CURBSIDE RECYCLING
PROGRAM EVALUATION AND STRATEGIC PLANNING
Phase I

Islandwide Automated 3-Cart Residential Collection System

Prepared by:
Department of Environmental Services
City and County of Honolulu
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PROGRAM HIGHLIGHTS

The City & County of Honolulu curbside recycling program launched in November 2007 and islandwide implementation was completed in May 2010. (The program was evaluated after a full year of islandwide operation.)

During fiscal year 2011, the curbside collection system recovered 18,000 tons of mixed recyclables and 53,000 tons of green waste for a total of 71,000 tons recycled.

Oahu's curbside recycling contributes a full six percent to the overall reduction of municipal solid waste (MSW) going to the landfill.

Oahu's green waste capture rate of 77 percent reflects high participation and recovery levels of 85 percent participation at 90 percent recovery levels (or vice versa). Although increases are possible, this program has achieved a maximum goal comparable to matured programs.

Oahu's mixed recyclables capture rate of 52 percent reflects moderate participation and recovery levels of possibly 70 percent participation at 70 percent recovery levels. It is a good start for a new program, but higher rates are achievable.

A 75 percent capture rate for mixed recyclables (85 percent participation at 90 percent recovery) would increase recovery by an additional 8,000 tons, resulting in an increase of $500,000 in revenue to the City and further decreasing waste to landfill.

At a 52 percent capture rate, the blue cart mixed recyclables generated net revenue of $1.5 million in fiscal year 2011. At a 75 percent capture rate, the mixed recyclables would return $2 million in revenue to the City, further offsetting costs to operate the program.

The City has awarded a composting contract that allows for the addition of food waste to green waste recycling (green cart). Oahu households are disposing of more than 31,000 tons of food annually, accounting for more than 15 percent of island refuse. Fruit and vegetable peelings constitute more than 12,000 tons; post-consumer leftovers amount to more than 19,000 tons. In Phase 2, the City will consider the feasibility of a two-pronged approach that would allow fruit/vegetable peelings to be included in the green cart and address the other food leftovers through a waste prevention education campaign.

Contamination (unacceptable materials in recycling carts) can impact processing costs at recycling facilities should levels exceed allowable limits. Contamination levels in the blue cart averaged 10 percent of the material collected in fiscal year 2011 (15 percent limit). Contamination levels in the loads of green waste exceeded the three (3) percent limit for less than one (1) percent of the collected green waste, which incurred $18,000 in additional costs.

Participation will be measured through scientific market research (polling Oahu residents) in the next phase of this evaluation process. The results will provide insight for affecting behavioral changes to improve participation and recycling habits.

PURPOSE

To assess the effectiveness of the curbside recycling program and develop strategies for improvement.

Objectives: Increase Recovery Rates
Decrease Contamination (collection of unacceptable materials)

The evaluation and strategic planning is being conducted in phases:

Phase I	Operational Data
Phase II	Behavioral Data
Phase III	Strategic Planning
Phase IV	Pilot Implementation/Evaluation of Strategies
Phase V	Expanded Implementation of Strategies Based on Pilot Results

This report provides Phase I preliminary evaluation of the operational data, including recovery rates, contamination rates, capture rates, setout rates, and cost/revenue, and presents an overview of the tools and strategies currently employed to educate the public and manage participant error.

The approach to the strategic planning follows the principals of community-based social marketing to identify and foster the behavior changes that will result in the most effective results.

BACKGROUND

The City launched a curbside recycling program in November 2007, starting with pilot programs in Mililani and Hawaii Kai and completing islandwide implementation in May 2010. Currently, there are approximately 160,000 households participating in the program. June 2011 marked the completion of the first full year of islandwide operation, providing sufficient operational data to begin the Phase I program evaluation.

The City maintains detailed recovery data for mixed recyclables and green waste collected in the system, and additionally contracted Cascadia Consulting to conduct a waste composition analysis of the gray cart refuse to quantify the recyclable materials still being disposed with the trash. This combination of data provides an accurate picture of the current capture rates and recycling potential.

PROGRAM DESCRIPTION

The curbside recycling program is provided to 160,000 single-family homes that are serviced by the City using automated collection carts. For approximately 20,000 homes where automated service is not possible, the City provides a manual collection system that does not include recycling as yet.

Carts

Each household is provided three carts:

- Gray 96-gallon cart for refuse
- Green 96-gallon cart for green waste
- Blue 64-gallon cart for mixed recyclables

Additional carts are distributed based on need upon request by the household.

Collection Schedules

Neighborhoods are serviced twice per week: Monday/Thursday, Tuesday/Friday or Wednesday/Saturday. One day is designated for refuse pickup and the other for recycling pickup (alternating weekly between the blue and green recycling carts). Collection schedules and calendars are posted online at www.opala.org and were included in the instructional brochure provided at implementation.

Recyclable Materials

- Blue cart recyclables include aluminum cans, glass bottles and jars, plastic PET (#1) and HDPE (#2) containers, newspaper, and corrugated cardboard boxes.
- Green cart green waste includes yard trimmings, leaves, grass clippings, Christmas trees, palm fronds, weeds.

PRELIMINARY FINDINGS

Operational data: mixed recyclables and green waste recovery; food waste; capture rates, setout rates, participation rates; costs/revenue

Mixed Recyclables and Green Waste Recovery

During fiscal year 2011, 18,000 tons of mixed recyclables were collected in the blue carts and 53,000 tons of green waste collected in the green carts. Table 1 provides a detailed breakdown of the mixed recyclables by month and material types. Table 2 provides a detailed breakdown by month for green waste.

Note: The mixed recyclables recovery data does not include quantities that households may have additionally recycled in other collection systems, including HI-5 redemption or community recycling bins. It is not possible to extract these numbers from the available data. The green waste recovery data does not include quantities that households may have additionally taken themselves to convenience centers or directly to the composting facility. The City recovered an additional 16,000 tons of green waste from residential drop-off.

Table 1 Mixed Recyclables Recovery (Blue Cart) FY2011

	COMMODITIES (tons)									
Month	OCC	ONP	Plastic (PET)	Plastic (HDPE)	Aluminum	HI-5 Glass	Other Glass	Bi-Metal	Contamination	**Total Tonnage**
July	524	691	36	42	9	66	208	10	164	**1,748**
August	489	612	34	45	10	71	226	7	158	**1,653**
September	525	627	35	43	7	61	194	8	123	**1,624**
October	587	621	30	39	7	45	143	11	141	**1,624**
November	539	682	29	42	6	51	160	8	164	**1,682**
December	616	903	27	35	6	51	161	12	208	**2,020**
January	624	905	30	43	8	54	171	10	279	**2,125**
February	501	656	26	36	6	50	158	7	197	**1,637**
March	521	713	32	44	4	50	158	11	164	**1,696**
April	488	719	33	45	6	51	162	12	216	**1,732**
May	512	667	39	37	4	53	167	9	202	**1,691**
June	501	671	38	56	6	55	174	14	226	**1,739**
TOTALS	**6,425**	**8,467**	**388**	**508**	**80**	**657**	**2,082**	**119**	**2,245**	**20,971**

OCC	Old Corrugated Cardboard
ONP	Old Newsprint
PET	Polyethylene Terephthalate
HDPE	High Density Polyethylene Terephthalate
HI-5 Glass	Deposit Beverage Glass
Other Glass	Non-Deposit Glass Containers
Bi-Metal	Steel/Tin HI-5 Deposit Beverage Containers
Contamination	Unacceptable Materials/Trash

Table 2 Green Waste Recovery (Green Cart) FY2011

Month	Green Waste Recycled in Green Carts (tons)
July	4,618
August	4,456
September	4,210
October	4,149
November	3,983
December	3,808
January	4,865
February	4,113
March	4,893
April	4,674
May	4,763
June	5,106
TOTALS	**53,638**

Food Waste

The waste characterization study additionally analyzed the quantities of food waste collected residentially in the gray carts to aid the City in assessing potential programs to reduce or compost. The City awarded a new composting contract which allows for the addition of food waste organics in the green cart. The facility will be designed to process green waste, food waste and sewage sludge, and is expected to be operational in January 2013.

The study found that households dispose of more than 31,000 tons of food annually, accounting for more than 15 percent of the refuse collected in the gray cart. Of that total, fruit and vegetable peelings constitute more than 12,000 tons; post-consumer leftovers amount to more than 19,000 tons. Although the new composting facility will be capable of processing both types of food waste, there are concerns regarding the placement of food waste in the green carts with a two week collection cycle.

Further study is needed to evaluate the behaviors associated with this waste and to determine if the inclusion of some food waste in the green carts is feasible. A two-pronged approach may prove effective, allowing fruit and vegetable peelings to be included in the green carts for composting, while addressing the post-consumer leftovers with a waste prevention education campaign to assist households in reducing the amount they throw away through smarter purchasing, storing, preparing, and serving.

ENV conducted a small pilot program to assess the feasibility of including select types of food waste with the green waste in the green cart. The pilot included approximately 20 participants and used various types of kitchen food waste collection containers and compostable bags. The pilot solicited participant feedback on convenience and function of kitchen containers and compostable bags, with particular focus on how well the bags were able to contain the food waste and control any odor/vector problems in the green carts. The pilot program was limited to fruit and vegetable peelings and a few other compostables such as coffee grounds, tea bags, and egg shells. The results were positive. The bags worked well and the inclusion of the bagged food waste in the green carts did not attract flies or cause odor. Further pilot projects are needed to determine if the same types of food waste could be included in the green cart without using the compostable bag, and thus avoid the cost of the bags.

Capture Rates, Setout Rates and Participation Rates

Capture rates are measured by the proportional amount of recyclable material collected relative to the total amount available in the specific waste stream. Capture rates do not denote the participation rate. For example, a 50 percent capture rate could be the result of 70 percent participation at 70 percent recovery – i.e., 70 percent of the households participating in the program with each household sorting 70 percent of their recyclables into the blue cart. Or it could reflect 60 percent participation and 90 percent recovery.

Setout rates are measured by counting the number of carts placed at the curb for collection. Again, this does not denote participation as some households may place their recycling carts at the curb every two weeks while others do so monthly.

Participation rates are measured through participant surveys with questions that probe numerous aspects of household recycling behaviors, including whether they recycle, how much they recycle, and how often they place their carts at the curb for collection. Participant surveys will be conducted as part of the Phase II evaluation.

Table 3 provides the capture rates for mixed recyclables and green waste. The calculations combine actual recovery data maintained by the City with waste composition data from an analysis conducted by Cascadia Consulting. See Appendix A for the complete "Gray Cart Residential Waste Characterization Study".
Table 4 provides blue cart setout rates for 17 randomly selected routes counted in August and September, 2011.

Table 3 Capture Rates FY2011



(in tons)	Recyclables Collected in Blue Carts	Green Waste Collected in Green Carts	Recyclables and Green Waste Disposed in Gray Carts	Capture Rate
Mixed Recyclables	18,445	0	17,158	**52%**
Newspaper	8,185	0	5,404	60%
Corrugated Cardboard	6,425	0	4,476	59%
Glass Bottles and Jars	2,739	0	3,079	47%
Aluminum Containers	80	0	847	9%
Bi-Metal HI-5 Beverage Containers	119	0	23	84%
#1 PET Plastic Containers	388	0	1,869	17%
#2 HDPE Plastic Containers	508	0	1,461	26%
Green Waste	0	53,638	15,714	**77%**
Totals*	18,445	53,638	32,871	**69%**

**Columns may not total due to rounding.*

A preliminary analysis of the capture rates begins to direct the next phases of the evaluation and strategic planning:

- *Can green waste recovery be increased?* The green waste capture rate of 77 percent indicates high participation at a high recovery level, either 85 percent participation at 90 percent recovery level or vice versa. It is unlikely that a higher capture rate is possible, and would seem unnecessary to expend effort and funds to attempt to do so.

- *Can mixed recyclables recovery be increased?* The overall mixed recyclables capture rate of 52 percent reflects a moderate participation and recovery level, and indicates that there may be opportunity to capture greater volumes of material. The study revealed that there is a total of 35,000 tons of mixed recyclables generated by the 160,000 households in the 3-cart system. Increasing the capture rate to 75 percent, with say 85 percent participation at 90 percent recovery, would capture an additional 8,000 tons of material. With an average net revenue return to the City of approximately $70/ton, the City and the taxpayers would benefit by increasing revenue from the program by more than $500,000 per year. See the following section on Cost/Revenue.

