Wed**	**Thur**	**Fri**
Date	**11/02/2019**	**12/02/2019**	**13/02/2019**	**14/02/2019**	**15/02/2019**
WCA	**Street sweeping samples collected**				
Cheltenham		**1**			
Cotswold			**1**		
Forest of Dean		**1**			
Gloucester			**1**		
Stroud			**1**		
Tewkesbury		**1**			

B.4 Phase 4 daily summary of samples by residual waste stream

Table 34: Kerbside household waste and litter waste samples collected and sorted during the third and fourth week of phase 4 fieldwork

	Week 3						**Week 4**				
Day	Mon	Tue	Wed	Thur	Fri		Mon	Tue	Wed	Thur	Fri
Date	13/05/2019	14/05/2019	15/05/2019	16/05/2019	17/05/2019		20/05/2019	21/05/2019	22/05/2019	23/05/2019	24/05/2019
District	**Kerbside household waste collected**						**Kerbside household waste collected**				
Cheltenham		**50**	**50**	**50**							
Cotswold			**50**	**50**	**50**						
Forest of Dean (FoD)									**50**	**50**	**50**
Gloucester	**50**	**50**									**50**
Stroud								**50**	**50**	**50**	
Tewkesbury	**50**						**50**	**50**			
	Litter samples collected						**Litter samples collected**				
Cheltenham		1									
Cotswold				1							
Forest of Dean (FoD)										**1**	
Gloucester			1								
Stroud									1		
Tewkesbury								**1**			

Table 35: HRC waste samples collected and sorted during the first, second and fifth week of phase 4 fieldwork

	Week 1						Week 2				Week 5	
Day	Mon	Tue	Wed	Thur	Fri		Wed	Thur	Fri		Wed	Thur
Date	29/04/2019	30/04/2019	01/05/2019	02/05/2019	03/05/2019		08/05/2019	09/05/2019	10/05//20199		29/05/2019	30/05/2019
District	**HRC samples delivered**						**HRC samples delivered**				**HRC samples delivered**	
Cheltenham												
Cotswold												
Forest of Dean (FoD)												
Gloucester												
Stroud												
Tewkesbury												

Table 36: Street sweeping samples gathered in phase 4

Week 5					
Day	**Mon**	**Tue**	**Wed**	**Thur**	**Fri**
Date	**20/05/19**	**21/05/19**	**22/05/19**	**23/05/19**	**24/05/19**
WCA	**Street sweeping samples collected**				
Cheltenham			**1**		
Cotswold		**1**			
Forest of Dean			**1**		
Gloucester		**1**			
Stroud		**1**			
Tewkesbury			**1**		

Appendix C

C.1 WRATE calorific values applied to the waste sort categories

Composition sort categories		Net CV (MJ/kg)	Moisture (%)
Paper	Newspapers	12.01	25.57
	Magazines	9.97	11.3
	Other recyclable paper	9.73	25.45
	Non-recyclable paper	9.73	25.45
Card	Corrugated Card	11.18	26.73
	Thin card	11.18	26.73
	Tetra packs	12.64	27.52
	Non-recyclable card	11.61	24.15
Plastic film	Carrier bags	21.28	23.82
	Refuse/recycling sacks	21.28	23.82
	Wet wipes	14.06	18.07
	Other film	21.28	29.77
Dense plastics	Plastic bottles	19.88	7.06
	Plastic tubs, trays and pots	22.92	16.82
	Other dense plastics	26.1	6.07
Textiles	Reusable textiles	14.33	19.12
	Non reusable textiles, inc rags	14.33	19.12
	Filled textiles	14.33	19.12
	Shoes and accessories	14.06	18.07
Sanitary	Disposable nappies	5.53	62.88
	Other sanitary	5.53	62.88
Combustibles	Furniture (wooden)	16.84	9.6
	Mattresses	10.53	9.6
	Soft furniture	16.84	9.6
	Other wood	16.84	9.6
	Carpet and Underlay	14.06	18.07
	DIY waste	14.06	18.07
	Other combustibles	14.06	18.07
Non combustibles	Rubble, ceramics, plaster, bricks,	2.57	5.56

