City of Palo Alto, California

2017 Waste Characterization Study

JANUARY 2018

CITY OF PALO ALTO

CASCADIA CONSULTING GROUP

Acknowledgments

The project team would like to thank the following entities for their assistance in this study.

City of Palo Alto

GreenWaste of Palo Alto

City of Sunnyvale

Zanker Recycling

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Introduction and Summary

The following section presents the study's objectives, a project overview, the organization of the report, and how to interpret the findings.

Introduction and Study Objectives

The City of Palo Alto adopted a Zero Waste goal in 2005 and subsequently developed a Zero Waste Operational Plan to achieve that goal. The City also conducted a comprehensive waste characterization study in 2005 and a follow-up study in 2012. Since the 2012 study, the City has continued to implement some of the key programmatic changes outlined in the Zero Waste Operational Plan. The City of Palo Alto commissioned Cascadia Consulting Group to plan and implement a new waste characterization study to update the City's waste characterization information in 2017. The data collected in this waste characterization study will help the City plan for future programs to support the City's Zero Waste goals. This report presents the study's findings.

The composition and quantity data in this report is intended to:

- Identify materials with potential diversion opportunities.
- Provide a baseline for evaluating the future success of current diversion programs.
- Provide data useful in planning future programs to support the City's Zero Waste goals.

Project Overview

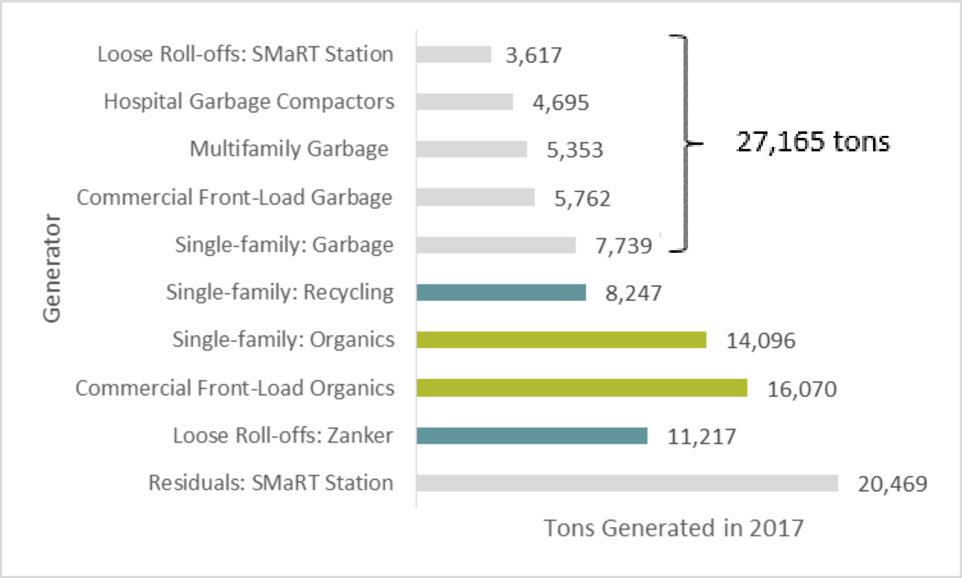
The consultant field team collected and sorted samples from single-family residential (including garbage, compost, and recycling), multifamily garbage, commercial front-load garbage, commercial front-load compost, hospital compactors, loose roll-offs arriving at the Sunnyvale Material Recycling and Transfer (SMaRT) Station, SMaRT Station residuals, and mixed C&D loads hauled by GreenWaste of Palo Alto (GreenWaste) to the Zanker Materials Processing Facility in October 2017. This report presents a statistical analysis of the 2017 characterization study results for Palo Alto. This report also compares the results of this study with the key findings of the 2005 and 2012 Palo Alto waste characterization studies.

The consultant team characterized a total of 135 samples by hand sorting and 32 samples using a visual characterization method. All samples were selected randomly from the generator groups considered for this study. Field staff sorted samples into a total of 77 standard material types (described in detail in Appendix A. Material Type Definitions). To help identify additional diversion opportunities, each of these 77 types was classified into one of four recoverability groups: **Recyclable**; **Compostable; Potentially Recyclable**; or **Problem Materials**. Material types included in each of these recoverability groups and the factors that affect recoverability are provided in the Summary of Methodology.

Ten waste streams, presented below in Figure 1, were analyzed in this study. The garbage streams that GreenWaste hauls are presented as the first five bars in the figure, and total to 27,165 tons when summed.

These streams do not represent all of the waste generated in Palo Alto. Additional waste is generated by self-haul of materials to any facility or landfill (e.g., SMaRT Station, Zanker Materials Recovery Facility, Corinda Los Trancos Landfill), commercial recycling, and multi-family recycling and organics.

Figure 1. Generators Included in 2017 Palo Alto Characterization Study, by Tons



Interpreting the Results

This section describes how to interpret the tables and figures in this report that show the composition of the garbage, recycling, and compost streams selected for this study.

HOW DATA ARE PRESENTED

For each sector, data are presented in three ways:

- First, an overview of composition by **recoverability group** is presented as a pie chart. In this pie and in all figures, **Compostable** materials are highlighted green, **Recyclable** materials are highlighted blue, **Potentially Recoverable** materials are highlighted orange, and **Problem Materials** are highlighted grey.
- Next, the six most prevalent individual *material types*, by weight, are shown in a table.

- Finally, a detailed table lists the full composition and quantity results for the 77 *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*:

- The percent-by-weight estimated composition, represented by the samples examined in the study; and
- 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 C. Waste Characterization Calculations.

The example below illustrates how the results can be interpreted. In this example, the best estimate of the amount of *edible food* present in the universe of waste sampled is 22.7%. The figure 2.6% reflects the precision of the estimate. When calculations are performed at the 90% confidence level, we are 90% certain that the true amount of *edible food* is between 22.7% plus 2.6% and 22.7% minus 2.6%. In other words, we are 90% certain that the mean lies between 20.1% and 25.3%.

Material Type	Est. Pct.	+ / -
Edible Food	22.7%	2.6%

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 167 samples collected for this study, the result would be a very narrow error range. By contrast, if some samples were composed of 75% *newspaper* and others were 0% *newspaper,* the results would show a much broader error range.

ROUNDING

To keep the 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%.

Organization of the Report

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

- **Summary of Methodology** defines the six waste sectors and explains the methodology used to design and implement the data collection portion of this study. It also briefly describes the data analysis methods.
- **Findings** presents key findings and waste composition results for each of the eight waste sectors and the SMaRT Station residuals.
- **Comparison to 2005 and 2012 Study Results** compares the key findings of this waste composition study with the key findings of the study performed for Palo Alto in 2005 and 2012.
- **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 composition calculations, and copies of field forms.

Summary of Methodology

The following section summarizes the three main tasks of the study methodology: Develop Plan, Collect Data, and Analyze Data.

Task 1: Develop Plan

COORDINATE WITH STAFF AND HAULERS

Before scheduling the fieldwork, the consultant team coordinated with key staff at the City of Palo Alto, representatives from the haulers, and sampling facility staff. Key personnel from the hauler and sampling facilities included operations supervisors (to coordinate the selection of routes for sampling and the delivery of selected loads) and facility managers (to coordinate the sample collection, sorting logistics, and other details involved with the field data collection effort).

DEFINE SAMPLING UNIVERSE

The waste sectors listed below were analyzed in this study. They do not represent all of the waste generated in Palo Alto. Additional waste is generated by self-haul of materials to any facility or landfill (e.g., SMaRT Station, Zanker Materials Recovery Facility, Corinda Los Trancos Landfill), commercial recycling, and multi-family recycling and organics.

This study included the following waste sectors:

- **Residential single-family garbage, recyclables, and compost** are materials GreenWaste of Palo Alto collects from single-family residences (single-family homes and townhouses or buildings with up to four residential units). These materials typically arrive at the SMaRT Station in packer trucks (e.g., side loaders, front loaders, etc.). During this study, Cascadia staff collected samples of these materials directly from carts at the curb in front of single-family homes on collection day and brought collected samples to the SMaRT Station for sorting by the Cascadia field team stationed there.
- **Residential multifamily garbage** is garbage that GreenWaste of Palo Alto collects from multifamily residences (apartments or condominiums with more than four residential units). It typically arrives at the SMaRT Station in packer trucks (e.g., front loaders). GreenWaste typically collects multifamily garbage in the same truck as commercial garbage. During this study, GreenWaste collected multifamily garbage on a special route separate from commercial garbage.
- **Commercial garbage** is garbage collected from the commercial sector in a front-load, side-load, or rear-load self-contained compacting vehicle.

- **Commercial compost** is compostable material collected from the commercial sector in a front-load, side-load, or rear-load self-contained compacting vehicle. It is typically delivered to Zanker Recycling's ZWED facility. Selected loads were rerouted to the SMaRT station for sampling during this study.
- **Hospital garbage** is garbage collected in compactors from the three local hospitals.
- **SMaRT Station loose roll-off garbage** is garbage collected from the commercial sector in a non-compacted open-top roll-off container, commonly referred to as a "debris box" or "drop-box."
- **Zanker Mixed C&D** is recoverable material generated from construction activities and bulky materials delivered to Zanker Road in loose drop-boxes.
- **SMaRT Station residuals** are produced as byproducts from the SMaRT Station's material recovery facility (MRF). Residuals do not include fines screened from the trommels.

DEFINE MATERIAL CLASSES AND MATERIAL TYPES

The consultant team worked with Palo Alto to identify material types and definitions for this study. They are based on CalRecycle's standard list of materials, with small changes to reflect this project's objectives and local solid waste management practices. The material types are grouped into the standard CalRecycle material classes: Paper, Plastic, Glass, Metal, Organic, Hazardous, Construction and Demolition Debris, and Other Materials. See Appendix A. Material Type Definitions for a list of the material types and detailed definitions.

To identify additional diversion opportunities, the consultant team also classified material types according to their recoverability using four recoverability groups:

- **Recyclable**—Materials for which recycling technologies, programs, and markets are well developed, readily available, and currently utilized.
- **Compostable**—Organic materials typically accepted for use in commercial compost or digestion systems.
- **Potentially Recyclable**—Materials for which recycling technologies, programs, and markets exist, but are either not well developed or not currently utilized. Examples include *carpet* and *aseptic containers.*
- **Problem Materials**—Materials that are not readily recyclable or face other market-related barriers.

Each material type was assigned to one of these recoverability groups based on the definitions listed above. Material types are color coded in the results section to indicate where each material type was allocated, and Table 1 shows how material types are categorized into each recoverability group.

Table 1. Recoverability Groups and Materials Types, 2017 Characterization Study

	Recyclable Paper	Other Recyclables	Compostable	Potential Recyclables	Problem Materials
Paper	Clean, Flattened, Uncoated OCC Clean, Unflattened, Uncoated OCC Newspaper Other Clean Paper		Paper Tissue & Towels Other Soiled Uncoated Fiber Coated OCC Other Coated Paper Gable Top Cartons Aseptics Paper Takeout Containers Coated Paper Cups Pizza Boxes	Aspetics	Other Composite Paper
Plastic		#1 PETE Plastic Packaging #2 HDPE Plastic Packaging Other #3-7 Plastic Packaging Durable Plastic Products Plastic Takeout Containers Recyclable Film Plastic	Compostable Plastic Bags Other Compostable Plastic		Expanded #6 Products & Packaging Flexible Plastic Pouches Other Composite Film Plastics Other Plastic
Glass		Glass Bottles & Jars			Blue or Red Glass Bottles & Jars Other Non-Composite Glass Other Composite Glass
Metal		Aluminum Cans & Foil Other Non-Ferrous Metal Steel Cans & Lids Appliances Other Ferrous Metal			Other Composite Metal
Organics			Plant Trimmings Edible Food Scraps Inedible Food Scraps Other Compostable Organics		Diapers Animal Feces & Litter Other Organics
C&D Debris		Clean Wood Clean Engineered Wood Inerts Clean Gypsum Painted Gypsum		Roofing Carpet	Painted Wood Treated Wood C&D Glass Fiberglass Insulation Other C&D
Hazardous		Electronics Paint Batteries Mercury Lamps Motor Oil Oil & Fuel Filters		Blue Wrap	Non-Empty Aerosol Cans Pesticides Cleaning Products Untreated Medical Waste Treated Medical Waste Medicine Cold Packs Other Hazardous
Other Materials		Tires & Rubber Textiles & Leather Non-Metal Appliances	Fines	Mattresses	Furniture Other Materials

ALLOCATE AND SCHEDULE SAMPLES

Using route information provided by GreenWaste, the consultant team **pre-selected** random loads of material for sampling from sectors with regular collection routes (including multifamily garbage, commercial garbage, commercial compost, and hospital compactors). Routes were selected using a random number generator and Microsoft Excel.

Loads from sectors that do not have regularly scheduled collection routes were **systematically selected** on each day of sampling (including loose roll-offs, mixed C&D from Zanker, and SMaRT Station residuals). Systematic selection involves creating a sampling frequency to ensure random selection. Although single-family households are on regular collection routes with GreenWaste, samples from the single-family sector were also systematically selected due to the nature of sample collection for that sector in this study.

Due to the limited number of incoming loads at the SMaRT Station, all loose roll-off loads from Palo Alto that arrived at the SMaRT Station during the study were selected for sampling. Similarly, all loads of mixed C&D hauled by GreenWaste during the time when Cascadia had a staff person onsite at Zanker for this study was selected to be a part of the study.

More detail about the sample selection process for each sector is included in Appendix B. Study Design.

The number of planned and actual samples from each sector, as well as the sample selection and characterization methodology used, is summarized in Table 2.

Table 2. Sample Allocation by Sector

Sector	Target Number of Samples	Actual Number of Samples	Sample Selection Method	Characterization Method
Residential				
Single-family (Garbage, Recyclables, and Compost)	*30*	*30*	*Systematic Selection*	*Hand-sort*
Multifamily Garbage	*26*	*26*	*Pre-Selection*	*Hand-sort*
Commercial				
Commercial Garbage	*40*	*40*	*Pre-Selection*	*Hand-sort*
Commercial Compost	*20*	*20*	*Pre-Selection*	*Hand-sort*
Hospital Garbage	*3*	*3*	*Pre-Selection*	*Hand-sort*
SMaRT Station Loose Roll-off Garbage	*Up to 20*	17	*Systematic Selection*	*Visual*
Zanker Mixed C&D	*Up to 20*	*15*	*Systematic Selection*	*Visual*
SMaRT Station Residuals	*16*	*16*	*Systematic Selection*	*Hand-sort*
Total	175	167		

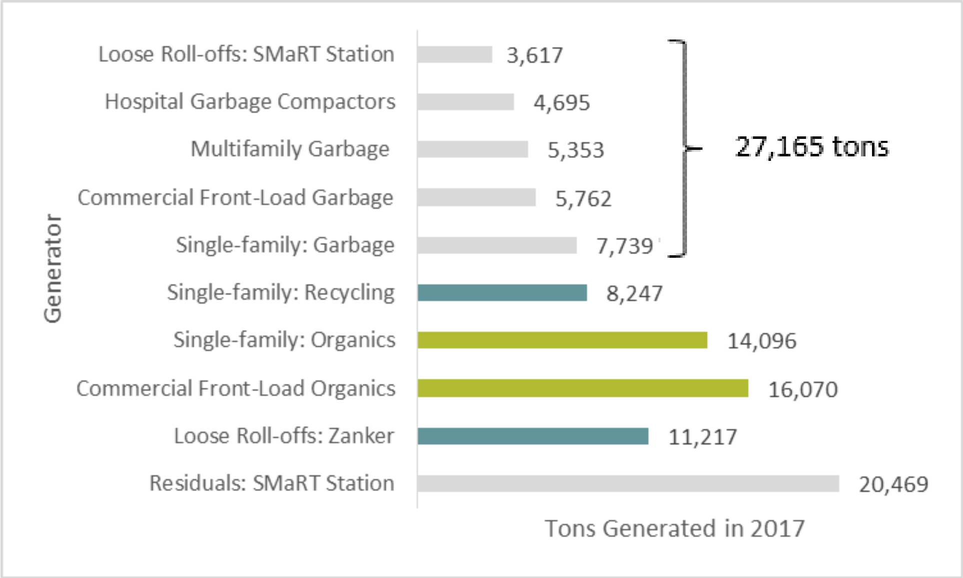
For the Loose roll-off and Mixed C&D (Zanker) sectors, the number of actual samples was fewer than planned because the number of incoming loads from these sectors was less than anticipated in the study design.

Task 2: Collect Data

DETERMINE WASTE QUANTITIES

The City of Palo Alto provided Cascadia with fiscal year 2016-17 tonnage information for each of the waste sectors considered in this study. According to this data, the City of Palo Alto disposed of about 27,165 tons of waste at the SMaRT Station in FY 2016-17. Residuals from the SMaRT Station attributed to Palo Alto totaled 20,469 tons. These tonnages are presented in Figure 2.

Figure 2. Generators Included in 2017 Palo Alto Characterization Study, by Tons



HAND SORT SAMPLES

For this study, the consultant team hand sorted all samples from single-family residential (including garbage, recyclables, and compost), multifamily garbage, commercial garbage, commercial compost, hospital compactors, and SMaRT Station residuals sectors. The field crew sorted and weighed each sample into 77 material types. Materials smaller than one-half inch were sorted into the *fines* material type. 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.

VISUALLY CHARACTERIZE SELF-HAUL AND LOOSE ROLL-OFF SAMPLES

The field crew visually characterized all loose roll-off and Zanker mixed C&D samples. The visual characterization method involved correlating the sample's composition estimate, net weight, and volume with industry standard material density factors that Cascadia developed in conjunction with CalRecycle. A trained crewmember used a seven-step process to visually characterize self-haul and loose roll-off loads as described in detail in Appendix B. Study Design.

Task 3: Analyze Data

Following on-site data collection, the consultant team entered all data recorded on field forms during hand sorting and visual characterization into a customized database. All data entry and analysis underwent a series of extensive quality checks to reduce the possibility of entry and calculation errors. To minimize data collection errors and maximize composition estimate accuracy, Cascadia implemented the following quality assurance/quality control procedures.

- Trained the scale house personnel to place placards on trucks selected for sampling.
- Checked all sample characterization field forms to ensure that forms were complete and data were properly recorded.
- Entered all characterization data into a customized database.
- Conducted an inspection of randomly selected records to monitor the accuracy of the data entry process.

The team calculated material composition and quantity estimates using the methods described in Appendix B. Study Design.

Findings

This section describes the composition and recoverability for Palo Alto's waste stream, for the each of the sectors studied:

- Residential and Commercial Garbage
- Single-Family Garbage, Recycling, and Compost
- Multifamily Garbage
- Commercial Garbage
- Commercial Compost
- Hospital Garbage
- SMaRT Station Loose Roll-off Garbage
- Zanker Mixed C&D
- SMaRT Station Residuals

RESIDENTIAL AND COMMERCIAL GARBAGE

The overall composition of Palo Alto's residential and commercial waste stream includes a combination of generators included in this study: single-family garbage, multifamily garbage, commercial garbage, garbage from hospital compactors, and SMaRT Station loose roll-off garbage. All of these are collected by GreenWaste. The consultant team characterized 112 samples of garbage from these generators and extrapolated the results of the characterization to apply to the 27,165 tons of material that these generators disposed in fiscal year 2016-17. Key findings from this extrapolation are presented below.

Key Findings

Figure 3 summarizes the recovery potential for this stream, and Figure 3 lists the top six materials found in the residential and commercial garbage (single-family garbage, multifamily garbage, commercial garbage, garbage from hospital compactors, and SMaRT Station loose roll-off garbage).

Figure 3. Material Recoverability, Residential and Commercial Garbage

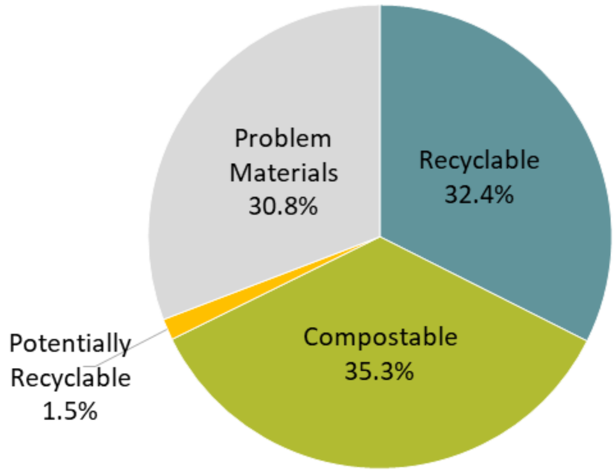


Table 3. Top Six Material Types, Residential and Commercial Garbage

Material	Est. Percent	Est. Tons
Edible Food Scraps	12.7%	3,455
Inedible Food Scraps	8.8%	2,391
Untreated Medical Waste	8.2%	2,233
Paper Tissue & Towels	8.0%	2,180
Other Clean Paper	7.3%	1,993
Diapers	6.6%	1,782
Total	**51.7%**	**14,035**

These sampling results suggest the following key findings about recovery potential for this stream:

- Approximately 68% (18,392 tons) of residential and commercial garbage from Palo Alto is recyclable or compostable in programs currently actively serving the city**.**
- About 35% (9,582 tons) of the stream is **Compostable**, the most prevalent recoverability group. As shown in Table 3, there were three compostable materials that were also in the top six most common materials in the stream:
  - *edible food scraps* (12.7% and 3,455 tons)
  - *inedible food scraps* (8.8% and 2,391 tons)
  - *paper tissue & towels* (8.0% and 2,180 tons)
- About 32% of the stream is **Recyclable** (8,810 tons). *Other clean paper* (7.3% and 1,993 tons), was the only recyclable material in the top six materials in the stream and was the most prevalent material in the recyclable portion of the stream.
- **Problem materials** is the third most common recoverability group, at 31% (8,371 tons) of Palo Alto's residential and commercial garbage stream. There were two problem materials that were also in the top six most common materials in the stream:

  - untreated medical waste (8.2% and 2,233 tons)
  - *diapers* (6.6% and 1,782 tons)
- About 1% (402 tons) of the stream consists of **Potentially Recyclable** materials. *Carpet* (0.6% and 164 tons), although not one of the top six materials in the stream, was the most prevalent material in the potentially recyclable portion of the stream.

Table 4 identifies the detailed material composition by material class and material type.

