

# **Organics Characterization Report**







April 2015 FINAL



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# 1. Introduction and Summary

In 2014, the King County Solid Waste Division (SWD) completed a characterization study of the singlefamily organics collection program as part of the County's ongoing waste monitoring program.

The composition and quantity data in this report provide the following information:

- The composition of material collected from organics routes throughout King County.
- The proportion of subscribers setting out an organics cart for collection.
- The proportion of carts that contain food scraps.
- The average quantity of food scraps set out by each household.

The Solid Waste Division contracted with Cascadia Consulting Group, Inc. (Cascadia) to collect and handsort 960 samples of organics over four seasons (winter, spring, summer, and fall) from King County single-family collection routes. Each season was broken into two sampling events — one each in March, April, May, July, August, October, November, and December of 2014. Cascadia sorted samples into 27 material types, described in detail in Appendix A: Material Type Definitions.

In 2014, the haulers delivered approximately 162,594 tons to Cedar Grove for composting from single-family residences in King County. The characterization results are summarized in Figure 1 and Figure 2.

#### **Key Findings**

- Composition
  - The majority of material collecte 88%) was *yard debris.*
  - Food and Compostable Paper cc almost 9% of curbside single-fan
- Set-outs
  - Approximately 52% of househole to organics service set out organ
  - Over half (52%) of set-outs conta
- Participation
  - About 27% of subscribing house all King County households, plac their organics carts.

#### Quantities

- The average food scraps particip 33 pounds of food scraps and co
- Capture rates
  - The King County household capture rate for food scraps and compostable paper was almost 15%.
  - An estimated 67% of the food scraps and compostable paper generated by food scraps participants was collected in their organics service cart instead of being disposed.









Figure 2. Summary of Key Findings and Definitions

A **household** is a single family customer to whom organics service is available. A **subscriber** is a household that pays an additional fee for organics service or is in a city where organics service is embedded in the garbage rate. A **set-out** is an organics service container placed at the curb/alley for pick up by the collection company. A food scraps **participant** is a household that includes food scraps in their organics service container.

The rate data as well as the food scraps and compostable paper collection data detailed throughout the report is summarized in Table 1.

	Subscription Rate	Set-out Rate	Food Scraps Participation Rate Paper/Month		Capture Rate
Household	72%	37%	19%	7.2	14.7%
Subscriber	100%	52%	27%	10.0	20.4%
Set-out	100%	100%	52%	19.4	39.5%
Food Scraps Participant	100%	100%	100%	32.7	66.6%

#### Table 1. Rate and Collection Data Summary

In 2011, food scraps and compostable paper accounted for nearly 42% of the single family residential disposal in King County making them important targets in King County's push to reach a 70% diversion rate by 2030.<sup>1</sup> Since 2009 the household capture rate in King County for food scraps and compostable paper has increased from 11.9% to 14.7% (Table 2) but this trend will need to accelerate if the County is to reach its diversion goal.

#### Table 2. Household Food Scraps and Compostable Paper Capture Rate

	2009	2011	2014
Household Capture Rate	11.9%	13.1%	14.7%

<sup>&</sup>lt;sup>1</sup> Based on the information in the 2011 King County Waste Characterization and Customer Survey Report.



The remainder of this report describes the study methodology and findings, and is organized as follows:

- Section 2. Summary of Methodology explains the methodology used to design and implement the data collection portion of this study.
- Section 3. Findings presents the organics composition and rates results.
- Appendices follow the main body of the report. They provide definitions for all material types, a complete explanation of the methodology, the formulas used in the characterization calculations, and copies of field forms.



# 2. Summary of Methodology

The following section summarizes the three main steps of the study methodology and highlights the revisions in the methodology from previous studies.

## **Develop Plan**

Before scheduling the fieldwork, the consultant team met with key staff at the SWD, representatives from the haulers, and sorting facility staff to define the study universe, schedule field seasons, develop field protocols, and discuss sort location logistics.

The study "universe" included all King County cities and unincorporated areas (excluding Seattle) where combined food scraps and yard debris collection service is offered. The list of included cities is shown in Table 3. The universe includes only routes primarily serving single family residences.

Has Organics Service					
Algona Hunts Point Renton					
Auburn	Issaquah	Sammamish			
Beaux Arts	Kenmore	SeaTac			
Bellevue	Kent	Shoreline			
Black Diamond	Kirkland	Snoqualmie			
Bothell	Lake Forest Park	Tukwila			
Burien	Maple Valley	Woodinville			
Carnation	Medina	Yarrow Point			
Clyde Hill	Mercer Island	Unincorporated County (except as noted			
Covington	Newcastle	below)			
Des Moines Normandy Park		Does Not Have Organics Service			
Duvall	North Bend	Town of Skykomish			
Enumclaw	Pacific	Unincorporated County-Vashon Island,			
Federal Way Redmond Snoqualmie Pass, and Skykomish area		Snoqualmie Pass, and Skykomish area			

#### Table 3. Cities and Regions With and Without Organics Service

This study includes several unique terms and definitions. Definitions for these terms are provided below.

- King County—Refers to King County, excluding Seattle.
- Organics Service—For the purposes of this study, organics service only includes franchised curbside/alley programs where residents are permitted to include food scraps in the organics service cart.
- Households—A household is a single family customer to whom organics service is available. Ninety nine percent of all single family residences in King County have organics service available to them.
- Subscriber—A subscriber is a household that pays an additional fee for organics service or is a household in a city where organics service is embedded in the garbage collection rate.



- Set-out—A set-out is an organics service container placed at the curb/alley for pick-up by the collection company. It is important to distinguish between a subscriber (a household that pays an additional fee for organics service or has organics service embedded in their garbage collection rates) and a set-out (where the resident uses the service and literally "sets out" the container for collection).
- **Food Scraps Participant**—A food scraps participant is a household that places at least some food scraps in their organics service container.

The consultant team also worked with SWD staff to identify material types and definitions for this study. The 27 material types are grouped into four material classes: **Food**, **Compostable Paper, Other Compostable,** and **Contaminants**. See Appendix A: Material Type Definitions for a complete list of the material types and detailed definitions.

Five routes per day were randomly selected for sampling. Each sampling event consisted of two days of sampling, and

#### **Material Designations**

Throughout this report, **Material Classes** such as **Food** and **Compostable Paper** are bolded and capitalized, while specific material types such as *dairy* and *pizza boxes* are italicized.

each season consisted of two sampling events, for a total of four sampling days each season. In most cases, the same routes were used for all four seasons. A route in Burien had a change of hauler after two seasons; in that case, the route was replaced with a similar route used by the new hauler. For each of the selected routes, the haulers provided the subscriber count and a map showing the route boundaries. The selected routes are summarized in Table 4.

Monday		Tuesday		
Hauler	Jurisdiction	Hauler	Jurisdiction	
Republic Services	Bellevue	Republic Services	Sammamish	
Republic Services	Kent	Republic Services	Bellevue	
Waste Management	Redmond	Republic Services	Petrovitsky Road UTC	
Waste Management	Renton	Republic Services	Covington	
Waste Management (replaced)	Burien	Waste Management	Bothell/Kirkland/Woodinville	
CleanScapes (replacement)	Burien			

Table 4.	Routes	Selected	for	Sampling
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Wednesday				
Hauler	Jurisdiction			
Republic Services	Kent			
Waste Management	Kirkland			
Waste Management	Renton			
Waste Management	Auburn			
CleanScapes	Shoreline			

Waste Management	Bothen/ Kirkiana/ Woodinvine		
Thursday			
Hauler	Jurisdiction		
Republic Services	Clyde Hill/Medina		
Republic Services	Mercer Island		
Republic Services	Petrovitsky Road UTC		
Republic Services	Kent		

#### Collect Data

On Monday, Tuesday, Wednesday, and Thursday during each of the field seasons, route surveyors, using route maps provided by the haulers, traversed the selected routes ahead of the regular collection vehicles to count the number of set-outs on each route and collect samples. The route surveyors

Waste Management



Unincorporated South

counted more than 30,000 set-outs over four seasons and collected 960 samples. The route surveyors transported samples to Shoreline Transfer Station (Shoreline) for hand sorting.

The average sample weighed approximately 58 pounds. The field crew sorted each sample into 27 material types; each material type was weighed independently. The crew leader recorded the weight for each sorted material type on the sampling form, reviewed the form, and later entered the data into a custom database for analysis. A full description of the hand-sort procedure is included in Appendix B: Study Design.

## Analyze Data

Following on-site data collection, the consultant team entered all data recorded on field forms into a customized database and reviewed it for data entry errors. The team calculated organics composition and quantity estimates using the methods described in Appendix D: Calculations.

#### Changes to the Methodology from Previous Studies

The objectives and methodologies of the current study and the 2011 study are very similar. There are two changes to note: first, the number of sampling days was increased, and second, the material list was updated.

- In 2011, sampling was completed over three field work periods of four days each for a total of 12 sampling days. In 2014, the sampling was completed over eight field periods of two days each for a total of 16 sampling days. The eight sampling periods were each separated by approximately one month. This change was made to better capture any seasonal variation in set-out rate, food scraps participation rate, sample size, and sample composition.
- The material list for this study included nine additional material types compared to the 2011 study. The increase in material types was meant to produce three new types of material data. First, the *purchased fruits and vegetables* and *meat* categories were split into *fruits and vegetables edible, fruits and vegetables non-edible, meat edible,* and *meat non-edible.* This change was made to identify whether the food being thrown away could possibly have been consumed instead of thrown away, or whether the food items were those that are not typically consumed (such as peels, pits, bones, and shells). The second change was the addition of *compostable paper cups, compostable plastic cups,* and *other compostable plastic.* With more compostable food packaging being used, these changes will help identify the amounts of these materials being put in the organics bin. And third, the *other recyclable materials* material type was broken into more detailed material types to identify the types of recyclables that people are incorrectly putting in their organics bin. Those materials types are *recyclable paper, other plastic cups, recyclables plastic, recyclable metal,* and *recyclable glass.*



# 3. Findings

#### Interpreting the Results

#### How Data Is Presented

Organics characterization data are presented in two ways:

- An overview of organics composition, by **Material Class**, in a pie chart, and
- A detailed table that lists the full composition and quantity results for the 27 material types. Please refer to Appendix A: Material Type Definitions for a detailed list of definitions for material types used in the study.