- *How to affect an increase in recovery rates will require identifying the behaviors behind the data.* For example, the approach would be different depending upon the participation/recovery levels. If 60 percent of the households were participating at an almost 100% recovery level, the participant study would need to uncover the barriers for non-participating households. But if the 52 percent capture rate reflects 80 percent participation at 65 percent recovery levels, then the approach may be to assist the participating households to sort more into their blue carts.

  A comparison of the capture rates for the different material types appears to indicate that the latter is more likely. The 60 percent recovery for paper versus 17-26 percent for plastic may indicate that there is a lack of understanding about what constitutes a No.1 and No.2 plastic container. The relatively low capture rate for aluminum cans may indicate that participants are unaware that, in addition to aluminum beverage cans, there are other products in aluminum cans which are quite common in Hawaii, including Spam, Vienna sausage, and cat food (perhaps 800 tons worth).

  Additionally, it is important to note that the impression of the recycling rates for aluminum, plastic and glass (based upon the capture rate) are likely to be skewed low due to additional recycling activity not captured in the data, most specifically HI-5 redemption. Households that recycle in the blue carts may also return HI-5 beverage containers to redemption centers or donate to fundraisers. Some households may have continued to drop-off their recyclables at the community bins to support the schools.

  The operational data prompts the questions about these behaviors and more, which will be further probed in the Phase II evaluation, and assist the City in formulating strategies to foster sustainable behaviors.

Table 4 Setout Rates

District	Route	Refuse Day	Recycle Day	No. Blue Carts at Curb	No. Homes	Setout Rate
Kapaa	7	Wednesday	Saturday	410	930	44.09%
Pearl City	19	Thursday	Monday	438	946	46.30%
Laie	10	Friday	Tuesday	240	950	25.26%
Pearl City	26	Monday	Thursday	541	898	60.24%
Waianae	11	Tuesday	Friday	243	820	29.63%
Pearl City	25	Wednesday	Saturday	540	844	63.98%
Honolulu	58	Saturday	Wednesday	573	925	61.95%
Wahiawa	14	Monday	Thursday	485	931	52.09%
Honolulu	65	Tuesday	Friday	547	972	56.28%
Kapaa	4	Tuesday	Friday	584	930	62.80%
Kapaa	5	Tuesday	Friday	606	930	65.16%
Pearl City	32	Thursday	Monday	429	905	47.40%
Pearl City	33	Friday	Tuesday	535	937	57.10%
Pearl City	17	Friday	Tuesday	604	941	64.19%
Kapaa	1	Thursday	Monday	405	930	43.55%
Honolulu	51	Thursday	Monday	489	981	49.85%
Honolulu	54	Thursday	Monday	541	949	57.01%
					Average	**52.17%**

Since the current green waste capture rate appeared to be at maximum levels, the focus for the setout study was placed on the blue carts to aid in further evaluation. The setout rates provide a cross-check for evaluating other data related to participation. For example, given a 52 percent setout rate for blue carts, the participation is likely to be more not less. However, when residents are asked about their participation in the survey questions, they may be inclined to respond with more positive statements about their recycling behavior than is really true. The setout rates, combined with participant responses about how frequently they place their blue carts at the curb (every two weeks, monthly?), can be used to check the veracity of the overall participation rate results. Additionally, an expanded study of setout rates could contribute to developing more efficient collection systems.

Contamination

Contamination refers to unacceptable materials in the blue and green recycling carts, and is assessed under two general categories: unacceptable types of paper, plastic, etc., that the household mistakenly thought was included in the recycling program, and trash. The latter is of greater concern as it is an indicator that the household is misusing the recycling carts for garbage. The overall concern is that contamination increases processing costs at the recycling facilities.

The City monitors contamination levels through several sources:

- The mixed recyclable processing contractor sorts out the unacceptable materials and provides quantity data each month along with the recycling data.
- The green waste processing contractor notifies the City if a truck delivers a load contaminated over the allowable limit (3%).
- City staff monitors trucks as they unload at the recycling and composting processing facilities to identify the levels of contamination by collection route.
- All collection trucks are fitted with video cameras that allow the collection operators to monitor the contents for contamination.
- City inspectors are dispatched to check carts in problem routes.

During fiscal year 2011, the program-wide contamination levels in the blue cart averaged 10 percent of the material collected (see Table 1). In comparison, during the pilot program in Mililani and Hawaii Kai, the contamination levels were under four (4) percent. The processing contract limits contamination to no more than 15 percent program-wide. Should contamination levels exceed 15 percent for more than three months, the contractor can request an adjustment in costs.

For green waste, precise data is not tracked in the same manner. The processing contract limits contamination to three (3) percent per truckload, not including the plastic yard bags used by households. Should contamination levels exceed three (3) percent, the contractor can assess a double tip fee charge for the entire load. The contractor notifies the City of each occurrence. Of the 53,000 tons of curbside collected green waste, a total of 282 tons was assessed at the higher rate due to contamination, costing the City an additional $18,330.

Costs/Revenue

Collection costs remained generally the same with the integration of recycling into the residential collection system. Collection service remained twice per week, with one day for refuse and one day for recycling replacing the two collections for all refuse.

Households sort into three carts – blue for mixed recyclables, green for green waste and gray for refuse – with each material type delivered to a separate facility for processing. The mixed recyclables are delivered to the materials recycling facility (MRF) for sorting, packing and shipping to markets for remanufacture into new products. The green waste is delivered to a composting facility to be processed into soil amendment products. The refuse is delivered to the H-POWER waste-to-energy facility for incineration and energy production.

For fiscal year 2011:

- The mixed recyclables returned a net revenue to the City of approximately $70 per ton. Monthly revenue varied with fluctuations in commodity values. The total revenue return to the City was $1.5 million. See Table 5.
- The tip fee for curbside collected green waste was $65 per ton. For the 53,638 tons collected in the green carts, the total cost to the City was $3.5 million.

Table 5 Mixed Recyclables Revenue FY2011

		REVENUE						
Month	Total Tonnage	HI-5	ADF Glass	Commodity	TOTAL REVENUE	Processing Charge	Revenue To City	Revenue Per Ton
July	1,748	$113,763	$33,228	$157,737	$304,728	$86,971	$108,879	$62
August	1,653	$123,602	$36,086	$152,645	$312,332	$82,243	$115,045	$70
September	1,624	$106,306	$31,079	$172,216	$309,600	$80,775	$109,264	$67
October	1,624	$93,988	$22,897	$189,419	$306,304	$80,793	$107,682	$66
November	1,682	$93,984	$25,667	$202,909	$322,560	$83,668	$114,071	$68
December	2,020	$93,217	$41,830	$249,477	$384,523	$100,495	$137,044	$68
January	2,125	$110,833	$44,506	$259,704	$415,043	$105,729	$149,396	$70
February	1,637	$90,151	$41,050	$204,430	$335,631	$81,422	$122,758	$75
March	1,696	$93,281	$41,121	$220,760	$355,162	$84,380	$130,721	$77
April	1,732	$104,277	$42,124	$225,937	$372,338	$86,178	$138,239	$80
May	1,691	$95,609	$43,445	$220,478	$359,532	$84,121	$132,965	$79
June	1,739	$115,851	$45,143	$229,592	$390,586	$86,522	$146,969	$85
TOTALS*	**20,971**	**$1,234,862**	**$448,175**	**$2,485,301**	**$4,168,339**	**$1,043,296**	**$1,513,032**	

**Columns and rows may not total due to rounding.*

Total Tonnage	18,445 tons mixed recyclables and 2,245 tons contamination. The processing charge is applied to the total.
HI-5	Deposit value of five cents per container plus handling fees of two-four cents per container.
ADF Glass	Advanced disposal fee on non-deposit glass containers which provides financial support for glass recycling of eight-thirteen cents per pound.
Commodity	Market value of the recyclable materials.

The mixed recyclables processing contract is a revenue sharing agreement. A per ton unit price for processing was established by bid. The City is credited the full value of the collected material to cover the processing charge, after which the remaining value is shared 50/50 between the contractor and the City.

In assessing the data in Table 5, the City delivered 20,971 tons of mixed recyclables to the contractor for a total processing charge of $1.04 million. The total value of the material was $4.17 million. The City was credited the full processing charge against the material value, and then split the remaining $3.1 million with the contractor, resulting in a net revenue to the City of $1.5 million.

The unit price processing charge was $49.75 per ton. The material value includes the total sum of the commodity market values, HI-5 deposit and handling fees, and ADF non-deposit glass subsidies. The commodity values for each material vary with fluctuations in the market. Approximate range of commodity values:

Old Corrugated Cardboard	$140-190/ton
Old Newsprint	$115-160/ton
PET Plastic	$360-670/ton
HDPE Plastic	$160-345/ton
Aluminum	$1060-1700/ton
Bi-Metal	$100-180/ton
Glass	$-100 to -105/ton (shipping costs exceed market value)

For upcoming years:

- The current mixed recyclables revenue sharing contract extends through May 2014 with all terms and conditions remaining the same.
- The current green waste processing contract extends through September 2012, and is intended to continue to provide an interim agreement until the new green waste/food waste/sewage sludge processing facility is ready to begin operation in January 2013.
- The tip fee for green waste, food waste and sewage sludge under the new organics processing contract will be $118 per ton. The increase in the unit price for green waste is related to premium costs for processing sewage sludge.

CONTRIBUTION TO LANDFILL DIVERSION

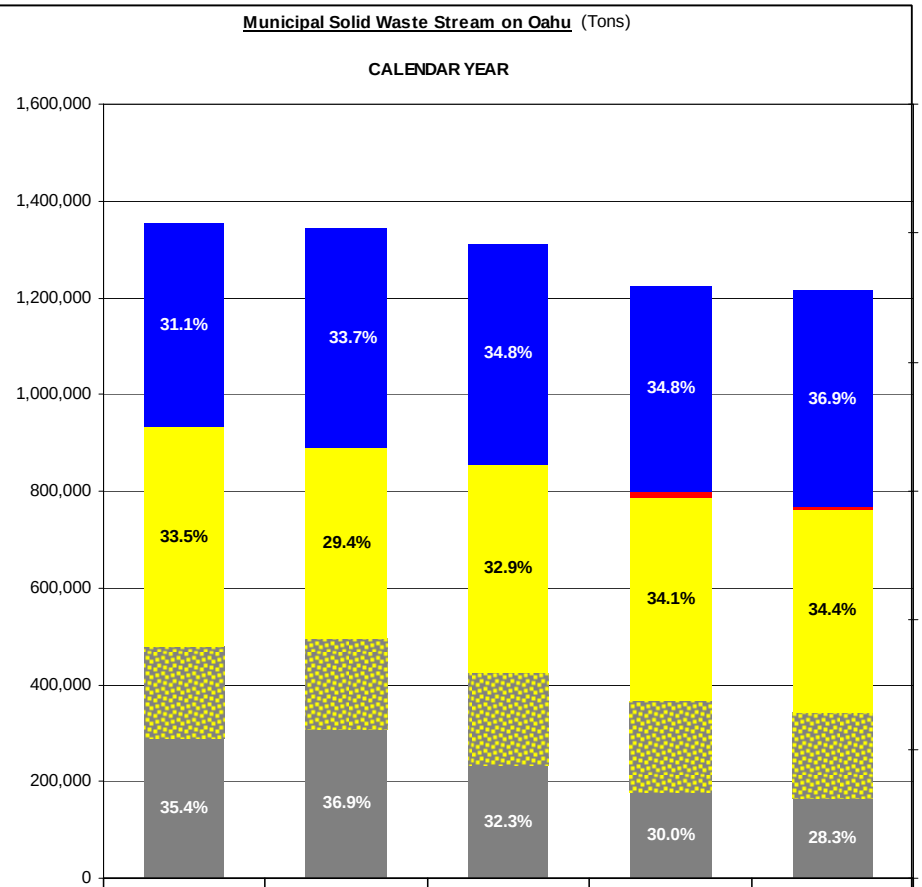
During fiscal year 2011, the curbside collection system recovered 18,000 tons of mixed recyclables in the blue carts and 53,000 tons of green waste in the green carts for a total of 71,000 tons recycled; 199,000 tons of waste was collected in the gray carts. The total amount of material collected was 270,000 tons. Proportionally, 26 percent of the residential waste collected in the 3-cart system was recycled, representing 16 percent of Oahu's general material recycling rate for the most recent year and contributing a full six (6) percent to the overall reduction of municipal solid waste (MSW) going to the landfill.