Table 4. Detailed Material Composition, Residential and Commercial Garbage

Material	Est. Percent	+ / -	Est. Tons
Paper	**22.0%**		**5,989**
Clean, Flattened, Uncoated OCC	1.7%	0.5%	474
Clean, Unflattened, Uncoated OCC	0.5%	0.1%	145
Newspaper	0.5%	0.1%	135
Other Clean Paper	7.3%	1.4%	1,993
Paper Tissue & Towels	8.0%	1.6%	2,180
Other Soiled Uncoated Fiber	0.4%	0.1%	100
Coated OCC	0.2%	0.1%	43
Other Coated Paper	0.5%	0.1%	142
Gable Top Cartons	0.1%	0.0%	29
Aseptics	0.2%	0.1%	45
Paper Takeout Containers	0.5%	0.1%	138
Coated Paper Cups	0.8%	0.1%	214
Pizza Boxes	0.1%	0.0%	28
Other Composite Paper	1.2%	0.3%	323
Plastic	**10.8%**		**2,930**
#1 PETE Plastic Packaging	0.9%	0.1%	231
#2 HDPE Plastic Packaging	0.4%	0.1%	97
Expanded #6 Products & Packaging	0.7%	0.3%	195
Other #3-7 Plastic Packaging	0.9%	0.2%	252
Durable Plastic Products	0.8%	0.1%	207
Plastic Takeout Containers	0.3%	0.1%	86
Compostable Plastic Bags	0.0%	0.0%	8
Other Compostable Plastic	0.1%	0.0%	19
Recyclable Film Plastic	2.0%	0.3%	555
Flexible Plastic Pouches	0.1%	0.0%	20
Other Composite Film Plastics	0.3%	0.1%	89
Other Plastic	4.3%	0.8%	1,169
Glass	**2.6%**		**714**
Glass Bottles & Jars	1.5%	0.3%	401
Blue or Red Glass Bottles & Jars	0.0%	0.0%	1
Other Non-Composite Glass	0.9%	1.0%	239
Other Composite Glass	0.3%	0.3%	72
Metal	**3.2%**		**881**
Aluminum Cans & Foil	0.4%	0.1%	112
Other Non-Ferrous Metal	0.0%	0.0%	12
Steel Cans & Lids	0.4%	0.1%	101
Appliances	0.2%	0.2%	43
Other Ferrous Metal	1.8%	0.7%	477
Other Composite Metal	0.5%	0.2%	136
Organics	**33.0%**		**8,953**
Plant Trimmings	2.2%	1.2%	599
Edible Food Scraps	12.7%	3.9%	3,455
Inedible Food Scraps	8.8%	2.1%	2,391
Other Compostable Organics	0.4%	0.3%	121
Diapers	6.6%	5.4%	1,782
Animal Feces & Litter	2.2%	1.6%	594
Other Organics	0.0%	0.0%	10

Material	Est. Percent	+ / -	Est. Tons
C&D Debris	**12.6%**		**3,419**
Clean Wood	4.5%	1.6%	1,220
Clean Engineered Wood	0.8%	0.3%	208
Painted Wood	0.7%	0.3%	177
Treated Wood	0.1%	0.1%	19
Inerts	3.3%	1.5%	888
Clean Gypsum	0.0%	0.0%	8
Painted Gypsum	0.1%	0.1%	26
Roofing	0.2%	0.3%	59
C&D Glass	0.5%	0.7%	125
Carpet	0.6%	0.5%	164
Fiberglass Insulation	0.0%	0.0%	7
Other C&D	1.9%	0.9%	518
Hazardous	**10.0%**		**2,728**
Electronics	0.2%	0.2%	60
Paint	0.1%	0.1%	20
Batteries	0.0%	0.0%	9
Non-Empty Aerosol Cans	0.0%	0.0%	0
Mercury Lamps	0.0%	0.0%	1
Pesticides	0.0%	0.0%	0
Cleaning Products	0.0%	0.0%	1
Motor Oil	0.0%	0.0%	0
Oil & Fuel Filters	0.0%	0.0%	0
Untreated Medical Waste	8.2%	3.2%	2,233
Treated Medical Waste	0.0%	0.0%	0
Blue Wrap	0.3%	0.2%	90
Medicine	0.1%	0.1%	26
Cold Packs	0.8%	0.4%	225
Other Hazardous	0.2%	0.3%	63
Other Materials	**5.7%**		**1,553**
Mattresses	0.2%	0.2%	45
Furniture	1.0%	0.6%	274
Tires & Rubber	0.5%	0.2%	129
Textiles & Leather	3.4%	0.8%	915
Non-Metal Appliances	0.0%	0.0%	4
Fines	0.4%	0.1%	114
Other Materials	0.3%	0.1%	72
Recyclable	**32%**		**8,810**
Compostable	**35%**		**9,582**
Potentially Recyclable	**1%**		**402**
Problem Materials	**31%**		**8,371**
Totals	**100%**		**27,165**
Sample Count	112		

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

SINGLE-FAMILY GARBAGE, RECYCLING, AND COMPOST

For single-family generators, the consultant team collected samples directly from the carts at 30 randomly selected households on randomly selected routes throughout the city. A sample at each household included any materials set out at that randomly selected household. After sample collection, the consultant team brought collected samples to the SMaRT Station for the sorting team there to sort by hand.

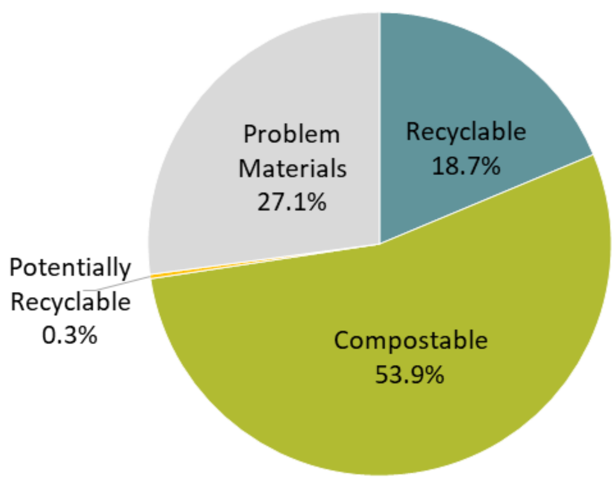
This sampling technique allows for more detailed data about behavioral patterns among single-family generators in Palo Alto, so this data will be presented differently than the data for other streams in this report. Results are presented below in five sections: overall summary, behavior patterns, capture rates, top six most prevalent materials, and detailed composition.

Overall Summary

Figure 4 summarizes the recovery potential for Palo Alto's single-family garbage, for comparability with other garbage streams characterized in this study.

Approximately 73% (5,619 tons) of single-family garbage from Palo Alto is recyclable or compostable in programs currently actively serving the city**.** About 54% (4,171 tons) of the stream is **Compostable**, the most prevalent recoverability group. About 27% of the stream is **Problem Materials** (2,097 tons). **Recyclable** materials is the third most common recoverability group, at 19% (1,447 tons) of Palo Alto's single-family garbage stream. Less than 1% of the stream (23 tons) was **Potentially Recyclable** materials.

Figure 4. Material Recoverability, Single Family Garbage



The height of each bar in Figure 5 below describes the tons of materials that single-family residents dispose in each stream. This figure is based on fiscal year 2016-17 tonnage information that the City of Palo Alto provided the project team. This figure also describes the recoverability of each single-family stream—disposed, curbside recycled, and curbside compost. 73% of materials that single-family residents disposed in garbage carts are recoverable through local recycling and composting programs. About 11% of materials in the single-family curbside recycling program are contaminants. The single-family curbside compost program is extremely clean, with only 1% contamination.

Figure 5. Single-Family Recoverability by Stream

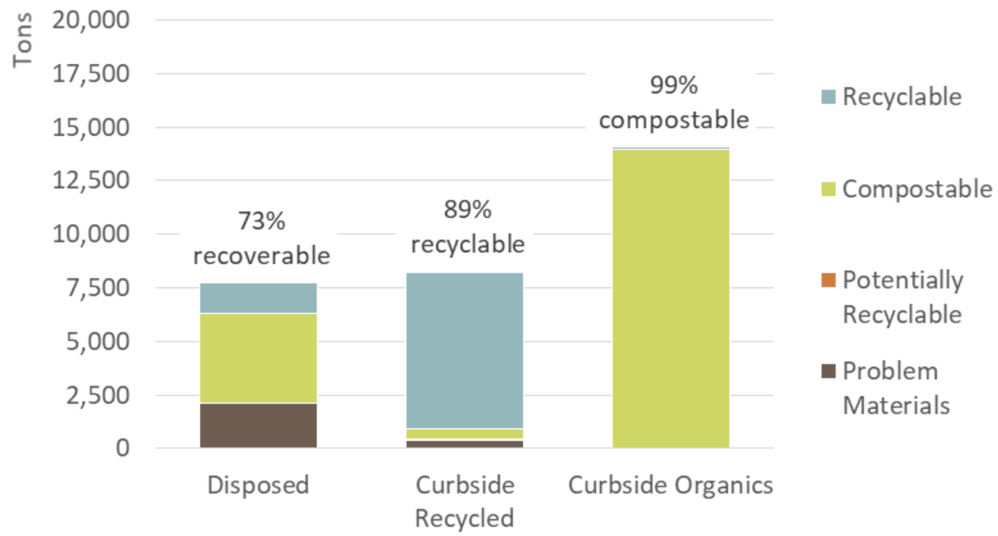


Figure 6 below uses a combination of City of Palo Alto collected set-out data and set-out data that the consultant team collected over the course of the study about the weekly set-out rates for each stream. Approximately 87% of households set out their garbage cart weekly, 80% set out their recycling cart, and 79% set out their compost cart.

Figure 6. Weekly Set-Out Rates by Cart Type

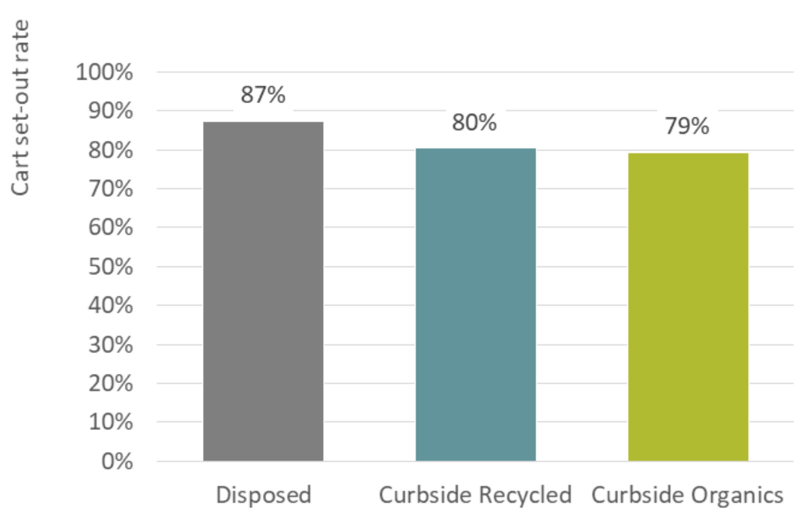
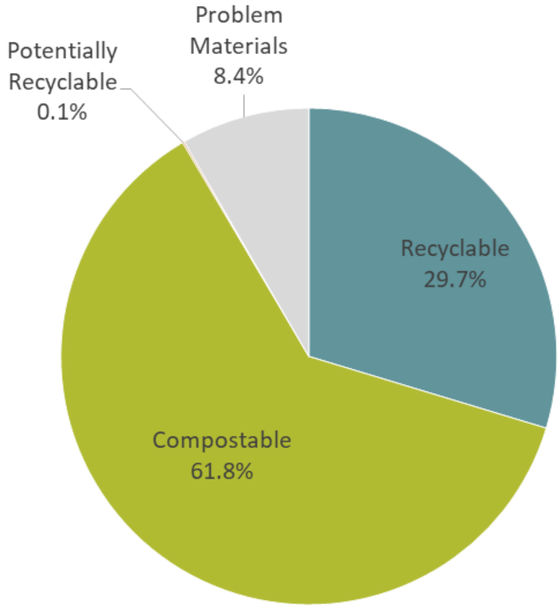


Figure 7 below describes overall single-family generation (garbage, recycling, and compost combined) by recoverability class. This figure represents all of the materials that the field team collected as samples from single-family residents for this study (materials from the garbage, recycling, and compost carts), combined in one figure. Of all of the materials that single-family residents generate and place at the curb in garbage, recycling, or compost carts, almost 62% of materials are compostable, and almost 30% are recyclable.

Figure 7. Material Recoverability, Overall Single-Family Generation (Recycling, Garbage, and Compost Combined)



Behavior Patterns

This section describes behavior patterns among single-family generators.

Figure 8 below indicates that 60% of single-family generators divert 80-100% of the recyclables that they generate, and 17% of single-family generators divert 60-79% of the recyclables that they generate. On the other end of the spectrum, 20% of households are not recycling at all and divert none of the recyclables that they generate.

Figure 8. Single-Family Recycling Diversion Efficiency Behavior Patterns

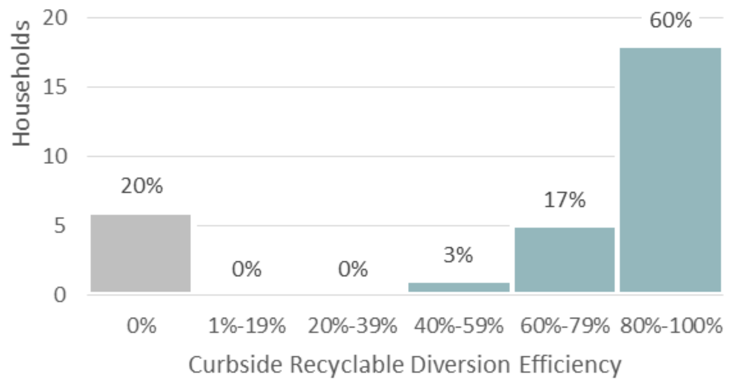
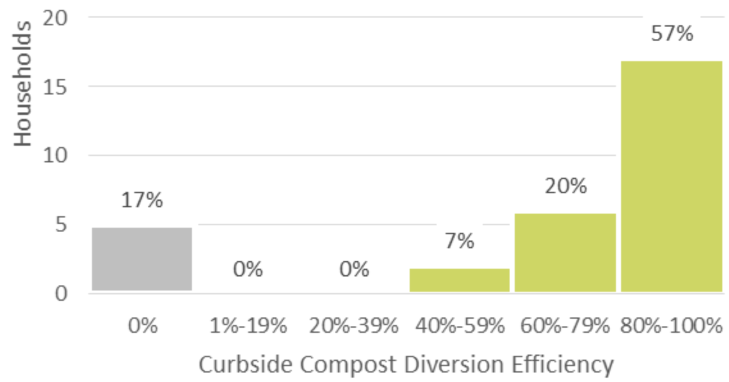


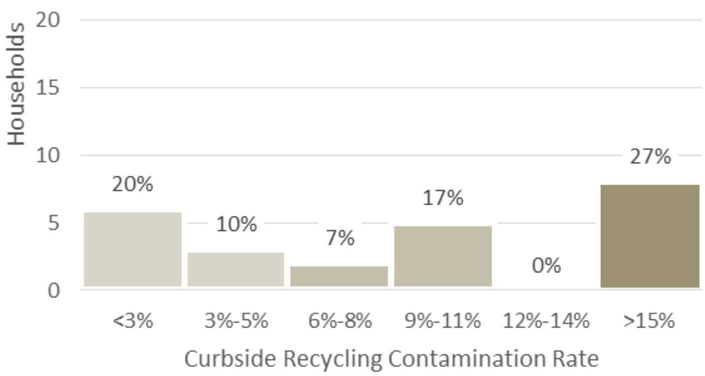
Figure 9 below indicates a similar pattern to that observed in single-family recycling: most households are either diverting almost all of the compostables that they generate or not diverting compostables at all. As indicated, 57% of single-family generators divert 80-100% of the compostables that they generate, and 20% of single-family generators divert 60-79% of the compostables that they generate. On the other end of the spectrum, 17% of households are not diverting compostables that they generate at all.

Figure 9. Single-Family Compost Diversion Efficiency Behavior Patterns



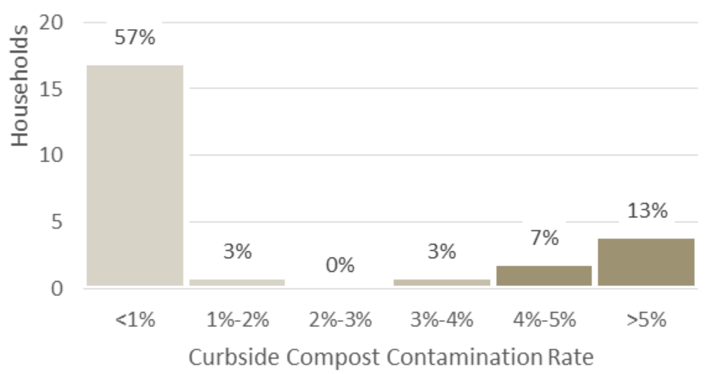
In terms of contamination, recycling contamination is relatively evenly spread. As Figure 10 demonstrates, 27% of single-family residents have a contamination rate of greater than 15% in their recycling stream; 20% of single-family residents have less than a 3% contamination rate; and 17% have between a 9-11% contamination rate.

Figure 10. Single-Family Recycling Contamination Rates Behavior Patterns



Conversely, the majority of single-family residents fall at either side of the compost contamination spectrum. As Figure 11 demonstrates, 57% of single-family residents have a contamination rate of less than 1% in their compost stream, and 13% have a contamination rate of greater than 5%.

Figure 11. Single-Family Compost Contamination Rates Behavior Patterns



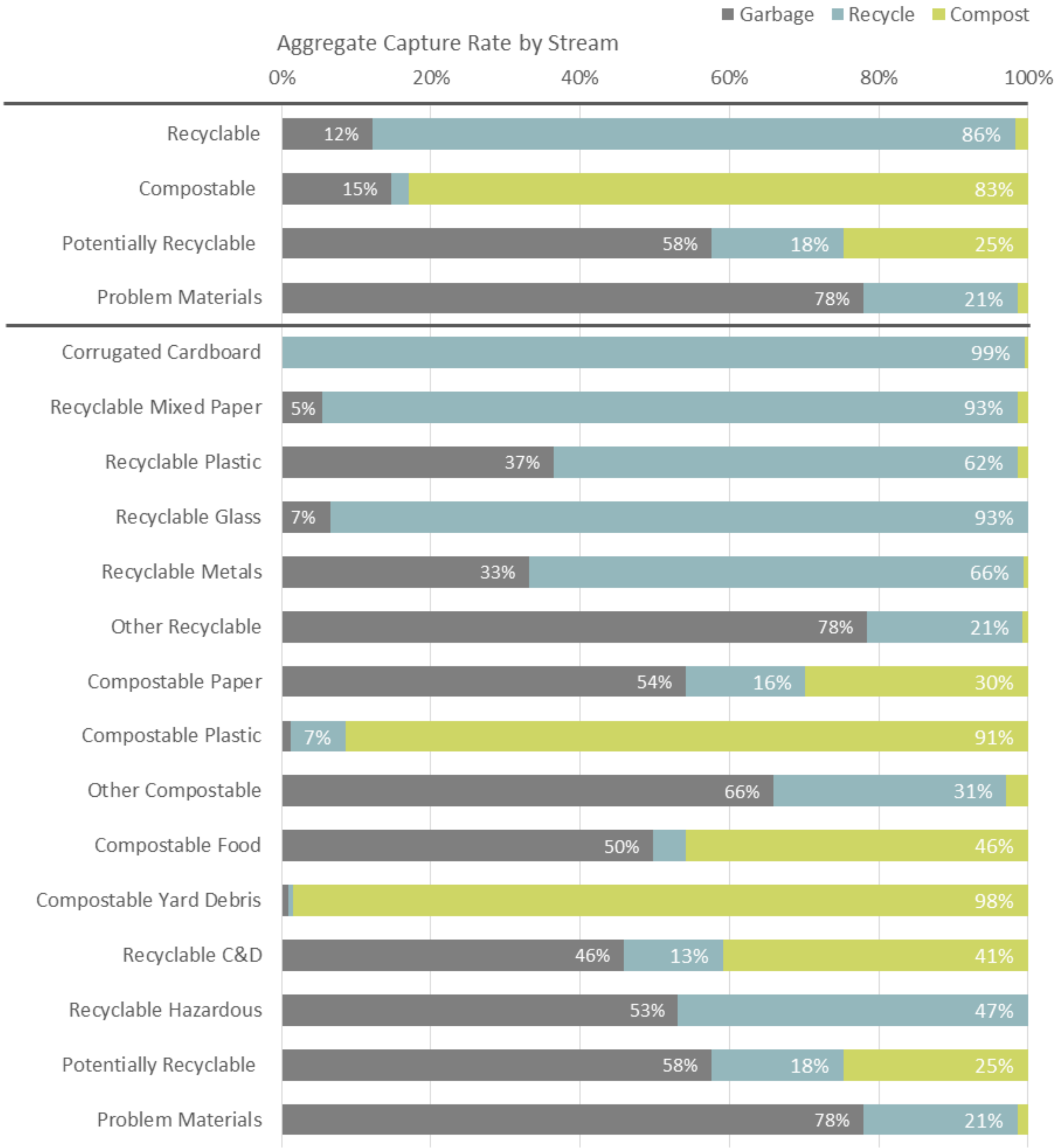
Capture Rates

Figure 12 describes capture rates for aggregated key materials of interest. We have rolled material types into larger material categories to demonstrate where there are general opportunities for improving materials capture. For example, we have rolled *clean, flattened, uncoated occ* and *clean, unflattened, uncoated occ* into an aggregated material type called as corrugated cardboard; and *newspaper* and *other clean paper* into recyclable mixed paper.

A capture rate indicates what proportion of each key material type single-family residents are placing in the correct container. For example, the capture rate for compostable paper (i.e., the pounds of compostable paper placed by single-family residents in the compost cart divided by the total pounds of compostable paper placed in either the garbage, recycling, or compost carts) from single-family generators indicated an opportunity for increased capture, with 30% of compostable paper captured in the single family compost stream, 16% entering the recycling stream as contamination, and 54%

disposed as garbage. Aggregated recyclable material types with high capture rates from single-family generators include corrugated cardboard (99% capture), recyclable mixed paper (93% capture), and recyclable glass (93% capture). Recyclable plastic (62% capture) and recyclable metals (66% capture) have relatively low capture rates among single-family generators. Compostable yard debris has a 98% capture rate, while compostable food has a 46% capture rate.

Figure 12. Aggregate Single-Family Capture Rates by Stream



Top Six

This section describes the top six materials in single-family garbage, recycling, and compost.

Of the top six materials in the single-family garbage stream (Table 5), three materials are compostable: *edible food scraps* (25.9% and 2,007 tons), *inedible food scraps* (14.2% and 1,098 tons), and *paper tissues & towels* (8.4% and 653 tons). *Diapers* (15.8% and 1,222 tons) are also a significant portion of the single-family garbage stream.

Table 5. Top Six Materials, Single-Family Garbage

Material	Est. Percent	Est. Tons
Edible Food Scraps	25.9%	2,007
Diapers	15.8%	1,222
Inedible Food Scraps	14.2%	1,098
Paper Tissue & Towels	8.4%	653
Animal Feces & Litter	5.7%	445
Other Clean Paper	4.7%	362
Total	**74.8%**	**5,786**

Five of the top six materials in the single-family recycling stream are recyclable. As shown in Table 6, *other composite metal* (2.7% and 219 tons) is the only non-recyclable material in the top six materials in the stream. *Other clean paper* (42.7% and 3,525 tons) is more than three times more prevalent than any other material in the stream.

Table 6. Top Six Materials, Single-Family Recycling

Material	Est. Percent	Est. Tons
Other Clean Paper	42.7%	3,525
Glass Bottles & Jars	12.4%	1,025
Clean, Flattened, Uncoated OCC	10.1%	836
Newspaper	10.0%	825
Clean, Unflattened, Uncoated OCC	3.0%	247
Other Composite Metal	2.7%	219
Total	**81.0%**	**6,676**

Plant trimmings (84.9% and 11,965 tons) is by far the most prevalent material in the single-family compost stream. *Inedible food scraps* (7.2% and 1,016 tons) and *edible food scraps* (4.8% and 679 tons) are also prevalent. *Paper tissue & towels* (1.0% and 137 tons) make up a relatively small portion of the single-family compost stream. *Inerts* (0.3% and 48 tons) and *other clean paper* (0.2% and 35 tons), are considered recyclable in Palo Alto, and are therefore contaminants in the single-family compost stream.

Table 7. Top Six Materials, Single-Family Compost

Material	Est. Percent	Est. Tons
Plant Trimmings	84.9%	11,965
Inedible Food Scraps	7.2%	1,016
Edible Food Scraps	4.8%	679
Paper Tissue & Towels	1.0%	137
Inerts	0.3%	48
Other Clean Paper	0.2%	35
Total	**98.5%**	**13,879**

Detailed Composition

The detailed composition table in Table 8 below presents detailed composition for single-family garbage, recycling, compost, and overall generation by material class, material type, and recoverability group. Additionally, capture rates are listed for each material type.