#### **Means and Error Ranges**

The data from the sorting process were treated with a statistical procedure that provided two kinds of information for each of the *material types*:

- Estimates of composition by weight
- The degree of precision of the composition estimates

All estimates of precision were calculated at the 90% confidence level. The equations used in these calculations appear in Appendix D: Calculations.

The example below illustrates how the results can be interpreted. In this example, the best estimate of the amount of *yard debris* present in the samples is 88.2%. The 1.8% figure reflects the precision of the estimate. When calculations are performed at the 90% confidence level, we are 90% certain that the true amount of *yard debris* is between 88.2% plus 1.8% and 88.2% minus 1.8%. In other words, we are 90% certain that the mean lies between 86.4% and 90.0%.

Material Type	Est. Pct.	+/-
Yard Debris	88.2%	1.8%

## Rounding

To keep the organics composition tables and figures readable, estimated tonnages are rounded to the nearest ton, and estimated percentages are rounded to the nearest tenth of a percent. Due to this rounding, the tonnages presented in the report, when added together, may not exactly match the subtotals and totals shown. Similarly, the percentages, when added together, may not exactly match the subtotals or totals shown. Percentages less than 0.05% are shown as 0.0%.

It is important to recognize that the tons shown in the report were calculated using the more precise (not rounded) percentages. Using the rounded percentages to calculate tonnages yields quantities that are different than the rounded numbers shown in the report.

For example, the rounded percentage for *yard debris* in Table 5 is shown as 88.2%, while the more precise number, 88.1964945496115%, was used in calculations. If the rounded numbers (88.2%,



162,594 tons) had been used in the calculations, *yard debris* would be 143,408 tons. Using the more precise numbers, *yard debris* is calculated to be 143,402 tons as shown in Table 5—a difference of 6 tons.

#### **Characterization and Rate Results**

This section describes the single family residential organics characterization and participation rate results in four subsections:

- 1. Composition of material set out in organics service carts.
- 2. Organics set-outs and food scraps participation rates.
- 3. Capture rates for food scraps and compostable paper.
- 4. A comparison among the various service types and collection schedules.

## **Organics Service Composition**

From January 2014 through December 2014, single family residents in King County set out nearly 162,600 tons of material in their organics service carts. Figure 3 summarizes composition by material class for organic materials collected in King County. Table 5 presents the detailed material composition for organics from King County.

**Key Findings** 

- The two most prevalent material types are yard debris (88.2%, 143,402 tons) and purchased fruits and vegetables, non-edible (2.2%, 3,570 tons). Together, these two materials comprise over 90% of the organics service material.
- Food and Compostable Paper combined are about nine percent (13,968 tons) of organics service material.
- **Contaminants** (3,884 tons) account for approximately two percent of the collected material.



#### Figure 3. Composition by Material Class



	Estimated		Estimated
Material	Percent	+/-	Tons
Food	6.5%		10,530
Purchased Fruits and Vegetables, Edible	1.4%	0.3%	2,266
Purchased Fruits and Vegetables, Non-edible	2.2%	0.3%	3,570
Homegrown Fruits and Vegetables	0.6%	0.2%	956
Meat, Edible	0.2%	0.1%	360
Meat, Non-edible	0.4%	0.1%	583
Dairy	0.0%	0.0%	52
Mixed/Other Food Scraps	1.7%	0.0%	2,742
Compostable Paper	2.1%		3,438
Uncoated Paper Bags	0.2%	0.0%	301
Pizza Boxes	0.8%	0.7%	1,340
Compostable Paper Cups	0.0%	0.0%	4
Other Compostable Paper	1.1%	0.2%	1,792
Other Compostable	89.0%		144,742
Yard Debris	88.2%	1.8%	143,402
Biodegradable Plastic Bags	0.1%	0.0%	156
Other Compostable Plastic	0.0%	0.0%	2
Compostable Plastic Cups	0.0%	0.0%	0
Other Compostables	0.7%	0.9%	1,181
Contaminants	2.4%		3,884
Difficult to Compost Materials	0.5%	0.3%	788
Recyclable Paper	0.2%	0.1%	382
Milk/Ice Cream Cartons	0.0%	0.0%	17
Other Paper Cups	0.0%	0.0%	24
Other Plastic Coated Papers	0.1%	0.0%	136
Recyclable Plastic	0.0%	0.0%	49
Plastic Bags	0.1%	0.0%	85
Other Plastic Cups	0.0%	0.0%	1
Recyclable Metal	0.0%	0.0%	27
Recyclable Glass	0.0%	0.0%	7
Other Materials	1.5%	1.1%	2,368
Totals	100.0%		162,594
Sample Count: 960			

#### Table 5. Detailed Composition

Confidence intervals calculated at the 90% confidence level. Percentages for material types may not total 100% due to rounding.

The material type *other materials* includes all materials not defined elsewhere that do not belong in organics service carts. Examples of *other materials* include: animal waste, kitty litter, treated wood, construction materials, Styrofoam, and plastic trash bags.

## Set-out and Food Scraps Participation Rates

The set-out and food scraps participation rates were calculated using the subscriber, set-out, and composition data collected by the route surveyors and the sort crew. The set-out rate is the proportion of subscribers with a set-out. The food scraps participation rate is the proportion of set-outs or subscribers who included food in their cart. As shown in Table 6, more than half of all set-outs contained



food scraps, but, because not all subscribers set out carts, the food scraps participation rate for subscribers is much lower (27%).

	Set-out Rate	Food Scraps Participation Rate
Subscriber	52%	27%
Set-out	100%	52%

#### Table 6. Set-out and Food scraps participation Rate Data

## Capture Rate

The food scraps and compostable paper capture rate is the proportion of total food scraps and compostable paper generated by single family households in King County that is collected in single-family organics programs. King County residents generate an estimated 49 pounds of food scraps and compostable paper per household per month.<sup>2</sup> The average food scraps participant sets out approximately 33 pounds per month for collection; thus, the capture rate among food scraps participants is estimated to be 67%. The food scraps and compostable paper capture rate analysis is summarized in Table 7.

#### Table 7. Capture Rates

	Lbs. of Food Scraps and Compostable Paper Collected/Month	Lbs. of Food Scraps and Compostable Paper Generated/Month	Capture Rate	
Household	7.2	49.1	14.7%	
Subscriber	10.0	49.1	20.4%	
Set-out	19.4	49.1	39.5%	
Food Scraps Participant	32.7	49.1	66.6%	

#### **Comparisons Among Service Types and Collection Schedules**

Using information provided by the hauler, every sampled route can be classified by its service type and collection schedule. The two service types are:

- Subscription Service—Cities where households have the option to pay an extra fee for organics service in addition to their regular garbage service.
- Embedded Service—Cities where the cost of organics service is embedded in the regular fee households pay for their garbage service. In embedded programs, households receive organics service automatically.

Depending on the jurisdiction, organics service may be provided either weekly or every other week (EOW). Some jurisdictions have weekly service during the summer months (typically April through October), then switch to EOW service for the winter months. For this study, jurisdictions with this split

<sup>&</sup>lt;sup>2</sup> Per household generation figure is calculated from data in this report and the 2011 King County Waste Characterization and Customer Survey Report.



service were considered weekly. Table 8 summarizes the service type and collection schedule information for each jurisdiction included in the study.

Jurisdiction	Schedule	Service Type
Auburn	Weekly	Subscription
Bellevue	Weekly	Embedded
Bothell/Kirkland/Woodinville	Weekly	Embedded
Burien	Weekly	Embedded
Clyde Hill/Medina	EOW	Subscription
Covington	EOW	Subscription
Kent	EOW	Embedded
Kirkland	Weekly	Embedded
Mercer Island	EOW	Embedded
Redmond	Weekly	Embedded
Renton	Weekly	Embedded
Petrovitsky Road UTC	EOW	Subscription
Sammamish	Weekly	Subscription
Shoreline	EOW	Subscription
Unincorporated South	Weekly	Subscription

Table 8. Service Type and Collection Schedules

Table 9 compares metric between service types. The set-out rate appears to be higher for households with subscription service, as is the average cart weight. The food scraps participation rate and average pounds of food and compostable paper seem to be higher for households with embedded service.

					Average Pounds Food &
	Number of	Set-out	Food Scraps	Average Cart	Compostable Paper per
	Samples	Rate	Participation Rate	Weight	Set-out*
Embedded	576	49%	56%	56.6	10.6
Subscription	384	59%	46%	61.2	8.1
Combined	960	52%	52%	58.2	9.7

Table 9. Comparison of Key Metrics by Service Type

\*Calculated using only set-outs from participants, the average excludes non participating set outs.

Table 10 compares results for weekly and EOW collection. The set-out rate, average cart weight, and average pounds of food and compostable paper tend to be higher for subscribers with every-other-week service; weekly subscribers on average appear to have a higher food scraps participation rate.