Composition sort categories		Net CV (MJ/kg)	Moisture (%)
	Soil	2.57	5.56
	Inorganic pet litter	2.57	5.56
Glass	Green bottles	0.96	0.36
	Clear bottles	1.69	2.32
	Brown bottles	1.27	0.93
	Jars	1.51	3.87
	Non packaging glass	1.64	0.84
Ferrous	Food and drink cans	0	12.26
	Aerosols	0	3.47
	Other ferrous	0	3.47
Non ferrous	Drinks cans	0	12.26
	Aerosols	0	10.39
	Alu foil	0	30.45
	Other non-ferrous	0	10.39
Organic	Garden waste	4.21	57.98
	Avoidable food waste	3.46	62.75
	Possible avoidable food waste	3.46	62.75
	Unavoidable food waste	3.46	62.75
	Pet bedding (organic)	4.21	57.98
	Other organic	3.46	62.75
	Liquid food and drink	3.46	100
WEEE	White goods	7.06	10.11
	Large electronic goods (exc CRT TVs)	7.06	10.11
	CRT TVs and monitors	7.06	10.11
	Mobile phones	7.06	10.11
	Other WEEE	7.06	10.11
HHW	Batteries	0	10.39
	Clinical waste	2.57	5.56
	Paint/varnish, oil, household chemicals	14.06	18.07
Fines	Fines <10mm	3.48	40.99

Appendix D Secondary category level kerbside composition analysis results

D.1 Kerbside household waste composition at subcategory level (% weight)

Category	Subcategory	Cheltenham	Cotswolds	Forest of Dean	Gloucester	Stroud	Tewkesbury	County average
Paper	Newspapers	0.7%	0.4%	0.9%	0.6%	0.7%	0.5%	0.6%
	Magazines	1.7%	1.5%	0.8%	1.0%	1.1%	0.6%	1.1%
	Other recyclable paper	2.1%	3.0%	1.8%	2.0%	2.6%	1.3%	2.1%
	Non-recyclable paper	7.1%	8.1%	6.9%	6.6%	9.1%	5.7%	7.1%
Card	Corrugated Card	0.9%	0.4%	0.6%	0.8%	0.3%	0.4%	0.6%
	Thin card	2.2%	1.8%	2.3%	2.5%	2.6%	1.7%	2.2%
	Tetra packs	0.4%	0.4%	0.4%	0.2%	0.2%	0.1%	0.3%
	Non-recyclable card	0.8%	0.8%	0.6%	0.8%	0.5%	0.6%	0.7%
Plastic film	Carrier bags	0.8%	1.1%	0.9%	1.2%	1.2%	0.8%	1.0%
	Refuse/recycling sacks	0.9%	1.0%	1.3%	1.1%	1.2%	0.9%	1.1%
	Wet wipes	0.5%	0.8%	0.5%	0.6%	0.8%	0.5%	0.6%
	Other film	5.7%	8.5%	7.7%	6.1%	9.9%	6.5%	7.1%
Dense plastics	Plastic bottles	1.2%	0.8%	1.4%	1.4%	0.8%	1.1%	1.1%
	Plastic tubs, trays and pots	3.2%	2.3%	5.1%	3.4%	3.1%	2.8%	3.3%
	Other dense plastics	3.4%	3.1%	3.5%	3.7%	3.2%	2.9%	3.4%
Textiles	Reusable textiles	1.7%	1.0%	1.1%	1.5%	1.7%	1.3%	1.4%
	Non reusable textiles, inc rags	1.3%	1.5%	1.6%	1.5%	2.3%	1.6%	1.6%
	Filled textiles	0.3%	0.4%	0.4%	0.4%	0.7%	0.6%	0.5%
	Shoes and accessories	1.1%	1.4%	1.2%	1.2%	1.3%	1.1%	1.2%
Sanitary	Disposable nappies	7.8%	4.0%	7.0%	6.8%	4.8%	9.4%	6.8%
	Other sanitary	0.8%	0.9%	1.1%	0.6%	1.2%	0.7%	0.8%
Combustibles	Furniture (wooden)	0.4%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%
	Mattresses	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Soft furniture	0.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%
	Other wood	2.3%	1.3%	0.8%	1.2%	0.9%	1.0%	1.3%
	Carpet and Underlay	0.8%	0.4%	0.3%	0.7%	0.5%	0.3%	0.5%
	DIY waste	0.1%	1.0%	0.2%	0.4%	0.1%	0.2%	0.3%
	Other combustibles	3.5%	4.4%	3.3%	3.2%	4.6%	3.2%	3.6%
Non combustibles	Rubble, ceramics, plaster, bricks,	3.1%	4.6%	2.6%	2.4%	3.3%	2.2%	2.9%
	Soil	0.7%	0.9%	0.2%	1.3%	0.3%	0.8%	0.8%
	Inorganic pet litter	4.0%	3.6%	2.5%	2.9%	1.5%	3.8%	3.1%
Glass	Green bottles	0.8%	0.3%	0.3%	0.2%	0.1%	0.2%	0.3%
	Clear bottles	0.5%	0.4%	0.5%	1.1%	0.2%	0.3%	0.6%
	Brown bottles	0.4%	0.2%	0.3%	0.2%	0.2%	0.1%	0.3%
	Jars	0.7%	0.5%	0.7%	0.6%	0.5%	0.6%	0.6%
	Non packaging glass	0.9%	0.8%	0.7%	0.6%	0.8%	0.6%	0.7%
Ferrous	Food and drink cans	0.6%	0.5%	0.6%	0.6%	0.4%	0.4%	0.5%
	Aerosols	0.1%	0.1%	0.2%	0.1%	0.1%	0.1%	0.1%
	Other ferrous	1.7%	1.2%	1.2%	1.1%	1.0%	1.3%	1.3%