Table 8. Detailed Composition, Single-Family Disposal, Recycling, Compost, and Overall Generation

	Disposal			Recycling			Compost			Generation			Capture Rates	
Material	Est. Percent	+/-	Est. Tons	Est. Percent	+/-	Est. Tons	Est. Percent	+/-	Est. Tons	Est. Percent	+/-	Est. Tons	Recycling Bin	Compost Bin
Paper	**15.7%**		**1,217**	**68.3%**		**5,631**	**2.3%**		**322**	**23.8%**		**7,170**		
Clean, Flattened, Uncoated OCC	0.0%	0.0%	2	10.1%	4.1%	836	0.0%	0.0%	3	2.8%	1.1%	840	99%	0%
Clean, Unflattened, Uncoated OCC	0.0%	0.0%	-	3.0%	1.5%	247	0.0%	0.0%	-	0.8%	0.4%	247	100%	0%
Newspaper	0.1%	0.1%	9	10.0%	3.1%	825	0.2%	0.2%	22	2.8%	0.9%	855	96%	3%
Other Clean Paper	4.7%	2.4%	362	42.7%	16.3%	3,525	0.2%	0.2%	35	13.0%	4.5%	3,921	90%	1%
Paper Tissue & Towels	8.4%	3.9%	653	0.4%	0.4%	36	1.0%	0.7%	137	2.7%	1.1%	826	4%	17%
Other Soiled Uncoated Fiber	0.2%	0.2%	16	0.1%	0.1%	5	0.1%	0.1%	8	0.1%	0.1%	28	17%	28%
Coated OCC	0.0%	0.0%	2	0.0%	0.0%	-	0.0%	0.0%	-	0.0%	0.0%	2	0%	0%
Other Coated Paper	0.4%	0.1%	29	0.2%	0.2%	14	0.2%	0.1%	25	0.2%	0.1%	67	21%	37%
Gable Top Cartons	0.1%	0.1%	8	0.1%	0.1%	9	0.2%	0.1%	27	0.1%	0.1%	44	20%	62%
Aseptics	0.3%	0.3%	23	0.1%	0.1%	5	0.0%	0.0%	6	0.1%	0.1%	34	15%	17%
Paper Takeout Containers	0.3%	0.2%	25	0.1%	0.1%	10	0.2%	0.1%	27	0.2%	0.1%	62	16%	44%
Coated Paper Cups	0.4%	0.2%	31	0.2%	0.1%	18	0.1%	0.0%	9	0.2%	0.1%	58	31%	15%
Pizza Boxes	0.0%	0.0%	-	0.9%	0.5%	71	0.1%	0.1%	17	0.3%	0.1%	87	81%	19%
Other Composite Paper	0.8%	0.4%	60	0.4%	0.2%	30	0.1%	0.1%	8	0.3%	0.1%	98	31%	8%
Plastic	**9.4%**		**729**	**7.9%**		**648**	**0.3%**		**48**	**4.7%**		**1,425**		
#1 PETE Plastic Packaging	0.9%	0.4%	68	2.3%	0.4%	192	0.0%	0.0%	1	0.9%	0.1%	262	73%	0%
#2 HDPE Plastic Packaging	0.1%	0.1%	11	1.6%	0.5%	132	0.0%	0.0%	-	0.5%	0.1%	143	92%	0%
Expanded #6 Products & Packaging	0.2%	0.1%	15	0.4%	0.4%	30	0.0%	0.0%	-	0.1%	0.1%	45	66%	0%
Other #3-7 Plastic Packaging	0.9%	0.4%	73	1.1%	0.3%	92	0.0%	0.0%	2	0.6%	0.1%	167	55%	1%
Durable Plastic Products	0.4%	0.2%	30	0.3%	0.2%	21	0.0%	0.0%	1	0.2%	0.1%	52	40%	2%
Plastic Takeout Containers	0.5%	0.3%	36	0.2%	0.1%	19	0.0%	0.0%	2	0.2%	0.1%	57	33%	4%
Compostable Plastic Bags	0.0%	0.0%	0	0.0%	0.0%	2	0.2%	0.1%	31	0.1%	0.0%	34	7%	92%
Other Compostable Plastic	0.0%	0.0%	1	0.0%	0.0%	1	0.0%	0.0%	2	0.0%	0.0%	4	24%	61%
Recyclable Film Plastic	3.0%	0.7%	230	1.2%	0.5%	95	0.0%	0.0%	4	1.1%	0.2%	329	29%	1%
Flexible Plastic Pouches	0.1%	0.1%	9	0.1%	0.0%	5	0.0%	0.0%	-	0.0%	0.0%	14	35%	0%
Other Composite Film Plastics	0.7%	0.2%	55	0.1%	0.1%	7	0.0%	0.0%	1	0.2%	0.1%	62	11%	2%
Other Plastic	2.6%	1.2%	200	0.6%	0.2%	52	0.0%	0.0%	4	0.8%	0.3%	256	20%	1%
Glass	**1.4%**		**109**	**12.7%**		**1,049**	**0.0%**		**-**	**3.8%**		**1,157**		
Glass Bottles & Jars	1.3%	0.6%	100	12.4%	6.0%	1,025	0.0%	0.0%	-	3.7%	1.7%	1,125	91%	0%
Blue or Red Glass Bottles & Jars	0.0%	0.0%	-	0.3%	0.5%	24	0.0%	0.0%	-	0.1%	0.1%	24	100%	0%
Other Non-Composite Glass	0.0%	0.0%	-	0.0%	0.0%	-	0.0%	0.0%	-	0.0%	0.0%	-		
Other Composite Glass	0.1%	0.2%	9	0.0%	0.0%	-	0.0%	0.0%	-	0.0%	0.0%	9	0%	0%
Metal	**2.5%**		**191**	**5.8%**		**482**	**0.0%**		**2**	**2.2%**		**676**		
Aluminum Cans & Foil	0.7%	0.4%	51	0.6%	0.3%	50	0.0%	0.0%	2	0.3%	0.1%	103	48%	2%
Other Non-Ferrous Metal	0.0%	0.1%	4	0.2%	0.2%	13	0.0%	0.0%	-	0.1%	0.1%	16	78%	0%
Steel Cans & Lids	0.5%	0.4%	40	0.8%	0.4%	63	0.0%	0.0%	-	0.3%	0.1%	103	61%	0%
Appliances	0.0%	0.0%	-	0.0%	0.0%	-	0.0%	0.0%	-	0.0%	0.0%	-		
Other Ferrous Metal	1.1%	1.8%	88	1.7%	2.6%	138	0.0%	0.0%	-	0.8%	0.8%	226	61%	0%
Other Composite Metal	0.1%	0.1%	9	2.7%	2.2%	219	0.0%	0.0%	-	0.8%	0.6%	228	96%	0%
Organics	**65.1%**		**5,041**	**3.8%**		**316**	**96.9%**		**13,663**	**63.2%**		**19,020**		
Plant Trimmings	2.6%	3.4%	200	1.1%	1.7%	90	84.9%	5.7%	11,965	40.7%	2.8%	12,254	1%	98%
Edible Food Scraps	25.9%	13.5%	2,007	1.6%	1.2%	133	4.8%	1.9%	679	9.4%	3.6%	2,819	5%	24%
Inedible Food Scraps	14.2%	7.1%	1,098	0.7%	0.9%	62	7.2%	3.9%	1,016	7.2%	2.6%	2,176	3%	47%
Other Compostable Organics	0.9%	0.7%	69	0.4%	0.6%	32	0.0%	0.0%	3	0.3%	0.2%	103	31%	3%
Diapers	15.8%	19.0%	1,222	0.0%	0.0%	-	0.0%	0.0%	-	4.1%	4.9%	1,222	0%	0%
Animal Feces & Litter	5.7%	5.5%	445	0.0%	0.0%	-	0.0%	0.0%	-	1.5%	1.4%	445	0%	0%
Other Organics	0.0%	0.0%	2	0.0%	0.0%	-	0.0%	0.0%	-	0.0%	0.0%	2	0%	0%
C&D Debris	**1.2%**		**96**	**0.2%**		**20**	**0.4%**		**60**	**0.6%**		**177**		
Clean Wood	0.0%	0.0%	2	0.1%	0.1%	8	0.0%	0.0%	3	0.0%	0.0%	12	61%	25%
Clean Engineered Wood	0.0%	0.0%	-	0.0%	0.0%	-	0.0%	0.0%	-	0.0%	0.0%	-		
Painted Wood	0.0%	0.0%	-	0.0%	0.0%	-	0.0%	0.0%	-	0.0%	0.0%	-		
Treated Wood	0.0%	0.0%	-	0.0%	0.0%	-	0.0%	0.0%	-	0.0%	0.0%	-		
Inerts	1.2%	1.0%	95	0.2%	0.2%	13	0.3%	0.5%	48	0.5%	0.4%	155	8%	31%
Clean Gypsum	0.0%	0.0%	-	0.0%	0.0%	-	0.0%	0.0%	-	0.0%	0.0%	-		
Painted Gypsum	0.0%	0.0%	-	0.0%	0.0%	-	0.0%	0.0%	-	0.0%	0.0%	-		
Roofing	0.0%	0.0%	-	0.0%	0.0%	-	0.0%	0.0%	-	0.0%	0.0%	-		
C&D Glass	0.0%	0.0%	-	0.0%	0.0%	-	0.0%	0.0%	-	0.0%	0.0%	-		
Carpet	0.0%	0.0%	-	0.0%	0.0%	-	0.0%	0.0%	-	0.0%	0.0%	-		
Fiberglass Insulation	0.0%	0.0%	-	0.0%	0.0%	-	0.0%	0.0%	0	0.0%	0.0%	0	0%	100%
Other C&D	0.0%	0.0%	-	0.0%	0.0%	-	0.1%	0.1%	9	0.0%	0.0%	9	0%	100%
Hazardous	**1.1%**		**82**	**0.5%**		**42**	**0.0%**		**-**	**0.4%**		**124**		
Electronics	0.3%	0.4%	21	0.2%	0.4%	19	0.0%	0.0%	-	0.1%	0.2%	40	47%	0%
Paint	0.1%	0.1%	5	0.0%	0.0%	-	0.0%	0.0%	-	0.0%	0.0%	5	0%	0%
Batteries	0.0%	0.1%	4	0.0%	0.0%	-	0.0%	0.0%	-	0.0%	0.0%	4	0%	0%
Non-Empty Aerosol Cans	0.0%	0.0%	-	0.0%	0.1%	4	0.0%	0.0%	-	0.0%	0.0%	4	100%	0%
Mercury Lamps	0.0%	0.0%	-	0.0%	0.0%	-	0.0%	0.0%	-	0.0%	0.0%	-		
Pesticides	0.0%	0.0%	-	0.0%	0.0%	-	0.0%	0.0%	-	0.0%	0.0%	-		
Cleaning Products	0.0%	0.0%	-	0.0%	0.0%	-	0.0%	0.0%	-	0.0%	0.0%	-		
Motor Oil	0.0%	0.0%	-	0.0%	0.0%	-	0.0%	0.0%	-	0.0%	0.0%	-		
Oil & Fuel Filters	0.0%	0.0%	-	0.0%	0.0%	-	0.0%	0.0%	-	0.0%	0.0%	-		
Untreated Medical Waste	0.0%	0.0%	1	0.0%	0.0%	-	0.0%	0.0%	-	0.0%	0.0%	1	0%	0%
Treated Medical Waste	0.0%	0.0%	-	0.0%	0.0%	-	0.0%	0.0%	-	0.0%	0.0%	-		
Blue Wrap	0.0%	0.0%	-	0.0%	0.0%	-	0.0%	0.0%	-	0.0%	0.0%	-		
Medicine	0.1%	0.1%	8	0.2%	0.4%	19	0.0%	0.0%	-	0.1%	0.1%	27	70%	0%
Cold Packs	0.5%	0.7%	42	0.0%	0.0%	-	0.0%	0.0%	-	0.1%	0.2%	42	0%	0%
Other Hazardous	0.0%	0.0%	2	0.0%	0.0%	-	0.0%	0.0%	-	0.0%	0.0%	2	0%	0%
Other Materials	**3.5%**		**272**	**0.7%**		**59**	**0.0%**		**1**	**1.1%**		**333**		
Mattresses	0.0%	0.0%	-	0.0%	0.0%	-	0.0%	0.0%	-	0.0%	0.0%	-		
Furniture	0.0%	0.0%	-	0.0%	0.0%	-	0.0%	0.0%	-	0.0%	0.0%	-		
Tires & Rubber	0.1%	0.1%	5	0.0%	0.1%	4	0.0%	0.0%	-	0.0%	0.0%	9	42%	0%
Textiles & Leather	2.7%	1.7%	212	0.5%	0.4%	38	0.0%	0.0%	1	0.8%	0.5%	251	15%	0%
Non-Metal Appliances	0.0%	0.0%	-	0.0%	0.0%	-	0.0%	0.0%	-	0.0%	0.0%	-		
Fines	0.5%	0.3%	35	0.0%	0.0%	4	0.0%	0.0%	-	0.1%	0.1%	39	10%	0%
Other Materials	0.3%	0.1%	20	0.2%	0.2%	14	0.0%	0.0%	-	0.1%	0.1%	34	41%	0%
Recyclable	**19%**		**1,447**	**89%**		**7,353**	**1%**		**123**	**30%**		**8,924**	**82%**	**1%**
Compostable	**54%**		**4,171**	**6%**		**486**	**99%**		**13,945**	**62%**		**18,602**	**3%**	**75%**
Potentially Recyclable	**0%**		**23**	**0%**		**5**	**0%**		**6**	**0%**		**34**	**15%**	**17%**
Problem Materials	**27%**		**2,097**	**5%**		**402**	**0%**		**22**	**8%**		**2,522**	**16%**	**1%**
Totals	**100%**		**7,739**	**100%**		**8,247**	**100%**		**14,096**	**100%**		**30,081**		
Sample Count	28			24			25							

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

MULTIFAMILY GARBAGE

The consultant team hand sorted 26 samples of multifamily residential garbage from Palo Alto, including both front-load-collected multifamily garbage and multifamily garbage collected in compactors. Multifamily front-load garbage is usually collected in a truck that also collects commercial front-load garbage. However, for the purposes of this study, GreenWaste ran an isolated front-load route that only collected multifamily garbage. The Cascadia team extrapolated the results of the characterization to apply to the 5,353 tons of multifamily garbage collected in front-load routes and in compactors in fiscal year 2016-17. Key findings from this extrapolation are presented below.

Palo Alto's commercial and multi-family garbage tons are collected in the same trucks and are combined in Palo Alto's annual tonnage reporting. Cascadia estimated the portion of tons that could be attributed to Palo Alto's multifamily generators based on the total number of units in Palo Alto and a per unit disposal rate. Palo Alto assembled garbage collection service levels and number of units at each multifamily property in the city. For properties where the unit count was unknown, Cascadia estimated the number of units by dividing the service level by the average weekly cubic yards of service per unit. This average was calculated from the properties with known unit counts. Cascadia then applied a multifamily disposal rate from the CalRecycle "2014 Generator-based Characterization of Commercial Sector Disposal and Diversion in California" study to the total number of units to estimate the total tons of garbage per year generated by multifamily properties in Palo Alto.

Key Findings

Figure 13 summarizes the recovery potential for Palo Alto's multifamily residential garbage, and Table 9 lists the six most common materials in the multifamily residential garbage stream by weight.

Figure 13. Material Recoverability, Multifamily Garbage

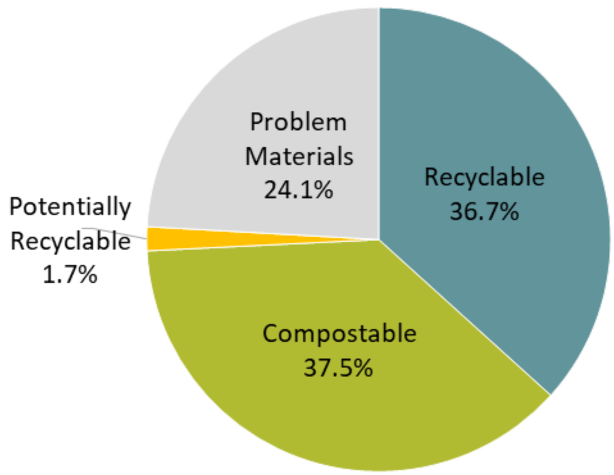


Table 9. Top Six Material Types, Multifamily Garbage

Material	Est. Percent	Est. Tons
Edible Food Scraps	12.1%	646
Inedible Food Scraps	11.8%	632
Other Clean Paper	9.7%	517
Paper Tissue & Towels	7.8%	418
Diapers	7.0%	377
Textiles & Leather	5.7%	304
Total	**54.1%**	**2,894**

Key findings include:

- About 74% (3,973 tons) of multifamily garbage in Palo Alto is recyclable or compostable in programs currently serving the city.
- **Compostable** material, the most common recoverability group, represents 38% (2,008 tons) of Palo Alto's multifamily garbage stream. The following **Compostable** materials were among the top six material types found in multifamily garbage:
  - *edible food scraps* (12.1% and 646 tons)
  - *inedible food scraps* (11.8% and 632 tons)
  - paper tissues & towels (7.8% and 418 tons)

- The second most prevalent recoverability group is **Recyclable** materials, which makes up about 37% (1,965 tons) of multifamily garbage. The following Recyclable materials are among the top six material types in the multifamily garbage stream:
  - *other clean paper* (9.7% and 517 tons)
  - *textiles and leather* (5.7% and 304 tons)
- **Problem Materials** compose 24% of multifamily garbage (1,290 tons). *Diapers* (7.0% and 377 tons) are considered a problem material and were identified as one of the six most common materials in the multifamily stream.
- **Potentially Recyclable** materials make up 2% (89 tons) of the multifamily garbage stream, the least prevalent recoverability group. *Carpet* (1.6% and 83 tons), although not one of the top six materials in the multifamily garbage stream overall, was the most prevalent material in the potentially recyclable portion of the stream.

Table 10 identifies the detailed material composition by material class and material type.

Table 10. Detailed Material Composition, Multifamily Garbage

Material	Est. Percent	+/-	Est. Tons
Paper	**26.1%**		**1,398**
Clean, Flattened, Uncoated OCC	2.7%	0.9%	143
Clean, Unflattened, Uncoated OCC	1.1%	0.6%	60
Newspaper	1.1%	0.4%	58
Other Clean Paper	9.7%	1.4%	517
Paper Tissue & Towels	7.8%	1.1%	418
Other Soiled Uncoated Fiber	0.3%	0.1%	16
Coated OCC	0.1%	0.1%	7
Other Coated Paper	0.6%	0.2%	34
Gable Top Cartons	0.2%	0.0%	8
Aseptics	0.1%	0.0%	6
Paper Takeout Containers	0.5%	0.2%	24
Coated Paper Cups	0.4%	0.1%	22
Pizza Boxes	0.3%	0.1%	14
Other Composite Paper	1.3%	0.5%	70
Plastic	**10.9%**		**582**
#1 PETE Plastic Packaging	1.1%	0.2%	60
#2 HDPE Plastic Packaging	0.6%	0.2%	30
Expanded #6 Products & Packaging	0.3%	0.1%	17
Other #3-7 Plastic Packaging	1.4%	0.3%	73
Durable Plastic Products	1.4%	0.4%	76
Plastic Takeout Containers	0.3%	0.1%	17
Compostable Plastic Bags	0.0%	0.0%	1
Other Compostable Plastic	0.1%	0.0%	4
Recyclable Film Plastic	2.5%	0.3%	134
Flexible Plastic Pouches	0.1%	0.0%	4
Other Composite Film Plastics	0.3%	0.0%	14
Other Plastic	2.8%	0.5%	151
Glass	**3.1%**		**164**
Glass Bottles & Jars	2.6%	0.7%	139
Blue or Red Glass Bottles & Jars	0.0%	0.0%	1
Other Non-Composite Glass	0.2%	0.1%	9
Other Composite Glass	0.3%	0.4%	15
Metal	**5.0%**		**269**
Aluminum Cans & Foil	0.4%	0.1%	22
Other Non-Ferrous Metal	0.1%	0.1%	6
Steel Cans & Lids	0.4%	0.1%	21
Appliances	0.6%	1.0%	34
Other Ferrous Metal	2.2%	1.4%	117
Other Composite Metal	1.3%	0.6%	69
Organics	**35.6%**		**1,905**
Plant Trimmings	2.3%	1.9%	125
Edible Food Scraps	12.1%	1.4%	646
Inedible Food Scraps	11.8%	2.0%	632
Other Compostable Organics	0.4%	0.3%	22
Diapers	7.0%	1.9%	377
Animal Feces & Litter	1.8%	1.2%	98
Other Organics	0.1%	0.1%	6

Material	Est. Percent	+/-	Est. Tons
C&D Debris	**9.7%**		**518**
Clean Wood	0.6%	0.4%	33
Clean Engineered Wood	0.1%	0.1%	7
Painted Wood	1.7%	0.8%	89
Treated Wood	0.2%	0.3%	10
Inerts	0.4%	0.2%	20
Clean Gypsum	0.2%	0.2%	8
Painted Gypsum	0.1%	0.2%	6
Roofing	0.0%	0.0%	0
C&D Glass	0.0%	0.0%	0
Carpet	1.6%	1.7%	83
Fiberglass Insulation	0.1%	0.1%	4
Other C&D	4.8%	4.0%	259
Hazardous	**1.6%**		**85**
Electronics	0.6%	0.5%	30
Paint	0.2%	0.2%	12
Batteries	0.1%	0.0%	3
Non-Empty Aerosol Cans	0.0%	0.0%	0
Mercury Lamps	0.0%	0.0%	1
Pesticides	0.0%	0.0%	0
Cleaning Products	0.0%	0.0%	0
Motor Oil	0.0%	0.0%	0
Oil & Fuel Filters	0.0%	0.0%	0
Untreated Medical Waste	0.2%	0.2%	13
Treated Medical Waste	0.0%	0.0%	0
Blue Wrap	0.0%	0.0%	0
Medicine	0.1%	0.1%	3
Cold Packs	0.4%	0.4%	22
Other Hazardous	0.0%	0.0%	0
Other Materials	**8.1%**		**431**
Mattresses	0.0%	0.0%	0
Furniture	0.9%	0.7%	50
Tires & Rubber	0.5%	0.4%	29
Textiles & Leather	5.7%	1.8%	304
Non-Metal Appliances	0.1%	0.1%	4
Fines	0.7%	0.2%	35
Other Materials	0.2%	0.1%	10
Recyclable	**37%**		**1,965**
Compostable	**38%**		**2,008**
Potentially Recyclable	**2%**		**89**
Problem Materials	**24%**		**1,290**
Totals	**100%**		**5,353**
Sample Count	26		

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

COMMERCIAL GARBAGE

The consultant team hand sorted 40 samples of Palo Alto's commercial front-load garbage and extrapolated the results of the characterization to apply to the 5,763 tons of material the commercial front-load garbage sector generated in fiscal year 2016-17. Key findings from this extrapolation are presented below.

Key Findings

Figure 14 summarizes the recovery potential for Palo Alto's commercial front-load garbage, and Table 11**Error! Reference source not found.** lists the top six materials found in Palo Alto's commercial front-load garbage stream by weight.

Figure 14. Material Recoverability, Commercial Garbage

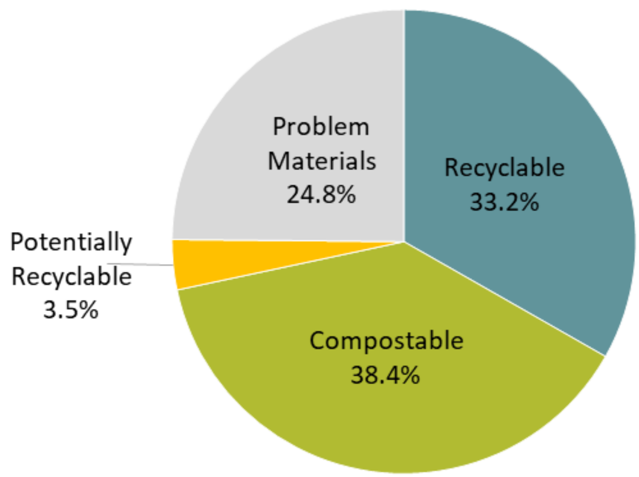


Table 11. Top Six Material Types, Commercial Garbage

Material	Est. Percent	Est. Tons
Paper Tissue & Towels	11.9%	684
Other Clean Paper	10.2%	587
Inedible Food Scraps	8.2%	474
Other Plastic	8.1%	465
Edible Food Scraps	8.0%	458
Plant Trimmings	3.5%	200
Total	**49.8%**	**2,867**

Key findings include:

- About 72% (4,129 tons) of Palo Alto's commercial front-load garbage is recyclable or compostable through recycling and composting programs currently serving Palo Alto.
- **Compostable** material represents the largest recoverability group in Palo Alto's commercial front-load garbage at 38% (2,213 tons) of the total. As shown in Table 11, **Compostable** material types represent four of the top six materials in the commercial front-load garbage stream:
  - paper tissue & towels (11.9% and 684 tons)
  - *inedible food scraps* (8.2% and 474 tons)
  - *edible food scraps* (8.0% and 458 tons)
  - *plant trimmings* (3.5% and 200 tons)
- The second most common recoverability group is **Recyclable** materials, composing about 33% (1,915 tons) of commercial front-load garbage. Of the top six most prevalent materials in this stream, only one was part of the recyclable recoverability group: *other clean paper* (10.2% and 587 tons).
- **Problem Materials** make up approximately 25% (1,432 tons) of the commercial front-load garbage stream; *other plastic* (8.1% and 465 tons) was the most common problem material type in the commercial front load garbage stream and the only material in this recoverability class in the top six most prevalent materials for this garbage stream.
- **Potentially Recyclable** materials made up 3% (201 tons) of the commercial front load garbage stream for Palo Alto. *Carpet* (1.4% and 80 tons), although not one of the top six materials in the commercial front load garbage stream overall, was the most prevalent material in the potentially recyclable portion of the stream.

Table 12 identifies the detailed material composition by material class and material type.