	Number of Samples	Set-out Rate	Food Scraps Participation Rate	Average Cart Weight	Average Pounds Food & Compostable Paper per Set-out*
Weekly	528	48%	54%	56.1	8.2
Every Other Week	432	58%	48%	60.8	11.8
Combined	960	52%	52%	58.2	9.7

Table 10. Comparison of Key Metrics by Collection Schedule

\*Calculated using only set-outs from participants, the average excludes non participating set outs.



## **Comparisons to Previous Studies**

There have been marked changes to curbside organics service throughout King County since the first organics study in 2007. Residents in nearly every jurisdiction within the county can now include food scraps in their carts (99% of households in 2014 compared to 57% in 2007). Programs have also had many years to mature and attract new users. Methodological changes between the 2007 and 2014 studies are significant, including a switch from collecting samples from route trucks as they complete their route to collecting samples directly from carts at the curbside, and an increase from a single sampling season to four seasons. For these reasons, direct comparisons of the results between 2007 and the three subsequent studies (2009, 2011, and 2014) are difficult; however, the methodology changes from 2011 to 2014 are minor so the results are more comparable.

For comparison purposes, where the methodology allows, the same metrics from each study are summarized in this section. Some of the differences are methodological, some are programmatic, and some are due to behavior changes on the part of King County residents.

#### **Rate Comparisons**

Table 11 presents several key measures from the 2007 through 2014 studies. As shown, the set-out food scraps participation rate increased slightly between 2011 and 2014. The set-out rate, subscriber food scraps participation rate, and capture rate show larger changes.

	2007	2009	2011	2014
Subscription Rate	68%	63%	67%	72%
Set-out Rate	38%	49%	38%	52%
Set-out Food Scraps Participation Rate	*	50%	49%	52%
Subscriber Food Scraps Participation Rate	*	24%	19%	27%
Capture Rate	*	77%	86%	67%

#### Table 11: Comparison of Key Data between 2011 and 2014

\*Methodology changes since 2007 prevent comparisons between years for this measure.

#### **Subscription Rate**

The decrease in the subscription rate from 2007 to 2009 may be due to an increase in jurisdictions implementing paid, subscription-based—rather than embedded—organics service programs. The total number of King County residents with organics service available to them increased faster than the number of residents who subscribe to the service, consequently the subscription rate decreased. Between 2009 and 2014, the trend appears to have reversed and the subscription rate increased.

#### Set-Out Rate

In addition to changes in the utilization of organics service carts by households, the changes in the setout rate may be influence by external factors such as:

 General weather patterns-A late spring or an early winter may influence the frequency of setouts.



- Weather in the week immediately preceding the sample collection-If the weather is good then the set-out rate may increase due to an increase in the amount of time spent doing yard work by subscribers. Conversely, if the weather is bad the set-out rate may decrease.
- Holidays-If sampling occurs during a holiday week the set-out rate may decrease. The study
  intentionally avoids all major holidays. Summer season sampling when families go on summer
  vacation may influence the summer set-out rate.

As shown in Table 12 the set-out rate was more seasonally variable in 2009 and 2011 than we found in 2014, and the 2014 set-out rate is consistently higher than the set out-rate estimated in any previous study period. Overall, the 2014 set out-rate (52%) is higher than the 2011 rate (38%).

	March	April	June	August		November	Overall
2009		54%		44%			49%
2011	26%		50%			37%	38%
2014	Spring		Summer		Fall	Winter	
	57%		53%		54%	43%	52%

Т	able	12.	Set-out	Rate	bv	Field	Season	1
•	abic		Jui-our	nate	NУ	i iciu	JCasor	•

#### **Participation Rate**

The food scraps participation rate for set-outs increased slightly from 2011 (49%) to 2014 (52%). The food scraps participation rate for all subscribers also increased in 2014, from 19% in 2011 to 27%. This is partly due to the method in which this rate is calculated as it is dependent on the set-out rate, which increased noticeably from 2011 and consequently increased the food scraps participation rate for all subscribers.

#### **Capture Rate**

The participant capture rate is calculated based on several inputs: subscription rate, set-out rate, participation rate, and composition. When the set-out <u>rate</u> increases, the <u>number</u> of set-outs increases which leads to an increase in the number of participating carts. The increase in the number of participating carts is one piece of the participant capture rate. The other piece is the estimated quantity of food scraps and compostable paper (13,968 tons in 2014). The quantity of food scraps and compostable paper (13,968 tons in 2014). The quantity of food scraps and compostable paper (FCP) is divided by the number of participating carts to calculate the pounds of FCP in each cart. When these 2014 metrics are compared to 2011, the number of participating carts is that the quantity of FCP in each cart, on average, decreased and thus the participant capture rate decreased. So, at its root, the decrease in the participant capture rate is likely due to the increase in the set-out rate from 38% in 2011 to 52% in 2014.

In addition to calculating the capture rate on a per participant basis this study calculated the capture rate on a per household basis. While the participant capture rate decreased from 2011 to 2014, the household capture rate has steadily increased to

# Table 13. Household Food Scraps andCompostable Paper Capture Rate

	2009	2011	2014
Household Capture Rate	11.9%	13.1%	14.7%



14.7% since it was first calculated in 2009 (Table 13). The household capture rate is best estimate of what proportion of the FCP generated by single family residents in King County is going to Cedar Grove; it is the metric least susceptible to measurement error.

In 2011, food scraps and compostable paper accounted for nearly 42% of the single family residential disposal in King County making them important targets in King County's push to reach a 70% diversion rate by 2030.<sup>3</sup> Table 14 summarizes the FCP capture rate in several major west coast cities and illustrates that higher FCP capture rates are feasible. Table 14 also summarizes a few of the approaches employed by these cities to increase diversion of FCP:

		Programs in Place to Encourage Diversion				
	Capture Rate	Education and Outreach	Every Other Week Garbage Collection	Mandatory Organics Service	Ban on Organics Disposal	
City A	49.9%	Х		Х	Х	
City B	28.6%	Х		Х		
King County	14.7%	х	In One City			

Table 14. Capture Rate and Diversion Programs around the West Coast

## **Composition Comparisons**

Because of the similarity in methods between the 2011 and 2014 studies, a t-test is used to check for statistically significant changes in composition data since 2011. This statistical calculation was used to test the null hypothesis "There is no statistically significant difference, between the 2011 and 2014 study periods, in the percentage of food scraps composted." The same null hypothesis was also tested for each of the other material classes. The t-test results are summarized in Table 15; none of the material classes exhibited a statistically significant change in composition since 2011. The calculations and a discussion of the t-test are included in Appendix D: Calculations.

	Composition		Change in			Statistically
Material Class	2011	2014	Composition	t-Statistic	p-Value	Significant Change*
Food	5.9%	6.5%	0.5% 🕇	0.7941	0.4272	No
Compostable Paper	1.8%	2.1%	0.3% 🕇	0.6441	0.5196	No
Other Compostable	90.2%	89.0%	-1.2% 📕	0.9518	0.3413	No
Contaminants	2.1%	2.4%	0.3% 🕇	0.3709	0.7107	No
Total	100%	100%				
Number of Samples	739	960				

\*(Cut-off for statistically significant difference = 0.025)

<sup>&</sup>lt;sup>3</sup> Based on the information in the 2011 King County Waste Characterization and Customer Survey Report.



# Appendix A: Material Type Definitions

#### Food

- Fruits and Vegetables, Edible—the edible portion of food that comes from a plant but does not appear to have grown on the subscriber's property. Examples include vegetables and fruits. Includes fruits and vegetables in the original or another container when the container weight is less than 10% of the total weight.
- 2. **Fruits and Vegetables, Non-edible**—the non-edible portions of food that comes from plants. Examples include fruit peels, vegetable peelings and potato skins, pits, cores, juiced oranges.
- 3. **Homegrown Fruits and Vegetables**—food that comes from a plant that is growing on or has been cleared from the subscribers property. Examples will include fruits and vegetables that have been disposed of in the set-out as a result of falling or pruning from trees and gardens.
- 4. **Meat, Edible**—the edible portion of non-dairy food that comes from an animal. Examples include eggs and eggs in shell, fresh meat, cooked meat, and meat scraps. Does not include dairy products such as cheese and milk. Includes meat in the original or another container when the container weight is less than 10% of the total weight.
- 5. **Meat, Non-edible** the non-edible portions of food that comes from an animal. Examples include egg shells, bones, gristle and meat trimmings, fish skins, and seafood shells.
- 6. **Dairy**—food that comes from an animal's milk. Examples include cheese, milk, and yogurt. Includes dairy products in the original or another container when the container weight is less than 10% of the total weight.
- 7. **Mixed/Other Food Waste**—any food that cannot be put in the above categories. Examples include food items that are a combination of the above categories, as well as coffee grounds, tea packets, grains, crackers, bread, and cereal. Includes food in the original or another container when the container weight is less than 10% of the total weight.

## **Compostable Paper**

- 8. **Uncoated Paper Bags**—any uncoated bag made of paper. Examples include paper grocery bags, soiled and unsoiled fast food bags, and department store bags if made entirely of paper.
- 9. **Pizza Boxes**—boxes without a plastic or foil liner that have been used for carrying pizza.
- 10. **Compostable Paper Cups**—paper cups without a plastic layer. Examples include cups bearing a Cedar Grove approval (Ecotainer, Brown is Green or the Cedar Grove logo) and single use "Dixie" paper cups (small bathroom cups or office water-cooler-style cups).
- 11. **Other Compostable Paper**—includes paper products, not included above, that do not contain a plastic coating. Examples include waxed cardboard boxes, uncoated or waxed paper plates, uncoated or waxed paper containers (such as for fast food), napkins, coffee filters, shredded paper, newspaper (if used to contain food waste), and paper towels.