Category	Subcategory	Cheltenham	Cotswolds	Forest of Dean	Gloucester	Stroud	Tewkesbury	County average
Nonferrous	Drinks cans	0.2%	0.2%	0.2%	0.3%	0.1%	0.3%	0.2%
	Aerosols	0.1%	0.1%	0.2%	0.2%	0.1%	0.1%	0.1%
	Alu foil	0.7%	1.0%	0.8%	0.7%	0.6%	0.6%	0.7%
	Other non-ferrous	0.2%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%
Organic	Garden waste	3.8%	1.8%	1.6%	2.6%	3.3%	4.2%	2.9%
	Avoidable food waste	15.5%	17.2%	17.4%	18.9%	15.7%	19.4%	17.4%
	Possible avoidable food waste	2.0%	2.4%	2.3%	3.3%	1.7%	2.5%	2.5%
	Unavoidable food waste	4.2%	4.8%	4.2%	5.0%	3.6%	4.0%	4.4%
	Pet bedding (organic)	0.7%	0.9%	1.7%	1.8%	2.1%	3.0%	1.7%
	Other organic	1.9%	4.3%	5.0%	2.5%	4.6%	4.8%	3.6%
	Liquid food and drink	0.7%	0.4%	1.3%	0.9%	0.4%	1.1%	0.8%
WEEE	White goods	0.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%
	Large electronic goods (exc CRT TVs)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	CRT TVs and monitors	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Mobile phones	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Other WEEE	1.7%	1.3%	1.1%	1.2%	1.2%	1.8%	1.4%
HHW	Batteries	0.2%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%
	Clinical waste	0.4%	0.2%	0.1%	0.0%	1.1%	0.1%	0.3%
	Paint/varnish, oil, household chemicals	0.5%	0.7%	0.8%	0.5%	0.4%	0.8%	0.6%
Fines	Fines <10mm	0.9%	1.2%	1.3%	1.1%	1.3%	1.0%	1.1%
Total		**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**