Table 12. Detailed Composition, Commercial Garbage

Material	Est. Percent	+/-	Est. Tons	Material	Est. Percent	+/-	Est. Tons
Paper	**32.4%**		**1,865**	**C&D Debris**	**10.4%**		**600**
Clean, Flattened, Uncoated OCC	1.4%	0.4%	80	Clean Wood	1.6%	1.3%	95
Clean, Unflattened, Uncoated OCC	0.7%	0.3%	38	Clean Engineered Wood	0.5%	0.5%	27
Newspaper	1.0%	0.5%	60	Painted Wood	0.6%	0.3%	36
Other Clean Paper	10.2%	1.8%	587	Treated Wood	0.2%	0.2%	9
Paper Tissue & Towels	11.9%	1.7%	684	Inerts	2.9%	2.8%	167
Other Soiled Uncoated Fiber	0.8%	0.3%	47	Clean Gypsum	0.0%	0.0%	0
Coated OCC	0.1%	0.1%	8	Painted Gypsum	0.0%	0.0%	0
Other Coated Paper	1.1%	0.3%	66	Roofing	1.0%	1.2%	59
Gable Top Cartons	0.2%	0.1%	11	C&D Glass	0.0%	0.0%	0
Aseptics	0.2%	0.1%	11	Carpet	1.4%	1.9%	80
Paper Takeout Containers	0.9%	0.4%	52	Fiberglass Insulation	0.0%	0.0%	1
Coated Paper Cups	1.9%	0.5%	111	Other C&D	2.2%	1.9%	126
Pizza Boxes	0.2%	0.2%	14				
Other Composite Paper	1.7%	0.4%	98	**Hazardous**	**4.4%**		**255**
				Electronics	0.0%	0.0%	1
Plastic	**17.0%**		**977**	Paint	0.0%	0.0%	2
#1 PETE Plastic Packaging	1.2%	0.2%	67	Batteries	0.0%	0.0%	2
#2 HDPE Plastic Packaging	0.6%	0.2%	32	Non-Empty Aerosol Cans	0.0%	0.0%	0
Expanded #6 Products & Packaging	1.3%	0.5%	72	Mercury Lamps	0.0%	0.0%	0
Other #3-7 Plastic Packaging	1.4%	0.3%	83	Pesticides	0.0%	0.0%	0
Durable Plastic Products	1.2%	0.3%	70	Cleaning Products	0.0%	0.0%	0
Plastic Takeout Containers	0.4%	0.1%	26	Motor Oil	0.0%	0.0%	0
Compostable Plastic Bags	0.1%	0.1%	6	Oil & Fuel Filters	0.0%	0.0%	0
Other Compostable Plastic	0.2%	0.1%	14	Untreated Medical Waste	3.1%	1.4%	177
Recyclable Film Plastic	2.1%	0.5%	121	Treated Medical Waste	0.0%	0.0%	0
Flexible Plastic Pouches	0.1%	0.1%	7	Blue Wrap	0.1%	0.2%	6
Other Composite Film Plastics	0.2%	0.1%	12	Medicine	0.1%	0.1%	6
Other Plastic	8.1%	1.3%	465	Cold Packs	1.0%	0.8%	58
				Other Hazardous	0.0%	0.0%	2
Glass	**2.6%**		**152**				
Glass Bottles & Jars	1.6%	0.4%	91	**Other Materials**	**8.4%**		**482**
Blue or Red Glass Bottles & Jars	0.0%	0.0%	0	Mattresses	0.8%	1.0%	45
Other Non-Composite Glass	0.9%	1.2%	53	Furniture	2.2%	1.9%	124
Other Composite Glass	0.1%	0.2%	8	Tires & Rubber	1.3%	0.8%	78
				Textiles & Leather	3.1%	1.3%	177
Metal	**2.4%**		**138**	Non-Metal Appliances	0.0%	0.0%	0
Aluminum Cans & Foil	0.5%	0.2%	30	Fines	0.7%	0.2%	40
Other Non-Ferrous Metal	0.0%	0.0%	2	Other Materials	0.3%	0.2%	19
Steel Cans & Lids	0.5%	0.2%	29				
Appliances	0.2%	0.3%	9	Recyclable	**33%**		**1,915**
Other Ferrous Metal	0.7%	0.3%	41	Compostable	**38%**		**2,213**
Other Composite Metal	0.5%	0.3%	27	Potentially Recyclable	**3%**		**201**
				Problem Materials	**25%**		**1,432**
Organics	**22.4%**		**1,293**	**Totals**	**100%**		**5,762**
Plant Trimmings	3.5%	2.4%	200				
Edible Food Scraps	8.0%	1.3%	458	Sample Count	40		
Inedible Food Scraps	8.2%	1.5%	474				
Other Compostable Organics	0.5%	0.7%	29				
Diapers	1.4%	0.9%	80				
Animal Feces & Litter	0.9%	1.1%	52				
Other Organics	0.0%	0.0%	0				

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

COMMERCIAL COMPOST

The consultant team hand sorted 20 samples of Palo Alto's commercial front-load compost, and extrapolated the results of the characterization to apply to the 16,070 tons of material the commercial front-load compost sector generated in fiscal year 2016-17. Key findings from this extrapolation are presented below.

Key Findings

Figure 15 summarizes the recovery potential for Palo Alto's commercial front-load compost, and Table 13 lists the top six materials found in Palo Alto's commercial front-load compost stream by weight.

Figure 15. Material Recoverability, Commercial Compost

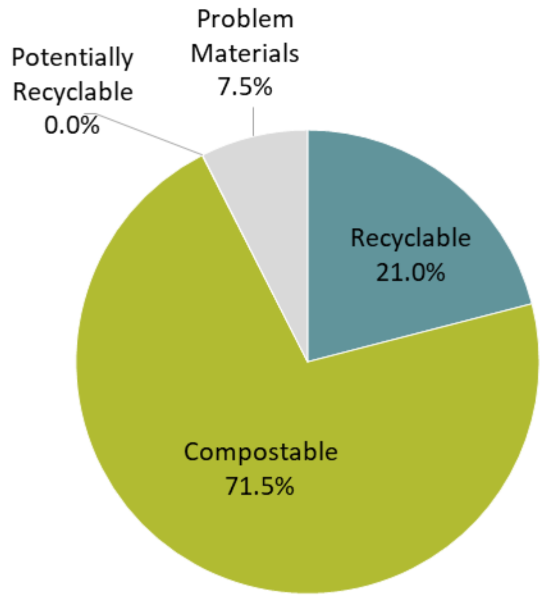


Table 13. Top Six Material Types, Commercial Compost

Material	Est. Percent	Est. Tons
Inedible Food Scraps	34.6%	5,563
Paper Tissue & Towels	10.6%	1,711
Edible Food Scraps	9.0%	1,445
Plant Trimmings	8.3%	1,341
Other Clean Paper	5.4%	865
Other Plastic	5.1%	815
Total	**73.1%**	**11,741**

Key findings include:

- **Compostable** material represents the largest recoverability group in Palo Alto's commercial front-load compost at 72% (11,491 tons) of the total. As shown in Table 13, **Compostable** material types represent four of the top six materials in the commercial front-load compost stream:
  - *inedible food scraps* (34.6% and 5,563 tons)
  - *edible food scraps* (9.0% and 1,445 tons)
  - *paper tissue & towels* (10.6% and 1,711 tons)
  - *plant trimmings* (8.3% and 1,341 tons)
- The second most common recoverability group is **Recyclable** materials, composing about 21% (3,370 tons) of commercial front-load compost. These materials are contaminants in the compost stream but could be recovered if the generator placed them in a recycling container for collection. Of the top six most prevalent materials in this stream, only one was part of the recyclable recoverability group: *other clean paper* (5.4% and 865 tons).
- **Problem Materials** make up approximately 7% (1,203 tons) of the commercial front-load compost stream; *other plastic* (5.1% and 815 tons) was the most common problem material type in the commercial front-load compost stream, and the only material in this recoverability class in the top six most prevalent materials for this stream.
- **Potentially Recyclable** materials made up 0% (6 tons) of the commercial front-load compost stream for Palo Alto. *Aseptics* (0.0% and 6 tons) was the only material in the potentially recyclable portion of the stream.

Table 14 identifies the detailed material composition by material class and material type.

Table 14. Detailed Composition, Commercial Compost

Material	Est. Percent	+/-	Est. Tons
Paper	**27.3%**		**4,382**
Clean, Flattened, Uncoated OCC	1.7%	0.8%	266
Clean, Unflattened, Uncoated OCC	1.5%	0.8%	244
Newspaper	0.4%	0.2%	72
Other Clean Paper	5.4%	1.5%	865
Paper Tissue & Towels	10.6%	2.6%	1,711
Other Soiled Uncoated Fiber	0.8%	0.5%	136
Coated OCC	0.7%	0.5%	111
Other Coated Paper	1.0%	0.6%	154
Gable Top Cartons	0.1%	0.1%	18
Aseptics	0.0%	0.0%	6
Paper Takeout Containers	1.4%	0.8%	233
Coated Paper Cups	2.7%	1.3%	427
Pizza Boxes	0.4%	0.3%	58
Other Composite Paper	0.5%	0.4%	81
Plastic	**11.1%**		**1,789**
#1 PETE Plastic Packaging	1.0%	0.4%	162
#2 HDPE Plastic Packaging	0.5%	0.3%	77
Expanded #6 Products & Packaging	0.2%	0.1%	28
Other #3-7 Plastic Packaging	0.9%	0.3%	143
Durable Plastic Products	0.2%	0.1%	35
Plastic Takeout Containers	0.4%	0.1%	69
Compostable Plastic Bags	0.6%	0.2%	90
Other Compostable Plastic	0.6%	0.4%	104
Recyclable Film Plastic	1.5%	0.3%	243
Flexible Plastic Pouches	0.0%	0.0%	5
Other Composite Film Plastics	0.1%	0.0%	18
Other Plastic	5.1%	1.6%	815
Glass	**1.8%**		**288**
Glass Bottles & Jars	1.7%	0.6%	271
Blue or Red Glass Bottles & Jars	0.0%	0.1%	7
Other Non-Composite Glass	0.1%	0.1%	10
Other Composite Glass	0.0%	0.0%	0
Metal	**2.4%**		**378**
Aluminum Cans & Foil	0.5%	0.3%	77
Other Non-Ferrous Metal	0.0%	0.0%	1
Steel Cans & Lids	0.4%	0.2%	62
Appliances	0.8%	1.3%	127
Other Ferrous Metal	0.3%	0.3%	47
Other Composite Metal	0.4%	0.5%	63
Organics	**52.4%**		**8,417**
Plant Trimmings	8.3%	8.1%	1,341
Edible Food Scraps	9.0%	2.0%	1,445
Inedible Food Scraps	34.6%	7.4%	5,563
Other Compostable Organics	0.3%	0.2%	44
Diapers	0.1%	0.1%	16
Animal Feces & Litter	0.0%	0.1%	7
Other Organics	0.0%	0.0%	1

Material	Est. Percent	+/-	Est. Tons
C&D Debris	**3.7%**		**597**
Clean Wood	0.2%	0.2%	26
Clean Engineered Wood	0.0%	0.0%	0
Painted Wood	0.0%	0.0%	0
Treated Wood	0.0%	0.0%	0
Inerts	3.2%	3.7%	522
Clean Gypsum	0.0%	0.0%	0
Painted Gypsum	0.0%	0.0%	0
Roofing	0.0%	0.0%	0
C&D Glass	0.0%	0.0%	0
Carpet	0.0%	0.0%	0
Fiberglass Insulation	0.0%	0.0%	0
Other C&D	0.3%	0.5%	48
Hazardous	**0.6%**		**97**
Electronics	0.0%	0.0%	3
Paint	0.0%	0.0%	0
Batteries	0.0%	0.0%	0
Non-Empty Aerosol Cans	0.0%	0.0%	0
Mercury Lamps	0.0%	0.0%	0
Pesticides	0.0%	0.0%	0
Cleaning Products	0.0%	0.0%	0
Motor Oil	0.0%	0.0%	0
Oil & Fuel Filters	0.0%	0.0%	0
Untreated Medical Waste	0.4%	0.7%	69
Treated Medical Waste	0.0%	0.0%	0
Blue Wrap	0.0%	0.0%	0
Medicine	0.0%	0.0%	0
Cold Packs	0.2%	0.2%	25
Other Hazardous	0.0%	0.0%	0
Other Materials	**0.8%**		**122**
Mattresses	0.0%	0.0%	0
Furniture	0.0%	0.0%	0
Tires & Rubber	0.1%	0.0%	10
Textiles & Leather	0.3%	0.1%	47
Non-Metal Appliances	0.0%	0.0%	0
Fines	0.3%	0.1%	56
Other Materials	0.1%	0.0%	10
Recyclable	**21%**		**3,370**
Compostable	**72%**		**11,491**
Potentially Recyclable	**0%**		**6**
Problem Materials	**7%**		**1,203**
Totals	**100%**		**16,070**
Sample Count	20		

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

HOSPITAL GARBAGE

The consultant team hand sorted samples from the three garbage compactors serving Palo Alto's hospitals, Stanford, the Veteran's Affairs Hospital, and the Palo Alto Medical Foundation. The team then extrapolated the results of the characterization to apply to the 4,695 tons of garbage that Palo Alto's hospitals dispose on an annual basis. Key findings from this extrapolation are presented below.

Key Findings

Figure 16 summarizes the recovery potential for Palo Alto's hospital garbage, and Table 15 lists the top six materials found in this stream by weight.

Figure 16. Material Recoverability, Hospital Garbage

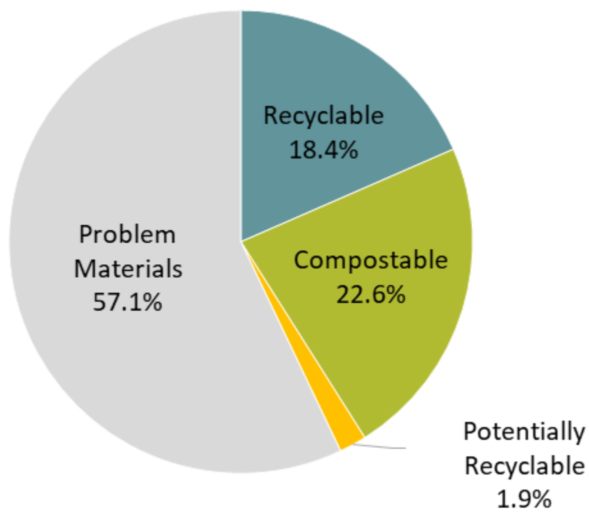


Table 15. Top Six Material Types, Hospital Garbage

Material	Est. Percent	Est. Tons
Untreated Medical Waste	43.5%	2,043
Other Clean Paper	9.3%	436
Paper Tissue & Towels	8.8%	415
Edible Food Scraps	7.3%	344
Other Plastic	6.4%	300
Textiles & Leather	4.1%	195
Total	**79.5%**	**3,733**

Key findings include:

- **Problem Materials** is the largest recoverability group present in Palo Alto's hospital garbage stream at 57% (2,680 tons). Two of the top six materials found in hospital garbage were **Problem Materials**:
  - *Untreated medical waste* (43.5% and 2,043 tons)
  - *other plastic* (6.4% and 300 tons)
- **Compostable** materials compose about 23% of hospital garbage (1,060 tons), making it the second most common recoverability group. The **Compostable** material types *paper tissues & towels* (8.8% and 415 tons) and *edible food scraps* (7.3% and 344 tons) were among the top six materials identified in hospital garbage.
- **Recyclable** materials make up about 18% (866 tons) of Palo Alto hospital garbage. Two of the top six materials found in hospital garbage were **Recyclable**:
  - *other clean paper* (9.3% and 436 tons)
  - *textiles and leather* (4.1% and 195 tons)
- **Potentially Recyclable** materials represent approximately 2% (89 tons) of the hospital garbage stream. *Blue wrap* (1.8% and 84 tons), although not one of the top six materials in the hospital garbage stream overall, was the most prevalent material in the potentially recyclable portion of the stream.

Table 16 identifies the detailed material composition by material class and material type.

Table 16. Detailed Composition, Hospital Garbage

Material	Est. Percent	+ / -	Est. Tons	Material	Est. Percent	+ / -	Est. Tons
Paper	**22.6%**		**1,062**	**C&D Debris**	**0.1%**		**4**
Clean, Flattened, Uncoated OCC	0.7%	0.5%	34	Clean Wood	0.0%	0.0%	0
Clean, Unflattened, Uncoated OCC	0.2%	0.3%	12	Clean Engineered Wood	0.0%	0.0%	0
Newspaper	0.1%	0.1%	6	Painted Wood	0.0%	0.0%	0
Other Clean Paper	9.3%	6.6%	436	Treated Wood	0.0%	0.0%	0
Paper Tissue & Towels	8.8%	6.0%	415	Inerts	0.1%	0.1%	4
Other Soiled Uncoated Fiber	0.0%	0.0%	0	Clean Gypsum	0.0%	0.0%	0
Coated OCC	0.6%	0.8%	27	Painted Gypsum	0.0%	0.0%	0
Other Coated Paper	0.2%	0.2%	12	Roofing	0.0%	0.0%	0
Gable Top Cartons	0.0%	0.0%	1	C&D Glass	0.0%	0.0%	0
Aseptics	0.1%	0.1%	5	Carpet	0.0%	0.0%	0
Paper Takeout Containers	0.5%	0.4%	22	Fiberglass Insulation	0.0%	0.0%	0
Coated Paper Cups	0.9%	0.2%	44	Other C&D	0.0%	0.0%	0
Pizza Boxes	0.0%	0.0%	0				
Other Composite Paper	1.0%	1.0%	48	**Hazardous**	**47.7%**		**2,239**
				Electronics	0.0%	0.0%	0
Plastic	**10.3%**		**483**	Paint	0.0%	0.0%	0
#1 PETE Plastic Packaging	0.6%	0.0%	30	Batteries	0.0%	0.0%	0
#2 HDPE Plastic Packaging	0.5%	0.3%	22	Non-Empty Aerosol Cans	0.0%	0.0%	0
Expanded #6 Products & Packaging	1.0%	1.2%	47	Mercury Lamps	0.0%	0.0%	0
Other #3-7 Plastic Packaging	0.4%	0.2%	18	Pesticides	0.0%	0.0%	0
Durable Plastic Products	0.3%	0.2%	15	Cleaning Products	0.0%	0.0%	0
Plastic Takeout Containers	0.1%	0.2%	6	Motor Oil	0.0%	0.0%	0
Compostable Plastic Bags	0.0%	0.0%	1	Oil & Fuel Filters	0.0%	0.0%	0
Other Compostable Plastic	0.0%	0.0%	1	Untreated Medical Waste	43.5%	18.7%	2,043
Recyclable Film Plastic	0.8%	0.5%	39	Treated Medical Waste	0.0%	0.0%	0
Flexible Plastic Pouches	0.0%	0.0%	0	Blue Wrap	1.8%	0.9%	84
Other Composite Film Plastics	0.1%	0.1%	4	Medicine	0.2%	0.3%	9
Other Plastic	6.4%	3.9%	300	Cold Packs	2.2%	1.9%	103
				Other Hazardous	0.0%	0.0%	0
Glass	**0.6%**		**30**				
Glass Bottles & Jars	0.6%	0.4%	30	**Other Materials**	**4.8%**		**225**
Blue or Red Glass Bottles & Jars	0.0%	0.0%	0	Mattresses	0.0%	0.0%	0
Other Non-Composite Glass	0.0%	0.0%	1	Furniture	0.0%	0.0%	0
Other Composite Glass	0.0%	0.0%	0	Tires & Rubber	0.1%	0.1%	5
				Textiles & Leather	4.1%	2.3%	195
Metal	**0.3%**		**15**	Non-Metal Appliances	0.0%	0.0%	0
Aluminum Cans & Foil	0.1%	0.1%	6	Fines	0.1%	0.0%	4
Other Non-Ferrous Metal	0.0%	0.0%	0	Other Materials	0.4%	0.3%	21
Steel Cans & Lids	0.2%	0.1%	8				
Appliances	0.0%	0.0%	0	Recyclable	**18%**		**866**
Other Ferrous Metal	0.0%	0.0%	1	Compostable	**23%**		**1,060**
Other Composite Metal	0.0%	0.0%	1	Potentially Recyclable	**2%**		**89**
				Problem Materials	**57%**		**2,680**
Organics	**13.6%**		**637**	**Totals**	**100%**		**4,695**
Plant Trimmings	0.0%	0.0%	0				
Edible Food Scraps	7.3%	3.9%	344	Sample Count	3		
Inedible Food Scraps	4.0%	2.2%	188				
Other Compostable Organics	0.0%	0.0%	1				
Diapers	2.2%	2.1%	104				
Animal Feces & Litter	0.0%	0.0%	0				
Other Organics	0.0%	0.0%	0				

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

SMART STATION LOOSE ROLL-OFF GARBAGE

The consultant team visually characterized 17 loads of Palo Alto loose roll-off garbage that GreenWaste of Palo Alto delivered to the SMaRT Station and extrapolated the results of the characterization to apply to the 3,617 tons of loose roll-offs that GreenWaste delivered to the SMaRT Station in FY 2016-17. The study team actually characterized 19 loads of material, but two of the loads were sewage grit. Since sewage grit is not a typical part of this stream, the consultant team excluded these two loads from the below analysis to avoid skewing results.

Key Findings

Figure 17 summarizes the recovery potential for Palo Alto's loose roll-off garbage, and Table 17 lists the top six materials found in Palo Alto's loose roll-off garbage by weight.

Figure 17. Material Recoverability, SMaRT Loose Roll-Off Garbage

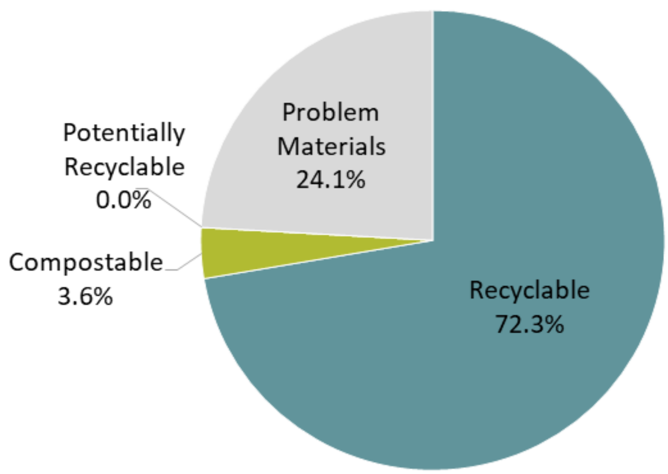


Table 17. Top Six Material Types, SMaRT Loose Roll-Off Garbage

Material	Est. Percent	Est. Tons
Clean Wood	30.2%	1,091
Inerts	16.7%	603
Other Ferrous Metal	6.4%	230
Clean, Flattened, Uncoated OCC	6.0%	215
Other Non-Composite Glass	4.9%	178
Clean Engineered Wood	4.8%	174
Total	**68.9%**	**2,492**

Key findings include:

- 76% (2,745 tons) of Palo Alto's loose roll-off garbage is recyclable or compostable through current programs serving the community.
- The primary recoverability group in loose roll-off garbage is **Recyclable**, which makes up about 72% (2,616 tons) of the stream. Five of the six most common materials found in roll-off garbage were **Recyclable**:
  - *clean wood* (30.2% and 1,091 tons)
  - *inerts* (16.7% and 603 tons)
  - other ferrous metal (6.4% and 230 tons)
  - clean, flattened, uncoated OCC (6.0% and 215 tons)
  - clean engineered wood (4.8% and 174 tons)
- **Problem Materials** is the second most prevalent recoverability group and represents about 24% (872 tons) of Palo Alto's loose roll-off garbage. *Other non-composite glass* (4.9% and 178 tons) was the most prevalent material in this recoverability group and was one of the top six materials found in the Palo Alto loose roll-off garbage stream.
- **Compostable** material is the third most prevalent recoverability group and represents 4% (129 tons) of Palo Alto's loose roll-off garbage. *Plant trimmings* (2.1% and 74 tons), although not one of the top 6 materials in the loose roll-off garbage stream overall, was the most prevalent material in the compostable portion of the stream.
- There were no **Potentially Recyclable** materials present in the loose roll-off garbage stream.

Table 18 identifies the detailed material composition by material class and material type.