## Other Compostables

12. **Yard Debris**—includes leaves, grass clippings, sod, garden wastes, brush, prunings, logs, and clumped soil and rocks associated with yard debris.



- 13. **Biodegradable Plastic Bags**—plastic bags that are made of materials such as corn starch or soy and are designed to biodegrade or compost. The bags will most likely have the company's logo including BioBag, Biocorp, Natu-Ur, BioSource, Eco Film/Eco Works, and Bio Tuf.
- 14. **Other Compostable Plastic**—plastic containers (excluding cups) such as clamshells, plates, trays, cutlery, and straws designed to compost. They are marked with the words "compostable" or "#7 PLA" in the plastic identifier.
- 15. **Compostable Plastic Cups**—corn-based or other natural plastic cups. Items are nearly always prominently labeled as compostable and sometimes marked with the letters PLA.
- 16. **Other Compostables**—other compostable organic materials, not included above, such as hair, Popsicle sticks, and toothpicks.

#### Contaminants

- 17. **Difficult to Compost Materials**—organic items whose durability makes them hard to compost. Examples include wine corks, burlap sacks, pallets, wood crates, and rope.
- 18. **Recyclable Paper**—includes non-coated paper normally recycled in curbside collection programs when not significantly contaminated. Examples include newspapers (not used to contain food waste), newspaper inserts, corrugated cardboard, magazines, phone books, junk mail, chipboard, boxboard, egg cartons, printing, and writing paper.
- 19. Milk/Ice Cream Cartons—bleached polycoated paperboard cartons of various sizes and shapes that contained milk, ice cream, or other liquids. Does not include paper containers with a foil liner or aseptic containers (these will be considered other recyclable materials).
- 20. **Other Paper Cups**—all cups with a plastic layer designed to be used for beverages or food. Examples include most to-go coffee cups and fast food soda cups.
- 21. **Other Plastic Coated Papers**—food service papers coated with plastic. Examples include some types of fast food wrapping, plastic-coated take-out containers, and plastic-coated paper plates and bowls.
- 22. **Recyclable Plastic**—includes plastic normally recycled in curbside collection programs when not significantly contaminated. Examples include plastic tubs, bottles, and jars.
- 23. **Plastic Bags**—plastic bags that are NOT made of materials that compost or biodegrade.
- 24. **Other Plastic Cups**—all other non-compostable plastic cups. Usually marked with a #1 or #6 recycling code. Examples include plastic party cups, plastic champagne flutes, and plastic coffee mugs.
- 25. **Recyclable Metal**—includes metal normally recycled in curbside collection programs when not significantly contaminated. Examples include aluminum cans, tin cans, and items made mostly of ferrous or non-ferrous metal.
- 26. **Recyclable Glass**—includes glass normally recycled in curbside collection programs when not significantly contaminated. Examples include glass bottles and jars.
- 27. **Other Materials**—any material that does not fit into the above categories. Examples include textiles, grease, foil-lined paper products, Styrofoam, gypsum waste, treated wood, pet waste, loose soil and rocks, stumps, demolition debris, hazardous wastes, and non-recyclable metals, glass, and plastics.



# Appendix B: Study Design

This section presents the study plan as it was written prior to collecting and characterizing organics samples.

## **Objectives**

The objective of the 2014 study was to enhance the methodology employed in the 2011 study and compare results with the baseline composition of material collected from organics routes throughout King County established in 2007. This study also measured set-out and food waste participation levels.

#### Summary

Composition, set-out, and participation data was collected over four seasons of field work, each season is split into two sampling events— one each in March, April, May, July, August, October, November, and December 2014. Each sampling event covered 10 randomly selected routes from around the county and included two days of sample collection and one day of sample sorting. There are two significant changes to note from the 2011 study:

- 1. We have added an additional season of study, the summer season.
- 2. We have broken each season into two, two-day sampling events instead of one, four-day sampling event.

The net goal of these two changes was to more accurately represent the seasonal changes in the organics stream and reduce the bias caused by a particularly bad weather week or nice weather week. Table 16, below, shows the sampling schedule for the 2014 study.

Sampling			1st Collection Day		2nd Collection Day		Sorting Day	
Event	Season	Month	Date	Day	Date	Day	Date	Day
1	Winter	March	03/19/14	Wed	03/20/14	Thu	03/21/14	Fri
2	Spring	April	04/28/14	Mon	04/29/14	Tue	04/30/14	Wed
3	Spring	May	05/28/14	Wed	05/29/14	Thu	05/30/14	Fri
4	Summer	July	07/21/14	Mon	07/22/14	Tue	07/23/14	Wed
5	Summer	August	08/20/14	Wed	08/21/14	Thu	08/22/14	Fri
6	Fall	October	10/27/14	Mon	10/28/14	Tue	10/29/14	Wed
7	Fall	November	11/12/14	Wed	11/13/14	Thu	11/14/14	Fri
8	Winter	December	12/08/14	Mon	12/09/14	Tue	12/10/14	Wed

#### Table 16: 2014 Organics Sampling Schedule

Each sampling event's field work was broken into two broad elements—sample collection and sample sorting—with separate work crews dedicated to each. Using route data provided by local haulers, 20 random routes were selected from within King County. Each season, the route surveyors traversed the selected routes recording set-out information for the route as well as collecting material from 12 organics carts for hand sorting. The entire contents of each set-out constituted a single sample; 12 samples were collected per route on 20 routes per season (ten routes per sampling event) for a total of 240 samples per season.



The route surveyors delivered the samples to a waste facility for hand sorting by a trained sorting crew. Following the sorts, the project team analyzed the data to determine the composition of the organics material collected, the number of households that set-out the bin for collection, the number that placed food in the bin, and the quantity of food waste set-out by each participating household.

This document provides a detailed description of the study methodology. The sampling plan is organized into six sections.

- Section 1: Study Terms and Definitions—a list of several unique terms used throughout this document.
- Section 2: Route Selection—a description of the method used to define the universe of routes and the random selection process.
- Section 3: Sample Collection—the method used to collect random, representative samples.
- Section 4: Route Data Collection—a description of the method in which data was collected along each of the selected routes.
- Section 5: Sorting Procedures—a description of the method used to characterize samples.

## Section 1: Study Terms and Definitions

This plan includes several unique terms and definitions. Definitions for these terms are provided below.

King County—Refers to King County, excluding Seattle.

**Organics Service**—For the purposes of this study, *organics service* only includes commercially collected curbside/alley programs where residents are permitted to combine food waste and yard waste in a single cart. Table 17shows the King County cities and regions that are considered to have *organics service*, and those that are not:

Has Organics Service				
Algona	Hunts Point	Renton		
Auburn	Issaquah	Sammamish		
Beaux Arts	Kenmore	SeaTac		
Bellevue	Kent	Shoreline		
Black Diamond	Kirkland	Snoqualmie		
Bothell	Lake Forest Park	Tukwila		
Burien	Maple Valley	Woodinville		
Carnation	Medina	Yarrow Point		
Clyde Hill	Mercer Island	Unincorporated County (except as noted		
Covington	Newcastle	below)		
Des Moines	Normandy Park	Does Not Have Organics Service		
Duvall	North Bend	Town of Skykomish		
Enumclaw	Pacific	Unincorporated County-Vashon Island,		
Federal Way	Redmond	Snoqualmie Pass, and Skykomish area		

Table 17: Cities and Regions with and without Organics Service



**Subscriber**—A subscriber is a King County household that pays an additional fee for organics service or is a household in a city where organics service is embedded in the garbage collection service.

**Set-Out**—A set-out is an organics service container placed out on the curb/alley for pick up by the collection company, regardless of whether is contains food. It is important to distinguish between a subscriber (a household that has organics service available to them) and a set-out (where the resident uses the service and literally sets out the container for collection).

**Food Waste Participant**—A food waste participant (participant) is a household that places at least some food waste in the organics service container.

#### Section 2: Route Selection

All organics service routes in King County were included in the sampling universe. Waste Management, Republic Services, City of Enumclaw, and CleanScapes provided complete route lists for their respective service areas. The routes were sorted by collection day and five routes per day were randomly selected for sampling using the *=rand()* function in Microsoft Excel.

The routes selected for sampling are listed in Table 18.

Monday			
Hauler	Jurisdiction		
Republic Services	Bellevue		
Republic Services	Kent		
Waste Management	Redmond		
Waste Management	Renton		
Waste Management (replaced)	Burien		
CleanScapes (replacement)	Burien		

#### Table 18: Randomly Selected Routes for Sampling in 2014

Tuesday			
Hauler	Jurisdiction		
Republic Services	Sammamish		
Republic Services	Bellevue		
Republic Services	Petrovitsky Road UTC		
Republic Services	Covington		
Waste Management	Bothell/Kirkland/Woodinville		

Wednesday		
Hauler	Jurisdiction	Haul
Republic Services	Kent	Repu
Waste Management	Kirkland	Repu
Waste Management	Renton	Repu
Waste Management	Auburn	Repu
CleanScapes	Shoreline	Wast

Thursday			
Hauler	Jurisdiction		
Republic Services	Clyde Hill/Medina		
Republic Services	Mercer Island		
Republic Services	Petrovitsky Road UTC		
Republic Services	Kent		
Waste Management	Unincorporated South		

## Section 3: Route Data Collection

At the start of every sampling day, each route surveyor received a route map, driving directions, the route start location, and the count of subscribers along the route. The route surveyors traversed each of the five routes, one surveyor per route, counting set-outs. An example of the set-out count form is included in Appendix E.

The route surveyor began traversing the route 30 minutes before the hauler began collection and ran the route in the same order as the hauler. This ensured that the sampler was sufficiently ahead of the hauler to prevent any disruptions to collection operations while allowing residents the maximum amount of time to set out their organics containers for counting and collection.



The route surveyor was also responsible for selecting set-outs for sampling. Using a predetermined sampling interval, each route surveyor collected all material from 12 set-outs each day. The sampling interval was determined using the following procedure:

- For each sampling day and route, the expected number of set-outs, *L*, was estimated using route data provided by the haulers. The number *L* was then reduced by one-fifth (producing 0.8 x *L*). This was done in order to ensure that the targeted number of set-outs was selected on each sampling day, even if there were fewer set-outs than expected.
- 2. Next, the interval *n* was determined to ensure systematic sampling of set-outs. If *r* represented the number of samples needed, and .8 x *L* represented the number of expected set-outs, then  $n = (.8 \times L) \div r$ ; every  $n^{\text{th}}$  set-out was selected for sampling. To help facilitate this process, the sampling interval was noted on the set-out count form.

All the material from each set-out constituted a sample. Each sample was stored and labeled separately. An example sample label is included in Appendix E. After the route surveyors completed their routes they transported the samples to the sorting facility.

# Section 5: Sorting Procedures

Approximately 120 samples were sorted over one day for each sampling event, resulting in 240 samples total for each season. The sorting procedure included the following four steps.

**Step 1: Review methodology and sorting categories with the crew.** To provide consistent sorting, Cascadia used trained crewmembers throughout the project. Before the sorting began, all crewmembers reviewed the procedures, forms, and material definitions in detail. The material definitions are included in Appendix A.

**Step 2: Sort sample.** Once the sample was placed on the sorting table, the material was sorted by hand into the prescribed material categories. The sorting crewmembers typically specialized in groups of materials, such as food or compostable paper, while the field crew manager monitored the homogeneity of the sorted material, rejecting materials that were improperly classified.

**Step 3: Weigh the sample.** The field crew manager verified the purity of each material as it was weighed (using a pre-tared scale) and recorded the data on the sample tally sheet. An example of a sample tally sheet is included in Appendix E.

**Step 4: Review data.** At the conclusion of each sorting day, the field crew manager conducted a quality control review of the data recorded.



# Appendix C. Organics Diversion Greenhouse Gas and Cost Data

Cities and counties around Puget Sound have implemented organics service for many reasons including reductions in greenhouse gas (GHG) emissions and costs. This appendix quantifies current and potential GHG reductions and cost savings associated with organics diversion. It is divided into two sections, the first covering current organics programs and the second covering future programs with increased diversion of organics from the disposed waste stream. Each section considers the estimated GHG reductions and cost savings. All GHG reduction calculations are performed using MEBCalc<sup>™</sup>, a life cycle assessment (LCA) model for measuring the environmental footprint of a community's solid waste management system, from collection through final disposition of each discarded product or packaging material.

## **Current Organics Service**

## Greenhouse Gas Emissions Estimates

Measuring or calculating GHG reductions is complicated; however, the United Nations Intergovernmental Panel on Climate Change (IPCC) provides some methodological guidelines. This analysis follows the IPCC guidelines and takes into account local conditions (such as local landfill gas management practices and the local power grid) when data are available. Factors included in the GHG analysis include the following:

- Emissions from organics collection vehicles compared to garbage collection vehicles. This assumes a 70%/30% mix between diesel/CNG powered collection equipment.
- Emissions from equipment used to handle materials at compost facilities and landfills.
- Emissions from hauling organics to the Cedar Grove composting facility compared to hauling garbage to Cedar Hills landfill. This assumes an average 36 mile round trip for both organics and disposed waste. That number is the weighted average distance between the transfer stations and Cedar Hills landfill or Cedar Grove composting.
- Carbon storage in landfills.<sup>4</sup>
- Emissions from petroleum-based fertilizers. (Compost provides a replacement for these fertilizers, decreasing demand and associated embodied emissions.)
- Carbon storage in compost and from applications of compost.
- Ten percent methane oxidation rate of fugitive emissions from landfills.
- Emissions from landfill gas (LFG) to energy projects. This assumes a 90% capture rate for methane at the landfill and energy production at the landfill.

Some of these factors tend to support the case for increasing diversion of organics to compost (increased diversion reduces the use of petroleum-based fertilizers, for instance) and some support reduced diversion of organics to compost (landfilling organics can increase electricity generation from captured LFG, thus displacing other petroleum-based fuels in the power grid).

<sup>&</sup>lt;sup>4</sup> MEBCalc<sup>™</sup> accounts for carbon storage using data and techniques developed and outlined in Morris, Jeffery. "Bury or Burn North America MSW? LCAs Provide Answers for Climate Impacts & Carbon Neutral Power Potential." Environmental Science & Technology 44 (2010): 7944-7949



As shown in Table 19, organics service programs collected nearly 14,000 tons of food and compostable paper and more than 143,000 tons of yard debris during the study period. Compared to landfilling the material, curbside organics service programs reduced emissions by nearly 63,000MTCO2e with current landfill operations (LFG is collected for energy generation).

	Curbside Tons Collected	GHG Reduction (MTCO2e)
Yard Debris	143,402	55,349
Food Scraps/Compostable Paper	13,968	7,562
Total	157,370	62,911

Table	19.	Estimated	GHG	Reductions	from	Organics	Service
IGNIC	<b>_</b>	Lotinated	0.10	neaderons		organico	0010100

Notes: Assumes 90% landfill gas capture

For perspective, more practical measures of the importance of composting include the following<sup>5</sup>:

- The average food scrap participant household sent approximately 1,687 pounds of organics to Cedar Grove in 2014, reducing their GHG emissions by an estimated 721 pounds for the year. The GHG reductions from this are equivalent to an average King County household reducing vehicle fuel consumption by 3%.
- Each full 96-gallon cart from a food scraps participant reduces GHG emissions by approximately 34 pounds CO2e.

## Cost Savings Estimates

Calculating the costs of garbage service and organics service is another very complicated task with a variety of complex variables including subsidies, penalties, incentives, hauling costs, transfer costs, disposal costs, material management costs, product revenues, moisture content, and a host of other factors. A simplified model comparing the tipping costs of organics and garbage makes the following assumptions:

- Hauling costs are the same for both organics and garbage. Whether the material is placed into an organics service cart or a garbage cart, the same total volume and weight of material needs to be hauled requiring the same amount of labor, equipment, and driving.
- Transfer costs, disposal costs, material management costs, and product revenues for the garbage and organics are captured in the different tipping fees charged for those materials.
- The tipping fee for garbage is \$120.17 per ton; the tipping fee for organics varies between \$48.70/ton<sup>6</sup> and \$66.96/ton. At the time of this report \$66.96 per ton is the gate rate for mixed organics at Cedar Grove. Haulers may pay an amount much lower than the gate rate, estimated for this study to be around \$48.70 per ton.
- The effects of subsidies, penalties, and incentives are marginal.

<sup>&</sup>lt;sup>6</sup> This value was calculated based on the posted gate rate at Cedar Grove and the estimated low hauler rate in the 2014 study. The hauler rate was estimated at 73% of the gate rate.



<sup>&</sup>lt;sup>5</sup> Calculations for these two comparisons can be found in Appendix C: Calculations and are based on data contained in this report, other Solid Waste Division reports, from the U.S. Census, and MEBCalc<sup>TM</sup>, an LCA model for measuring the environmental footprint of a community's solid waste management system, from collection through final disposition of each discarded product or packaging material.

Under these assumptions, the cost savings to the solid waste system of the current organics service program range between \$8.7 million if a user pays a \$66.96/ton organics tip fee and \$11.6 million if a user pays a \$48.70/ton organics tip fee. That is to say, users of the solid waste system pay up to \$11.6 million less per year with the current level of organics service than they would if there were no curbside organics service. These results are shown in Table 20.

	Organics Tip Fees			
	\$48.70 \$66.96			
Current program	\$11 620 601	\$8 651 632		
cost savings	\$11,020,001	Ş8,031,032		

Table 20. Current Organics Program System-wide Cost Savings

#### **Future Potential**

In 2014, King County single family households landfilled nearly 86,000 tons of yard waste, food, and compostable paper.<sup>7</sup> If subscription rates, set-out rates, and food scraps participation rates increase, the quantity of these materials captured in curbside organics programs will likely increase as well. Table 21 shows the additional quantities of these materials composted at Cedar Grove assuming an additional 25%, 50%, or 75% of these materials can be diverted from curbside single family residential garbage. The following sections offer estimates of the additional GHG reductions and costs savings from diverting these additional quantities of materials.

	Tons Disposed	Tons Diverted at 25% Diversion	Tons Diverted at 50% Diversion	Tons Diverted at 75% Diversion
Yard Debris	4,765	1,191	2,382	3,573
Food Scraps/Compostable Paper	80,897	20,224	40,449	60,673
Total	85,662	21,416	42,831	64,247

Table 21. Single Family Residential Disposed Tons, 2014<sup>8</sup>

## Greenhouse Gas Emissions Estimates

Under current landfill operations (LFG to energy), diverting additional quantities from the landfill reduces GHG emissions, and higher levels of diversion lead to greater GHG reductions. As shown in Table 22, diverting 25% of the currently disposed organics to compost would result in an estimated GHG reduction of 11,638MTCO2e. Diverting 75% of the currently disposed organics would result in an estimated GHG reduction of 34,915MTCO2e per year. These reductions are on top of the reductions

<sup>&</sup>lt;sup>8</sup> Food scraps is the sum of *packaged vegetative items, unpackaged/scrap vegetative items, packaged non-vegetative items,* and *unpackaged/scrap non-vegetative items* from the 2011 waste characterization study. Yard debris is the sum of *yard wastes* and *large prunings* from the 2011 waste characterization study. Compostable paper is the sum of *waxed corrugated cardboard, single use food service compostable paper* and *other compostable paper* in the 2011 waste characterization study.



<sup>&</sup>lt;sup>7</sup> Using the composition results from 2011 King County Waste Characterization and Customer Survey report applied to 2014 disposed tons.

already achieved through current diversion levels. These calculations are based on the same assumptions used in the current program GHG estimates.

	GHG Reduction (MTCO2e)				
	25% Diversion 50% Diversion 75%				
Yard Debris	460	919	1,379		
Food Scraps/Compostable Paper	11,178	22,357	33,535		
Total	11,638	23,276	34,915		

Table 22. Estimated GHG Reductions from Diverting Additional Materials from the Landfill

Notes: Assumes 90% landfill gas capture

## **Cost Savings Estimates**

Using the same assumptions used to estimate the current program cost savings, capturing and diverting additional material from the garbage to the compost could increase system-wide cost savings by \$2.2 million to \$8.7 million, depending on organics tipping fees and the amount of increased diversion. That is to say, users of the solid waste system may save up to an additional \$8.7 million per year with increased organics diversion over the current level of organics diversion. See Table 23 for a summary of these results.

Table 23. System-wide Cost Savings at Various Levels of Increased Organics Diversion

	Organics Tip Fees		
	\$48.70	\$66.96	
Cost savings at 25%	\$2,005,150	\$2,162,908	
increased diversion	\$2,905,150		
Cost savings at 50%	\$5,810,200	¢1 225 916	
increased diversion	\$3,810,300	\$4,525,810	
Cost savings at 75%	¢0 715 /51	¢6 199 771	
increased diversion	<i>\$6,715,451</i>	۶0,488,724	



# Appendix D: Calculations

#### **Estimating Organics Composition**

Organics composition estimates were calculated using a method that gave equal weighting or "importance" to each sample. Confidence intervals (error ranges) were calculated based on assumptions of normality in the composition estimates.

In the descriptions of calculation methods, the following variables are used frequently:

- *i* denotes an individual sample
- *j* denotes the material type
- *c<sub>j</sub>* is the weight of the material type *j* in a sample
- w is the weight of an entire sample
- *r<sub>j</sub>* is the composition estimate for material *j* (*r* stands for *ratio*)
- s denotes a particular sector or subsector of the organics stream
- *n* denotes the number of samples in the particular group that is being analyzed at that step

## **Estimating the Composition**

For a given sampling stratum, the composition estimate denoted by  $r_i$  represents the ratio of the component's weight to the total weight of all the samples in the stratum. This estimate was derived by summing each component's weight across all of the selected samples belonging to a given stratum and dividing by the sum of the total weight for all of the samples in that stratum, as shown in the following equation:

$$r_j = \frac{\sum_{i} c_{ij}}{\sum_{i} w_i}$$

where:

- c = weight of particular component
- w = sum of all component weights
- for i = 1 to n, where n = number of selected samples
- for j = 1 to m, where m = number of components



For example, the following simplified scenario involves three samples. For the purposes of this example, only the weights of the material type *dairy* are shown.

	Sample 1	Sample 2	Sample 3
Weight (c) of <i>dairy</i> (in lbs)	5	3	4
Total Sample Weight ( <i>w</i> ) (in lbs)	80	70	90

$$r_{meat} = \sum \frac{5+3+4}{80+70+90} = 0.05$$

To find the composition estimate for the component *meat*, the weights for that material are added for all selected samples and divided by the total sample weights of those samples. The resulting composition is 0.05, or 5%. In other words, 5% of the sampled material, by weight, is *dairy*. This finding is then projected onto the stratum being examined in this step of the analysis.

The confidence interval for this estimate was derived in two steps. First, the variance around the estimate was calculated, accounting for the fact that the ratio included two random variables (the component and total sample weights). The variance of the ratio estimator equation follows:

$$\operatorname{Var}(r_j) \approx \left(\frac{1}{n}\right) \left(\frac{1}{\overline{w}^2}\right) \left(\frac{\sum_{i} (c_{ij} - r_j w_i)^2}{n - 1}\right)$$

where:

$$\overline{w} = \frac{\sum_{i} w_i}{n}$$

(For more information regarding these equations, refer to *Sampling Techniques, 3rd Edition* by William G. Cochran [John Wiley & Sons, Inc., 1977].)

Second, precision levels at the 90% confidence level were calculated for a component's mean as follows:

$$r_j \pm \left( z \sqrt{\operatorname{Var}(r_j)} \right)$$

where z = the value of the z-statistic (1.645) corresponding to a 90% confidence level.



## **Subscription Rate**

The subscription rate is calculated by dividing the monthly average number of King County residents with garbage service in the included jurisdictions by the monthly average number of organic service customers in the included jurisdictions. The King County Solid Waste Division (SWD) provided customer number data for the period from January 2014 through December 2014.

average monthly organics customers 
$$\div$$
 average monthly garbage customers = subscription rate  

$$232.193 \div 321.964 = 72\%$$

#### Set-out Rate

The set-out rate is calculated by dividing the total number of subscribers along surveyed routes by the total number of carts set out for collection along surveyed routes. The haulers provided the number of subscribers on a route and the route surveyors counted the number of set-outs on a route.

```
number of set outs on routes \div number of subscribers on routes = set out rate

30,064 \div 58,215 = 52\%
```

## Food Scraps Participation Rate

The subscriber food scraps participation rate is a measure of the people who have signed up for organics service (not all households subscribe to organics service even if it's available) that place food scraps in their cart. The set-out food scraps participation rate is a measure of the number of carts set out for collection that contain food scraps.

The set-out food scraps participation rate is calculated by dividing the total number of samples collected by the number that contained food scraps.

```
495(samples with food) \div 960(total samples) = 52\%
```

The subscriber food scraps participation rate is calculated by multiplying the set-out food scraps participation rate by the set-out rate. The premise is that we know what percent of set-outs have food scraps and we know what percent of subscribers set their carts out, so the percent of subscribers who participate is the product of those two numbers.

52%(set out rate)  $\times$  52%(set out participaton rate) = 27%

## **Capture Rate**

The capture rate is a measure of the amount of food scraps and compostable paper collected per food scraps participant per month in their organics service, divided by the amount of food scraps and compostable paper generated per participant per month. The amount of food scraps and compostable paper generated is the sum of food scraps and compostable paper disposed in the garbage and food scraps and compostable paper collected in organics service programs.

The amount of food scraps and compostable paper collected per participant per month in their organics service is calculated from this study's composition data and tonnage. The amount of food scraps and compostable paper disposed per participant per month is provided by the SWD.



The capture rate is:

 $c \div (c + d)$ 

where:

- c = food scraps and compostable paper collected in organics service programs per participant per month
- d = food scraps and compostable paper disposed per participant per month

## **Evaluating Changes in the Composition Between Studies**

Comparisons examined the changes in the in composition percentages for each of the four material classes. In order to control for population changes and other factors that may influence the total amount of material composted from year to year, the tests described in this appendix measure material <u>proportions</u>, not actual <u>tonnage</u>. For example, say that **Food** accounts for 10% of composted material each year, and that a total of 1,000 tons of material was composted in one year and 2,000 tons composted in the next. While the amount of **Food** increased from 1,000 to 2,000 tons, the percentage remained the same. Therefore, the tests would indicate that there had been no change.

The purpose of conducting these comparisons is to identify trends within the organics stream in the percentage of selected types of waste disposed over time. One specific example is stated as follows:

*Hypothesis:* "There is no statistically significant difference, between the 2011 and 2014 study periods, in the percentage of **Food** composted."

Statistics are then employed to look for evidence disproving the hypothesis. A "significant" result means that there is enough evidence to disprove the hypothesis and it can be concluded that there is a true difference across years. "Insignificant" results indicate that either a) there is no true difference, or b) even though there may be a difference, there is not enough evidence to prove it.<sup>9</sup>

The purpose of these tests is to identify changes across years; however, the study did not attempt to investigate *why* or *how* these changes occurred. The changes may be due to a variety of factors. Future studies could be designed to test the influence of various potential sources of the increase/decrease of specific materials in the disposed waste stream.

## **Statistical Considerations**

The analyses were based on the component percentages, by weight. As described in Appendix D: Calculations, these percentages are calculated by dividing the sum of the selected component weights by the sum of the corresponding sample weights. T-tests (modified for ratio estimation) were used to examine the variations from year to year.

#### Normality

The distributions of some of the material types may be skewed and may not follow a normal distribution. Although t-tests assume a normal distribution, they are very robust to departures from this

<sup>&</sup>lt;sup>9</sup> Please see the "Power Analysis" discussion on page 30.



assumption, particularly with large sample sizes. In addition, the material classes are sums of the material types, which improve our ability to meet the assumptions of normality.

#### Dependence

There may be dependence between material types (i.e., if a person disposes of material A, they always dispose of material B at the same time).

There is certainly a degree of dependence between the calculated percentages. Because the percentages sum to 100 (in the case of year-to-year comparisons), if the percentage of material A increases, the percentage of some other material must decrease.

#### **Multiple T-Tests**

In all statistical tests, there is a chance of incorrectly concluding that a result is significant. The year-toyear comparison required conducting several t-tests (one for each material class), **each** of which carries that risk. However, we were willing to accept only a 10% chance, **overall**, of making an incorrect

conclusion. Therefore, each test was adjusted by setting the significance threshold to  $\frac{0.10}{w}$  (w = the

number of t-tests).

The adjustment can be explained as follows:

For each test, we set a  $1 - \frac{0.10}{w}$  chance of not making a mistake, which results in a  $\left(1 - \frac{0.10}{w}\right)^w$  chance of not making a mistake during all *w* tests.

Since one minus the chance of not making a mistake equals the chance of making a mistake, by making this adjustment, we have set the overall risk of making a wrong conclusion during any one of the tests at

$$\left(1-\left(1-\frac{0.10}{w}\right)^{w}\right)=0.10$$
.

The chance of a "false positive" for the year-to-year comparisons made in this study is restricted to 10% overall, or 2.5% for each test (10% divided by the four tests equals 2.5%).

For more detail regarding this issue, please refer to Section 11.2 "The Multiplicity Problem and the Bonferroni Inequality" of *An Introduction to Contemporary Statistics* by L.H. Koopmans (Duxbury Press, 1981).

#### **Power Analysis**

As the number of samples is increased, so is the ability to detect differences. In the future, an a *priori* power analysis might benefit this research by determining how many samples would be required to detect a particular minimum difference of interest.

## Interpreting the Calculation Results

For the purposes of this study, only those calculation results with a p-value of less than 2.5% are considered to be statistically significant. As described above, the threshold for determining statistically



significant results (the "alpha-level") is conservative, accounting for the fact that so many individual tests were calculated. An asterisk notes the statistically significant differences.

The t-statistic is calculated from the data. According to statistical theory, the larger the absolute value of the t-statistic, the less likely the two populations are to have the same mean. The p-value describes the probability of observing the calculated t-statistic if there were no true difference between the population means.

#### **GHG** Calculations

The following several tables illustrate the calculations and sources used in Appendix C. Organics Diversion Greenhouse Gas and Cost Data .

As shown in Table 24, the average food scraps participant composts approximately 452 pounds of food scraps and compostable paper per year. The data in this table is compiled from elsewhere in this report.

the second second second second second second	432
Annual pounds food scraps and	452
Number of participants	61,829
paper composted	13,500
Annual tons food scraps and	13 968

# Table 24. Annual Pounds of Food Scraps and Compostable Paperper Food Scraps Participant

As shown in Table 25, the average organics service subscriber composts approximately 1,235 pounds per year of yard debris. The data in this table is compiled from elsewhere in this report.

Table 25. Annual Pounds of Yard Waste
per Subscriber

annually per subscriber	1,255		
Pounds yard debris composted	1 225		
Number of subscribers	232,193		
annually	143,402		
Tons yard debris composted	142 402		

Table 26 shows the sum of materials composted per participant per year: 1,687 pounds. This is the sum of the composted food scrap, compostable paper, and yard debris amounts.

# Table 26. Annual Pounds of Diverted Compostablesper Food Scraps Participant

Annual pounds of compostables	1 (07
per food scraps participant	1,687

Table 27 illustrates the pounds of emitted CO2e avoided by organics participants each year. Data used in this calculation are from Table 24, Table 25, and MEBCalc<sup>™</sup>, an LCA model for measuring the environmental footprint of a community's solid waste management system, from collection through final disposition of each discarded product or packaging material.



	Pounds Composted	Pounds CO2e	Pounds CO2e
	per Household per	Avoided per Ton	Avoided Annually
	Year	Composted	from Composting
Yard Debris	1,235	772	477
Food Scraps and Compostable Paper	452	1,083	245
Totals	1,687		721

Table 27. Pounds of CO2e Avoided Annually from Composting

As shown in Table 28, the average King County family emits nearly 9.6MTCO2e annually from their vehicles. This converts to nearly 21,200 pounds CO2e annually. Data in this table come from the U.S. Census and MEBCalc<sup>™</sup>.

Table 28. Average CO2e Emitted from Vehicle Fuel Consumption

consumption Average King County household	2.4 people
Average per household MTCO2e emitted from vehicle fuel	9.6
emitted from vehicle fuel consumption	9.6

The conversion from MTCO2e to pounds CO2e is shown in Table 29.

Table 29. Conversion Factor from Metric Tons to Pounds

Pounds per metric ton	2,204.6
Average per household pounds CO2e emitted from vehicle fuel consumption	21,164



As shown in Table 30, the CO2e emissions avoided through composting by the average participant are equivalent to a household reducing their annual motor vehicle fuel consumption by three percent. Data in this table is compiled from Table 27 and Table 29.

Pounds CO2e avoided by composting	721
Average per family pounds CO2e emitted from vehicle fuel consumption	21,164
Percent emissions reduction equivalent	3%

#### Table 30. Vehicle Emission Reduction Equivalency

As shown in Table 31, each food scraps participant's full organics service cart avoids more than 34 pounds CO2e. Data in this table is compiled from elsewhere in this report and from  $MEBCalc^{TM}$ .

	Average Weight in Full Organics Cart (pounds)	Pounds CO2e Avoided per Ton Composted	Pounds CO2e Avoided per Full Organics Cart
Yard Debris	76.4	772	29.5
Food Scraps and Compostable Paper	9.1	1,083	4.9
Totals	85.5		34.4

#### Table 31. Pounds CO2e Avoided per Organics Service Cart



# Appendix E: Example Field Forms

This appendix contains examples of the field forms used throughout the study, including:

- Route count form
- Sample placard
- Sample tally sheet



#### **Scalehouse Vehicle Selection Sheet**

#### King County Waste Monitoring Study Set Out and Participant Count Form

Hauler:         n=           Jurisdiction:	Day:	Route:
Jurisdiction:	Hauler:	n=
	Jurisdiction:	

1. Cross off one number from the set out column for each set out

2. Once the circled interval is reached, cross off the number and take the entire set out as a sample.

3. Once all 12 samples are collected, continue counting set outs until the entire route has been driven.

1       2       3       4       5       6       7       8       9       10         11       12       13       14       15       16       17       18       19       20         12       12       23       24       25       26       27       28       30       44       45       464       465       466       467       488       489       490         11       12       23       34       45       46       47       48       49       50 <t< th=""><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th>Set</th><th>Out</th><th>S</th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th></t<>										Set	Out	S										
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211       212       213       214       215       216       217       218       219       220       661       662       663       664       665       666       667       668       669       670       672         221       222       223       224       225       226       227       228       229       230       661       662       663       664       665       666       667       688       689       690         231       232       233       234       235       236       237       238       239       240       661       662       663       664       665       666       667       688       689       690         241       242       243       244       245       246       247       248       249       250       691       691       692       693       694       695       696       697       698       690       700       708       709       710       727       728       729       280       711       712       713       714       755       756       757       758       759       760       770       778       779       780       7	201	202	203	204	205	206	207	208	209	210	6	51	652	653	654	655	656	657	658	659	660	S
221       222       223       224       225       226       227       228       229       230         231       232       233       234       235       236       237       238       239       240         241       242       243       244       245       246       247       248       249       250         251       252       253       254       255       256       257       258       259       260       701       702       703       704       705       706       707       708       709       710         261       262       263       264       265       266       267       268       269       270       711       712       713       714       715       716       717       718       719       720         271       272       273       274       275       276       277       278       279       280       731       732       734       735       736       737       738       739       740       750         271       272       273       274       725       756       757       758       759       760	211	212	213	214	215	216	217	218	219	220	6	61	<b>6</b> 62	663	664	665	666	667	668	669	670	Tota
231       232       233       234       235       236       237       238       239       240       681       682       683       684       685       686       687       688       689       690         241       242       243       244       245       246       247       248       249       250       691       692       693       694       695       696       697       698       699       700         251       252       253       254       255       256       257       258       259       260       701       702       703       704       705       706       707       708       709       710         261       262       263       264       265       267       278       279       280       711       712       713       714       715       716       717       718       719       720         271       272       273       274       275       266       267       288       289       290       711       712       713       714       745       746       747       748       749       750       770       770       778       7	221	222	223	224	225	226	<b>2</b> 27	228	229	230	6	71	672	673	674	675	676	677	678	679	680	
241       242       243       244       245       246       247       248       249       250       691       692       693       694       695       696       697       698       699       700         251       252       253       254       255       256       257       258       259       260       701       702       703       704       705       706       707       708       709       710         261       262       263       264       265       266       267       288       299       270       711       712       713       714       715       716       717       718       719       720       723       724       725       726       727       728       729       730       731       732       733       734       735       736       737       738       739       740       750       751       752       756       757       758       759       760       770       778       779       770       771       778       779       770       776       777       778       779       780       760       761       762       763       764       7	231	232	233	234	235	236	<b>2</b> 37	238	239	240	6	81	682	683	684	685	686	687	688	689	690	
251       252       253       254       255       256       257       258       259       260       701       702       703       704       705       706       707       708       709       710         261       262       263       264       265       266       267       268       269       270       711       712       713       714       715       716       717       718       719       720         271       272       273       274       275       276       277       278       279       280       721       722       723       724       725       726       727       728       729       730       731       732       733       734       735       736       737       738       739       740       750         201       302       303       304       305       306       307       308       309       310       751       752       753       756       767       758       759       760         311       312       313       314       315       316       317       318       319       320       771       772       773       7	241	242	243	244	245	246	<b>2</b> 47	248	249	250	6	91	692	693	694	695	696	697	698	699	700	
261       262       263       264       265       266       267       268       269       270       711       712       713       714       715       716       717       718       719       720         271       272       273       274       275       276       277       278       279       280       721       722       723       724       725       726       727       728       729       730       721       722       723       734       735       736       737       738       739       740       755       756       757       758       759       760       770       7	251	252	253	254	255	256	<b>2</b> 57	258	259	260	7	01	702	703	704	705	706	707	708	709	710	
271       272       273       274       275       276       277       278       279       280       721       722       723       724       725       726       727       728       729       730       7	261	262	263	264	265	266	267	268	269	270	7	'11	712	713	714	715	716	717	718	719	720	
281       282       283       284       285       286       287       288       289       290       731       732       733       734       735       736       737       738       739       740       740         291       292       293       294       295       296       297       298       299       300       741       742       743       744       745       746       747       748       749       750         301       302       303       304       305       306       307       308       309       310       751       752       753       754       755       756       757       758       759       700       731       7	271	272	273	274	275	276	277	278	279	280	7	21	722	723	724	725	726	727	728	729	730	te
291       292       293       294       295       296       297       298       299       300       741       742       743       744       745       746       747       748       749       750         301       302       303       304       305       306       307       308       309       310       751       752       753       754       755       756       757       758       759       760         311       312       313       314       315       316       317       318       319       320       761       762       763       764       765       766       767       778       779       780         321       322       323       324       325       326       327       328       329       330       771       772       773       774       775       776       777       778       799       800         311       342       343       344       345       346       347       348       349       350       791       792       793       794       795       796       777       788       799       800         311       3	281	282	283	284	285	286	287	288	289	290	7	31	732	733	734	735	736	737	738	739	740	Rou
301       302       303       304       305       306       307       308       309       310       751       752       753       754       755       756       757       758       759       760         311       312       313       314       315       316       317       318       319       320       761       762       763       764       765       766       767       768       769       770         321       322       323       324       325       326       327       328       329       330       771       772       773       774       775       776       777       778       799       790       798       799       800       751       752       753       754       755       756       757       758       759       760       777       770       7	291	292	293	294	295	296	297	298	299	300	7	41	742	743	744	745	746	747	748	749	750	
311       312       313       314       315       316       317       318       319       320       761       762       763       764       765       766       767       768       769       770         321       322       323       324       325       326       327       328       329       330       771       772       773       774       775       776       777       778       779       780       793       794       795       796       787       788       789       790       800         311       342       344       345       346       347       348       349       350       791       792       793       794       795       796       797       798       799       800         361       362       363       364       365       366       367       368       369       370       811       812       813       814       815       816       817       818       819       820       831       831       833       830       831       831       832       833       841       814       815       816       817       818       819       8	301	302	303	304	305	306	307	308	309	310	7	51	752	753	754	755	756	757	758	759	760	
321       322       323       324       325       326       327       328       329       330       771       772       773       774       775       776       777       778       779       780         331       332       333       334       335       336       337       338       339       340       781       782       783       784       785       786       787       788       789       790       731       774       775       776       777       778       779       790       790       790       791       792       793       794       795       796       797       798       799       800       801       802       803       804       805       806       807       808       809       810       801       802       803       804       805       806       807       808       809       810       801       802       803       804       805       806       807       808       809       810       801       802       803       804       805       806       807       808       809       810       801       802       824       825       826       8	311	312	313	314	315	316	317	318	319	320	7	61	762	763	764	765	766	767	768	769	770	
331       332       333       334       335       336       337       338       339       340       781       782       783       784       785       786       787       788       789       790       790         341       342       344       345       346       347       348       349       350       791       792       793       794       795       796       797       798       799       800         351       352       353       354       355       356       357       358       359       360       801       802       803       804       805       806       807       808       809       810         361       362       364       365       366       367       368       369       370       811       812       813       814       815       816       817       818       819       820         371       372       373       374       375       376       377       378       399       800       831       832       834       835       836       839       840       841       842       843       844       845       846       8	321	322	323	324	325	326	327	328	329	330	7	71	772	773	774	775	776	777	778	779	780	
341       342       343       344       345       346       347       348       349       350       791       792       793       794       795       797       798       799       800         351       352       353       354       355       356       357       358       359       360       801       802       803       804       805       806       807       808       809       810         361       362       363       364       365       366       367       368       369       370       811       812       813       814       815       816       817       818       819       820         371       372       373       374       375       376       377       378       379       380       821       822       823       824       825       826       827       828       829       830         381       382       383       384       385       386       387       388       389       900       841       842       843       844       845       846       847       848       849       850         401       402       4	331	332	333	334	335	336	337	338	339	340	7	81	782	783	784	785	786	787	788	789	790	Dav
351       352       353       354       355       356       357       358       359       360       801       802       803       804       805       806       807       808       809       810         361       362       364       365       366       367       368       369       370       811       812       813       814       815       816       817       818       819       820         371       372       373       374       375       376       377       378       379       380       821       822       823       824       825       826       827       828       829       830         381       382       383       384       385       386       387       388       389       390       831       832       833       834       835       836       837       889       840         391       392       393       394       395       396       397       398       399       400       841       842       843       844       845       846       847       848       849       850         401       402       403       4	341	342	343	344	345	346	347	348	349	350	7	91	792	793	794	795	796	797	798	799	800	
361       362       363       364       365       366       367       368       369       370         371       372       373       374       375       376       377       378       379       380       811       812       813       814       815       816       817       818       819       820         381       382       384       385       386       387       388       389       390       831       832       833       834       835       836       837       388       389       390       831       832       833       834       845       846       847       848       849       850         401       402       403       404       405       406       407       408       409       410       851       852       856       857       858       859       860         411       412       413       414       415       416       417       418       419       420       861       862       866       867       868       869       870         421       422       423       424       425       426       427       428       4	351	352	353	354	355	356	357	358	359	360	8	01	802	803	804	805	806	807	808	809	810	
371       372       373       374       375       376       377       378       379       380       821       822       823       824       825       826       827       828       829       830         381       382       384       385       386       387       388       389       390       831       832       833       834       835       836       837       388       389       900       831       832       833       834       845       846       847       848       849       850         401       402       403       404       405       406       407       408       409       410       851       852       853       854       857       858       859       860         411       412       413       414       415       416       417       418       419       420       861       862       863       864       865       866       867       868       869       870         421       422       423       424       425       426       427       428       439       430       881       882       886       887       886       8	361	362	363	364	365	366	367	368	369	370	8	11	812	813	814	815	816	817	818	819	820	
381       382       383       384       385       386       387       388       389       390       831       832       833       834       835       836       837       838       839       900         391       392       393       394       395       396       397       398       399       400       841       842       843       844       845       846       847       848       849       850         401       402       403       404       405       406       407       408       409       410       851       852       853       854       855       856       857       858       859       860         411       412       413       414       415       416       417       418       419       420       861       862       863       864       865       866       867       868       869       870         421       422       423       424       426       427       428       429       430       871       872       873       874       875       876       877       878       879       880         431       432       4	371	372	373	374	375	376	377	378	379	380	8	21	822	823	824	825	826	827	828	829	830	
391       392       393       394       395       396       397       398       399       400       841       842       843       844       845       846       847       848       849       850         401       402       403       404       405       406       407       408       409       410       851       852       853       854       855       856       857       858       859       860         411       412       413       414       415       416       417       418       419       420       861       862       863       864       865       866       867       868       869       870         421       422       423       424       425       426       427       428       429       430       871       872       873       874       875       876       877       878       879       880         431       432       433       434       435       436       437       438       440       881       882       883       884       885       886       887       888       889       890       890         441       4	381	382	383	384	385	386	387	388	389	390	8	31	832	833	834	835	836	837	838	839	840	
401       402       403       404       405       406       407       408       409       410       851       852       853       854       855       856       857       858       859       860         411       412       413       414       415       416       417       418       419       420       861       862       863       864       865       866       867       868       869       870         421       422       423       424       425       426       427       428       429       430       871       872       873       874       875       876       877       878       879       880         431       432       433       434       435       436       437       438       439       440       881       882       883       884       885       886       887       88       889       890         441       442       443       444       445       446       447       448       449       450       891       892       893       894       895       896       897       898       899       900	391	392	393	394	395	396	397	398	399	400	8	41	842	843	844	845	846	847	848	849	850	
411       412       413       414       415       416       417       418       419       420       861       862       863       864       865       866       867       868       869       870         421       422       423       424       425       426       427       428       429       430       871       872       873       874       875       876       877       878       879       880       881       882       883       884       885       886       887       888       889       890       897         441       442       443       444       445       446       447       448       449       450       891       892       893       894       895       896       897       898       899       900	401	402	403	404	405	406	407	408	409	410	8	51	852	853	854	855	856	857	858	859	860	
421       422       423       424       425       426       427       428       429       430       871       872       873       874       875       876       877       878       879       880       881       882       883       884       885       886       887       888       889       890       891         441       442       444       445       446       447       448       449       450       891       892       893       894       895       896       897       898       899       900	411	412	413	414	415	416	417	418	419	420	8	61	862	863	864	865	866	867	868	869	870	
431       432       433       435       436       437       438       439       440       881       882       883       884       885       886       887       888       889       890       8         441       442       444       445       446       447       448       449       450       891       892       893       894       895       896       897       898       899       900	421	422	423	424	425	426	427	428	429	430	8	71	872	873	874	875	876	877	878	879	880	bler
441 442 443 444 445 446 447 448 449 450 891 892 893 894 895 896 897 898 899 900	431	432	433	434	435	436	437	438	439	440	8	81	882	883	884	885	886	887	888	889	890	Sam
n en	441	442	443	444	445	446	447	448	449	450	8	91	892	893	894	895	896	897	898	899	900	



**Sample Placard** 





#### Hand-sort Data Entry Sheet