The chart below presents a comparative overview of the proportional quantities of municipal solid waste (MSW) diverted from landfill through recycling and waste-to-energy over the most recent five years. This data is specific to MSW and diversion from the City's Waimanalo Gulch Sanitary Landfill, and does not include construction and demolition (C&D) waste recycling or disposal at the PVT C&D landfill.

MSW = Municipal Solid Waste

*MSW delivered for shipping 2009-10 was eventually disposed at HPOWER in 2011.

**HPOWER Ash/Residue tons are shown separately to avoid double counting in both HPOWER and landfill receivables.



	2006	2007	2008	2009	2010
General Material Recycling (MSW)	421,072	453,372	456,876	426,947	448,639
Trash Shipping (MSW)*	0	0	0	13,142	4,487
HPOWER - Waste to Energy (MSW)	454,068	396,218	431,599	418,618	418,095
HPOWER (Ash & Residue)**	191,800	189,351	191,713	188,683	179,946
MSW Landfill	286,842	306,691	233,065	178,512	163,736
Total Landfill Diversion % (MSW)	64.6%	63.1%	67.7%	70.0%	71.7%
TOTAL Tonnage (MSW)	1,353,782	1,345,632	1,313,253	1,225,902	1,214,904

PUBLIC PARTICIPATION STRATEGIES IN USE

Since the launch of the curbside recycling program, the City has developed and expanded its public education and outreach to further public awareness and provide information regarding the how-to's of the program. The following provides a brief description of the educational materials and strategies currently in use. The Phase II participant surveys will provide additional information regarding behaviors and effective messaging that could be applied to further enhance these existing strategies and contribute to the development of new approaches.

Participation Information/Education

These tools promote awareness and provide information regarding what and how to recycle.

- Recycling Carts
  Recycling information is embossed into the plastic on all of the blue and green recycling carts. The list of recyclable materials are on the back side of the cart, under the handle. The opala.org website and phone number is on the cart lid.

- Website – www.opala.org
  The opala website is the central source of public information on all things related to refuse and recycling on Oahu. It is branded on all print materials, media and on the recycling carts. A direct link from the home page connects users to their collection schedule and program information. Collection schedules and calendars are easy to access by typing in the street address. Can you sort it out into the correct carts? -- Play the "Where Do Things Go?" game from the home page or Learning Center to test your knowledge.

- The Green Channel
  This new interactive television channel on Oceanic 332 and online at www.opala.org provides 24/7 viewing of short stories about recycling, including the automated technology in the City's collection trucks, the sorting operation at the material recycling facility (MRF), the process of turning green waste into compost, and a series of creative shorts under the title "Secrets of Recycling" designed to provide easy tips to households for recycling at home. The channel features a cast of young local actors who explain the world of recycling to local viewers in entertaining, 3-minute episodes. The Green Channel is branded on all print media and featured prominently on the opala.org home page. The audience is general public plus it is being used as a teaching tool in school classrooms. (http://opala.org/solid_waste/media/Green_Channel.html)

- Brochure – Recycling and Disposal Guide for Oahu
  This general brochure provides guidelines for refuse and recycling services and programs, including a centerfold spread about what materials to sort into the blue, green and gray carts, and the benefits to Oahu in new products, compost and energy. Online at www.opala.org in the Media Library. (http://www.opala.org/solid_waste/media/Print_Media.htm)

- Activity Books – Schools/Classrooms
  The Opala IQ Book (5th grade up) is a fun and informative educational tool to help students and families become more opala akamai. The Word Finder and Crossword Puzzle introduce students to waste and recycling vocabulary, and the Opala IQ questions guide them through the critical thinking about managing our waste. *Where Do Things Go? Coloring Activity Book* (K-3) helps students to sort it out with Kevin and the three animated carts, adapted from the Honolulu Theatre for Youth production by the same name, which was performed during their 2010-11 Season of Science. Both books include a Sort It Out at Home information page and a "Where Do Things Go?" sorting activity. Online at www.opala.org in the Media Library. (http://www.opala.org/solid_waste/media/Print_Media.htm)

- School Recycling Shows
  The *Sort It Out* recycling education show toured 30 Oahu schools in April/May 2011, teaching the students the ins and outs of curbside recycling through a series of skits, songs and game shows. The Honolulu Theatre for Youth production of *Where Do Things Go?* entertained more than 20,000 students and families at the Tenney Theatre with a series of playlets about recycling, wastewater, litter and energy. Every student from both shows went home or back to class with an activity book to further reinforce the messages. Highlights of both shows are featured on The Green Channel on Oceanic 332 and online at www.opala.org. Select "Sort It Out" and "Where Things Go." (http://www.opala.org/solid_waste/media/Green_Channel.html)

- School Recycling Projects Grant Program
  The grant program provides financial assistance, up to $500 per school, to support schools that want to establish and implement a sustainable recycling project on their campus. The grant pays for an approved Recycling Teaching Partner that provides recycling training and implementation assistance to the school for programs including campus composting for green waste, campus worm composting for food waste, and school-wide mixed materials recycling. Recycling Teaching Partners include the Kokua Hawaii Foundation, The Green House and Waikiki Worm. All participating schools utilize the activity books to help students take the recycling ethic learned through the campus project home to their families. The program was initiated in 2006 and has supported more than 200 school recycling projects, 25 to 50 projects each school year. More details and grant proposal forms are online at www.opala.org in the Learning Center.
  (http://www.opala.org/solid_waste/learning_center/Recycling_Projects_And_Assistance.html)
  As an example, Hokulani Elementary's worm composting project is profiled on The Green Channel on Oceanic 332 and online at www.opala.org. Select "Food for Worms."
  (http://www.opala.org/solid_waste/media/Green_Channel.html)

- Costco Customer Education Project
  Costco's in-store recycling education program helps consumers as they shop to easily identify which products on the shelves are recyclable. The City's recycling team worked collaboratively with Costco Hawaii store managers to survey all of their products and develop a system to amend product signs to include blue cart recycling instructions and integrate recycling messaging throughout the store. The program was launched in April 2011 at all four Costco stores on Oahu and will remain for the year while the potential for sustaining the program is evaluated. If it proves successful and effective, it could provide a model for other retail stores to follow. Costco's program is featured on The Green Channel on Oceanic 332 and online at www.opala.org. Select "What's in Your Cart?" (http://www.opala.org/solid_waste/media/Green_Channel.html)

- The Green Channel/Curbside Recycling Display
  The City's recycling education display toured libraries and took residence at Costco stores during the campaign launch and in Honolulu Hale and Kapolei Hale courtyards. The display features the curbside recycling program, life-size representations of the cast of The Green Channel, a built-in television/DVD player and the brochures and activity books described above. Library visitors, shoppers and those coming to do business with the City at satellite city hall or vote could watch The Green Channel, check out the blue/green/gray recycling carts, pick up a brochure. The libraries additionally included a display of recycling and opala-related books, recycled craft activities, storytelling and workshops on "Garbology." The library tour and display is featured on The Green Channel on Oceanic 332 and online at www.opala.org. Select "Recycling Display Tour."
  (http://www.opala.org/solid_waste/media/Green_Channel.html)
  (http://www.opala.org/solid_waste/recycling_education_display.htm)

Contamination Specific Tools

These tools are used to correct participant error regarding unacceptable materials and trash in recycling carts.

- Ohia Database
  The City tracks additional cart requests/distribution and error notices on an address database linked to the City's GIS (geographic information system). This enables City staff to better assist residents and enforce regulations by having an accurate history of the household's requests and errors.

- Operator Reports
  Collection trucks are outfitted with cameras that enable the operators to view the contents of the cart as it is emptied into the hopper. The operators report the addresses where trash was spotted in the recycling carts. The resident is sent a letter advising them of the reported problem and providing information about proper sorting and the importance of doing it correctly. Also, the resident is advised of the potential removal of their recycling carts if they continue to misuse recycling carts for trash.

- Cart Inspections
  City inspectors check the contents of recycling carts at the curb and tag the carts with corrective notices. The cart tags indentify the error as well as provide proper sorting instructions.

- Cart Removal
  Households with repeated violations are sent a final warning by mail that their recycling carts will be removed if there is another incident of trash found in the recycling carts. When the carts are removed, a removal notice is left at the house by the City supervisor.

- Processing Facility Monitoring
  City staff monitor trucks unloading at the recycling and composting facilities, noting routes with high amounts of trash and contamination. Inspectors are dispatched to those neighborhoods to check and tag carts.

Operator reports and cart removal apply to trash contamination only; the household is misusing the recycling carts for garbage. Cart inspections/tags and processing facility monitoring additionally check for unacceptable materials such as other paper and other plastics, which can be corrected through more education.

RECOMMENDATIONS

Increase recovery rates for mixed recyclables to further reduce waste to landfill and to generate additional revenue. By increasing the capture rate from 52 percent to 75 percent, the City would divert an additional 8,000 tons from the landfill and receive an more than $500,000 annually in additional net revenue. Total revenue generated by the program would increase from $1.5 million to $2 million annually. A 75 percent capture rate sets the goal to achieve 85 percent participation at a 90 percent recovery level.

Maintain current recovery rates for green waste. A 77 percent capture rate indicates that the program is already achieving a high participation and recovery level, say 90 percent participation at an 85 percent recovery level or vice versa.

Develop strategies for reducing food waste through waste prevention.

Develop an operational plan for collecting food waste in green carts that can minimize odor/vectors within the two week collection cycle.

Reduce levels of contamination in the blue and green recycling carts to minimize additional costs associated with sorting and processing.

NEXT STEPS

Tentative timetable for further study, strategic planning and implementation

Phase I, Evaluation of Operational Data
Data compiled during fiscal year 2011. Report prepared and submitted November 2011.

Phase II, Behavioral Data
Public participation surveys to be developed and conducted November 2011 through March 2012, contributing data to the strategic planning in Phase III.

Phase III, Strategic Planning
Development of tools and strategies to affect changes in participant recycling behaviors. February through April 2012.

Phase IV, Pilot Implementation/Evaluation of Strategies
Implementation of pilot programs to assess the effectiveness of the strategies. April through June 2012.

Phase V, Expanded Implementation of Strategies Based on Pilot Results
Full scale implementation of strategies that prove effective. July 2012 through June 2013.

Appendix A

Gray Cart Residential Waste Characterization Study
Cascadia Consulting Group

2011 City and County of Honolulu Gray Cart Residential Waste Characterization Study

October 2011

CASCADIA CONSULTING GROUP

Seattle, WA | San Jose, CA

www.cascadiaconsulting.com

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Introduction and Objectives

In 2011 the City and County of Honolulu (the City) commissioned Cascadia Consulting Group to characterize the disposed residential waste collected by the City in gray carts. The City will use this data to further evaluate the effectiveness of the three cart system that collects refuse, recycling, and green waste in gray, blue, and green carts respectively. The primary purpose of this study was to identify the remaining quantity of recyclable materials and green waste disposed in the gray carts. The secondary objective was to identify the amount of food waste disposed in the gray carts.

The City is divided into seven collection districts served primarily by automated collection trucks. Manual trucks serve a small portion of households, primarily those that the side-loading automated trucks can't serve. Only gray cart residential waste, which is collected by automated trucks, was eligible for sampling in this study. The gray cart residential waste stream includes single-family households and some townhouses.

The remainder of this report is organized into two sections: Summary of Methodology and Results. The appendices that follow the main body of the report provide additional detail on the study, including definitions of waste categories, a detailed methodology, an explanation of the composition calculations, and examples of the field forms.

Summary of Methodology

To characterize the gray cart residential waste stream in the City, Cascadia implemented a three-phase methodology:

- **Develop a sampling plan** to ensure a representative and efficient approach for meeting the City's objectives.
- **Collect composition data** through hand-sort characterization methods.
- **Analyze data and provide a report** to document findings of the study.

Each of the three phases is summarized below. More details on the study methodology are provided in Appendix B.

Develop Plan

Before the field work began, a sampling plan was developed to ensure a representative and efficient approach for meeting the City's objectives.

Step 1: Identify Sampling Universe

The first step in planning a waste characterization study is to identify and carefully define the waste streams to be studied. For this study the universe included all automated residential refuse routes in the City, which includes approximately 160,000 single family homes and townhouses. To be eligible for automated collection, a residence must be accessible to the automated trucks, have enough curb space for the collection, and use the City-issued gray carts. Manual collection routes, bulky items collections, refuse disposed of at the convenience centers, and multi-family refuse were excluded from the universe of eligible loads.

Step 2: Define Waste Sectors

This study divided the City's gray cart waste stream into sectors based on seven existing collection districts: Honolulu, Kapaa, Laie, Pearl City, Wahiawa, Waialua, and Waianae. The Honolulu collection district was further divided into East and West sectors to create eight sectors for sampling. Subdividing the overall gray cart waste stream into these eight sectors provided detailed information at the collection districts level and allows for comparisons between districts while still permitting a calculation of the City's overall gray cart composition. The remainder of the report will reference the eight study sectors as "collection districts" or "districts."

Step 3: Classify Waste

The study defined 11 material types based on the materials currently accepted in the existing blue cart recycling and green cart green waste programs. This material list was designed to quantify the recyclables and green waste remaining in the gray cart waste stream. These material types were organized into four **Material Classes**: **Recyclables, Green Waste, Food Waste,** and **Other Materials**, as shown in Table 1. The 11 material types are defined in Appendix A.

Table 1. Material Types by Material Class

Material Class	*Material Type*
Recyclables	
	Newspaper
	Corrugated Cardboard
	Glass Bottles and Jars
	Aluminum Containers
	Bi-Metal HI-5 Beverage Containers
	#1 PET Plastic Containers
	#2 HDPE Plastic Containers
Green Waste	
	Green Waste
Food Waste	
	Food-Fruit and Vegetable Peelings
	Food-Post Consumer
Other Materials	
	Other Materials

Step 4: Allocate Samples

The number of samples needed to achieve a specified relative error increases as the relative error decreases and is equal to the most variable commodity of interest. In the case of gray cart waste in Honolulu, the most variable commodity was expected to be *green waste*. The project team agreed on a target relative error of 15% for recyclables and 25% for *green waste* and calculated that 135 samples were needed to achieve these targets. The sample number calculations were based on the measured variability of samples from similar jurisdictions. The level of precision is closely tied to the number of samples and nearly independent of the population size, given a large enough sample population.

The 135 samples were then approximately evenly distributed across each of the eight collection districts to maintain approximately equal levels of precision for each of the collection districts. Equal levels of precision facilitate comparisons of composition data from one district to the next.

Table 2. Allocated and Actual Sample Counts

Collection District	Allocated Number of Samples	Actual Number of Samples
Honolulu East	19	19
Honolulu West	18	18
Kapaa	19	19
Laie	15	15
Pearl City	19	19
Wahiawa	15	15
Waialua	15	15
Waianae	15	15
Total	**135**	**135**

As the next step in the allocation process, the consultant team pre-selected random routes for sampling from each of the collection districts. Several of the collection districts were served by a relatively small number of trucks on a few days per week instead of many trucks on every day of the week. For example, the Pearl City collection district is served by at least seven and as many as 10 trucks per day, six days per week. In contrast, the Waialua collection district is served by one truck per day, three days per week. For this reason, samples were not exactly equally distributed among districts.

Samples were allocated as shown in Table 2. At least 15 samples were collected from each district. This allocation maximized the precision of the composition data for the small districts and attempted to minimize the difference in the number of samples between the large districts and the small districts. As also shown in Table 2, all samples were collected as allocated. To achieve the 15 sample target from some districts sometimes required collecting multiple samples from one truck.

Collect Data

Implementing the sampling plan to collect data required coordinating with collections and facility staff and collecting and sorting the samples into the 11 defined material types.

Step 1: Coordinate with Collection and Facility Staff

Before the scheduled fieldwork began, the consultant team met with key staff at the City, including collection yard supervisors and collection drivers, to coordinate the random selection of routes for sampling and the delivery of loads selected for sampling. The consultant team also met staff at Kapaa and Keehi transfer stations and at the H-POWER plant (the sampling facilities) to coordinate sample collection, sorting logistics, and other logistics involved with the field data collection effort.

For all selected route trucks, collection yard supervisors ensured that drivers followed the special collection instructions and distributed sample placards to drivers as they began their route each day. See Figure 1 for an example of a collection vehicle with a placard in the windshield. The collection drivers placed the sample placards (see Appendix D for examples of all field forms) in the windshield of their vehicle so that they were visible to facility staff and the sorting crew. Scalehouse staff at the transfer stations and at H-POWER assisted the sampling crew by directing the selected route vehicles to the sampling area. The loader operators and other facility staff also helped with the collection of samples and the removal of sorted material.

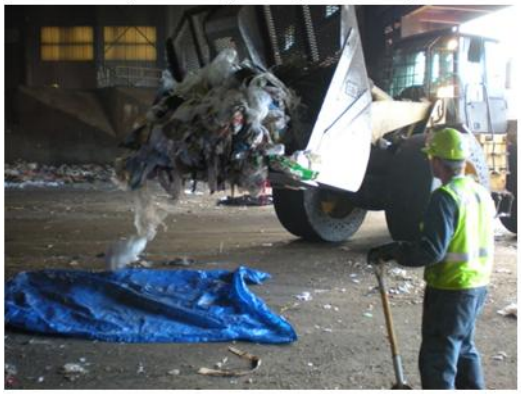
Figure 1. Collection Vehicle with Placard

Step 2: Collect and Characterize Samples

Sampling took place from May 23, 2011 through June 2, 2011 at Keehi and Kapaa transfer stations and at the H-POWER plant. A total of 135 samples of gray cart waste, each weighing approximately 200 pounds, were extracted from pre-selected loads. In most cases a single sample was collected from each load. However, from the districts with a limited number of loads, more than one sample was often collected from different parts of a single load. The professional sampling crew hand-sorted each sample into 11 material types. For every sample, the crew manager recorded the weight for each sorted material type into a customized database and reviewed entries for accuracy. Figure 2 illustrates the hand sorting procedure. A full description of the hand-sorting procedure is included in Appendix B.

Figure 2. Five Steps to Hand Sorting a Gray Cart Sample

Step 1. Placing a Sample on a Tarp



Step 2. Dragging a Sample to the Sorting Table

Step 3. Collecting Sample Information from the Sample Placard

Step 4. Sorting Materials

Step 5. Weighing Sorted Materials

Analyze Data and Draft Report

Step 1: Determine Waste Quantities

The City provided information on the total tons of gray cart waste disposed annually from each collection district.

Step 2: Enter and Analyze Data

The sorting crew manager entered characterization data into a custom database as each sample was weighed. Following the sampling event, Cascadia staff reviewed data for completeness and accuracy. Cascadia then calculated waste composition estimates using the methods described in Appendix C.

Step 3: Draft Report

Cascadia documented and summarized the final composition results and study methodology in this report for the City.

Results

Interpreting the Results

The Composition Results section presents results for the composition of the City's overall gray cart waste stream as well as for each of the eight collection districts. To further analyze the CIty's current recycling rates and assess recycling potential, this also section combines gray cart waste data with blue cart recycling data to provide capture rates for each blue cart material.

Composition data are presented in two ways for each collection district and for the City overall:

- A pie chart presents an overview of waste composition by **Material Class**.
- A detailed table lists the full composition and quantity results for the 11 *material types*. Please refer to Appendix A for detailed descriptions and definitions of each *material type*.

Material Designations

For clarity, **Material Classes** such as **Recyclable, Food Waste**, and **Green Waste** are bolded and capitalized while *material types* such as *newspaper*, *aluminum containers*, and *green waste* are italicized.

The capture rate data is shown for each of the blue cart materials independently, the blue cart materials combined, for the green cart materials independently (*green waste*), and for the sum of the blue cart and green cart materials. Not all recycling is accomplished through the blue cart system. In particular, *aluminum containers* are commonly recycled at HI-5 redemption centers in the City. The capture rate calculations only consider tons recycled through the blue cart program.

Means and Error Ranges

Cascadia statistically analyzed the data from the sorting process to provide two pieces of information for each of the *material types*:

- The estimated percent-by-weight composition of the waste stream as represented by the samples examined in this study.
- The error ranges (+/-) of our composition estimates.

All error ranges (+/-) were calculated at the 90% confidence level. The equations used in these calculations are included in Appendix C.

Error Range (+/-)

The error range is a measure of the spread of values in a collection of data. For instance, if the quantities of *newspaper* were found to be nearly the same in each of the 135 samples collected for this study, then this would result in a very narrow error range. By contrast, if some samples were 75% *newspaper* and others were 0% *newspaper,* there would be a much broader error range.

The example in Table 3 illustrates how the results can be interpreted. The best estimate of the amount of *other materials* present in the overall gray cart waste stream is 67.7%. The amount 1.5% reflects the precision of the estimate. When calculations are performed at the 90% confidence level, we are 90% certain that the true mean for *other materials* is between 67.7% + 1.5% and 67.7% - 1.5%. In other words, we are 90% certain that the true mean lies between 69.2% and 66.2%.

Table 3. Example Percentage Composition and Error Range

Material	Est. Percent	+ / -
Other Materials	67.7%	1.5%

Rounding

When interpreting the results presented in the tables and figures in this report, it is important to consider the effect of rounding.

To keep the waste 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. Also, percentages less than 0.05% are rounded to 0.0% even though there may be a quantity associated with the material.

Quantity Estimates

Composition data for the City's gray cart waste was collected over a two-week period in late spring. Throughout this report, the resulting composition estimates were applied to the City's annual gray cart tonnages to calculate annual quantity estimates as is standard practice in waste composition studies.

Waste Quantities

The City disposed of a total of 198,959 tons of gray cart waste between July 2010 and June 2011. The allocation of gray cart tonnage to the eight districts appears in Table 4. Pearl City was the largest district, disposing of more than 30% of the City's waste, followed by Kapaa (20.3%), Honolulu East (18.3%), Honolulu West (9.2%), Wahiawa (8.9%), Waianae (7.0%), Laie (4.0%), and Waialua (1.8%).

Table 4. Gray Cart Waste Disposal by District

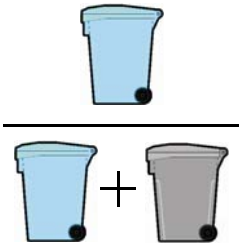
Collection District	Tons	Percent of Total
Honolulu East	36,482	18.3%
Honolulu West	18,241	9.2%
Kapaa	40,400	20.3%
Laie	7,981	4.0%
Pearl City	60,448	30.4%
Wahiawa	17,767	8.9%
Waialua	3,625	1.8%
Waianae	14,016	7.0%
Total	**198,959**	**100%**

Recycling Diversion Potential

Capture rates are one measure to gauge the success of diversion programs and recycling diversion potential. The capture rate is the proportion of the total quantity of material that is being "captured" for recycling. As the capture rate increases, the recycled (instead of disposed) proportion of a material increases, up to a theoretical maximum of 100%. The capture rate is calculated by dividing the recycled quantity of a material by the sum of the recycled and disposed quantities for that material. Equations 1 and 2 show examples of the capture rate calculations for *newspaper* and *green waste* respectively:

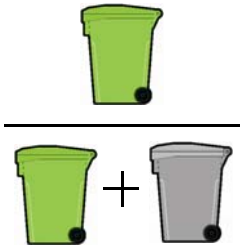
Equation 1. *Newspaper* Capture Rate Example

$$\frac{8,185}{8,185 + 5,410} = 60.2\%$$



Equation 2. *Green Waste* Capture Rate Example

$$\frac{53,638}{53,638 + 15,705} = 77.4\%$$



What the capture rate doesn't calculate is the level of participation in a recycling program. Using *newspaper* as an example again, the capture rate doesn't detail whether 60% of households are recycling 100% of their *newspaper*, if 100% of households are recycling 60% of their *newspaper,* or somewhere in between. Figure 3 shows *newspaper* the field crew sorted from one of the samples. This

is "uncaptured" *newspaper* as it was disposed in the gray cart rather than recycled in a blue cart. The capture rate calculations only consider tons recycled through the blue cart program and do not include quantities recycled at redemption centers.

As shown in Table 5, the City's blue cart capture rate for recyclables varies from about 9% for *aluminum containers* to about 84% for *bi-metal HI-5 beverage containers*.

Figure 3. Disposed *Newspaper*

Table 5. Capture Rates for Currently Diverted Materials[1]

	Tons Currently Recycled in Blue Carts	Tons Currently Recycled in Green Carts	Tons Currently Disposed in Gray Carts	Current Capture Rate
Newspaper	8,185	0	5,410	60%
Corrugated Cardboard	6,425	0	4,472	59%
Glass Bottles and Jars	2,739	0	3,082	47%
Aluminum Containers	80	0	845	9%
Bi-Metal HI-5 Beverage Containers	119	0	22	84%
#1 PET Plastic Containers	388	0	1,868	17%
#2 HDPE Plastic Containers	508	0	1,460	26%
Subtotal for Blue Cart Materials	***18,445***	***0***	***17,159***	***52%***
Green Waste	0	53,638	15,705	77%
Totals	**18,445**	**53,638**	**32,864**	**69%**

[1] The City provided the currently recycled tonnage information.

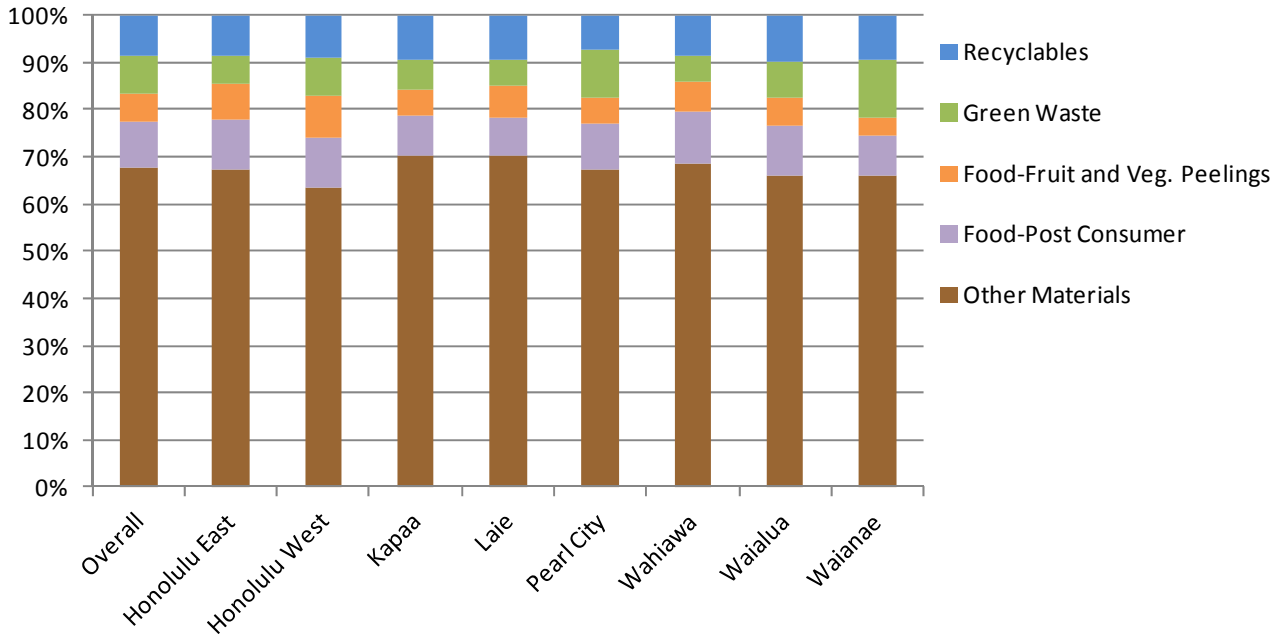
Composition Results

This section presents the gray cart waste stream composition results for the City overall and for each of the eight collection districts.

Overview of Results by District

Figure 4 presents an overview of waste composition results for each of the collection districts. As shown, **Recyclables** contributed between 7% and 10% to each district's total gray cart waste. Wahiawa (5.4%) and Laie (5.6%) had the lowest proportions of **Green Waste**, while Waianae (12.3%) had the highest proportion.

Figure 4. Comparison of Gray Cart Waste Composition, by District, 2011



Overall Gray Cart Residential Composition Results

Figure 5. Summary of Overall Gray Cart Waste Composition, 2011

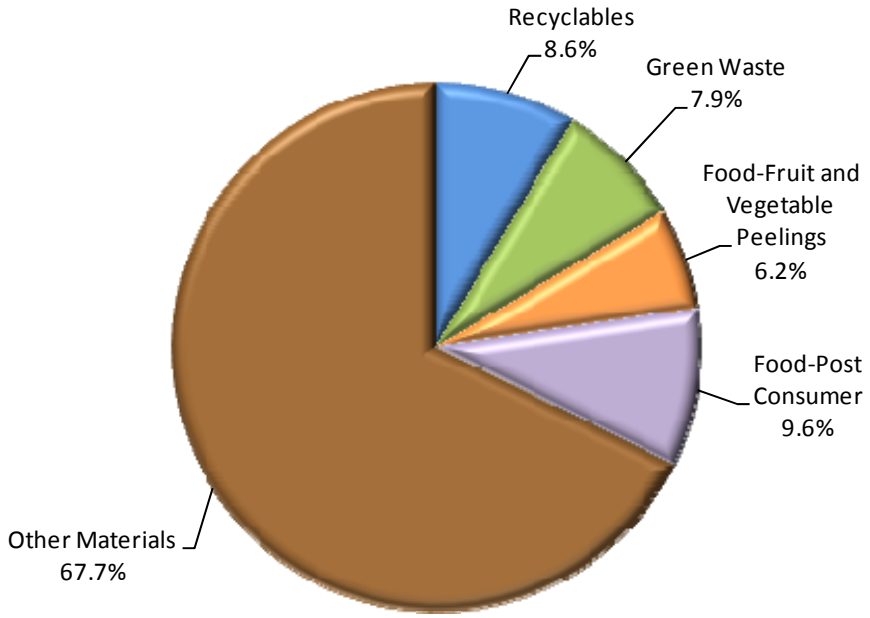


Table 6. Detailed Overall Gray Cart Waste Composition, 2011

Material	Estimated Percent	+ / -	Estimated Tons
Recyclables	**8.6%**		**17,159**
Newspaper	2.7%	0.4%	5,410
Corrugated Cardboard	2.2%	0.2%	4,472
Glass Bottles and Jars	1.5%	0.2%	3,082
Aluminum Containers	0.4%	0.1%	845
Bi-Metal HI-5 Beverage Containers	0.0%	0.0%	22
#1 PET Plastic Containers	0.9%	0.1%	1,868
#2 HDPE Plastic Containers	0.7%	0.1%	1,460
Green Waste	**7.9%**		**15,705**
Green Waste	7.9%	1.5%	15,705
Food Waste	**15.8%**		**31,454**
Food-Fruit and Vegetable Peelings	6.2%	0.5%	12,311
Food-Post Consumer	9.6%	0.7%	19,144
Other Materials	**67.7%**		**134,640**
Other Materials	67.7%	1.5%	134,640
Totals	**100.0%**		**198,959**
Sample Count	**135**		

Confidence intervals calculated at the 90% confidence level. Sums may not total 100% due to rounding.

Figure 6. Summary of Gray Cart Waste Composition: Honolulu East, 2011

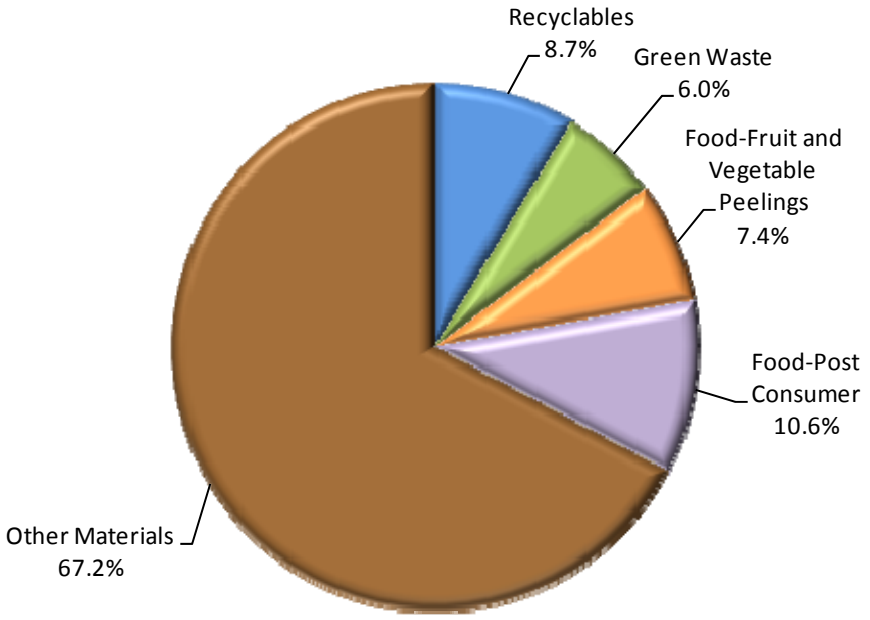


Table 7. Detailed Gray Cart Waste Composition: Honolulu East, 2011

Material	Estimated Percent	+ / -	Estimated Tons
Recyclables	**8.7%**		**3,184**
Newspaper	3.0%	1.1%	1,088
Corrugated Cardboard	2.4%	0.6%	858
Glass Bottles and Jars	1.5%	0.5%	562
Aluminum Containers	0.3%	0.1%	106
Bi-Metal HI-5 Beverage Containers	0.0%	0.0%	1
#1 PET Plastic Containers	0.9%	0.2%	345
#2 HDPE Plastic Containers	0.6%	0.1%	223
Green Waste	**6.0%**		**2,191**
Green Waste	6.0%	2.0%	2,191
Food Waste	**18.0%**		**6,580**
Food-Fruit and Vegetable Peelings	7.4%	1.2%	2,715
Food-Post Consumer	10.6%	1.6%	3,865
Other Materials	**67.2%**		**24,527**
Other Materials	67.2%	2.8%	24,527
Totals	**100.0%**		**36,482**
Sample Count	**19**		

Confidence intervals calculated at the 90% confidence level. Sums may not total 100% due to rounding.

Gray Cart Residential Sampling Results: Honolulu West

Figure 7. Summary of Gray Cart Waste Composition: Honolulu West, 2011

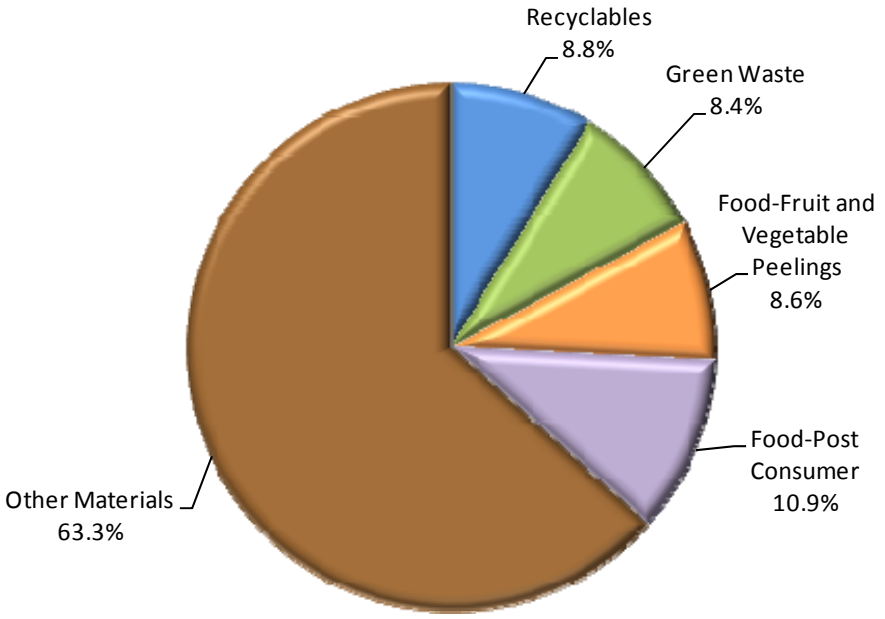


Table 8. Detailed Gray Cart Waste Composition: Honolulu West, 2011

Material	Estimated Percent	+ / -	Estimated Tons
Recyclables	**8.8%**		**1,609**
Newspaper	3.0%	0.6%	547
Corrugated Cardboard	2.1%	0.5%	387
Glass Bottles and Jars	1.7%	0.3%	312
Aluminum Containers	0.3%	0.1%	56
Bi-Metal HI-5 Beverage Containers	0.0%	0.0%	1
#1 PET Plastic Containers	0.9%	0.3%	165
#2 HDPE Plastic Containers	0.8%	0.2%	142
Green Waste	**8.4%**		**1,526**
Green Waste	8.4%	2.9%	1,526
Food Waste	**19.5%**		**3,557**
Food-Fruit and Vegetable Peelings	8.6%	1.5%	1,569
Food-Post Consumer	10.9%	1.3%	1,987
Other Materials	**63.3%**		**11,549**
Other Materials	63.3%	3.5%	11,549
Totals	**100.0%**		**18,241**
Sample Count	**18**		

Confidence intervals calculated at the 90% confidence level. Sums may not total 100% due to rounding.

Gray Cart Residential Sampling Results: Kapaa

Figure 8. Summary of Gray Cart Waste Composition: Kapaa, 2011

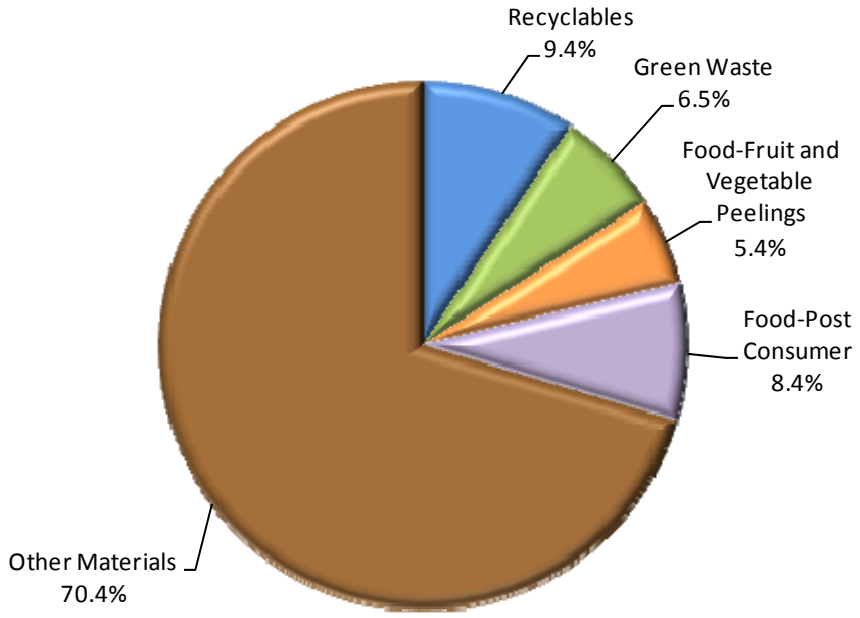


Table 9. Detailed Gray Cart Waste Composition: Kapaa, 2011

Material	Estimated Percent	+ / -	Estimated Tons
Recyclables	**9.4%**		**3,815**
Newspaper	3.5%	1.1%	1,431
Corrugated Cardboard	2.0%	0.4%	798
Glass Bottles and Jars	2.0%	0.6%	792
Aluminum Containers	0.3%	0.1%	141
Bi-Metal HI-5 Beverage Containers	0.0%	0.0%	0
#1 PET Plastic Containers	0.9%	0.1%	371
#2 HDPE Plastic Containers	0.7%	0.2%	283
Green Waste	**6.5%**		**2,610**
Green Waste	6.5%	2.6%	2,610
Food Waste	**13.7%**		**5,540**
Food-Fruit and Vegetable Peelings	5.4%	0.9%	2,165
Food-Post Consumer	8.4%	1.7%	3,375
Other Materials	**70.4%**		**28,434**
Other Materials	70.4%	3.1%	28,434
Totals	**100.0%**		**40,400**
Sample Count	**19**		

Confidence intervals calculated at the 90% confidence level. Sums may not total 100% due to rounding.

Gray Cart Residential Sampling Results: Laie

Figure 9. Summary of Gray Cart Waste Composition: Laie, 2011

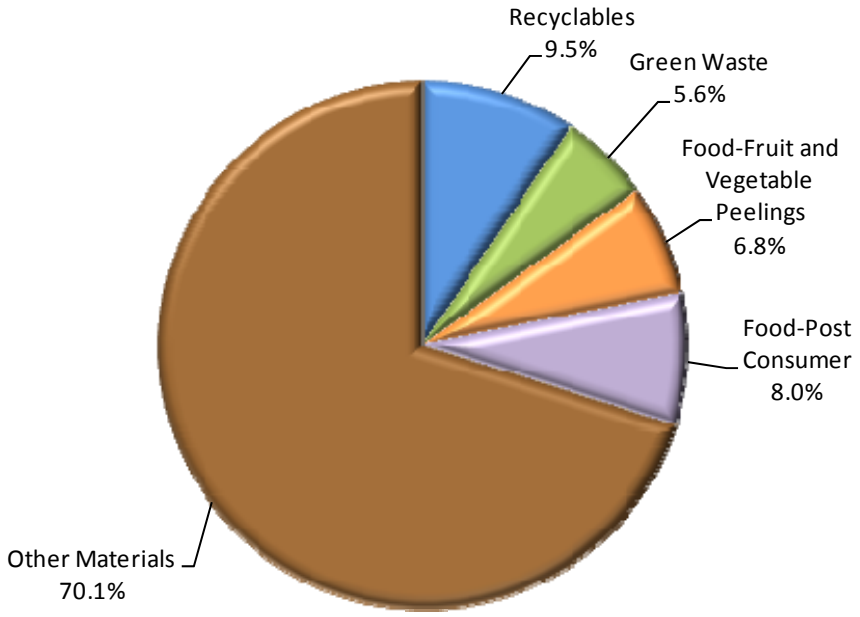


Table 10. Detailed Gray Cart Waste Composition: Laie, 2011

Material	Estimated Percent	+ / -	Estimated Tons
Recyclables	**9.5%**		**759**
Newspaper	1.6%	0.5%	127
Corrugated Cardboard	3.9%	1.2%	311
Glass Bottles and Jars	1.5%	0.4%	123
Aluminum Containers	0.4%	0.1%	31
Bi-Metal HI-5 Beverage Containers	0.0%	0.0%	1
#1 PET Plastic Containers	1.2%	0.3%	95
#2 HDPE Plastic Containers	0.9%	0.1%	72
Green Waste	**5.6%**		**445**
Green Waste	5.6%	2.3%	445
Food Waste	**14.8%**		**1,182**
Food-Fruit and Vegetable Peelings	6.8%	1.3%	542
Food-Post Consumer	8.0%	0.8%	640
Other Materials	**70.1%**		**5,595**
Other Materials	70.1%	3.0%	5,595
Totals	**100.0%**		**7,981**
Sample Count	**15**		

Confidence intervals calculated at the 90% confidence level. Sums may not total 100% due to rounding.

Gray Cart Residential Sampling Results: Pearl City

Figure 10. Summary of Gray Cart Waste Composition: Pearl City, 2011

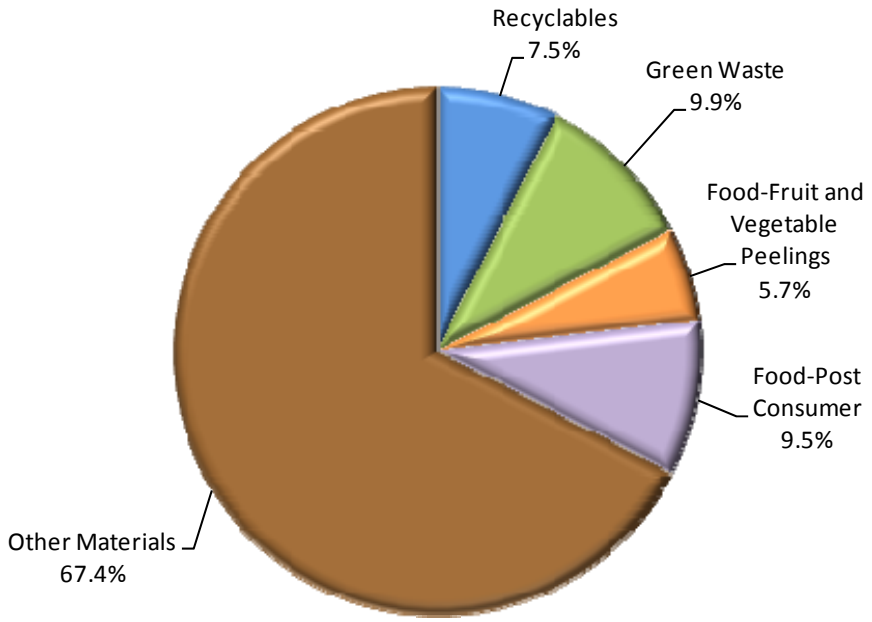


Table 11. Detailed Gray Cart Waste Composition: Pearl City, 2011

Material	Estimated Percent	+ / -	Estimated Tons
Recyclables	**7.5%**		**4,557**
Newspaper	2.2%	0.7%	1,325
Corrugated Cardboard	1.9%	0.4%	1,166
Glass Bottles and Jars	1.3%	0.4%	809
Aluminum Containers	0.5%	0.2%	307
Bi-Metal HI-5 Beverage Containers	0.0%	0.0%	6
#1 PET Plastic Containers	0.9%	0.2%	538
#2 HDPE Plastic Containers	0.7%	0.1%	405
Green Waste	**9.9%**		**5,979**
Green Waste	9.9%	4.0%	5,979
Food Waste	**15.2%**		**9,199**
Food-Fruit and Vegetable Peelings	5.7%	1.0%	3,473
Food-Post Consumer	9.5%	1.6%	5,726
Other Materials	**67.4%**		**40,713**
Other Materials	67.4%	3.5%	40,713
Totals	**100.0%**		**60,448**
Sample Count	**19**		

Confidence intervals calculated at the 90% confidence level. Sums may not total 100% due to rounding.

Gray Cart Residential Sampling Results: Wahiawa

Figure 11. Summary of Gray Cart Waste Composition: Wahiawa, 2011

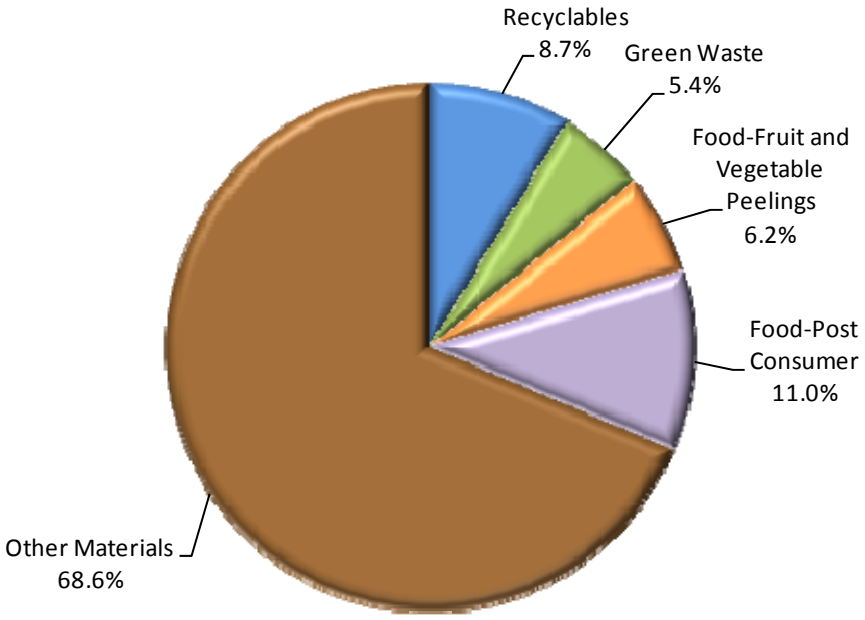


Table 12. Detailed Gray Cart Waste Composition: Wahiawa, 2011

Material	Estimated Percent	+ / -	Estimated Tons
Recyclables	**8.7%**		**1,551**
Newspaper	3.0%	0.7%	526
Corrugated Cardboard	2.1%	0.6%	377
Glass Bottles and Jars	1.3%	0.6%	230
Aluminum Containers	0.5%	0.2%	84
Bi-Metal HI-5 Beverage Containers	0.0%	0.0%	2
#1 PET Plastic Containers	0.8%	0.2%	149
#2 HDPE Plastic Containers	1.0%	0.3%	183
Green Waste	**5.4%**		**961**
Green Waste	5.4%	4.1%	961
Food Waste	**17.2%**		**3,062**
Food-Fruit and Vegetable Peelings	6.2%	1.5%	1,103
Food-Post Consumer	11.0%	2.9%	1,959
Other Materials	**68.6%**		**12,194**
Other Materials	68.6%	4.2%	12,194
Totals	**100.0%**		**17,767**
Sample Count	**15**		

Confidence intervals calculated at the 90% confidence level. Sums may not total 100% due to rounding.

Gray Cart Residential Sampling Results: Waialua

Figure 12. Summary of Gray Cart Waste Composition: Waialua, 2011

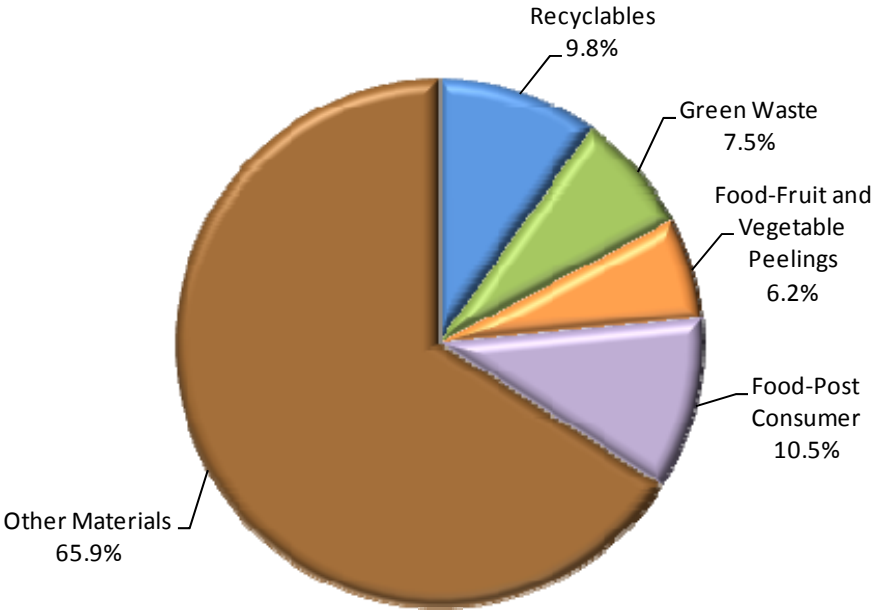


Table 13. Detailed Gray Cart Waste Composition: Waialua, 2011

Material	Estimated Percent	+ / -	Estimated Tons
Recyclables	**9.8%**		**356**
Newspaper	2.5%	0.9%	92
Corrugated Cardboard	3.5%	1.6%	126
Glass Bottles and Jars	1.5%	0.5%	56
Aluminum Containers	0.8%	0.4%	28
Bi-Metal HI-5 Beverage Containers	0.0%	0.0%	0
#1 PET Plastic Containers	0.9%	0.2%	34
#2 HDPE Plastic Containers	0.5%	0.1%	20
Green Waste	**7.5%**		**273**
Green Waste	7.5%	4.2%	273
Food Waste	**16.7%**		**606**
Food-Fruit and Vegetable Peelings	6.2%	0.9%	224
Food-Post Consumer	10.5%	2.0%	382
Other Materials	**65.9%**		**2,390**
Other Materials	65.9%	4.2%	2,390
Totals	**100.0%**		**3,625**
Sample Count	**15**		

Confidence intervals calculated at the 90% confidence level. Sums may not total 100% due to rounding.

Figure 13. Summary of Gray Cart Waste Composition: Waianae, 2011

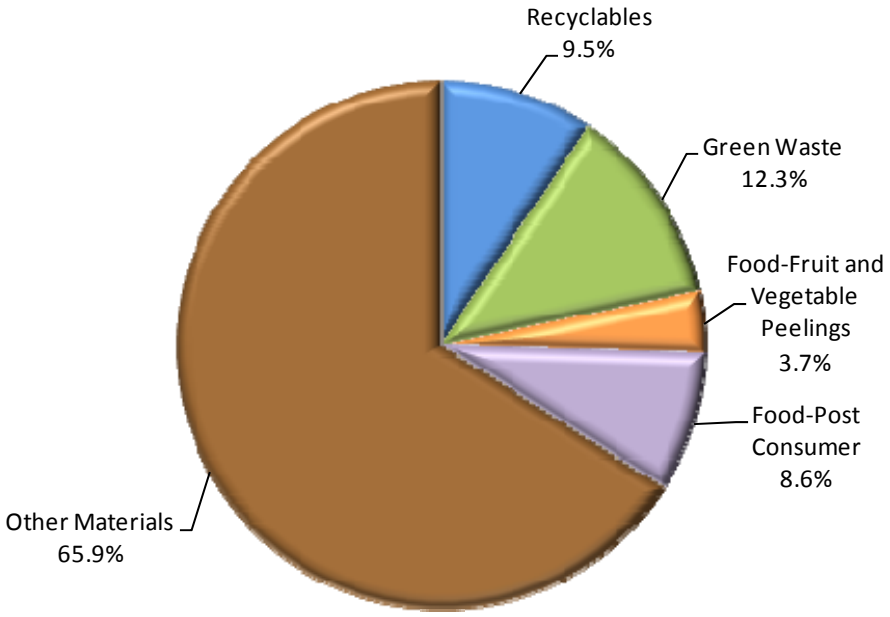


Table 14. Detailed Gray Cart Waste Composition: Waianae, 2011

Material	Estimated Percent	+ / -	Estimated Tons
Recyclables	**9.5%**		**1,328**
Newspaper	2.0%	0.7%	274
Corrugated Cardboard	3.2%	0.9%	447
Glass Bottles and Jars	1.4%	0.3%	199
Aluminum Containers	0.7%	0.2%	94
Bi-Metal HI-5 Beverage Containers	0.1%	0.1%	11
#1 PET Plastic Containers	1.2%	0.3%	172
#2 HDPE Plastic Containers	0.9%	0.1%	132
Green Waste	**12.3%**		**1,721**
Green Waste	12.3%	2.9%	1,721
Food Waste	**12.3%**		**1,730**
Food-Fruit and Vegetable Peelings	3.7%	0.8%	520
Food-Post Consumer	8.6%	1.2%	1,210
Other Materials	**65.9%**		**9,237**
Other Materials	65.9%	3.1%	9,237
Totals	**100.0%**		**14,016**
Sample Count	**15**		

Confidence intervals calculated at the 90% confidence level. Sums may not total 100% due to rounding.

Appendix A. Material List and Definitions

1. **Newspaper** means paper used in newspapers. Examples include all non-glossy newspapers, newspaper inserts, and all items made from newsprint, such as free advertising guides, election guides, and tax instruction booklets. Glossy inserts found in newspapers are not included in this material.
2. **Corrugated Cardboard** usually has three layers. The center wavy layer is sandwiched between the two flat outer layers. It does not have any wax coating on the inside or outside. Examples include entire cardboard containers, such as shipping and moving boxes, computer packaging cartons, and sheets and pieces of boxes and cartons. This type does not include chipboard boxes such as cereal and tissue boxes.
3. **Glass Bottles and Jars** include whole or broken soda and beer bottles, fruit juice bottles, wine bottles, peanut butter jars, mayonnaise jars, and other bottles and jars.
4. **Aluminum Containers** means food or beverage containers made mainly of aluminum. Examples include aluminum soda or beer cans, and some pet food cans. This type does not include bimetal containers with steel sides and aluminum ends.
5. **Bi-metal HI-5 Beverage Containers** means rigid containers of metal containing the HI-5 logo. Examples include containers for soda, water, juice, coffee, tea, or alcohol. Dairy containers do not pay a deposit and are not included in this material type.
6. **PETE Containers (#1 PET)** means PETE (polyethylene terephthalate) containers including beverage bottles, boxes, clamshells, jars, bottles, and cartons. When marked for identification, they bear the number 1 in the center of the triangular recycling symbol and may also bear the letters PETE or PET. A PETE container usually has a small dot left from the manufacturing process, not a seam. It does not turn white when bent. Examples include single-serve water bottles, soft drink and liquor bottles, cooking oil bottles, food jars, some to-go food service cups, hardware, small electronics and battery packaging; and food or other packaging trays.
7. **HDPE Containers (#2 HDPE)** means natural and colored HDPE (high-density polyethylene) containers. This plastic is usually either cloudy white, allowing light to pass through it (natural), or a solid color, preventing light from passing through it (colored). When marked for identification, it bears the number 2 in the triangular recycling symbol and may also bear the letters HDPE. Examples include milk jugs, water jugs, detergent bottles, some hair-care bottles, HDPE sealed containers (must be cut, pried, or torn to be opened), empty motor oil, empty antifreeze, and other empty vehicle and equipment fluid containers.
8. **Green Waste** means organic materials including leaves, grass clippings, plants, seaweed, prunings, shrubs, branches, and stumps.
9. **Food Waste-fruit and vegetable peelings** means all raw or cooked, whole or partial, fruits and vegetables.
10. **Food Waste-post consumer** means all food items not already defined above. Examples include meats, dairy, eggs, nuts, rice, and prepared foods that are a combination of food types.

11. **Other Materials** means material that cannot be put in any other type or category. This includes all hazardous waste, paper chipboard, white paper, magazines, aluminum foil, tin food cans, bulky items, diapers, kitty litter, construction debris, film plastics, food soiled paper, etc.

Appendix B. Sampling Methodology

This appendix includes the study design as written and approved prior to beginning field work. It may include some minor language and grammar differences when describing the waste stream, collection districts, or sampling procedures as compared to the main body of the report.

Study Objectives

The primary purpose of this study was to identify the quantity of recyclable materials and green waste remaining in waste disposed by the residential sector. The secondary objective was to identify the amount of food waste disposed in the gray carts.

Sampling Universe

The study universe included all automated residential refuse routes on Oahu. Oahu is composed of eight collection districts (districts): Honolulu East, Honolulu West, Kapaa, Laie, Pearl City, Wahiawa, Waialua, and Waianae.[2] Most study planning occurred at the district level. The number of included residential routes in each district is shown in Table 15.

Table 15. Total Collection Routes by Day and District

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Total Routes
Honolulu East	9	0	8	9	0	9	**35**
Honolulu West	0	9	0	0	9	0	**18**
Kapaa	4	5	5	4	4	4	**26**
Laie	0	0	0	3	2	2	**7**
Pearl City	10	10	8	8	8	7	**51**
Wahiawa	4	4	4	2	2	3	**19**
Waialua	1	1	1	0	0	0	**3**
Waianae	5	5	5	0	0	0	**15**
Total	**33**	**34**	**31**	**26**	**25**	**25**	**174**

Sampling Calendar and Distribution

Samples were allocated and scheduled to maximize the strength of the analysis and minimize disruptions to the City's waste operations. Samples were collected the same day that district typically had collection service. A total of 135 samples were collected. Because it was difficult to collect more than 15 samples from the smaller districts, additional samples were allocated among the larger districts. Sampling took place from May 23, 2011 through June 2, 2011. Samples were collected and sorted at two transfer stations and the H-POWER plant. Table 16 shows the samples sorted by day and district.

[2] Oahu is composed of seven collection districts. For the purposes of this study, the Honolulu collection district was divided into two districts, Honolulu East and Honolulu West, based on collection day.

Table 16. Samples by Day and District

	Day	Monday	Tuesday	Wednesday	Thursday	Friday	Monday	Tuesday	Wednesday	Thursday	
	Date	5/23/11	5/24/11	5/25/11	5/26/11	5/27/11	5/30/11	5/31/11	6/1/11	6/2/11	
	Site	H-Power	H-Power	H-Power	Keehi	Keehi	Kapaa	Keehi	H-Power	H-Power	**Total Sorted**
Collection District	Honolulu East				8		3	4		4	**19**
	Honolulu West					9		9			**18**
	Kapaa				3	3	8	2	1	2	**19**
	Laie				3	4	4			4	**15**
	Pearl City	4	4	4		1			4	2	**19**
	Wahiawa	4	4	4		1				2	**15**
	Waialua		5	2				5	3		**15**
	Waianae	5	5	5							**15**
	Total Sorted	**13**	**18**	**15**	**14**	**18**	**15**	**20**	**8**	**14**	**135**

Obtaining and Sorting Samples

Load Selection

The City provided a complete list of residential routes in the districts served. Routes for sampling were selected at random from this list. Table 17 shows an example of the load data for one day of the week.

Table 17. Example Load Selection

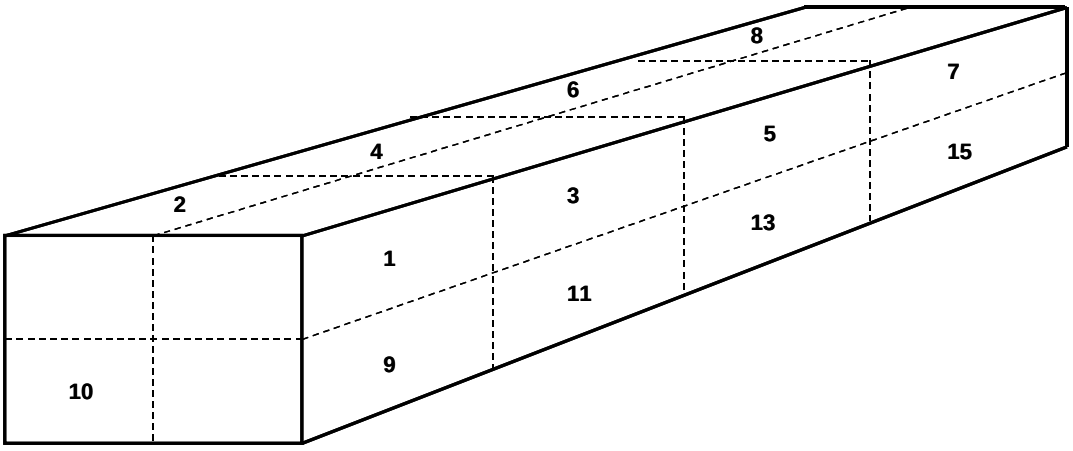
District	Day	Route #
Pearl City	Monday	A
Pearl City	Monday	B
Pearl City	Monday	C
Pearl City	Monday	D
Pearl City	Monday	E
Wahiawa	Monday	F
Wahiawa	Monday	G
Wahiawa	Monday	H
Waianae	Monday	I
Waianae	Monday	J
Waianae	Monday	K

At the beginning of each sampling day, the scale house staff received a list of pre-selected residential refuse routes and expected truck numbers in a customized *Vehicle Selection Form,* as well as brightly colored *Sample Placards* for each vehicle. *Samples Placards* were also distributed ahead of time to the collection yard supervisors who handed them out to drivers of selected routes. Each morning, the collection yard supervisors provided a final verification of truck numbers associated with each route. When the pre-selected vehicle arrived at the scale house, the scale house operator confirmed that a *Sample Placard* was visible in the windshield of the vehicle and directed the vehicle to the sorting area. If the route driver was missing their *Sample Placard*, the scale house operator placed one in the windshield. The placard alerted the waste characterization crew manager that the vehicle was designated for participation in the study. Changes to the anticipated drivers or truck numbers were communicated to the crew manager who corrected *Sample Placards* and *Vehicle Selection Forms* prior to distribution to ensure that vehicle identification and sample selection occurred as planned at the transfer station.

Hand-sorting Procedure

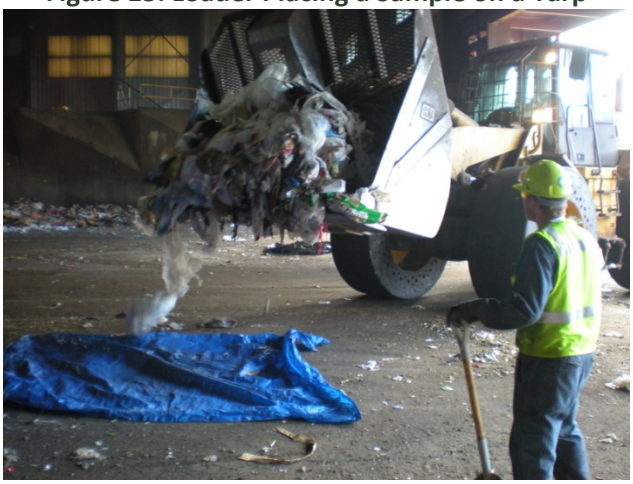
All samples were hand sorted. Selected loads were dumped in an elongated pile. From each load, a sample was selected using an imaginary 16-cell grid (as shown in Figure 14) superimposed over the dumped material.

Figure 14. 16-Cell Grid for Sampling



The crew manager identified the randomly selected grid cell from which a sample was to be collected. Working with the sorting staff and transfer station staff, the crew manager ensured that a sample of waste weighing at least 200 pounds was obtained from the selected cell and transported to the characterization area. Figure 15 shows a sample being placed on a tarp. Samples were collected before facility staff diverted any materials from the load.

Figure 15. Loader Placing a Sample on a Tarp



Each sample was placed on a clean tarp with the *Sample Placard* prominently displayed. Each sample was photographed with the sample placard clearly visible. Figure 16 shows a sample ready to be sorted, on a tarp with a placard. Each sample was sorted by hand into the material types defined for the study. See Appendix A for the complete list of material types. Sorted materials were placed in containers for weighing and recording, one material type per container. The crew manager monitored the homogeneity of the containers as material accumulated, rejecting items that were improperly classified. The crew manager also verified the purity of each material type as it was weighed, before the weight was recorded. The weights of all materials were recorded in a database designed for this study. Figure 17 shows one sample's sorted *#2 HDPE containers*. Printed copies of *Material Weight Tally Sheets*, as shown in Appendix D, were on hand as a back-up data recording method. The crew manager ensured that the sorting crew followed the sorting protocol and the health and safety requirements, and

Figure 16. Tarped Sample Waiting to be Sorted

closely evaluated each individual sample to ensure that the sorting crew understood and uniformly interpreted the material categories. At the conclusion of each sorting day, the crew manager conducted a quality-control review of the entered data.

Figure 17. #2 HDPE Containers

Throughout and after each sorting day, the project team ensured that the workspace was in good condition. Our field crew took steps to reduce or eliminate the risk of litter, particularly in open-air environments. A thorough clean-up effort followed each day of work and included:

- Organizing and stowing of sorting supplies in a designated location.
- Removing all sorted waste discarded throughout the day (the host facility loader operator helped with this).
- Sweeping and cleaning the sort area to prevent windblown litter.
- Removing and properly disposing of any single-use personal protective equipment.
- Checking out with the facility manager each day.

Method to Obtain Tonnage Data

Accurate tonnage information is necessary to compile the composition and quantity analysis. The City provided the automated collection annual tonnage information for each of the eight collection districts.

Appendix C. Composition Calculations

Composition Calculations

The composition estimates represent the **ratio of each material type's weight to the total weight of waste** for each collection district and for Oahu's overall residential waste. They were derived by summing each material type's weight across all of the selected records and dividing by the sum of the total weight of waste, as shown in the following equation:

$$r_j = \frac{\sum_i c_{ij}}{\sum_i w_i}$$

where:

c	=	weight of particular material type		
w	=	sum of all material type weights		
for		i	1 to n; where n =	number of selected samples
for		j	1 to m; where m=	number of material types

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 includes two random variables (the material type and total sample weights). The **variance of the ratio estimator** equation follows:

$$\bar{V}_{r_j} = \left(\frac{1}{n}\right) \cdot \left(\frac{1}{\bar{w}^2}\right) \cdot \left(\frac{\sum_i \left(c_{ij} - r_j w_i\right)^2}{n-1}\right)$$

where:

$$\bar{w} = \frac{\sum_i w_i}{n}$$

Second, **precision levels** at the 90% confidence interval were calculated for each material type's mean as follows:

$$r_j \pm \left(t \cdot \sqrt{\bar{V}_{r_j}}\right)$$

where:

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

For more detail, please refer to Chapter 6 "Ratio, Regression and Difference Estimation" of *Elementary Survey Sampling* by R.L. Scheaffer, W. Mendenhall and L. Ott (PWS Publishers, 1986).

Weighted Averages

Waste composition estimates were calculated by using a weighted average procedure. For example, slightly more importance was given to samples from collection districts that disposed of a greater portion of Oahu's residential waste.

The City provided the estimate of tonnage annually disposed by each of the eight collection districts. The composition estimates were applied to the relevant tonnages to estimate the amount of each material type disposed for each collection district.

The **weighted average for an overall composition estimate** was performed as follows:

$$O_j = \left(p_1 * r_{j1}\right) + (p_2 * r_{j2}) + (p_3 * r_{j3}) + \ldots$$

where:

p = the proportion of tonnage contributed by the noted collection district

r = ratio of material type weight to total waste weight in the noted collection district

for j 1 to m

where m = number of material types

The **variance of the weighted average** was calculated as follows:

$$VarO_j = (p_1^{\,2} * \bar{V}_{r_{j1}}) + (p_2^{\,2} * \bar{V}_{r_{j2}}) + (p_3^{\,2} * \bar{V}_{r_{j3}}) + \ldots$$

Table 18 shows the weighting percentages that were used to produce the estimates for the overall residential waste stream.

Table 18. Weighting Factors

Collection District	Tons	Percent of Total
Honolulu East	36,482	18.3%
Honolulu West	18,241	9.2%
Kapaa	40,400	20.3%
Laie	7,981	4.0%
Pearl City	60,448	30.4%
Wahiawa	17,767	8.9%
Waialua	3,625	1.8%
Waianae	14,016	7.0%
Total	**198,959**	**100%**

Appendix D: Field Forms

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

- *Vehicle Selection Form*
- *Sample Placard*
- *Material Weight Tally Sheet*

Vehicle Selection Form

2011 Waste Characterization Study

Facility Vehicle Selection Form

Date: **Wednesday June 1** **Total Trucks** 7

Facility: **Kapaa TS, H-Power**

When the driver of the following loads arrive at your facility please make sure they have a brightly colored placard for and direct them to tipping area set aside for selected study vehicles.

Truck #	District	# of Samples	Truck Arrived?	Comments/Notes
	Kapaa	2		This truck to Kapaa. Route 2. John collect, yard already has tags.
	Laie	2		This truck to Kapaa. Route 10. John collect, John deliver tags.
	Laie	2		This truck to Kapaa. Route 10. John collect, John deliver tags.
	Pearl City	1		This truck to HPower. Route 17. William collect, yard already has tags.
	Pearl City	1		This truck to HPower. Route 31. William collect, yard already has tags.
	Wahiawa	1		This truck to HPower. Route 11. William collect, Mike will deliver tags.
	Wahiawa	1		This truck to HPower. Route 12. William collect, Mike will deliver tags.

Sample Placard

Facility: **Keehi TS**	District: **Honolulu (East)**	Cell: **5**
		Route:
	Date: **5/26/2011**	Truck:
	Sample ID: HE-1	# of Samples: **1**

Material Weight Tally Sheet

Honolulu Residential Waste Characterization 2011
Sample Tally Sheet

SORT DATE	SAMPLE ID	SAMPLE DAY	TRUCK #	ROUTE #

DISTRICT

HONOLULU EAST	HONOLULU WEST	KAPA'A	LAIE
PEARL CITY	WAHIAWA	WAIALUA	WAI'ANAE

SITE

H-POWER	KEEHI TS
KAPA'A TS	

VOLUME

LENGTH= _____ inches

WIDTH= _____ inches

HEIGHT= _____ inches

NOTES:

PICTURE? ☐

	Wt.1	Wt.2	Wt.3	Wt.4	Wt.5	Wt.6
Newspaper						
Corrugated Cardboard						
Glass Bottles & Jars						
Aluminum Containers						
Bi-Metal HI-5 Beverage Containers						
#1 PET Plastic Containers						
#2 HDPE Plastic Containers						
Green Waste						
Food Waste-Fruits and Vegetable Peelings						
Food Waste-Post Consumer						
Food Soiled Paper						
Other Materials						