Table 18. Detailed Composition, SMaRT Loose Roll-Off Garbage

Material	Est. Percent	+/-	Est. Tons	Material	Est. Percent	+/-	Est. Tons
Paper	**12.3%**		**446**	**C&D Debris**	**60.8%**		**2,200**
Clean, Flattened, Uncoated OCC	6.0%	3.3%	215	Clean Wood	30.2%	11.6%	1,091
Clean, Unflattened, Uncoated OCC	1.0%	0.3%	35	Clean Engineered Wood	4.8%	2.0%	174
Newspaper	0.1%	0.1%	2	Painted Wood	1.4%	1.4%	52
Other Clean Paper	2.5%	1.5%	92	Treated Wood	0.0%	0.0%	0
Paper Tissue & Towels	0.3%	0.3%	9	Inerts	16.7%	10.3%	603
Other Soiled Uncoated Fiber	0.6%	0.8%	22	Clean Gypsum	0.0%	0.0%	0
Coated OCC	0.0%	0.0%	0	Painted Gypsum	0.5%	0.9%	19
Other Coated Paper	0.0%	0.1%	2	Roofing	0.0%	0.0%	0
Gable Top Cartons	0.0%	0.0%	1	C&D Glass	3.5%	5.2%	125
Aseptics	0.0%	0.0%	0	Carpet	0.0%	0.0%	0
Paper Takeout Containers	0.4%	0.4%	15	Fiberglass Insulation	0.1%	0.1%	2
Coated Paper Cups	0.2%	0.2%	6	Other C&D	3.7%	2.6%	133
Pizza Boxes	0.0%	0.0%	0				
Other Composite Paper	1.3%	1.1%	48	**Hazardous**	**1.8%**		**67**
				Electronics	0.2%	0.2%	8
Plastic	**4.4%**		**158**	Paint	0.0%	0.0%	0
#1 PETE Plastic Packaging	0.2%	0.1%	6	Batteries	0.0%	0.0%	0
#2 HDPE Plastic Packaging	0.0%	0.0%	1	Non-Empty Aerosol Cans	0.0%	0.0%	0
Expanded #6 Products & Packaging	1.2%	1.0%	43	Mercury Lamps	0.0%	0.0%	0
Other #3-7 Plastic Packaging	0.1%	0.2%	5	Pesticides	0.0%	0.0%	0
Durable Plastic Products	0.4%	0.2%	15	Cleaning Products	0.0%	0.0%	0
Plastic Takeout Containers	0.0%	0.0%	0	Motor Oil	0.0%	0.0%	0
Compostable Plastic Bags	0.0%	0.0%	0	Oil & Fuel Filters	0.0%	0.0%	0
Other Compostable Plastic	0.0%	0.0%	0	Untreated Medical Waste	0.0%	0.0%	0
Recyclable Film Plastic	0.9%	0.7%	31	Treated Medical Waste	0.0%	0.0%	0
Flexible Plastic Pouches	0.0%	0.0%	0	Blue Wrap	0.0%	0.0%	0
Other Composite Film Plastics	0.1%	0.1%	4	Medicine	0.0%	0.0%	0
Other Plastic	1.5%	1.2%	53	Cold Packs	0.0%	0.0%	0
				Other Hazardous	1.6%	2.4%	59
Glass	**7.2%**		**259**				
Glass Bottles & Jars	1.2%	1.1%	42	**Other Materials**	**4.0%**		**143**
Blue or Red Glass Bottles & Jars	0.0%	0.0%	0	Mattresses	0.0%	0.0%	0
Other Non-Composite Glass	4.9%	7.5%	178	Furniture	2.8%	2.8%	100
Other Composite Glass	1.1%	1.8%	40	Tires & Rubber	0.3%	0.3%	12
				Textiles & Leather	0.8%	0.9%	28
Metal	**7.4%**		**268**	Non-Metal Appliances	0.0%	0.0%	0
Aluminum Cans & Foil	0.1%	0.1%	3	Fines	0.0%	0.0%	1
Other Non-Ferrous Metal	0.0%	0.0%	0	Other Materials	0.1%	0.1%	3
Steel Cans & Lids	0.1%	0.1%	3				
Appliances	0.0%	0.0%	0	Recyclable	**72%**		**2,616**
Other Ferrous Metal	6.4%	3.0%	230	Compostable	**4%**		**129**
Other Composite Metal	0.9%	0.7%	32	Potentially Recyclable	**0%**		**0**
				Problem Materials	**24%**		**872**
Organics	**2.1%**		**76**	**Totals**	**100%**		**3,617**
Plant Trimmings	2.1%	1.9%	74				
Edible Food Scraps	0.0%	0.0%	0	Sample Count	15		
Inedible Food Scraps	0.0%	0.0%	0				
Other Compostable Organics	0.0%	0.0%	0				
Diapers	0.0%	0.0%	0				
Animal Feces & Litter	0.0%	0.0%	0				
Other Organics	0.1%	0.1%	2				

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

ZANKER MIXED C&D

The consultant team visually characterized 15 samples of loads of mixed construction and demolition debris that GreenWaste delivered to the Zanker Material Processing Facility. The team extrapolated the results of the characterization to apply to the 11,217 tons of mixed C&D that GreenWaste reported hauling to the Zanker Material Processing facility in FY 2016-17. Key findings from this extrapolation are presented below.

Key Findings

Figure 18 summarizes the recovery potential for Palo Alto's mixed C&D stream, and Table 19 lists the top six materials found in the stream by weight.

Figure 18. Material Recoverability, Zanker Delivered Mixed C&D

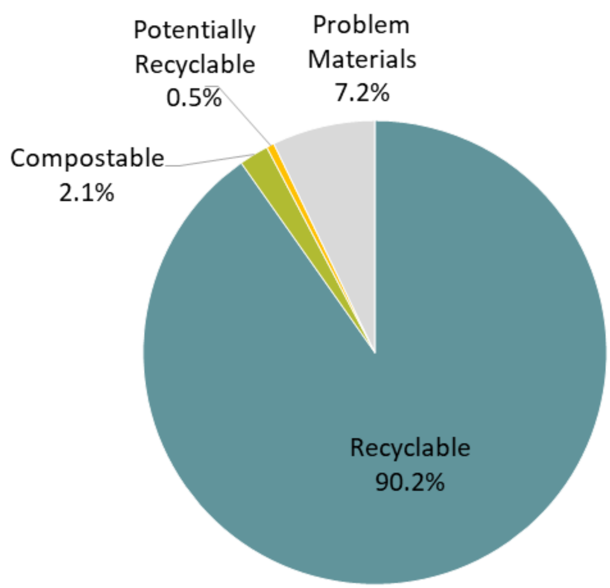


Table 19. Top Six Material Types, Zanker Delivered Mixed C&D

Material	Est. Percent	Est. Tons
Painted Gypsum	33.0%	3,699
Clean Wood	19.9%	2,231
Clean Gypsum	14.1%	1,585
Clean Engineered Wood	11.8%	1,320
Inerts	4.0%	449
Clean, Flattened, Uncoated OCC	3.7%	417
Total	**86.5%**	**9,700**

Key findings include:

- About 92% (10,351 tons) of Palo Alto's mixed C&D stream is recyclable or compostable through current programs serving the community.
- **Recyclable** is the largest recoverability group present in the mixed C&D stream, totaling about 90% (10,120 tons) of the stream. All six of the top six materials shown in Table 19 are **Recyclable**:
  - *painted gypsum* (33.0% and 3,699 tons)
  - *clean wood* (19.9% and 2,231 tons)
  - *clean gypsum* (14.1% and 1,585 tons)
  - *clean engineered wood* (11.8% and 1,320 tons)
  - *inerts* (4.0% and 449 tons)
  - clean, flattened, uncoated OCC (3.7% and 417 tons)
- The second most prevalent recoverability group is **Problem Materials**, composing about 7% (806 tons) of the mixed C&D stream. *Other composite paper* (2.5% and 279 tons), although not one of the top six materials in the mixed C&D stream overall, was the most prevalent material in the problem materials portion of the stream.
- **Compostable** materials (2% and 231 tons) is the next most prevalent recoverability group. *Fines* (1.2% and 139 tons), although not one of the top six materials in the mixed C&D stream overall, was the most prevalent material in the compostable portion of the stream.
- **Potentially Recyclable** materials represent about 1.0% (60 tons) of the mixed C&D stream. *Carpet* (0.5% and 60 tons), although not one of the top six materials in the mixed C&D stream overall, was the most prevalent (and only) material in the potentially recyclable portion of the stream.

Table 20 identifies the detailed material composition by material class and material type.

Table 20. Detailed Composition, Zanker Delivered Mixed C&D

Material	Est. Percent	+/-	Est. Tons	Material	Est. Percent	+/-	Est. Tons
Paper	**7.0%**		**789**	**C&D Debris**	**85.3%**		**9,566**
Clean, Flattened, Uncoated OCC	3.7%	4.6%	417	Clean Wood	19.9%	12.6%	2,231
Clean, Unflattened, Uncoated OCC	0.3%	0.2%	33	Clean Engineered Wood	11.8%	3.8%	1,320
Newspaper	0.0%	0.0%	2	Painted Wood	1.1%	0.5%	127
Other Clean Paper	0.4%	0.4%	50	Treated Wood	0.0%	0.0%	0
Paper Tissue & Towels	0.0%	0.0%	2	Inerts	4.0%	3.9%	449
Other Soiled Uncoated Fiber	0.0%	0.0%	2	Clean Gypsum	14.1%	5.9%	1,585
Coated OCC	0.0%	0.0%	1	Painted Gypsum	33.0%	32.3%	3,699
Other Coated Paper	0.0%	0.0%	0	Roofing	0.0%	0.0%	0
Gable Top Cartons	0.0%	0.0%	0	C&D Glass	0.0%	0.0%	0
Aseptics	0.0%	0.0%	0	Carpet	0.5%	0.9%	60
Paper Takeout Containers	0.0%	0.0%	2	Fiberglass Insulation	0.0%	0.0%	4
Coated Paper Cups	0.0%	0.0%	0	Other C&D	0.8%	0.8%	91
Pizza Boxes	0.0%	0.0%	0				
Other Composite Paper	2.5%	2.7%	279	**Hazardous**	**0.0%**		**0**
				Electronics	0.0%	0.0%	0
Plastic	**0.6%**		**68**	Paint	0.0%	0.0%	0
#1 PETE Plastic Packaging	0.0%	0.0%	2	Batteries	0.0%	0.0%	0
#2 HDPE Plastic Packaging	0.0%	0.0%	0	Non-Empty Aerosol Cans	0.0%	0.0%	0
Expanded #6 Products & Packaging	0.1%	0.1%	10	Mercury Lamps	0.0%	0.0%	0
Other #3-7 Plastic Packaging	0.0%	0.0%	1	Pesticides	0.0%	0.0%	0
Durable Plastic Products	0.1%	0.1%	9	Cleaning Products	0.0%	0.0%	0
Plastic Takeout Containers	0.0%	0.0%	0	Motor Oil	0.0%	0.0%	0
Compostable Plastic Bags	0.0%	0.0%	0	Oil & Fuel Filters	0.0%	0.0%	0
Other Compostable Plastic	0.0%	0.0%	0	Untreated Medical Waste	0.0%	0.0%	0
Recyclable Film Plastic	0.3%	0.1%	31	Treated Medical Waste	0.0%	0.0%	0
Flexible Plastic Pouches	0.0%	0.0%	0	Blue Wrap	0.0%	0.0%	0
Other Composite Film Plastics	0.1%	0.0%	8	Medicine	0.0%	0.0%	0
Other Plastic	0.1%	0.1%	8	Cold Packs	0.0%	0.0%	0
				Other Hazardous	0.0%	0.0%	0
Glass	**0.0%**		**0**				
Glass Bottles & Jars	0.0%	0.0%	0	**Other Materials**	**2.8%**		**314**
Blue or Red Glass Bottles & Jars	0.0%	0.0%	0	Mattresses	0.0%	0.0%	0
Other Non-Composite Glass	0.0%	0.0%	0	Furniture	0.9%	1.3%	96
Other Composite Glass	0.0%	0.0%	0	Tires & Rubber	0.0%	0.0%	1
				Textiles & Leather	0.0%	0.0%	1
Metal	**3.5%**		**390**	Non-Metal Appliances	0.0%	0.0%	0
Aluminum Cans & Foil	0.0%	0.0%	0	Fines	1.2%	0.7%	139
Other Non-Ferrous Metal	0.7%	0.4%	76	Other Materials	0.7%	0.3%	77
Steel Cans & Lids	0.0%	0.0%	0				
Appliances	0.0%	0.0%	0	Recyclable	**90%**		**10,120**
Other Ferrous Metal	1.9%	1.6%	212	Compostable	**2%**		**231**
Other Composite Metal	0.9%	0.9%	102	Potentially Recyclable	**1%**		**60**
				Problem Materials	**7%**		**806**
Organics	**0.8%**		**89**	**Totals**	**100%**		**11,217**
Plant Trimmings	0.2%	0.1%	17				
Edible Food Scraps	0.0%	0.0%	1	Sample Count	13		
Inedible Food Scraps	0.0%	0.0%	0				
Other Compostable Organics	0.6%	1.0%	66				
Diapers	0.0%	0.0%	0				
Animal Feces & Litter	0.0%	0.0%	0				
Other Organics	0.0%	0.1%	4				

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

SMART STATION RESIDUALS

The consultant team hand sorted 16 samples from the SMaRT Station's residual stream and extrapolated the results of the characterization to apply to the 20,469 tons of residuals that the SMaRT Station generated in FY 2016-17 that are attributable to Palo Alto. Key findings are presented below.

Key Findings

Figure 19 summarizes the recovery potential for the SMaRT Station residuals, and Table 21 lists the top six materials found in the SMaRT Station residuals by weight.

Figure 19. Material Recoverability, SMaRT Station Residuals

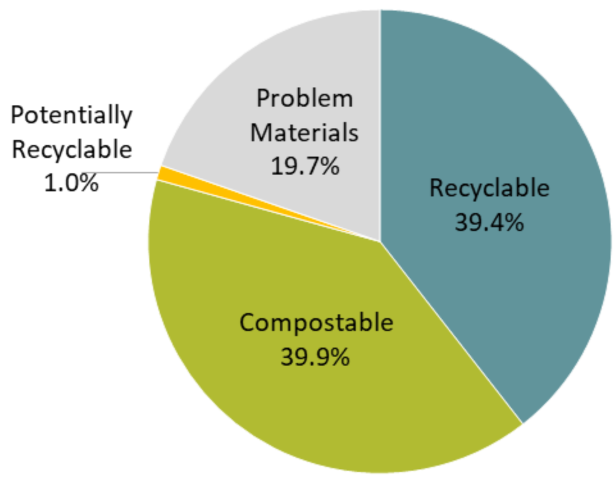


Table 21. Top Six Material Types, SMaRT Station Residuals

Material	Est. Percent	Est. Tons
Paper Tissue & Towels	17.1%	3,502
Other Clean Paper	13.0%	2,658
Other Plastic	7.0%	1,441
Inedible Food Scraps	6.6%	1,344
Textiles & Leather	5.2%	1,070
Edible Food Scraps	5.0%	1,021
Total	**53.9%**	**11,035**

Key findings include:

- About 79% (16,234 tons) of the SMaRT Station residuals consist of **Compostable** and **Recyclable** materials.
- **Compostable** materials, the most prevalent recoverability group, made up 40% of the residuals (8,165 tons). **Compostable** materials represented three of the top six materials found in the residual stream:
  - *paper tissue & towels* (17.1% and 3,502 tons)
  - *edible food scraps* (5.0% and 1,021 tons)
  - *inedible food scraps* (6.6% and 1,344 tons)
- **Recyclable** materials are the second greatest recoverability group at about 39% (8,069 tons) of the residual stream. **Recyclable** materials types were two of the top six materials in the residual stream:
  - *other clean paper* (13.0% and 2,658 tons)
  - *textiles & leather* (5.2% and 1,070 tons)
- **Problem Materials** compose about 20% (4,026 tons) of the residuals. *Other plastic* (7.0% and 1,441 tons) was the only problem material in the top six most prevalent materials in the residuals stream.
- **Potentially Recyclable** materials represent about 1% (209 tons) of the SMaRT Station residual stream. *Carpet* (0.7% and 153 tons), although not one of the top six materials in the SMaRT Station residuals overall, was the most prevalent material in the potentially recyclable portion of the stream.

Table 22 identifies the detailed material composition by material class and material type.

Table 22. Detailed Composition, SMaRT Station Residuals

Material	Est. Percent	+ / -	Est. Tons
Paper	**41.1%**		**8,404**
Clean, Flattened, Uncoated OCC	3.5%	1.1%	725
Clean, Unflattened, Uncoated OCC	0.8%	0.7%	159
Newspaper	1.8%	1.1%	359
Other Clean Paper	13.0%	2.3%	2,658
Paper Tissue & Towels	17.1%	3.3%	3,502
Other Soiled Uncoated Fiber	0.5%	0.2%	100
Coated OCC	0.3%	0.3%	63
Other Coated Paper	1.1%	0.3%	225
Gable Top Cartons	0.3%	0.1%	53
Aseptics	0.2%	0.0%	37
Paper Takeout Containers	0.6%	0.2%	118
Coated Paper Cups	1.0%	0.4%	206
Pizza Boxes	0.1%	0.1%	17
Other Composite Paper	0.9%	0.3%	179
Plastic	**19.7%**		**4,035**
#1 PETE Plastic Packaging	1.1%	0.2%	218
#2 HDPE Plastic Packaging	0.8%	0.2%	156
Expanded #6 Products & Packaging	0.6%	0.2%	123
Other #3-7 Plastic Packaging	2.6%	0.7%	537
Durable Plastic Products	1.3%	0.4%	272
Plastic Takeout Containers	0.8%	0.3%	164
Compostable Plastic Bags	0.1%	0.1%	28
Other Compostable Plastic	0.1%	0.0%	30
Recyclable Film Plastic	4.9%	0.9%	994
Flexible Plastic Pouches	0.0%	0.0%	10
Other Composite Film Plastics	0.3%	0.1%	62
Other Plastic	7.0%	1.4%	1,441
Glass	**0.5%**		**99**
Glass Bottles & Jars	0.1%	0.1%	31
Blue or Red Glass Bottles & Jars	0.0%	0.0%	0
Other Non-Composite Glass	0.0%	0.0%	0
Other Composite Glass	0.3%	0.5%	69
Metal	**1.8%**		**377**
Aluminum Cans & Foil	0.6%	0.2%	133
Other Non-Ferrous Metal	0.0%	0.0%	2
Steel Cans & Lids	0.5%	0.2%	97
Appliances	0.0%	0.0%	0
Other Ferrous Metal	0.3%	0.3%	65
Other Composite Metal	0.4%	0.2%	80
Organics	**19.1%**		**3,899**
Plant Trimmings	2.0%	1.5%	419
Edible Food Scraps	5.0%	1.5%	1,021
Inedible Food Scraps	6.6%	1.7%	1,344
Other Compostable Organics	0.7%	0.8%	141
Diapers	4.2%	1.5%	857
Animal Feces & Litter	0.6%	0.4%	117
Other Organics	0.0%	0.0%	1

Material	Est. Percent	+ / -	Est. Tons
C&D Debris	**5.0%**		**1,020**
Clean Wood	0.2%	0.1%	44
Clean Engineered Wood	0.3%	0.3%	56
Painted Wood	1.0%	0.7%	205
Treated Wood	0.0%	0.0%	0
Inerts	0.7%	0.6%	145
Clean Gypsum	0.0%	0.0%	0
Painted Gypsum	0.0%	0.0%	9
Roofing	0.1%	0.1%	19
C&D Glass	0.0%	0.0%	0
Carpet	0.7%	0.5%	153
Fiberglass Insulation	0.0%	0.0%	0
Other C&D	1.9%	1.7%	388
Hazardous	**0.9%**		**183**
Electronics	0.3%	0.3%	58
Paint	0.1%	0.1%	11
Batteries	0.0%	0.0%	3
Non-Empty Aerosol Cans	0.0%	0.0%	0
Mercury Lamps	0.0%	0.0%	2
Pesticides	0.0%	0.0%	0
Cleaning Products	0.0%	0.0%	2
Motor Oil	0.0%	0.0%	0
Oil & Fuel Filters	0.0%	0.0%	0
Untreated Medical Waste	0.3%	0.4%	55
Treated Medical Waste	0.0%	0.0%	0
Blue Wrap	0.0%	0.0%	0
Medicine	0.0%	0.0%	0
Cold Packs	0.2%	0.3%	45
Other Hazardous	0.0%	0.1%	7
Other Materials	**12.0%**		**2,452**
Mattresses	0.0%	0.0%	0
Furniture	1.3%	1.1%	269
Tires & Rubber	0.5%	0.4%	100
Textiles & Leather	5.2%	1.4%	1,070
Non-Metal Appliances	0.0%	0.0%	0
Fines	4.4%	2.8%	898
Other Materials	0.6%	0.4%	115
Recyclable	**39%**		**8,069**
Compostable	**40%**		**8,165**
Potentially Recyclable	**1%**		**209**
Problem Materials	**20%**		**4,026**
Totals	**100%**		**20,469**
Sample Count	16		

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

Comparison to 2005 and 2012 Study Results

This section compares the key findings of this waste characterization study with the results of the characterization studies conducted in 2005 and 2012—specifically, the findings for the overall waste stream and for the SMaRT station residuals are presented, compared, and contrasted below.

Comparison of Key Findings—City Overall Garbage

The key findings for the overall waste stream in this waste characterization study are compared below with the results for the overall waste stream in the characterization studies conducted in 2005 and 2012. Figure 20 compares the breakdown of the overall waste stream by recoverability group in the 2005, 2012, and 2017 studies. Table 23 summarizes the key findings from the 2005, 2012, and 2017 studies, and compares each recoverability group and ranks the top materials within each group.

The streams included in "overall city garbage" varied slightly from study to study:

- In 2017, the overall composition of Palo Alto's residential and commercial waste stream includes a combination of generators included in this study: single-family garbage, multifamily garbage, commercial garbage, garbage from hospital compactors, and GreenWaste hauled loose roll-offs arriving at the SMaRT Station.
- In 2012, the overall composition of Palo Alto's residential and commercial waste stream included single-family garbage, multifamily garbage, commercial front-load garbage, commercial compactor garbage, GreenWaste hauled loose roll-offs arriving at the SMaRT Station, and self-hauled waste.
- In 2005, the overall composition of Palo Alto's residential and commercial waste stream included only single-family garbage, mixed commercial and multifamily garbage, GreenWaste hauled loose roll-offs arriving at the SMaRT Station, and self-hauled waste.

Note that while the 2005 and 2012 studies included material self-hauled to the SMaRT Station, the 2017 study did not include this stream, which limits complete comparability of results between studies. Also, the 2012 study included commercial compactor garbage; the 2005 study did not. The 2017 study included only multifamily and hospital compactors because other commercial garbage compactors were similar businesses to those captured in the front load commercial garbage stream. Only the 2017 study included hospital compactor garbage.

Also, some changes in composition are related to changes in what materials are acceptable as recyclable and compostable between study years.

- The percentage of recoverable material in Palo Alto's waste stream decreased slightly, from **70%** in 2012 to **68%** in 2017.
- **Compostables** increased as a percentage of the waste stream, from **29%** in 2005 to **39%** in 2012, and now back down to **35%** in 2017. The key material types, as well as their relative prevalence in the waste stream, were unchanged from 2005 to 2012: *food* (all types), *compostable paper*, *leaves & grass*, *prunings and trimmings*, and *branches & stumps*. The 2012 study classified food in greater detail, and found that even when considered individually, *loose/scrap vegetative food*, *loose/scrap non-vegetative food,* and *packaged vegetative food* were among the top **Compostable** material types. In 2017, the material types included in the study changed slightly again, but food, compostable paper, and yard waste remained the most prevalent types of compostable materials disposed.
- **Recyclable Paper** decreased from **14%** of the waste stream in 2005 to **9%** in 2012, and then increased slightly to **10%** in 2017. Between 2012 and 2017, cardboard became less prevalent in the overall disposed waste stream compared with other recyclable paper types.
- **Other Recyclables** decreased from **29%** in 2005 to **23%** in 2012, and then decreased further to **22%** in 2017. The 2012 study found that the top materials by weight included *lumber, textiles*, *durable plastic items*, *rock, soil, and fines,* and *HDPE containers*. In 2017, the top material by weight was still *clean wood*, and other C&D related materials like *inerts* and *other ferrous metal* remained in the top 5 other recyclable materials.
- **Potential Recyclables** increased from **3%** of the waste stream in 2005 to over **6%** of waste in 2012, and then decreased to **1%** of the waste stream in 2017. *Carpet* was among the most prevalent **Potential Recyclables** in all three studies. *Blue wrap* and *roofing* was unique to the 2017 study.
- **Problem Materials** decreased slightly as a percentage of Palo Alto's waste, from **25%** in 2005 to **23%** in 2012. In 2017, **Problem Materials** increased to 31% of the stream. *Remainder/composite C&D* was the largest **Problem Material** by weight in 2005, *remainder/composite organics* was the greatest material type in 2012, and *untreated medical waste* was the most prevalent material in 2017.

Figure 20. Overall Recoverability, 2005 vs. 2012 vs. 2017

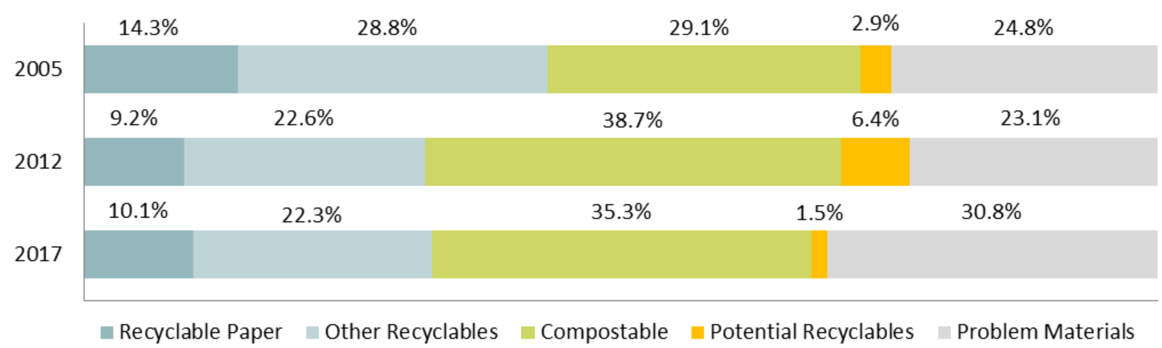


Table 23. Comparison of Overall Findings, 2005 vs. 2012 vs. 2017

Metric	2005	2012	2017
Palo Alto disposal	**78,200 tons**	**31,360 tons**	**27,165 tons**
Recoverability	72% (56,500 tons) of waste stream is **Recyclable** or **Compostable**	70% (22,100 tons) of waste stream is **Recyclable** or **Compostable**	68% (18,392 tons) of waste stream is **Recyclable** or **Compostable**
Compostable Material	29% (22,700 tons)	39% (12,125 tons)	35% (9,582 tons)
	▪ Food	▪ Loose/scrap food	▪ Edible food scraps
	▪ Compostable paper	▪ Compostable paper	▪ Inedible food scraps
	▪ Leaves & grass	▪ Leaves & grass	▪ Paper tissues & towels
	▪ Prunings and trimmings	▪ Pruning and trimmings	▪ Plant trimmings
	▪ Branches & stumps	▪ Packaged food (vegetative)	▪ Coated paper cups
Recyclable Paper	14% (11,200 tons)	9% (2,900 tons)	10% (2,747 tons)
	▪ Other miscellaneous paper	▪ Uncoated cardboard	▪ Other clean paper
	▪ Newspaper	▪ Other miscellaneous paper	▪ Clean, flattened, uncoated OCC
	▪ Magazines & catalogs	▪ White ledger	▪ Clean, unflattened, uncoated OCC
	▪ Cardboard	▪ Magazines & catalogs	▪ Newspaper
	▪ White ledger	▪ Newspaper	
Other Recyclables	29% (22,500 tons)	23% (7,075 tons)	22% (6,063 tons)
	▪ Rock, soil and fines	▪ Lumber	▪ Clean wood
	▪ Wood-untreated	▪ Textiles	▪ Textiles & leather
	▪ Asphalt roofing	▪ Durable plastic items	▪ Inerts
	▪ Other ferrous metal	▪ Rock, soil and fines	▪ Recyclable film plastic
	▪ Gypsum board	▪ HDPE containers	▪ Other ferrous metal
Potential Recyclables	3% (2,300 tons)	6% (2,015 tons)	1% (402 tons)
	▪ Other bulky items	▪ Bulky items	▪ Carpet
	▪ R/C metal	▪ Carpet	▪ Blue wrap
	▪ Carpet	▪ Film products	▪ Roofing
Problem Materials	25% (19,400 tons)	23% (7,250 tons)	31% (8,371 tons)
	▪ R/C C&D	▪ R/C organics	▪ Untreated medical waste
	▪ Wood-treated	▪ Mixed residue/MSW	▪ Diapers
	▪ Other film plastics	▪ Other film	▪ Other plastic
	▪ Diapers	▪ R/C C&D	▪ Animal feces & litter
	▪ R/C paper	▪ Trash bags	▪ Other C&D

Comparison of Key Findings—SMaRT Station Residuals

The key findings for the SMaRT Station residuals in this 2017 waste characterization study are compared below with the results for the SMaRT Station residuals from the 2005 and 2012 characterization studies. Figure 21 compares the breakdown of the SMaRT Station residuals by recoverability group in the 2005, 2012, and 2017 studies. Table 24 summarizes the key findings from the 2005, 2012, and 2017 studies, compares each recoverability group, and ranks the top materials within each recoverability group.

- Palo Alto's residual tonnage from the SMaRT Station decreased by **29%** between 2005 and 2012, from 40,000 tons in 2005 to 28,300 tons in 2012. The residual tonnage decreased **28%** between 2012 and 2017, from 28,300 tons in 2012 to 20,469 tons in 2017.
- The percentage of the residual stream composed of recoverable material dropped from **77%** in 2005 to about **58%** in 2012, and then increased again in 2017 to **79%** recoverable.
- **Compostable** materials account for about the same percentage of the SMaRT Station residuals between 2005 and 2012—**36%** in 2005 and **35%** in 2012. In 2017, compostable materials increased to make up about **40%** of the SMaRT Station residuals stream. In 2005, *food* was the largest compostable material type; in 2012, *compostable paper* was the most prevalent; and in 2017, *paper tissues & towels* was the most prevalent.
- **Recyclable Paper** decreased from **17%** of the residual stream in 2005 to **8%** in 2012, and then increased to **19%** in 2017. The two most common **Recyclable Paper** materials in 2005 were *newspaper* and *magazines and catalogs*; in 2012, the top two materials in this recoverability group were *other miscellaneous paper* and *uncoated cardboard*; and in 2017, the two most prevalent recyclable paper materials were *other clean paper* and *clean, flattened, uncoated OCC*.
- **Other Recyclables** accounted for **23%** of the residuals in 2005; this dropped to **16%** in 2012, and then increased to **20%** in 2017. While the top **Other Recyclables** materials in 2005 were largely C&D-related—the most common materials were *rock, soil & fines* and *gypsum board*—by 2012, the top materials in this group had shifted to *HDPE containers* and *textiles*. In 2017, the most prevalent materials in the other recyclables group were *textiles & leather* and *recyclable film plastic*.
- **Problem Materials** accounted for **21%** of the SMaRT Station residuals in 2005; **Problem Materials** increased to **41%** of residuals in 2012, and then decreased to **20%** in 2017. *Other film plastics* and *remainder/composite C&D* were the most common **Problem Materials** in 2005. In 2012, they were *mixed residue/MSW* and *remainder/composite organics*, and in 2017, they were *other plastic* and *diapers*.
- The **Potential Recyclables** fraction of the residual stream shrank from **2%** in 2005 to **0.7%** in 2012 and increased slightly to **1%** in 2017. In 2005, the **Potential Recyclables** consisted of *remainder/composite metal*, *other rubber*, and *carpet*; in 2012, this fraction consisted

almost entirely of *film products*; and in 2017, the two most prevalent potentially recyclable materials in the residuals stream were *carpet* and *aseptics*.

Figure 21. SMaRT Residuals Recoverability, 2005 vs. 2012 vs. 2017

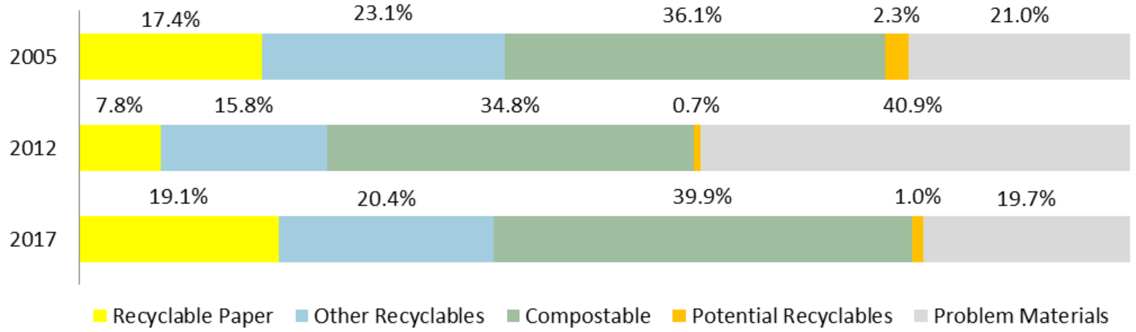


Table 24. Comparison of SMaRT Residuals Findings, 2005 vs. 2012 vs. 2017

Metric	2005	2012	2012
SMaRT residuals - Palo Alto	40,000 tons	28,300 tons	20,469 tons
Recoverability	77% (30,700 tons) of residual stream is **Recyclable** or **Compostable**	59% (16,557 tons) of residual stream is **Recyclable** or **Compostable**	79% (16,234 tons) of residual stream is **Recyclable** or **Compostable**
Compostable material	36% (14,500 tons)	35% (9,865 tons)	40% (8,165 tons)
	▪ Food	▪ Compostable paper	▪ Paper tissues & towels
	▪ Leaves & grass	▪ Loose/scrap food (all types)	▪ Inedible food scraps
	▪ Compostable paper	▪ Pruning and trimmings	▪ Edible food scraps
	▪ Compostable organics	▪ Leaves & grass	▪ Fines
	▪ Prunings and trimmings	▪ Packaged food (non-vegetative)	▪ Plant trimmings
Recyclable Paper	17% (7,000 tons)	8% (2,216 tons)	19% (3,902 tons)
	▪ Newspaper	▪ Other miscellaneous paper	▪ Other clean paper
	▪ Magazines & catalogs	▪ Uncoated cardboard	▪ Clean, flattened, uncoated OCC
	▪ Other miscellaneous paper	▪ Magazines & catalogs	▪ Newspaper
	▪ Cardboard	▪ White ledger	▪ Clean, unflattened, uncoated OCC
	▪ White ledger	▪ Newspaper	
Other Recyclables	23% (9,200 tons)	16% (4,477 tons)	20% (4,167 tons)
	▪ Rock, soil and fines	▪ HDPE containers	▪ Textiles & leather
	▪ Gypsum board	▪ Textiles	▪ Recyclable film plastic
	▪ Other ferrous metal	▪ Misc plastic containers	▪ Other #3-#7 plastic packaging
	▪ Textiles	▪ Tin/steel cans	▪ Durable plastic products
	▪ Misc plastic containers	▪ Lumber	▪ #1 PETE plastic packaging
Potential Recyclables	2% (900 tons)	0.7% (187 tons)	1% (209 tons)
	▪ R/C metal	▪ Film products	▪ Carpet
	▪ Other Rubber	▪ Carpet	▪ Aseptics
	▪ Carpet	▪ Flat glass	▪ Roofing
Problem Materials	21% (8,400 tons)	41% (11,573 tons)	20% (4,026 tons)
	▪ Other film plastics	▪ Mixed residue/MSW	▪ Other plastic
	▪ R/C C&D	▪ R/C organics	▪ Diapers
	▪ Diapers	▪ Other film	▪ Other C&D
	▪ Wood-treated	▪ Trash bags	▪ Furniture
	▪ R/C solid waste	▪ R/C C&D	▪ Painted wood

Appendix A. Material Type Definitions

Samples were characterized according to the below list of 77 materials.

PAPER

1. **CLEAN, FLATTENED, UNCOATED CORRUGATED CARDBOARD**: Uncoated boxes, packaging, sheets and other pieces with a corrugated layer sandwiched between two outer layers that has been flattened to reduce the volume. Examples include shipping boxes, and some shoe boxes.
2. **CLEAN, UNFLATTENED, UNCOATED CORRUGATED CARDBOARD**: Uncoated boxes, packaging, sheets and other pieces with a corrugated layer sandwiched between two outer layers that has **NOT** been flattened to reduce the volume. Examples include shipping boxes, clean pizza box, and some shoe boxes.
3. **NEWSPAPER**: Ground wood paper used in newspapers. Includes clay coated (not poly coated) glossy ad inserts and other items made from newsprint, such as advertising circulars, election guides and tax instruction booklets.
4. **OTHER CLEAN PAPER**: Paper and products recycled curbside except newspaper, and corrugated cardboard. Includes high grade white or colored ledger, paper bags, bond, rag, stationary, office, copy or printing paper and low grade mixed junk mail, envelopes (plastic windows ok), magazines, clay coated glossy catalogs, brochures and pamphlets, hardback and paperback books, spiral notebooks, manila folders, index cards, self-adhesive notes, phonebooks, shredded paper, construction paper, butcher paper, kraft or bleached sheets, toilet paper tubes, non-corrugated box/liner/chip/paper board (e.g., cereal and tissue boxes, six pack holders), egg cartons, tissue wrapping paper, blueprints, photographs (not Polaroid), hard cover books, and carbonless forms. Minor amounts of glue or other binding are okay.
5. **PAPER TISSUE & TOWELS**: Paper towels, napkins, tissues, toilet paper, and other short fiber, potentially soiled, paper that is not recyclable, but is compostable. Includes cotton balls, pads and non-plastic swabs and wipes.
6. **OTHER SOILED UNCOATED FIBER**: Uncoated paper and paper products that are not tissue & towels, that may be recyclable, but are too food-soiled or dirty and can be composted such as, food-soiled paper plates, french fry containers and coffee filters. Recyclable paper that was likely soiled in the collection bin or truck should be included in the appropriate recyclable paper category.
7. **COATED CORRUGATED CARDBOARD**: Boxes, packaging, sheets and other pieces with a corrugated layer sandwiched between two outer layers where at least one of the 3 layers is "waxed" or paraffin or poly coated, typically to make it liquid resistant such as for perishable produce shipping boxes.
8. **OTHER COATED PAPER**: Paper and paper products that are poly, compostable plastic or wax (not clay) coated inside and/or outside. Includes fast food wrappers, pizza box liners, butcher paper, and ice cream and other frozen/refrigerated food packaging. This does not include coated corrugated cardboard, items with a gable top, or prepared food takeout containers
9. **GABLE TOP CARTONS**: Containers that are poly or wax (not clay) coated inside and/or outside with a gable top such as milk and juice cartons (including those with plastic spouts). Does not include aseptic packaging.
10. **ASEPTICS**: Multilayer composite cartons of bleached paper, poly film and foil, such as juice, milk, soup and tofu boxes.

11. **PAPER TAKEOUT CONTAINERS:** Rigid paper containers used for serving or transporting single-use, ready to eat, prepared foods from a food service point-of-sale. This material type includes containers that could have been avoided had a customer brought a re-usable food container to the point-of-sale. Example include boxes and clamshells for items from the "hot food" bar or salad bar at a grocery store or deli, "Chinese food" take out cartons, etc. This does not include paper cups or paper wraps (like for a hamburger, deli sandwich, or burrito). This does not include items in paper retail packaging like frozen foods, cereals.
12. **COATED PAPER CUPS**: Cups that are poly, compostable plastic or wax coated inside and/or outside such as for coffee and other hot drinks or soda and other cold drinks.
13. **PIZZA BOXES:** Boxes used for take-out or delivery of prepared pizza. Includes both clean and soiled boxes.
14. **OTHER COMPOSITE PAPER**: Items, not including aseptics, predominantly paper, but with one or more other material rendering them hard to recycle or compost, such as orange juice concentrate cans, carbon copy paper, foil laminated paper boxes and gum wrappers, packaging with large plastic windows (blister packs) or integrated foam, and heavily plastic laminated or painted paper.

PLASTIC

15. **#1 PETE PLASTIC PACKAGING**: Polyethylene terephthalate (PET) bottles, jars, clamshells, frozen food trays, retail packaging and other rigid items such as food and beverage containers.
16. **#2 HDPE PLASTIC PACKAGING**: High-density polyethylene (HDPE) bottles, jars, tubs, lids and other rigid items such as distilled water, milk, juice, vinegar, yogurt, detergent and empty motor oil or antifreeze containers.
17. **EXPANDED #6 PRODUCTS AND PACKAGING**: Styrofoam and other expanded polystryrene cups, plates, bowls, clamshells, packaging blocks and peanuts (except compostable ones), insulation, non-corrugated foamcore (Include sandwiched between two layers of paper or plastic)and other rigid items.
18. **OTHER #3-7 PLASTIC PACKAGING**: Polyvinyl chloride (PVC), low-density polyethylene (LDPE), polypropylene (PP), non-expanded styrene (PS), other (#7, various resins) and unlabeled, unidentifiable bottles, jars, tubs, lids, and other rigid items such as some salad dressing, syrup and prescription bottles, CD cases, auto parts. Items are typically constructed of a single plastic resin and smaller than a basketball.
19. **DURABLE PLASTIC PRODUCTS:** Large, rigid items made predominately from plastic (usually a single resin) and intended for multiple uses. Examples include clothes hangers, buckets, lawn furniture, plastic pipe, and some toys,
20. **PLASTIC TAKEOUT CONTAINERS:** Rigid plastic containers used for serving or transporting single-use, ready to eat, prepared foods from a food service point-of-sale. This material type includes containers that could have been avoided had a customer brought a re-usable food container to the point-of-sale. Example include boxes and clamshells for items from the "hot food" bar or salad bar at a grocery store or deli, "Chinese food" take out cartons, plastic tubs and bowls from fast food restaurants, etc. This does include plastic to-go cups. This does not include items in plastic retail packaging like frozen foods, microwavable soups, etc.
21. **COMPOSTABLE PLASTIC BAGS**: Polylactic acid (PLA) and other bags labeled "compostable" (such as used for kitchen composting pails and produce, or in bathroom hand towel or restaurant food scrap collection). Does not include compostable plastic bags that are not ASTM D6400 or D6868 compliant.

22. **OTHER COMPOSTABLE PLASTIC**: Polylactic acid (PLA), polyhydroxyalkanoate (PHA) and other cups, lids, plates, bowls, clamshells, trays, utensils and other non-bags labeled "compostable." Does not include compostable plastic products that are not ASTM D6400 or D6868 compliant.
23. **RECYCLABLE FILM PLASTIC**: Single layer clear or colored film without an inner foil or metallic layer accepted in the Palo Alto recycling carts. Includes, dry cleaner, newspaper, Ziploc, bread, cracker, tortilla chip, stretch, shrink and bubble wrap, plastic sheeting, frozen food, and clear or colored grocery, department store and other retail and food establishment merchandise and to go bags.
24. **FLEXIBLE PLASTIC POUCHES**: means plastic pouches made of thicker, multi-layer flexible material. May have a flat bottom so that package would stand up on its own, but not always. Material is thicker than potato chip bags and frozen vegetable bags. Includes plastic coffee bags like Starbucks and Peet's; Capri Sun pouches; baby food pouches – may have plastic screw top; soup pouches; salad dressing pouches; wine pouches; backpacking meals in pouches; soap refill pouches; laundry detergent pouches; and other similar items.

INCLUDED – THICKER, MULTI-LAYER PACKAGING	EXCLUDED – THINNER, SINGLE-LAYER PACKAGING
Plastic coffee bags (Starbucks and Peet's)	Potato chip bags and similar
Juice pouches (Capri Sun)	Candy wrappers
Baby food pouches – may have plastic screw top	Tortilla bags
Soup pouches	Frozen food bags (vegetables, berries)
Salad dressing pouches	Nut/snack bags
Wine pouches	Shrink plastic wrappers (Slim Jim and string cheese wrappers)
Backpacking meals in pouches	Ziplock bags intended for home use
Soap refill pouches	Thin produce bags as used in grocery stores
Laundry detergent pouches	Newspaper bags
Other similar items	Bread bags
	Small (2 inch) pouches for condiments (mustard, relish, etc.)
	Yogurt tubes (Gogurt)
	Mailing pouches, usually colored or white (not clear) (LL Bean, medication pouches)
	100% Plastic mailing pouches with bubble wrap
	Other similar items

25. **OTHER COMPOSITE FILM PLASTICS:** Items made of multi-layer, multi-material films, typically with a metallic or foil layer. Examples include potato chip bags, candy bar wrappers, energy bar wrappers, and anti-static electronics wrappers.
26. **OTHER PLASTIC**: Items that are predominantly rigid plastic, but have more than one type of plastic and/or other materials like metal or film plastics not described elsewhere. Includes toothbrushes, disposable razors, pens, some toys, lighters, vinyl binders, hoses, foil and plastic blister packs (such as for medications), and fiberglass products except insulation. Does not include appliances or electronics. Includes non-recyclable film like trash bags, condiment pouches, mailing pouches, shower curtain, woven polyethylene (e.g., grain bags, wipes, dryer sheets), and mylar balloons**.**

GLASS

27. **GLASS BOTTLES & JARS**: Any container grade glass bottles and jars (except red or blue), for water, soda, juice, wine, beer, liquor, vinegar, condiments, pickles, body care and other products.
28. **BLUE OR RED GLASS BOTTLES & JARS**: Any red or blue bottles, jars, and other container grade glass.
29. **OTHER NON-COMPOSITE GLASS**: Items made only of clear or tinted glass that is not container glass. Includes drinking glasses, crystal, and laboratory ware, table tops, or blown glass. Includes tempered or toughened glass (such as flat side or rear window auto glass).
30. **OTHER COMPOSITE GLASS**: Items that are predominantly glass, but have other materials like wire mesh or plastic lamination (curved auto windshields, bus shelter and other safety glass), silvering (mirrors), or other components (incandescent and halogen bulbs). Does not include mercury lamps, which go in the *mercury lamps* hazardous category. Does not include glass used for construction purposes which goes in *C&D glass*.

METAL

31. **ALUMINUM CANS & FOIL**: Aluminum cans and bi-metal cans made mostly of aluminum (for beverages, pet food, etc.), empty aluminum aerosol cans for hazardous products, all (empty or full) aluminum aerosol cans with non-toxic contents, and aluminum food containers, trays, pie tins and foil.
32. **OTHER NON-FERROUS METAL**: Items at least 75% non-ferrous metal (metals not derived from iron, to which a magnet will not adhere, and not stainless steel). Includes aluminum products and scrap that are not cans & foil, such as window frames, siding and cookware. Includes other metals and alloys such as copper, brass, bronze, lead and zinc and products such as pipe and shell casings.
33. **STEEL CANS & LIDS**: Steel containers including bi-metal cans made mostly of steel. Includes food cans, empty steel paint cans, empty steel aerosol cans for hazardous products, and all (empty or full) steel aerosol cans with non-toxic contents.
34. **APPLIANCES**: Intact or parts of predominantly ferrous metal (iron or steel that is magnetic or stainless steel), analog appliances such as toasters, stoves, refrigerators, washers and dryers, and hot water heaters. May be enamel coated in any color. If it contains a significant plastic or electronic portion (a microwave, for example), it goes in the *electronics* material type.
35. **OTHER FERROUS METAL**: Items at least 75% ferrous metal (iron or steel that is magnetic or stainless steel), but not cans & lids or appliances. Includes items like coat hangers, stainless steel cookware, bed frames, pipe, beams, rebar, security bars, small car parts and other ferrous scrap.
36. **OTHER COMPOSITE METAL**: Items predominately metal, made of both ferrous and non-ferrous metal and/or with more than 25% non-metal materials, such as certain motors, insulated wire and other products that are not appliances.

ORGANIC

37. **PLANT TRIMMINGS**: Prunings and cuttings from bushes, shrubs and trees, and non-woody plant materials including grass clippings, sod, leaves, dead flowers, weeds, loose or rolled tobacco (without filters but including any rolling paper), cork, hemp rope and other plant material. Includes all plant types, and branches, trunks and stumps of any size.
38. **EDIBLE FOOD SCRAPS:** The components of food that, in a particular food supply chain, are intended to be consumed by humans. What is considered edible varies among users (e.g., chicken feet are

consumed in some food supply chains but not others), changes over time, and is influenced by a range of variables.

39. **INEDIBLE FOOD SCRAPS:** The components of food not included in the edible food (skins, pits, bones, eggshells, coffee grounds, tea bags, etc.)
40. **OTHER COMPOSTABLE ORGANICS**: Includes bagasse foodware and disposable wood utensils, wood stirrers, toothpicks, wood popsicle sticks, candles, compostable packaging peanuts, hair, finger nails, etc.
41. **DIAPERS***:* Diapers made from a combination of fibers, synthetic and/or natural, primarily for single use. Includes disposable baby diapers, adult protective undergarments, feminine hygiene products. Includes diaper and any contents, including human feces not in diapers, etc.
42. **ANIMAL FECES & LITTER**: Any non-human animal feces and litter such as cat feces and kitty litter, dog poop, bird droppings, and horse manure and soiled bedding. Includes soiled paper and other litter materials. Also includes animal carcasses not resulting from food storage or preparation.
43. **OTHER ORGANIC**: Predominantly organic items that are mixed with non-organic materials and cannot easily be separated for composting.

HAZARDOUS

44. **ELECTRONICS**: All types of products which include one or more integrated circuits, circuit boards, or "chips" and/or have a visual display greater than (or equal to) four inches on the diagonal. Generally includes anything that can be programmed. Includes televisions, computer monitors, CPUs and computer peripherals, fax machines, stereo equipment, VCRs, some games and toys. Does NOT include items powered by electricity ("plug or battery") if electronic circuitry or a video display are not present, for example non-robotic vacuum cleaners. Note that there may be products intended for the same use of which some will be electronic waste and some will not – for example, coffeemakers (some just plug in and are switched on manually and some contain chips/boards because they have on/off/grind etc. features which can be programmed).
45. **PAINT**: Latex paint, alkyd paint, oil-base paint, architectural paint, automotive and specialty (traffic marking) paint NOT packaged under pressure.
46. **BATTERIES:** All chemistries, including alkaline batteries, Ni-Cd, Ni-MH, Lithium, Lithium-ion, and small sealed lead acid (SSLA) batteries often used in battery backup units.
47. **NON-EMPTY AEROSOL CANS:** All non-empty pressurized containers which hold a consumer product characterized as a hazardous waste (paint/pesticides/cleaners). Includes spray paint, bug sprays, hair spray, oven cleaners, waterproofing sprays. Does NOT include cooking oil, deodorant, room/air freshener, starch, or compressed air (keyboard cleaner).
48. **MERCURY LAMPS:** All tubes and bulbs with intentionally added mercury, includes fluorescent tubes and compact fluorescents, High Intensity Discharge (HID) bulbs, sodium vapor lamps, and neon signs. Does NOT include incandescent or halogen tubes or bulbs.
49. **PESTICIDES:** Includes pesticides, insecticides, herbicides, and wood preservatives NOT packaged under pressure.
50. **CLEANING PRODUCTS:** (except aerosols) Consumer products intended for cleaning NOT packaged under pressure includes ammonia, bleach, "green" cleaners, waxes and polishes.
51. **MOTOR OIL**: Lubricating oil, either used or unused, primarily used in vehicles or internal combustion engines.
52. **OIL & FUEL FILTERS**: Metal and plastic filters for oil and fuel used in vehicles or other types of equipment.

53. **UNTREATED MEDICAL WASTE**: Materials used in medical processes, including tubing, surgical tray liners, exam table liners, latex gloves, bandages, and any materials in red biohazard bags. Also includes needles, syringes, and lancets.
54. **TREATED MEDICAL WASTE:** Medical waste that has been processed in order to change its physical, chemical, or biological character or composition, or to remove or reduce its harmful properties or characteristics, as defined in Section 25123.5 of the Health and Safety Code. Bags of treated medical waste may appear shrunken from sterilization.
55. **BLUE WRAP:** A blue wrap made from polypropylene (# 5 plastic) and used for wrapping surgical instruments for sterilization.
56. **MEDICINE**: All medicine intended for human or veterinary use, including prescription and non-prescription (over-the-counter) drugs as well as vitamins and nutritional products.
57. **COLD PACKS:** Re-usable liquid or gel packs commonly used to keep food cool in portable coolers, or as a cold compress to alleviate the pain of minor injuries. Packs may be either flexible or rigid.
58. **OTHER HAZARDOUS**: Items and materials not fitting into any of the other hazardous categories but which meet California's hazardous waste characteristic descriptions for ignitability, corrosivity, reactivity, or toxicity. Includes lab chemicals, solvents (paint thinner, nail polish & nail polish remover), mercury thermometers & thermostats, adhesives, glues, fuel, non-empty and pressurized gas canisters and cylinders, antifreeze, asbestos containing material, ammunition, writing and printing ink, hair dye. Does NOT typically include cosmetics or personal care products. Does NOT include empty containers 5 gallons in size and smaller which previously contained a hazardous material.

CONSTRUCTION AND DEMOLITION DEBRIS

59. **CLEAN WOOD**: Unpainted, untreated, new or demolition dimensional lumber (milled lumber commonly used in construction), pallets and crates (whole or broken), packaging panelboard and sawdust. Includes wood with small amounts of paint (such as 2 x 4s with painted ends), nails and other contaminants.
60. **CLEAN ENGINEERED WOOD**: means unpainted new or demolition scrap from sheeted goods such as plywood, particleboard, wafer board, oriented strand board, and other residual materials used for sheathing and related construction uses. May contain nails or other trace contaminants.
61. **PAINTED WOOD**: Painted, stained, varnished or shellacked lumber and wood products from construction or demolition, and assembled items with minimal fasteners or glue.
62. **TREATED WOOD:** Wood treated with a chemical preservative for protection against pests and environmental conditions. Includes dimensional lumber treated with creosote, arsenic, chromium, copper, or pentachlorophenol – typically identified by "staple marks" by which chemical was injected into the wood, a characteristic green color, and/or presence of obvious crystals. Does NOT include painted or stained wood.
63. **INERTS**: Concrete (building foundations, sidewalk paving and cinder blocks), cement mix, asphalt, brick, clay roofing, ceramic or porcelain (toilets, sinks, tile and some dishware), rock, gravel, soil and sand with minimal organic contamination. Includes concrete containing steel mesh and/or reinforcement bars (rebar).
64. **CLEAN GYPSUM**: Calcium sulfate dehydrate sandwiched between layers of kraft-type paper. Includes unpainted and untreated, new or old, broken or whole sheets of drywall, sheetrock, wallboard, plasterboard (without plaster), gypboard or gyproc. Excludes exterior or roof paneling that is gypsum sandwiched between fiberglass-reinforced coatings.

65. **PAINTED GYPSUM**: Used or demolition gypsum drywall that has been painted, treated or plastered. Includes exterior paneling that is gypsum sandwiched between fiberglass-reinforced coatings.
66. **ROOFING**: Asphalt shingles, built-up roof membranes, other asphaltic roofing membranes, single-ply roofing membranes, roof paneling that is gypsum sandwiched between fiberglass-reinforced coatings, contaminated wood shingles, contaminated clay roofing, and contaminated metal roofing (if clean put in respective wood, inerts, or metal category), etc.
67. **C&D GLASS**: Includes glass used for construction purposes, like window panes, sliding doors, and architectural glass.
68. **CARPET***:* Flooring applications of various natural (e.g., wool) or synthetic (e.g., nylon) fibers typically bonded to some type of backing material. Includes other soft floor coverings such as synthetic turf. Also includes carpet padding, commonly made of urethane foam, but could be felt from jute, hair, or other synthetic materials, such as recycled carpet fibers, and coated with latex or other resin.
69. **FIBERGLASS INSULATION**: Fiberglass building and mechanical insulation, batts, or rigid.
70. **OTHER C&D:** materials commonly used in residential and commercial construction that cannot be put in any other type. This type may include items from different types combined, which would be very hard to separate. Examples include Includes wood with significant metal, concrete, drywall, or other contaminants, such as substantial glue or binders in plywood, particleboard, wafer board or oriented strand board.

OTHER MATERIALS

71. **MATTRESSES**: Mattresses, box springs and platforms, but not frames. Includes futons, foam and contour mattresses, and infant and pet beds.
72. **FURNITURE**: Mixed-material furniture such as upholstered chairs and couches. Furniture made purely of one material, such as plastic or metal, would be categorized as that material.
73. **TIRES & RUBBER**: Vehicle (including scooters, bicycles, lawn mowers, etc.) tires and tubes of all types. Finished products and scrap made of natural or synthetic rubber, such as bath mats, rubber hoses, rubber bands and foam rubber.
74. **TEXTILES & LEATHER**: Items made of thread, yarn, fabric, or cloth from natural or synthetic materials such as cotton, wool, silk, nylon, rayon or polyester. Includes clothes, fabric trimmings, curtains, drapes, and linens. Also includes real and synthetic leather shoes, handbags, belts, scraps, etc. Does not include mattresses, furniture or carpet & upholstery.
75. **NON-METAL APPLIANCES**: Multi-material electric analog (not digital, no chips) appliances, primarily plastic, such as old toasters, power tools, curling irons, light fixtures, clocks and dial telephones
76. **FINES***:* Mixed inert (soil, sand, grit, ash) and non-inert (small bits of wood and other organics) materials smaller than 1/2" in diameter, sometimes from a sorting line or sweepings.
77. **OTHER MATERIALS**: All remaining, generally multi-material composite or indistinct items not elsewhere defined. Examples include whole filtered cigarettes and cigarette butts, dryer lint, and personal care products (shampoo, cosmetics, soaps, toothpaste, etc.).

Appendix B. Study Design

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

Overview and Objective

The City of Palo Alto adopted a Zero Waste goal in 2005 and subsequently developed a Zero Waste Operational Plan to achieve that goal. The City also conducted a comprehensive waste characterization study in 2005 and a follow-up study in 2012. Since the 2012 study, the City has continued to implement some of the key programmatic changes outlined in the Zero Waste Operational Plan. The City of Palo Alto has commissioned a new waste characterization study to update the City's waste characterization information in 2017. The data collected in this waste characterization study will help plan for future programs to support the City's Zero Waste goals.

This document describes the methodology to be used for sampling and is organized into the following sections:

- Overview and Objective
- Sampling Universe
- Sampling Calendar and Allocation of Samples
- Selecting and Obtaining Samples
- Characterizing Samples
- QA/QC Procedures
- Safety Procedures
- Method for Obtaining Tonnage Data

Attached appendices include material definitions (Appendix A) and examples of the field forms (Appendix B).

Sampling Universe

The first step in planning a waste characterization study is to identify and carefully define the waste streams that will be studied, or the "universe" of waste. In this study, the universe will include eight waste sectors. A sector is determined by the particular generation, collection, or composition characteristics that make it a unique portion of the total waste stream.

The sampling universe for this study includes the following eight waste-generating sectors. Only waste, recycling, and organics generated in Palo Alto will be eligible for sampling. The eight sectors include:

- **Residential** waste is generated by single family and multifamily residences.
  - **Residential single-family waste** is waste GreenWaste of Palo Alto collects from single-family residences (single family homes and townhouses or buildings with up to four residential units). It typically arrives at the SMaRT Station in packer trucks (e.g., side loaders, front loaders, etc.).
  - **Residential multifamily waste** is waste GreenWaste of Palo Alto collects from multifamily residences (apartments or condominiums with more than four residential units). It typically arrives at the SMaRT Station in packer trucks (e.g., front loaders). GreenWaste typically collects multifamily waste in the same truck as commercial waste. During this study GreenWaste will collect multifamily waste on a special route separate from commercial waste.
- **Commercial** waste and organics is material GreenWaste of Palo Alto collects from businesses, institutions, public venues, schools, and industrial sources. It typically arrives at the SMaRT Station in packer trucks (e.g., front loaders), compactor units, or open-top roll-off containers. For the purposes of this study, material from commercial generators will be distinguished as follows:
  - **Commercial packer** (a front-load, side-load, or rear-load self-contained compacting vehicle) **waste**.
  - **Commercial loose roll-off waste** (an un-compacted open-top roll-off container, commonly referred to as a "debris box" or "drop-box").
  - **Commercial front load compost** is typically delivered to Zanker Recycling's ZWED facility. Selected loads will be rerouted to the SMaRT station for sampling.
  - **Hospital waste** is waste collected in compactors from the three local hospitals.
- **C&D and bulky waste** is waste generated from construction activities and bulky waste delivered to Zanker Road in loose drop-boxes.
  - **SMaRT Station residuals** are waste produced as by products from the SMaRT Station's material recovery facility (MRF). Residuals do not include fines material screened from the trommels.

Sampling Calendar and Allocation of Samples

A total of 175 samples will be characterized for this study. Table 25 summarizes the sample targets by sector.

Table 25. Sample Characterization Method by Sector

Sector	Target Number of Samples	Characterization Method
Residential		
Single-family (Garbage, Recyclables, and Compost)	*30*	*Hand-sort*
Multifamily Garbage	*26*	*Hand-sort*
Commercial		
Commercial Garbage	*40*	*Hand-sort*
Commercial Compost	*20*	*Hand-sort*
SMaRT Station Loose Roll-off Garbage	*Up to 20*	*Visual*
Hospital Garbage	*3*	*Hand-sort*
Zanker Mixed C&D	*Up to 20*	Visual
SMaRT Station Residuals	*16*	Hand-sort
Total	175	

Sampling will occur over nine days between October 18th and 27th (including Saturday, October 21st, excluding Sunday October 22nd) at the SMaRT Station, and on one day in this same period at Zanker Road. Table 26 presents the daily sample targets by sector.

Table 26. Daily Sample Targets by Sector

Day	Residential		Commercial				C&D & Bulky Waste	SMaRT Residuals	Total
	SF	**MFD (packer and compactor)**	**Front Load Garbage**	**Loose Roll-off**	**Hospital Compactor**	**Front Load Compost**			
10/18/2017	0	3	4	TBD		3		2	
10/19/2017	0	3	6	TBD		3		2	
10/20/2017	0	3	7	TBD		3		2	
10/21/2017	0	3	2	TBD		2		2	
10/23/2017	6	3	6	TBD		3		2	
10/24/2017	6	3	6	TBD		2	20	2	
10/25/2017	6	3	4	TBD		2		2	
10/26/2017	6	3	5	TBD		2		2	
10/27/2017	6	3	6	TBD		2		2	
Total	**30**	**26**	**40**	**20**	**3**	**20**	**20**	**16**	**175**

Selecting and Obtaining Samples

Cascadia field crews will use two different methods to select a load for sampling. Loads from sectors with regularly scheduled waste collection routes will be **pre-selected** using a random selection method. Loads from sectors that do not have regularly scheduled waste collection routes will be **systematically selected** on each day of sampling. Single-family households will also be systematically selected. Systematic selection involves creating a sampling frequency to ensure random selection; this selection methodology is further described below. The SMaRT Station residuals samples will be selected throughout each sampling day at pre-determined time intervals. Table 27 summarizes the load selection method to be used for each sector.

Table 27. Sample Selection Method by Sector

Sector	Sample Selection Method
Residential	
Single-family (Garbage, Recyclables, and Compost)	*Households will be systematically selected*
Multifamily Garbage	*Pre-selected*
Commercial	
Commercial Garbage	*Pre-selected*
Commercial Compost	*Pre-selected*
SMaRT Station Loose Roll-off Garbage	*Systematic selection*
Hospital Garbage	*Pre-selected*
Zanker Mixed C&D	Systematic selection
SMaRT Station Residuals	Sampled throughout day at pre-determined intervals

Single-family Residential Waste, Recycling, and Organics

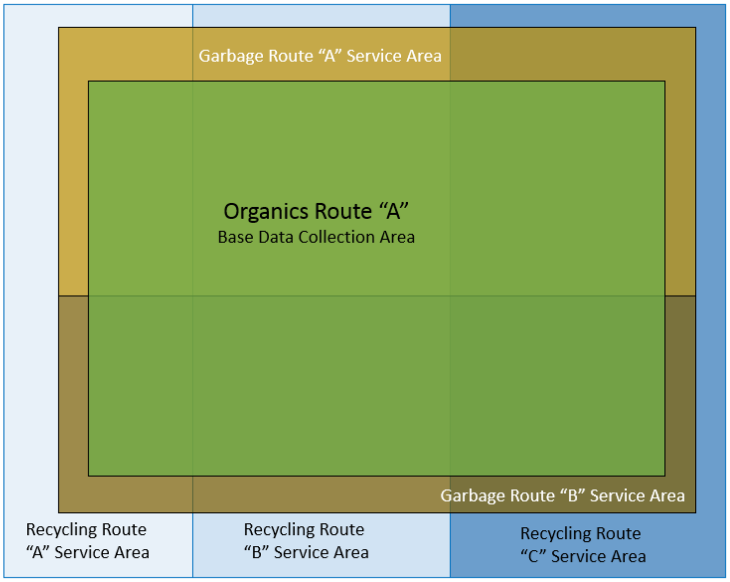
Cascadia will sample single-family residential material by collecting “paired samples” including garbage, recycling, and organics from single-family dwellings. “Paired” samples refer to the simultaneous collection and sorting of multiple carts from a single household, as part of the same set-out. This approach enables combining composition data from all carts collected to produce more reliable estimates of diversion than can be derived based on samples from entire truckloads of materials from multiple households and set-outs. Cascadia will select and obtain samples from 30 households. Sampling for this sector will occur daily from Monday, October 23rd through Friday, October 27th.

In addition to selecting samples from households as described above, Cascadia will note setout information for each household along the route.

Select Households

Cascadia will obtain a list of residential organics routes by day of the week from GreenWaste. From this list, we will randomly select one organics route from each weekday, for a total of 5 routes for the field event. We will define these selected routes as our data collection area for each day of the study. For the purposes of this study, the data collection area (DCA) is the area inside the boundaries of a single organics route and includes the sections of garbage and recycling routes that fall into the boundaries of that organics route. Figure 22 describes this data collection area concept visually.

Figure 22. Data Collection Area Visual



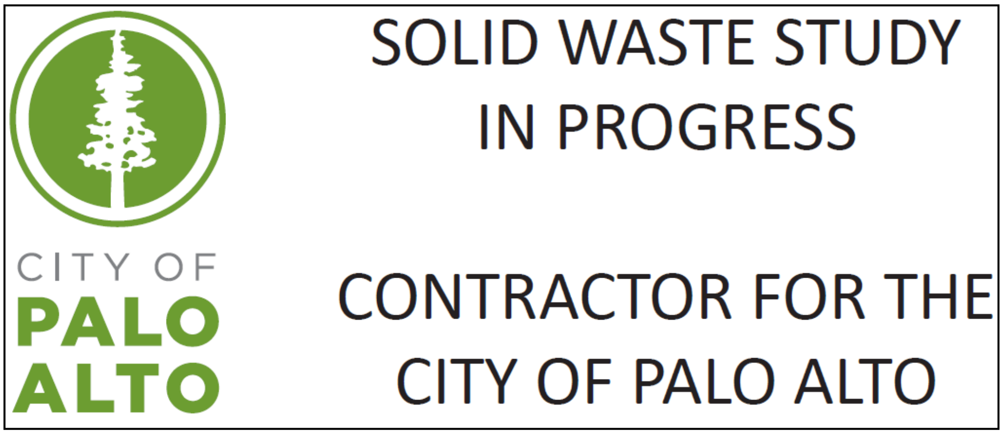
The organic route boundaries will be the data collection area (DCA) boundaries. We are assuming that every household in the DCA boundary has garbage and recycling service. We can then calculate set-out rates for households within the DCA boundaries because we know the total number of households within the boundaries from GreenWaste provided data.

Prior to sampling, Cascadia will prepare a *Household Selection Sheet* for each day that specifies the household selection protocol from which to select samples of garbage, recycling, and organics. We will use a random systematic selection procedure to select households from each route included in the study. We will determine sampling intervals by dividing the estimated number of households likely to have paired set-outs on a selected route by the number of samples needed each day. The resulting number is the sampling frequency, which determines, for example, whether every sixth household, every tenth household, or every twelfth household with paired set-outs on the day of the sampling event is selected for sampling. This sampling interval will be of sufficient size to capture material from along the entire route.

Obtain Samples

Two route surveyors working as a team will be assigned to the base data collection area (DCA). At the start of every sampling day, each route surveyor will receive a DCA map, driving directions, data collection sheets, and the count of households in the in the DCA. Each route surveyor will wear a name tag with the City of Palo Alto logo on it. Additionally, each truck will have a banner with the City of Palo Alto logo name and "study in progress" signs displayed on the side should any customers along the route have questions about the study; this banner is displayed in Figure 23 below. The team will travel the selected DCA, recording the number of garbage, recycling, and organics set-outs at each household on an electronic set-out count form.

Figure 23. Single Family Sample Collection Truck Banner



The route surveyors will begin traversing the DCA 30 minutes before GreenWaste begins collection – 5:30am each morning. This ensures that the sampler will be sufficiently ahead of the hauler to prevent any disruptions to collection operations while allowing residents the maximum amount of time to set out their carts for counting and collection.

Cascadia will inform local police in the areas we will be collecting samples of our sampling and collection plan the week prior to the start of sampling to ensure that all channels are properly informed should any resident questions or interactions come up. We will also have handouts with information about the study to provide to customers who have questions about the study. Cascadia will also be tracking the number and type of customer interactions we have, including recording the addresses of any customers who choose to opt out of the study. Examples of a customer handout and interaction tracking form are included in Appendix D.

The route survey teams will also be responsible for selecting set-outs for sampling. Using a predetermined sampling interval, each route survey team will collect all material from six set-outs each day. The sampling interval is determined using the following procedure:

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

If there is no set out at a household selected using the random sampling interval, field staff will sample from the next house with material set out. All the material from a single stream from each set-out constitutes a sample. Each sample will be stored and labeled separately. After the route survey team completes their DCA they will transport the samples to the SMaRT Station for sorting.

If the household has set out at least one stream (garbage, recycling, or organics), they will be selected as part of the study.

When each sample collection team identifies a household for sample collection, the team will empty the contents of each cart into its own tarp. The team will then label each tarp with a *Sample Placard* pre-printed with a unique ID number for each household, secure the tarp to prevent cross contamination between samples, and place the samples in the truck.

After the team collects garbage, recycling, and organics samples from the designated number of households, the team will transport collected samples to the SMaRT Station for sorting.

Multifamily Residential Waste

Cascadia will sample multifamily residential waste from special routing conducted for the purposes of this study; the goal is to collect 26 samples of multi-family waste over the course of the study. GreenWaste typically collects multi-family waste on the same route as they collect commercial waste, so commercial and multi-family waste arrive at the SMaRT Station mixed in a packer truck. Since this study is interested in assessing the composition of multifamily waste alone, GreenWaste has agreed to create a special route that only collects multifamily waste for the duration of our study. GreenWaste is assembling these multifamily-only routes, and will collect them using vehicles from a sister company. This special route will deliver one truckload of material to the SMaRT Station per day for the duration of our study, from Wednesday, 10/18 through Friday, October 27th (including Saturday, October 21st, excluding Sunday October 22nd).

Since one truck route per day is not sufficient to meet the 26 sample goal for the study, GreenWaste will also deliver 3 compactors from multi-family sites to the SMaRT Station for sampling over the course of the study.

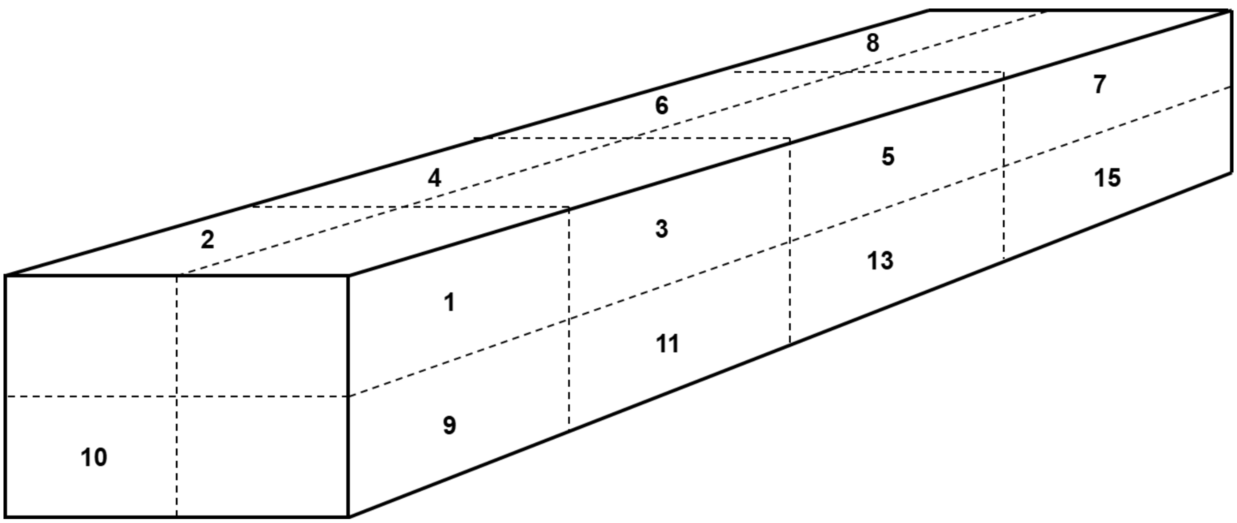
Select Vehicles

GreenWaste will collect from special routes to ensure pure samples of multifamily waste on all weekdays of the sampling period, and on one weekend day (Saturday, October 21st).

Obtain Samples

Selected loads will be tipped in an elongated pile. From each load, a sample will be selected using an imaginary 16-cell grid (as shown in Figure 24) superimposed over the tipped material.

Figure 24. 16-Cell Grid for Sampling



The Cascadia Field Manager will identify the randomly selected cell grid from which a sample will be collected. Working with facility staff, the Field Manager will ensure that a sample of garbage weighing 200 to 250 pounds is obtained from the selected cell and transported to the characterization area. Samples will be collected before facility staff divert any materials from the load. Each sample will be placed on a clean tarp with the *Sample Placard*, which identifies and provides key information (such as generator and vehicle type) about the sample. For multifamily waste, this procedure will be repeated so that two or three samples will be captured from each special route truck each day, and one sample will be taken from each of the three multi-family compactors currently active in Palo Alto, for a total of 26 samples over the eight weekdays.

Commercial Packer Trucks

Packer and compactor loads of commercial waste will be pre-selected using a random selection method. Cascadia will select and obtain 40 samples of commercial packer truck loads. Sampling for this sector will occur from Wednesday, October 18th through Friday, October 27th, including Saturday, October 21st.

Select Vehicles

As a starting point for load selection, GreenWaste will provide Cascadia a list all their Palo Alto routes. The list of loads will be sorted by day of service. Loads will then be randomly selected using Excel's random number generator until the daily load selection goals are realized. Daily *Vehicle Selection Forms* will summarize selected loads for each sampling day. A driver often tips more than one load per route; in these instances, a specific tip (first tip, second tip, etc.) will be designated for sampling. See Appendix B for examples of all field forms.

The scalehouse staff will receive a list pre-selected loads and expected truck numbers for each sampling day. When a designated vehicle arrives at the scale house and is selected for sampling, the scale house operator will place a *Sample Placard* on the windshield of the vehicle and direct the vehicle to the sorting area.

The Cascadia Field Manager will also have a list of the eligible routes and vehicles for each day. When a commercial load is directed to the field crew, the Field Manager will verify the vehicle against the list and will verify that the vehicle contains the correct type of waste.

Obtain Samples

Samples will be obtained using the same method as described above for *Multifamily Residential*.

Commercial Loose Drop-boxes

A systematic selection method will be used to select commercial loose drop-boxes for sampling. Sampling for this sector will occur from Wednesday, October 18th through Friday, October 27th, including Saturday, October 21st. During this time period, Cascadia will characterize as many loads arriving at the SMaRT Station as possible, up to 20.

Select Vehicles

The Cascadia team will use a systematic selection method to randomly select individual commercial loose drop-boxes for sampling. The systematic selection method ensures that the mix of sampled vehicles is representative of the sector. We use the total number of loads arriving at the facility (based on historical data provided by facility staff) to establish a "sampling frequency" for each day of sampling. The sampling frequency is calculated by dividing the total expected number of loads for each stream by the target number of samples to determine what fraction of vehicles must be sampled—such as every third vehicle, every sixth vehicle, or every 20th vehicle. This strategy is referred to as "selecting every *n*th vehicle."

The scalehouse staff will use a *Vehicle Selection Form* that Cascadia develops and that clearly communicates the sampling frequency required for each facility and day. When a vehicle is selected, the scalehouse staff will place a *Sample Placard* in the windshield of the selected vehicle.

Obtain Samples

For this stream, a sample will consist of the entire load. Visually characterizing the entire load provides a more representative characterization for loose drop-boxes and C&D waste, which typically contain a variety of materials including large and bulky waste.

Hospital Waste

The study includes characterizing one sample of waste from the compactors at each of three local hospitals.

Select Vehicles

Over the sampling period, GreenWaste will deliver one compactor from each of the three hospitals in Palo Alto for sampling. GreenWaste will be in communication with the Cascadia project manager about when each of these compactors will arrive. Once the arrival date has been set, the Cascadia project manager will communicate this to the scalehouse operator and to the Cascadia Field Manager, so that both can be on the lookout for the compactor as it arrives. When one of the three designated vehicles arrives at the scale house, the scale house operator will place a *Sample Placard* on the windshield of the vehicle and direct the vehicle to the sorting area.

Obtain Samples

The method for obtaining samples is the same as described above for *Multifamily*

Commercial compost

Commercial compost loads will be pre-selected using a random selection method. Typically these loads are delivered to Zanker Recycling's ZWED facility, but for this study will be rerouted to the SMaRT station for sampling. Cascadia will select and obtain 20 samples of commercial front load compost. Sampling for this sector will occur from Wednesday, October 18th through Friday, October 27th, including Saturday, October 21st.

Select Vehicles

Vehicles will be selected using the same pre-selection method as described above under *Commercial Packer Trucks*.

Obtain Samples

Samples will be obtained using the same method as described above *Multifamily*

C&D and Bulky Waste

Loads of C&D and bulky waste will be visually characterized at Zanker Road by one Cascadia staff person. This staff person will select loads for sampling using a systematic selection method. Cascadia will select and characterize up to 20 samples of C&D and bulky waste on one day during the course of the study. If loads are not as homogenous as expected, Cascadia may recommend an additional day of sampling at Zanker Road to collect a number of samples appropriate to the heterogeneity of the loads.

Select Vehicles

Vehicles will be selected using the same pre-selection method as described above under *Commercial Loose Drop-boxes*.

Obtain Samples

A sample of C&D and bulky waste will consist of the entire load and a visual characterization method as described above under *Commercial Loose Drop-boxes*.

SMaRT Residuals

During a planning facility site visit at the SMaRT Station, Cascadia met with SMaRT Station personnel to determine the best methodology for sampling residuals at the facility. The site visit revealed that there are two primary residual streams at the SMaRT Station: 2" minus materials and 2" plus materials. Cascadia decided that it would be best to exclude 2" minus residuals from the study, since not sorting this material is consistent with the 2012 study; much of the material is either very small (so it will end up in the mixed residue category when the field team sorts it) or it is too indistinct to determine what it is (meaning it will end up in the mixed residue category when our team sorts it); and the 2" minus material isn't going to landfill and ZWED does good job recovering it.

See Figure 25 below for a photograph of the 2" plus stockpile of material taken during Cascadia staff site visit to the SMaRT Station on 10/10/17.

Figure 25. 2" Plus Material Stockpile at SMaRT Station

Cascadia will select and obtain a total of 16 samples of 2" residuals over the course of the study, approximately two samples per day. Sampling for this sector will occur from Wednesday, October 18th through Friday, October 27th, including Saturday, October 21st.

Sample Selection

Cascadia will select samples from the 2" plus residuals stockpile area at a randomly selected time, using the random number generator in MS Excel. At the selected time, 100 pounds residual material from the stockpiled 2" plus pile will be collected and transported to a sorting location. Residual samples will be randomly selected by subdividing the container into cells and using the assistance of a facility loader to randomly select a cell (see Figure 26 for an example of this process). Samples will then be transported to the sorting area.

Figure 26. Visual Overlay for Stockpiled Method Showing "Cells" of Material

Characterizing Samples

Depending on the sector, samples will be either hand-sorted or visually characterized using the methods described in this section. Table 28 identifies which method will be used and the target sample size for each waste sector.

Table 28. Sample Characterization Method by Sector

Sector	Sampling Method	Characterization Method	Approximate Target Sample Size
Residential waste			
Single-family waste	*Paired Carts*	*Hand-sort*	*Entire contents of all three carts*
Multifamily waste	*Back of truck*	*Hand-sort*	*200 pounds*
Commercial waste/organics			
Packer waste	*Back of truck*	*Hand-sort*	*200 pounds*
Loose roll-off	*Back of truck*	*Visual*	*Entire load*
Hospital Waste	*Back of truck*	*Hand-sort*	*200 pounds*
Front load compost	*Back of truck*	*Hand-sort*	*200 pounds*
C&D and Bulky Waste	Back of truck	Visual	Entire load
SMaRT Station Residuals	Processing ejection points	Hand-sort	Sample size will be determined by average particle size

The two characterization methods are described below.

Sample Characterization – Hand Sort

A professional, Cascadia field crew will hand sort all selected samples, and Cascadia's Field Manager will be on-site during all sorting activities to ensure that the field crew follows approved protocols and maintains consistency across samples and sampling events. The Field Manager will also brief personnel on any facility-specific health and safety requirements, personal protective equipment (PPE) requirements, and contingency protocols.

Our standard process for hand-sorting most MSW, incoming recyclable materials, organics, and processing residuals includes the following steps:

1. A member of the field crew will take photographs of the sample using a digital camera. The *Sample Placard* identifying the sample will be positioned to be visible in each photo.
2. The field crew will sort the sample into the material categories and store separated materials in plastic laundry baskets. Individual members of the field crew typically specialize in groups of materials, such as papers or plastics. The Field Manager will monitor the homogeneity of material in the baskets as they accumulate, rejecting any materials that are improperly classified.
3. The Field Manager will then visually inspect the purity of each material as it is weighed in its basket using a pre-calibrated scale, and will record each material weight on the *Material Weight Tally Sheet*.

Sample Characterization – Visual

Cascadia's process for visually characterizing waste includes the following steps:

1. A member of the field crew will take photographs of the sample using a digital camera. The *Sample Placard* identifying the sample will be positioned to be visible in each photo.
2. A member of the field crew will use a tape measure to obtain the length, width, and height of the sample and record the total volume on the *Visual Characterization Form* (see Attachment B).
3. The field crew member will walk around the entire load and write down the major material classes that are present in the load on the *Visual Characterization Form*.
4. Beginning with the largest major material class present by volume, the crewmember will estimate the volume percentage of each material class (e.g., paper or glass) and record it on the *Visual Characterization Form*. This process is repeated for the next most common material class, and so forth, until the volume percentage of every material class has been estimated. The crewmember will then calculate the sum for this step, ensuring that it totals 100 percent.

5. Next, the crewmember will consider each material class separately and estimate the percentage of each material class that is made up of each material component. For example, newspaper may be a material component within the material class of paper. While considering only the paper material class, the crewmember will estimate the volume percentage of paper materials that is composed of newspaper. The crewmember will then do the same for every other material component within the paper material class (such as cardboard). The total of percentages for all of the material components must equal 100 percent.
6. The crewmember will ensure that the percentage estimates for the major material classes add up to 100 percent. The percentage estimates for the specific material components within each major class must also total 100 percent.

Cascadia converts the volume estimates to weight estimates using accepted density conversion factors.

QA/QC Procedures

To minimize data collection errors and maximize composition estimate accuracy, Cascadia will implement the following quality assurance/quality control procedures.

- Train the scale house personnel to place placards on trucks selected for sampling.
- Train the field crew to capture and weigh samples.
- Check all sample characterization field forms to ensure that forms are complete and data is properly recorded.
- Enter all characterization data into a customized Microsoft Access database.
- Conduct an inspection of randomly selected records to monitor the accuracy of the data entry process.

Safety Procedures

All personnel involved in surveying and sampling will comply with SMaRT Station safety protocols and will wear appropriate safety gear, including:

- High visibility clothing
- A hard hat
- Steel toe boots
- Safety glasses

In addition, gloves, hearing protection, and dust masks will be worn as needed.

Method for Obtaining Tonnage Data

Accurate tonnage information is necessary to compile the composition and quantity analysis. It is expected that the City of Palo Alto will provide annual tonnage data for each of the eight sampling sectors:

- Single-family waste
- Multifamily waste
- Commercial packer waste
- Commercial loose roll-off waste
- Hospital waste
- Commercial front load compost
- C&D and bulky waste
- SMaRT Station residuals

Appendix C. Waste Characterization Calculations

Estimating Waste Composition

Waste composition estimates were calculated using a method that gave equal weighting or "importance" to each sample within a given stratum. 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_j is the weight of the material type j in a sample;
- w is the weight of an entire sample;
- r_j is the composition estimate for material j (r stands for *ratio*);
- s denotes a particular sector or subsector of the waste stream; and
- n denotes the number of samples in the particular group that is being analyzed at that step.

Estimating the Composition

The following method was used to estimate the composition of Palo Alto's waste.

For a given stratum (that is, for the samples belonging to the same waste sector within the same jurisdiction), the composition estimate denoted by r_j 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 of waste 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; and
- 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 component *carpet* are shown.

	Sample 1	**Sample 2**	**Sample 3**
Weight (c) of carpet (in lbs)	5	3	4
Total Sample Weight (w) (in lbs)	80	70	90

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

To find the composition estimate for the component *carpet*, 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 *carpet*. 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:

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

where:

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

(For more information regarding Equation 2, 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:

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

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

Composition results for strata were then combined, using a weighted averaging method, to estimate the composition of larger portions of the waste stream. The relative tonnages associated with each stratum served as the weighting factors. The calculation 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 waste stratum (the weighting factor);
- r = ratio of component weight to total waste weight in the noted waste stratum (the composition percent for the given material component); and
- for j = 1 to m, where m = number of material components.

For example, the above equation is illustrated here using three waste strata.

	Stratum 1	**Stratum 2**	**Stratum 3**
Ratio (r) of carpet	5%	10%	10%
Tonnage	25,000	100,000	50,000
Proportion of tonnage (*p*)	14.3%	57.1%	28.6%

To estimate the portion of larger portions of the waste stream, the composition results for the three strata are combined as follows.

$$O_{Carpet} = (0.143 * 0.05) + (0.571 * 0.10) + (0.286 * 0.10) = 0.093 = 9.3\%$$

Therefore, 9.2% of this examined portion of the waste stream is *carpet*.

The variance of the weighted average was calculated as follows:

$$\mathrm{Var}(O_j) = \left(p_1^2\ \mathrm{Var}(r_{j1})\right) + \left(p_2^2\ \mathrm{Var}(r_{j2})\right) + \left(p_3^2\ \mathrm{Var}(r_{j3})\right) + \mathrm{K}$$

Estimating Composition of Palo Alto's Overall Disposed Waste Stream

Composition results for all waste sectors were combined, using a weighted averaging method, to estimate the composition of the entire Palo Alto waste stream. The relative tonnages associated with each sector served as the weighting factors. The calculation 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 waste sector (the weighting factor);
- r = ratio of component weight to total waste weight in the noted waste sector (the composition percent for the given material component); and
- for j = 1 to m, where m = number of material components.

The following scenario illustrates the above equation. This example involves the component *carpet* in three waste sectors.

	Waste Sector 1	Waste Sector 2	Waste Sector 3
Ratio of carpet (*r*)	0.05	0.10	0.15
Proportion of Tonnage (*p*)	50%	25%	25%

$$O_{Carpet} = (0.50*0.05) + (0.25*0.10) + (0.25*0.15) = 0.0875$$

The variance of the weighted average was calculated as follows:

$$\mathrm{Var}(O_j) = \left(p_1^2\ \mathrm{Var}(r_{j1})\right) + \left(p_2^2\ \mathrm{Var}(r_{j2})\right) + \left(p_3^2\ \mathrm{Var}(r_{j3})\right) + \mathrm{K}$$

Appendix D. Example Field Forms

Examples of the forms used in the study are included in this appendix as follows:

- Vehicle Selection Form
- Material Weight Tally Sheet
- Visual Characterization Form
- Sample Placard
- Single Family Sample Collection Customer Handout
- Resident Interaction Form

City of Palo Alto Waste Characterization Study
Vehicle Selection Sheet

Site: SMaRT Station

Date: Wednesday, October 18th, 2017 **Goal:** **8 Vehicles Total**

Each number represents an expected vehicle based on the available data.

Cross off one number for each vehicle entering the landfill.

When you reach the number circled, place a pink placard in the windshield and ask this vehicle to go to the sorting area.

Loose Roll-Off Loads:

NEED 2 **TOTAL**

(1) (2) 3 4

(expect 4)

Pre-Selected Vehicles

These vehicles have been pre-selected to participate in this study.

When one of these vehicles enters the facility, find the pink placard for that vehicle, place it on the windshield, and ask this vehicle to go to the sorting area.

Commercial Trash

EXPECT 2 **TOTAL**

Route #	Truck #	Load #	Expected By
120	PA551	1	10:15
123	PA553	1	10:30

Commercial Compost

EXPECT 3 **TOTAL**

Route #	Truck #	Load #	Expected By
122	PA555	1	6:45
121	PA554	1	7:15
121	PA554	2	11:15

Multifamily Trash

EXPECT 1 **TOTAL**

Route #	Truck #	Load #	Expected By
Special Route		1	

If found please call Cascadia Consulting, 206 343 9759

2017 Palo Alto Waste Composition Study

Tally Sheet - Page 1

Sample Date:____________ Sample ID:__________________ Route #:_________ Truck #:____________ Load #:__________ # Of Sample From Load:___ of ____

PAPER	Clean, Flattened, Uncoated OCC				
	Clean, Unflattened, Uncoated OCC				
	Newspaper				
	Other Clean Paper				
	Paper Tissue & Towels				
	Other Soiled Uncoated Fiber				
	Coated OCC				
	Other Coated Paper				
	Gable Top Cartons				
	Aseptics				
	Paper Takeout Containers				
	Coated Paper Cups				
	Pizza Boxes				
	Other Composite Paper				
PLASTIC	#1 PETE Plastic Packaging				
	#2 HDPE Plastic Packaging				
	Expanded #6 Products & Packaging				
	Other #3-7 Plastic Packaging				
	Durable Plastic Products				
	Plastic Takeout Containers				
	Compostable Plastic Bags				
	Other Compostable Plastic				
	Recyclable Film Plastic				
	Flexible Plastic Pouches				
	Other Composite Film Plastics				
	Other Plastic				
GLASS	Glass Bottles & Jars				
	Blue or Red Glass Bottles & Jars				
	Other Non-Composite Glass				
	Other Composite Glass				
METAL	Aluminum Cans & Foil				
	Other Non-Ferrous Metal				
	Steel Cans & Lids				
	Appliances				
	Other Ferrous Metal				
	Other Composite Metal				
ORGANICS	Plant Trimmings				
	Edible Food Scraps				
	Inedible Food Scraps				
	Other Compostable Organics				
	Diapers				
	Animal Feces & Litter				
	Other Organics				

C&D DEBRIS	Clean Wood				
	Clean Engineered Wood				
	Painted Wood				
	Treated Wood				
	Inerts				
	Clean Gypsum				
	Painted Gypsum				
	Roofing				
	C&D Glass				
	Carpet				
	Fiberglass Insulation				
	Other C&D				
HAZARDOUS	Electronics				
	Paint				
	Batteries				
	Non-Empty Aerosol Cans				
	Mercury Lamps				
	Pesticides				
	Cleaning Products				
	Motor Oil				
	Oil & Fuel Filters				
	Untreated Medical Waste				
	Treated Medical Waste				
	Blue Wrap				
	Medicine				
	Cold Packs				
	Other Hazardous				
OTHER MATERIALS	Mattresses				
	Furniture				
	Tires & Rubber				
	Textiles & Leather				
	Non-Metal Appliances				
	Fines				
	Other Materials				

Material Stream for Single Family Samples (circle one):

Single Family Garbage Single Family Recycling Single Family Organics

If applicable, Indicate:

MF Property Name:______________________ Hospital Name:______________________________

Notes:

2017 Palo Alto WCS Visual Characterization Form

If found, please contact Cascadia Consulting Group at (206) 343-9759

Step 1:
Sample ID: ____________ **Stream:**______
Sample Date:__________
Route:_________ **Truck:** ____________
Load:_____ **Sample # From Load:**___ of _____

Step 2: Measure and record the load volume
(Include trailer dimensions if applicable)
Dimensions (vehicle):
________ft x ________ft x ________ft
Dimensions (trailer):
________ft x ________ft x ________ft

Step 3: Collect the vehicle net weight
________________ **Lbs. \ Tons**

Step 4: Photograph the sample. **PHOTO?** ☐
Step 5: Identify and record all material classes (in bold) that appear in the load.
Step 6: Estimate composition of load by volume for each material class (in bold).
Step 7: For each material class, estimate composition by volume of each material type.
Step 8: Make sure material class estimates AND material type estimates EACH total 100%.

Sample Notes:

☐ **Paper:** _____%

	Clean, Flattened, Uncoated OCC
	Clean, Unflattened, Uncoated OCC
	Newspaper
	Other Clean Paper
	Paper Tissue & Towels
	Other Soiled Uncoated Fiber
	Coated OCC
	Other Coated Paper
	Gable Top Cartons
	Aseptics
	Paper Takeout Containers
	Coated Paper Cups
	Pizza Boxes
	Other Composite Paper
%	*Subtotal (must equal 100%)*

☐ **Plastic:** _____%

	#1 PETE Plastic Packaging
	#2 HDPE Plastic Packaging
	Expanded #6 Products & Packaging
	Other #3-7 Plastic Packaging
	Durable Plastic Products
	Plastic Takeout Containers
	Compostable Plastic Bags
	Other Compostable Plastic
	Recyclable Film Plastic
	Flexible Plastic Pouches
	Other Composite Film Plastics
	Other Plastic
%	*Subtotal (must equal 100%)*

☐ **Glass:** _____%

	Glass Bottles & Jars
	Blue or Red Glass Bottles & Jars
	Other Non-Composite Glass
	Other Composite Glass
%	*Subtotal (must equal 100%)*

☐ **Metal:** _____%

	Aluminum Cans & Foil
	Other Non-Ferrous Metal
	Steel Cans & Lids
	Appliances
	Other Ferrous Metal
	Other Composite Metal
%	*Subtotal (must equal 100%)*

☐ **Organics:** _____%

	Plant Trimmings
	Edible Food Scraps
	Inedible Food Scraps
	Other Compostable Organics
	Diapers
	Animal Feces & Litter
	Other Organics
%	*Subtotal (must equal 100%)*

☐ **Other Materials:** _____%

	Mattresses
	Furniture
	Tires & Rubber
	Textiles & Leather
	Non-Metal Appliances
	Fines
	Other Materials
%	*Subtotal (must equal 100%)*

☐ **C&D Debris:** _____%

	Clean Wood
	Clean Engineered Wood
	Painted Wood
	Treated Wood
	Inerts
	Clean Gypsum
	Painted Gypsum
	Roofing
	C&D Glass
	Carpet
	Fiberglass Insulation
	Other C&D
%	*Subtotal (must equal 100%)*

☐ **Hazardous:** _____%

	Electronics
	Paint
	Batteries
	Non-Empty Aerosol Cans
	Mercury Lamps
	Pesticides
	Cleaning Products
	Motor Oil
	Oil & Fuel Filters
	Untreated Medical Waste
	Treated Medical Waste
	Blue Wrap
	Medicine
	Cold Packs
	Other Hazardous
%	*Subtotal (must equal 100%)*

Grand Total:_______%

(Must equal 100%)

Generator: **Com**	Load: **1**	Truck: **PA551**	Sample ID: **ComG-1**
	Stream: **G**	Route: **120**	**# of samples from load: 1 of 2**

Date:

10/18/2017

Random Cell #: **10**

CITY OF PALO ALTO
PUBLIC WORKS
Environmental Services
3201 E. Bayshore Road
Palo Alto, CA 94303
650.496.5910

Palo Alto Waste Composition Study

The City of Palo Alto is sampling materials in the black, blue, and green carts along randomly selected routes as part of a study on garbage, recycle, and compost composition in Palo Alto. The study provides the City with data on how to better serve residents and achieve the community's waste reduction goals. The sampling will take place in October 2017.

Palo Alto's last waste composition study was done in 2012. At that time, approximately 32% of what the community placed in the garbage was recyclable and approximately 39% was compostable. Since 2012, the City has added the residential food scraps collection program and increased program outreach and education. These efforts were based, in part, on the findings from the 2012 waste composition study.

Why is the City sampling from carts?
This new waste composition study is needed to measure the success of the City's current programs and to determine next steps. The data collected from this sampling will be used to better plan services, and recycling and composting education programs for residents across the City of Palo Alto. This data will be used for informational purposes only.

Why was I selected for the sampling?
Your household is one of 6 randomly selected from among households along a waste collection route included in the study. No personal information from any household is examined or used in any way.

Can I opt-out of this study?
Yes. If you choose to opt out, we will have our team go past your house when we collect samples today and for the rest of the study.

Who is doing the sampling?
Staff from Cascadia Consulting Group, on behalf of the City of Palo Alto.

How do I get more information?
For questions or concerns, please contact:

Wendy Hediger
Environmental Specialist
Public Works Department
wendy.hediger@cityofpaloalto.org
(650) 496-5912

Thank you for participating in today's study.

CityOfPaloAlto.org

Date: **Hauler:** **Field Staff Name(s):**

Jurisdiction: **Given Handout? (circle one):** **Yes** **No**

What occurred between you and the resident?

- O Resident asked a question about activity/staff answered
- O Resident expressed concern and complained
- O Resident asked a question not related to study

Note:

How was the response of the resident?

O Positive O Neutral O Negative

Did the resident request to opt-out of the study?

O No O Yes

If Yes, please note address: