

Source-Separation and Mixed Waste Recycling Systems: A Comparative Analysis



DECEMBER 2013



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Prepared for:

**SWANA Applied Research Foundation
FY2013 Recycling Group Subscribers and
FY2013 Collection Group Subscribers**



December 2013

TABLE OF CONTENTS

SECTION	PAGE
1.0 INTRODUCTION	1
2.0 THE SOURCE-SEPARATION RECYCLING SYSTEM	4
2.1 Introduction	4
2.2 Seattle's Solid Waste Management System.....	4
2.3 Single-Family Collection Services	6
2.3.1 Introduction	6
2.3.2 Recyclables Collection.....	6
2.3.3 Organics Collection.....	7
2.3.4 Garbage Collection.....	9
2.3.5 Bulky Waste Collection	10
2.3.6 Electronics Collection.....	11
2.3.7 What's Not Collected Curbside	11
2.4 Multi-Family Collection Services	11
2.4.1 Introduction	11
2.4.2 Recyclables Collection.....	12
2.4.3 Organics Collection.....	12
2.4.4 Garbage Collection.....	14
2.5 Processing and Disposal Facilities.....	14
2.5.1 Introduction	14
2.5.2 Recyclables Processing	14
2.5.3 Organics Processing	15
2.5.4 Garbage Disposal	15
2.6 Residential Waste Diversion Rates	16
2.7 Service Costs	17
2.8 Source-Separation Recycling Systems - Conclusions	18
3.0 THE MIXED WASTE RECYCLING SYSTEM.....	19
3.1 Introduction	19
3.2 The San José Mixed Waste Recycling System.....	20
3.2.1 Introduction	20
3.2.2 Recyclables and Mixed Waste Collection	21
3.2.3 Mixed Waste Processing	22
3.2.4 Mixed Waste Diversion Rates	23
3.2.5 Mixed Waste System Costs	24
3.2.6 Observations	25
4.0 COMPARATIVE ANALYSIS OF SOURCE-SEPARATION RECYCLING AND MIXED WASTE RECYCLING SYSTEMS	26
4.1 Introduction	26
4.2 Waste Diversion	26
4.3 System Costs.....	29
4.4 Air Pollution Impacts.....	30
4.5 Accident Risks	32
5.0 CONCLUSIONS	34



LIST OF TABLES

TABLE	TITLE	PAGE
1-1	SWANA ARF Fiscal Year 2013 Group Subscribers	2
2-1	Seattle's Residential Source-Separation Recyclables Collection Service – Items and Materials Collected in the Recycling Cart	7
2-2	Seattle's Food and Yard Waste Collection Service – Monthly Rates for Single-Family Residents	7
2-3	Seattle's Residential Organics Collection Service – Items Collected in the Organics Cart.....	8
2-4	Seattle's Residential Garbage Collection Service – Items and Materials Collected in the Garbage Cart.....	9
2-5	Seattle's Garbage Collection Service – Monthly Rates for Single-Family Residents.....	10
2-6	Recommended Organics Cart Sizes for Apartment Buildings	13
2-7	SPU Rates for Organics Collection from Multi-Family Buildings.....	14
2-8	SPU Garbage Collection Rates for Multi-Family Dumpster Service	14
2-9	Seattle, WA – Management of Residential Solid Waste – 2012 Data	16
2-10	Seattle Public Utilities Residential Customers – Recycling and Disposal Service Costs – 2012.....	17
2-11	Seattle Public Utilities Residential Customers – Organics Program Service Costs – 2012.....	18
3-1	San José, CA - Multi-Family Garbage/Recyclables Collection Rates.....	22
3-2	GreenWaste Recovery Multi-Family MSW Sorts – Data Summary	24
3-3	Analysis of San José Mixed Waste System Costs	25
4-1	Comparative Analysis of Diversion Rates for Recycling Systems in Seattle and San José for Multi-Family Residences.....	27
4-2	Source-Separation and Mixed Waste Processing Systems – Comparison of Costs for Multi-Family Customers....	29
4-3	Air Pollution Impacts of Additional Source-Separation Collection Services.....	31
4-4	Single-Unit Truck Accident Data.....	34
4-5	Additional Truck Accident Risks – Source-Separation Recycling Systems	34

LIST OF FIGURES

FIGURE	TITLE	PAGE
1-1	Houston: One Bin For All.....	3
2-1	Seattle's Integrated MSW Management System	5
2-2	Seattle Multi-Family Building	12
2-3	Organics Collection Containers at a Multi-Family Building in Seattle	13
2-4	Cedar Grove Compost Facility	15
2-5	Tipping of a Waste Transfer Trailer at the Columbia Ridge Landfill	16
3-1	GreenWaste Material Recovery Facility	22
4-1	NTSB – Single-Unit Truck Classifications.....	33



1.0 INTRODUCTION

The purpose of this report is to provide recycling managers with up-to-date technical and programmatic information regarding residential source-separation and mixed waste recycling systems.

The ultimate goal of both systems is to recover recyclables from municipal solid waste (MSW) that meet the specifications of the secondary materials markets that will purchase the recovered materials and/or products.

To meet market specifications, curbside recyclables collection services originally required residents and businesses to keep recyclables separated from their wastes and to place each type of recyclable in separate bins at the curb for collection. While this approach produced recyclables of high quality, it was inconvenient for residents and required the provision of an additional curbside collection service that was relatively inefficient and expensive.

Over the last 20 years, improvements in processing technologies have enabled collection agencies to provide recyclables collection services – such as single-stream or dual-stream recycling – that are more efficient, less costly, and, perhaps most importantly, more convenient for the resident. During this time, numerous communities also implemented a residential curbside collection service for yard waste, which is often banned from landfill disposal. As a result, residential customers typically receive three curbside collection services on a regular basis: (1) mixed waste collection, (2) yard waste collection, and (3) recyclables collection. Residents are required to assist in these services by separating their discards into these three categories, placing them into their assigned containers, and moving the containers to and from the curb on their collection days.

Municipal solid waste managers are now facing another "watershed" moment as they are tasked with the implementation of collection and processing systems for organic wastes. As with materials recycling, there is – once more – a need to implement collection services that are efficient, cost-effective, and convenient to the resident. In this regard, many communities are staying with the source-separation approach and instructing residents to place their food waste and other organics in the yard waste container.

Some communities, however, are starting to consider and implement other residential recycling options. For example, the City of Houston, Texas, was recently awarded a \$1 million grant from the Bloomberg Philanthropies "2012-2013 Mayors Challenge" to support the city's implementation of its "One Bin For All" residential recycling program.¹ As described in its grant application (see Figure 1-1), this program will instruct residents to place all their discards into a single bin

¹The Mayors Challenge is a competition to inspire American cities to generate innovative ideas that solve major challenges and improve city life – and that ultimately can be shared with cities across the nation.

Source-Separation and Mixed Waste Recycling Systems: A Comparative Analysis

for collection and will rely on processing technologies to separate out recyclables and organics from the mixed residential waste at a central processing facility.

The SWANA Applied Research Foundation's (ARF) Recycling Group decided to target this topic for investigation during FY2013 (July 2012 through June 2013). The goal of this research project was to conduct a comparative analysis of the costs, benefits, and issues associated with residential source-separation and mixed waste recycling systems. Due to the relatively limited amount of funding, the analysis that was conducted was limited to systems that have been implemented to serve residents living in multi-family buildings.

This report presents the results of the research conducted for this project, which was conducted with input and support provided by the FY2013 ARF Recycling and Collection Group Subscribers listed in Table 1-1.²

TABLE 1-1		
SWANA ARF FISCAL YEAR 2013 GROUP SUBSCRIBERS		
Jurisdiction	Representative	Title
SWANA ARF Fiscal Year 2013 Recycling Group Subscribers		
Edmonton, Alberta, Canada	Christian Felske, PhD, P Eng.	Director – Engineering, Processing and Disposal
Fairfax County, VA	Pamela Gratton	Chief, Recycling and Administrative Services
North Vancouver, British Columbia, Canada	Allen Lynch	Manager – Waste Reduction
Solid Waste Agency of Northern Cook County, IL	Dave Van Vooren	Executive Director
Monterey CA Regional Waste Management District	Tim Flanagan	Assistant General Manager
Tucson, AZ	Fran LaSala	Environmental Manager
SWANA ARF Fiscal Year 2013 Collection Group Subscribers		
Charlotte, NC	Victoria Johnson	Solid Waste Services Director
Manteca, CA	James Stone	Deputy Director of Public Works
Tucson, AZ	Pat Tapia	Collections Administrator
Whitby, ON Canada	Murray Gale	Superintendent - Solid Waste Management

² The SWANA Applied Research Foundation was founded in 2001 with the purpose of conducting collectively-defined and funded applied research on pressing solid waste issues. It is funded by local governments and other organizations that contribute a “penny per ton” of waste managed to the Foundation on an annual basis. For more information on the SWANA Applied Research Foundation, please contact Jeremy O'Brien, Director of Applied Research, SWANA, (301) 585-2898.



Idea Summary: *One Bin for All is a revolutionary idea for residents to discard all materials in one bin, treating "trash" as valuable assets and dramatically increasing recycling using game changing technologies.*

What if everything you put in a waste bin could be recycled? What if "trash" became extinct? And what if you no longer had to sort your plastic cups from your glass jar from your banana peel?

What if Houston led an innovation that transformed the way we think about all discarded materials? It can happen here.

One Bin for All is a revolutionary idea for residents to discard all materials in one bin, treating "trash" as valuable assets, dramatically increasing recycling using game changing technologies.

Recycling, admittedly, is difficult. Though I am an avid recycler, I can be stumped by aluminum foil or a wet paper towel or a plastic straw. Not surprisingly, so are millions of citizens, and it is estimated that cities only effectively recycle about 30 percent of their trash.

Houston is a can-do city with world-class engineering and refining sectors. I believe that technology can do a better job separating trash from recyclables, and am working on creating a public-private partnership to construct and operate a high-tech recycling and sorting facility, diverting up to 75 percent of the material residents discard (up from Houston's current 14 percent) - using technology from the mining and refining industries, not individuals. Residents will be able to place all discarded materials in one bin and technology will do the rest.

This cost-neutral, technological innovation represents a huge paradigm shift, changing how people will think about "trash" and recycling in the future. Houston will apply proven technologies and new processes, redefining municipal solid waste from a liability to a valuable asset. Houston already has a well-established industrial and energy base. This development will provide incentives for networks and businesses to form around newly separated materials that will be available as feedstocks.

This first-of-its-kind innovation uses technology in a way that has never been done before. Allowing technology and new process systems to sort household "trash" and derive an initial 55 percent diversion rate, and upwards of 75 percent with composting, anaerobic digestion and catalytic conversion (biomass-to-fuel) is more efficient and effective. The technologies (shredders, sensors, density separators, and optical scanners) have been used previously in the waste, mining, or refining industries, but will be combined in a new process which will yield a much higher diversion rate. This system has the potential for cities across the globe to reduce greenhouse gas emissions and make a significant contribution to improved air quality, provide an easy-to-use program for residents, save money and increase revenues.

Our innovation will:

- Provide every residence with curbside One Bin for All services;
- Decrease the volume of waste sent to landfills and increase recycling rates;
- Improve air quality by eliminating truck routes and reducing methane emissions from landfills; and
- Manage costs associated with waste collection and disposal and recycling, saving cities money.

By building the first total material resource recovery facility in the US, Houston has the opportunity to improve the health and quality of life of its citizens, divert more municipal solid waste than any other large City in the nation, save money, change the way citizens think about materials, reduce extraction of raw materials and influence other cities to embrace this transformation.

Houston is a city of solutions. If you can dream it, you can achieve it here. One Bin for All.

*Bloomberg Philanthropies - 2012-2013 Mayors Challenge. <http://mayorchallenge.bloomberg.org/index.cfm?objectid=19B99FC0-0426-11E2-9FD1000C29C7CA2F>

*Figure 1-1
Houston: One Bin For All**

2.0 THE SOURCE-SEPARATION RECYCLING SYSTEM

2.1 Introduction

The implementation of residential source-separation recycling programs began in earnest in the early 1990s. By 2011, it was estimated that there were more than 9,800 curbside collection programs in the United States to collect source-separated recyclables that served over 70 percent of the population.³

As described above, residential source separation programs typically involve the provision of three, regularly-scheduled curbside collection services for residential customers: (1) mixed waste (2) yard waste, and (3) recyclables. Residents are required to assist in these services by separating their discards into these three categories and placing them into their assigned bins or wheeled containers at the curb.

One of the premier residential source-separation programs in the United States has been implemented by the city of Seattle – a city well-known for its strong environmental ethic and commitment to recycling. In addition to achieving very high diversion rates, the city has made a commitment to the principles of full-cost accounting, accurate accounting of diversion rates, and public transparency with respect to the costs and performance levels associated with each of its recycling services.

In the 2011 update of the *Seattle Solid Waste Management Plan*, the city committed to achieving a 60 percent recycling goal by 2012 and set a new goal of 70 percent to be achieved by 2025.⁴

For these reasons, the SWANA ARF selected the city of Seattle for analysis as an excellent representative of a modern residential source-separation recycling system.

2.2 Seattle's Solid Waste Management System

Seattle Public Utilities (SPU) – a department in the government of the city of Seattle – is responsible for the provision of water supply, wastewater and stormwater management, and solid waste management services to the residents, businesses, and industries in the city's jurisdiction.

Almost 714,000 tons of MSW were generated in Seattle and managed in 2012.⁵ The city's 2012 estimated population of 634,535 is divided into single-family (163,483 households) and multi-

³ US EPA Office of Solid Waste. *Municipal Solid Waste in the United States: 2011 Facts and Figures*. (EPA-530-R-13-001). May 2013. www.epa.org.

⁴ Seattle Public Utilities. *Picking Up the Pace Toward Zero Waste: Seattle's Solid Waste Plan - 2011 Revision*.

⁵ Seattle Public Utilities. *2012 Recycling Rate Report*.



Source-Separation and Mixed Waste Recycling Systems: A Comparative Analysis

family residents (132,840 households).⁶ The 132,840 multi-family units are housed in 5,980 apartment complexes with an average of 22 units per complex.

The *Seattle Solid Waste Plan - 2011 Revision* includes a graphic of the city's MSW system, which is presented in Figure 2-1 and summarized below:

- SPU has divided the city into two residential franchise collection districts, each of which is provided with garbage, organics collection, and recyclables collection services. For single-family residences, garbage and organics are collected on a weekly basis while recyclables are collected every other week. For multi-family residences, the collection frequency for garbage varies according to the needs of the building while organics are still collected weekly and recyclables every other week.
- The collected wastes are transported to either of two transfer facilities (north or south) while the organics and recyclables are hauled directly to processors. From the transfer facilities, waste is trucked to an intermodal rail station, from which it is transported by train approximately 250 miles to the Columbia Ridge Landfill (located near Arlington, Oregon, and owned by Waste Management, Inc.) for disposal.

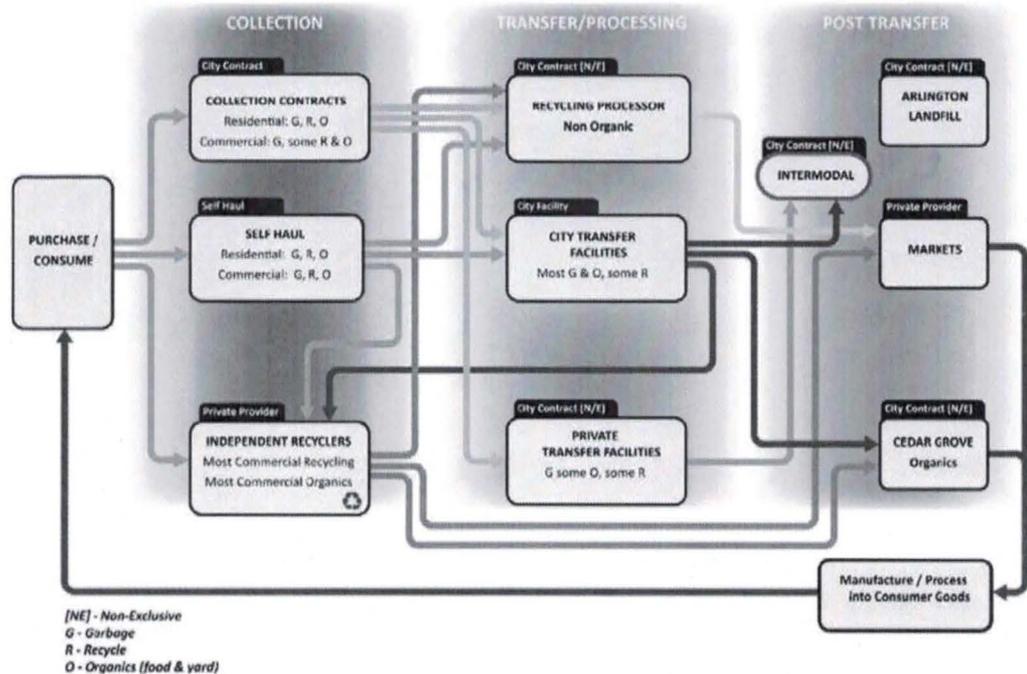


Figure 2-1. Seattle's Integrated MSW Management System
 (Source: Seattle Solid Waste Plan - 2011 Revision)

⁶ Seattle Public Utilities – Economic Services Section. *Seattle Garbage Report – Second Quarter 2013*.

2.3 Single-Family Collection Services

2.3.1 Introduction

Single-family residences in Seattle are defined to include detached single-family houses, duplexes, and multi-family buildings with four or less housing units. The distinguishing factor about this service is that cans (12, 20 or 32 gallons in size) or carts (64 or 96 gallons) are used for garbage collection. In contrast, multi-family residences utilize dumpsters for garbage collection.

Two companies – Waste Management, Inc., and Cleanscapes, Inc. – are under contract with SPU to collect the residential garbage, recycling, and organics generated in the city's two franchise collection districts. Current contracts began in March 2009 and will run at least until 2017.

Each company provides up to three collection services (recyclables collection, food and yard wastes collection, and garbage collection) to each residence. Residents are required by law to subscribe to the garbage collection service. They are provided the recyclables collection as a free service, which they are encouraged to use. However, residents may opt out of the organics collection if they have an approved backyard composting operation.

The collection services are provided on the same day to each residence or apartment building. Garbage and organics are collected every week while recyclables are collected every other week.

2.3.2 Recyclables Collection

In Seattle, the placement of recyclable paper, cardboard, glass and plastic bottles, and aluminum and tin cans in garbage containers is banned by city ordinance. As a result, the SPU provides recyclables collection services to the residents and businesses in Seattle through its two franchise contract haulers.

Single-family residents can utilize either 64- or 96-gallon rollout containers, which are provided free of charge, for the collection of their recyclables. Residents are instructed to place recyclables commingled into the container, which is collected on an every-other-week basis at the curb.

The SPU specifies what discarded products and materials can be placed in the recycling cart, which are listed in Table 2-1. In this regard, it is noteworthy that a number of items are not considered recyclable and therefore cannot be placed in the recycling cart for collection.

TABLE 2-1
Seattle's Residential Source-Separation Recyclables Collection Service
Items and Materials Collected in the Recycling Cart

Acceptable Items and Materials	Not Acceptable
<ul style="list-style-type: none"> ▪ Aluminum foil and food trays ▪ Plastic plant pots ▪ Plastic bags (bagged together) ▪ Plastic bottles, jars and tubs ▪ Pill bottles (no prescription vials) ▪ Glass bottles and jars ▪ Lids wider than 3 inches ▪ Metal cans ▪ Paper (dry) ▪ Plastic trays, cup, containers ▪ Cardboard (unwaxed, flattened) ▪ Scrap metal (less than 2 ft. x 2 ft. x 2 ft.) 	<ul style="list-style-type: none"> ▪ Used motor oil (in 1-gallon, sealed containers) ▪ Drinking glasses ▪ Empty gasoline cans ▪ Window pane glass ▪ Foil pouches ▪ Blister packs ▪ Egg cartons (foam) ▪ Keys ▪ Motor oil containers ▪ Used oil filters ▪ Packing peanuts ▪ Prescription drug containers

2.3.3 Organics Collection

Yard wastes are banned from disposal in MSW landfills in the state of Washington.

SPU provides single-family residents with a weekly collection service for organics.⁷ Residents can choose a different-size wheeled cart (13-, 32- or 96-gallon) to participate in this service. Either container is provided free of charge as a part of the collection service. Residents are not provided with an in-house organics container.

SPU charges single-family residents for the organics collection service with rates varying by size of container (see Table 2-2). All single-family residents must subscribe to the service, unless they compost their food waste in an approved, backyard compost system.

TABLE 2-2
Seattle's Food and Yard Waste Collection Service
Monthly Rates for Single-Family Residents

Service Level (weekly)	Curb or Alley (per month)	Weight Limit	Dimensions
13-gallon (mini-can)	\$4.95	20 pounds	11"W x 12"D x 27"H
32-gallon	\$7.45	60 pounds	21"W x 23"D x 40"H
96-gallon	\$9.50	180 pounds	29"W x 34"D x 46"H
extra yard waste (per bundle)	\$4.75	60 pounds	4' x 2' x 2'

⁷ SPU increased the collection frequency for organics from single-family residences from bi-weekly to weekly in April 2009.



The organics collection service includes the collection of meat, poultry, seafood, and bones as well as yard trimmings, food-soiled paper, and food scraps. However, kitty litter, diapers, oil, and grease are not accepted for collection in the organics container (see Table 2-3).

TABLE 2-3	
Seattle's Residential Organics Collection Service	
Items Collected in the Organics Cart	
Acceptable Items and Materials	Not Acceptable
<p>FOOD-SCRAPS</p> <ul style="list-style-type: none"> ▪ Fruit and vegetables ▪ Bread, pasta, grains ▪ Eggshells, nutshells ▪ Coffee grounds, filters ▪ Tea bags ▪ Meat, fish, and chicken ▪ Dairy products - milk, butter, cheese ▪ Shells and bones <p>FOOD-SOILED PAPER</p> <ul style="list-style-type: none"> ▪ Paper towels, napkins - kitchen only ▪ Paper plates - uncoated only ▪ Food-soiled newspaper ▪ Greasy pizza boxes ▪ Shredded paper ▪ Paper bags (uncoated) with food scraps ▪ Compostable bags ▪ Approved compostable tableware <p>YARD WASTE</p> <ul style="list-style-type: none"> ▪ Plant material ▪ Grass ▪ Leaves, branches, twigs - up to 4 inches in diameter and 4 feet in length ▪ Plant and tree trimmings ▪ House plants - no pots ▪ Small amounts of sod - less than 60 pounds ▪ Holiday trees - no tinsel, ornaments, no longer than 6 feet long and 4 inches in diameter ▪ Bundles up to 4 feet long and 2 feet in diameter, tied with natural twine 	<ul style="list-style-type: none"> ▪ Biodegradable containers (unless approved by the City's compost contractor) ▪ Styrofoam containers ▪ Dirty coated paper cups, and plates. Clean ones can be recycled ▪ Disposable utensils ▪ Grease and fats in lidded container ▪ Facial or toilet tissue ▪ Diapers ▪ Pet waste and litter

Residents are prohibited from using plastic bags to contain organic discards but can use compostable bags. SPU acknowledges that odors and flies are potential problems associated with the organics collection service. The following guidelines have been issued to help residents to address these issues:

- Use old newspaper to line carts and kitchen containers and/or wrap food scraps in newspaper or paper towels.



- To reduce odors, sprinkle baking soda in the kitchen container, and food and yard waste cart.
- Wash kitchen containers thoroughly with detergent and water after every use.
- Use a vacuum cleaner to remove fruit flies.
- Put melon scraps immediately into the organics cart and cover the cart.
- Rub vinegar around the rim of kitchen containers.
- Cover food scraps in the organics cart with yard waste, shredded paper, or damp newspaper.
- Take the organics cart out to the curb each week even if it is not full.

2.3.4 Garbage Collection

All single-family residents are required to subscribe to a weekly collection service for garbage.

Residents can choose a can (12- or 20-gallon) or wheeled cart (32-, 64- or 96-gallon) to participate in this service. The can or roll-out container is provided as a part of the collection service.

Residents are allowed to place wastes that are not collected in the recycling or organics carts into the garbage container, including diapers, feminine hygiene products, cat litter and animal feces, clothing, linens, rags, and plastic items (i.e., wrappers and films) not targeted for recycling (see Table 2-4).

TABLE 2-4 Seattle's Residential Garbage Collection Service Items and Materials Collected in the Garbage Cart	
Acceptable Items and Materials	Not Acceptable
<ul style="list-style-type: none"> ▪ Styrofoam containers ▪ Dirty coated paper cups and plates. Clean ones can be recycled ▪ Disposable utensils ▪ Grease and fats in lidded container ▪ Facial or toilet tissue ▪ Diapers ▪ Pet waste and litter ▪ Household trash/litter ▪ Hoses ▪ Garden tools ▪ Bundles tied with wire, nylon cording, or plastic banding ▪ Loose soil ▪ Rocks/gravel ▪ Biodegradable containers unless marked "Approved" by City's compost facility contractor 	<ul style="list-style-type: none"> ▪ Syringes and other sharps ▪ Painted or treated wood ▪ Ducts ▪ Small appliances ▪ Microwave ovens ▪ Bulky wastes ▪ Large appliances ▪ Bed frames ▪ Electronics ▪ Computers/laptops ▪ Monitors ▪ Copiers/fax machines



SPU charges residents for the garbage collection service on a volume-based fee schedule (see Table 2-5). The revenues received for this service are used to pay for both the waste collection and the recyclables collection services.

Service Level (weekly)	Curb or Alley (per month)	Backyard (per month)	Weight Limit	Dimensions
micro-can (12-gallon)	\$18.65	not available	20 pounds	18"W x 15"D x 13"H
mini-can (20-gallon)	\$22.90	not available	30 pounds	15"W x 16"D x 21"H
one can (32-gallon)	\$29.80	\$41.70	60 pounds	24"W x 33"H
one 64-gallon cart	\$59.60	\$83.45	120 pounds	27"W x 29"D x 41"H
one 96-gallon cart	\$89.40	\$125.15	180 pounds	29"W x 34"D x 46"H

It is important to note that there are some items (such as discarded electronics or painted wood) that are not accepted in the garbage container. Residents are encouraged to drop these items off at one of the City's transfer stations or to have them collected at the curb. Both of these options involve additional fees.

2.3.5 Bulky Waste Collection

SPU does not provide a regularly scheduled bulky waste collection services but offers single-family residents the option of scheduling a curbside collection service for bulky waste items on an as-needed basis. The following items are collected as part of the bulky waste service:

- Appliances, refrigerators, freezers, stoves, dishwashers, dryers, trash compactors, air conditioners, and washing machines.
- Beds (box springs and mattresses).
- Furniture, dressers, cabinets, tables, chairs, and sofas.

SPU charges a fee of \$30 per item for this service.⁸ Residents can also drop their bulky waste off at one of SPU's two transfer stations for a fee of \$30 per appliance or \$30 per trip for other bulky wastes.

⁸SPU charges \$38 for refrigerators containing CFCs.



2.3.6 Electronics Collection

SPU provides single-family residents with an option to request the curbside collection of electronics waste (such as computers, monitors, and televisions) on an as-needed basis. SPU charges a fee of \$20 per pickup for this service.⁹

Residents can also drop their bulky waste off at one of SPU's two transfer stations for a fee of \$30 per appliance or \$30 per trip for other bulky wastes.

2.3.7 What's Not Collected Curbside

Based on an analysis of the items that are allowed to be placed in one of the three bins or set out for bulky waste or electronics collection, it appears that the following items are not collected at the curb by any of the services.

- Oil-based paint, paint thinners, and stains.
- Florescent light bulbs and tubes.
- Household cleaning products.
- Lawn and garden products.
- Propane and butane tanks.
- Antifreeze and other automotive products.
- Needles and syringes.
- Pool and spa supplies.
- Solvents.

Residents are encouraged to drop off these items free of charge at one of SPU's two household hazardous waste drop-off locations.¹⁰

2.4 Multi-Family Collection Services

2.4.1 Introduction

About 45 percent of Seattle's population of 634,535 residents live in multi-family apartment buildings. The 132,840 apartment units contained in the approximately 6,000-multi-family buildings equate to about 22 units per building. As described above, multi-family buildings are defined by SPU as buildings which contain more than four apartment units and utilize dumpsters for garbage collection.

⁹Three items and 60-pound limit.

¹⁰Residents can also use one of King County's household hazardous waste drop-off sites or mobile service.



*Figure 2-2. Seattle Multi-Family Building
Source: Seattle Solid Waste Plan - 2011 Revision*

2.4.2 Recyclables Collection

Multi-family building managers can utilize 1-, 1.5- or 2-CY dumpsters or either 64- or 96-gallon rollout containers, which are provided free of charge, for the collection of recyclables from their residents. Residents are instructed to place recyclables commingled into the rollout containers, which is collected on an every-other-week basis at the curb. Recycling dumpsters used in larger buildings are collected once per week. SPU does not charge multi-family building managers for the recyclables collection service.

2.4.3 Organics Collection

Seattle apartment and condominium properties of five or more units are required by law to provide a food waste collection cart for residents to use. As a result, SPU provides organics collection services to multi-family buildings in Seattle through its two franchise contract service providers.

The same rules that are described above for single-family residents for recycling organics apply to multi-family residents. Of particular importance in this regard is the prohibition against the use of plastic bags to contain the food wastes.

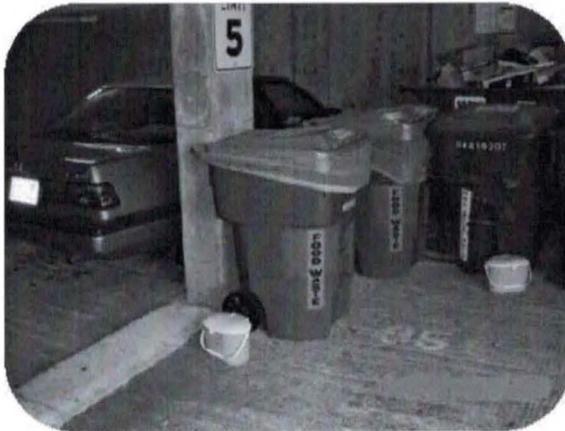


Figure 2-3. Organics Collection Containers at a Multi-Family Building in Seattle
(Source: Seattle Solid Waste Plan - 2011 Revision)

SPU offers two multi-family building service options:

- Curb/Alley Weekly Service – Carts must be set out weekly at the curb or alley by 7:00 a.m. and retrieved after collection. This is the most economical option.
- On-Site Service – Collectors access and empty the carts wherever they are located and at the desired collection frequency. Weekly collection is the most common option.

SPU has developed guidelines for the cart sizes and collection frequencies that are likely to be needed by apartment buildings of different sizes (see Table 2-6).¹¹ The monthly rates charged by SPU for organics collection from multi-family buildings are presented in Table 2-7. In this regard, it should be noted that all carts include compostable liners for carts used primarily for food waste and that the service provider driver is required to insert a fresh liner in each cart after the cart is tipped.

Size of Building	Recommended Cart Size
5 - 20 units	32 gallon (60 lb. weight limit)
20 - 40 units	64 gallon * (120 lb. weight limit)
40 - 100 units	96 gallon ** (180 lb. weight limit)
100 or more units	Add an additional 96 gallon cart **

*Larger cart sizes are recommended if apartment building owners have yard waste.

¹¹These guidelines are based on the monitoring of 40 properties over a year's timeframe.

TABLE 2-7
SPU Rates for Organics Collection from Multi-Family Buildings

Cart Size	Frequency	On-site Service Monthly Cost	Curb/Alley Service Monthly Cost
32 gallon	Weekly	\$27.68	\$7.45
64 gallon	Weekly	\$53.88	Not available
96 gallon	Weekly	\$63.16	\$9.50

2.4.4 Garbage Collection

SPU provides a dumpster-based garbage collection service for multi-family building residents. The restrictions regarding what multi-family residents can put in their garbage containers are the same as described above for single-family residents. The rates charged by SPU for this collection service are provided in Table 2-8. These rates include the costs of providing the recyclables collection service to multi-family residents.

TABLE 2-8
SPU Garbage Collection Rates for Multi-Family Dumpster Service*

Service Type	Monthly Rate for Weekly Pickup	Special Pickups, per container
3/4 yard	\$ 168.11	\$ 50.47
1 yard	\$ 188.57	\$ 56.62
1.5 yard	\$ 229.49	\$ 68.90
2 yard	\$ 270.41	\$ 81.19
3 yard	\$ 352.25	\$105.76
4 yard	\$ 434.08	\$130.33
6 yard	\$ 597.76	\$179.47
8 yard	\$ 761.43	\$228.61

*Rates are for non-compacted garbage.

2.5 Processing and Disposal Facilities

2.5.1 Introduction

The City of Seattle contracts with private service providers for recycling processing, organics composting, and landfill long-haul and disposal.

2.5.2 Recyclables Processing

SPU directs its two contractors (Waste Management and Cleanscapes) to bring the recyclables collected from Seattle’s residents and small businesses to the Republic Services’ materials recycling facility (MRF) in Seattle since Republic has the processing



contract with the City. Commercial businesses can contract with any private recycling company they choose.

2.5.3 Organics Processing

The organics collected from Seattle's residents and business are taken to the Cedar Grove compost facility in Everett, Washington, for processing. This facility is an open-air facility that utilizes the GORE® Cover and the OdoWatch™ systems to process the collected organics and turn them into compost.



*Figure 2-4. Cedar Grove Compost Facility
(Source: <http://cedar-grove.com/what-we-do>)*

2.5.4 Garbage Disposal

The garbage collected from the city's residents and businesses is taken to one of the city's two transfer stations. The wastes are then hauled in transfer trailers to an intermodal rail facility at which the trailers are placed onto a train for transport to the Columbia Ridge landfill located in eastern Oregon for disposal.



Figure 2-5. Tipping of a Waste Transfer Trailer at the Columbia Ridge Landfill
(Source: Seattle Solid Waste Plan - 2011 Revision)

2.6 Residential Waste Diversion Rates

The residential waste diversion rates achieved in the city of Seattle in 2012 are presented in Table 2-9.

Number of Households	163,484		132,840		296,324	
Management Method	Single-Family Residences		Multi-Family Residences		All Residences	
	Tons	%	Tons	%	Tons	%
Recycled ¹	58,575	28%	22,146	30%	80,720	28%
Composted ²	91,549	43%	1,889	3%	93,439	33%
SUBTOTAL³	150,124	71%	24,035	32%	174,159	61%
Disposed ³	60,906	29%	50,497	68%	111,403	39%
TOTAL	211,030	100%	74,532	100%	285,562	100%

1. Seattle Public Utilities, Economic Services Section. Recycling Programs - Second Quarter 2013.
 2. The 2012 composting tonnages were calculated based on the difference between the total recycling/composting tonnages reported in the Seattle Public Utilities' 2012 Recycling Rate Report and the recycling tonnages reported in the "Recycling Programs - Second Quarter 2013" report (see note 1).
 3. Seattle Public Utilities. 2012 Recycling Rate Report. July 1, 2013.

As indicated, 71 percent of the waste generated by single-family residents in 2012 were diverted from landfill disposal through recycling and composting programs. It is noteworthy that the materials recycling rate achieved by single-family households (28%) is roughly equal to the disposal rate (29%). It is also noteworthy that the organics diversion rate (43%) was one and a half times higher than the materials recycling rate.

In contrast, only 32 percent of multi-family waste was diverted from landfill disposal in 2012. In this regard, it is interesting to note that the materials recycling rate for multi-family households (30%) is actually higher than the rate achieved by single-family households. However, only 3 percent of the multi-family waste stream was diverted as compost.

In total, 61 percent of the residential waste stream was diverted through recycling (28%) and composting (33%).

In light of the city's population of 634,535, the per-capita residential disposal rate was 0.96 tons/person/day in 2012 while the residential waste generation rate was 2.47 pounds per person per day.

2.7 Service Costs

Since the recycling collection service is provided free of charge, Seattle residents pay for both garbage and recycling collection services in their garbage bill. As discussed above, residents are charged a variable rate depending on the size of their garbage container.

Data for 2012 on the types and number of residential customers and their associated rates are presented in Table 2-10. As shown, the total costs paid by single-family residential customers for their garbage and recycling services (collection, processing, and disposal) were \$55.7 million in 2012. These costs equate to an average monthly rate of \$28.37 per household, and an average cost of \$466 per ton of recyclables/waste managed.¹² In this regard, the SPU reported an average net cost of \$166.45 per ton for the collection and processing of recyclables.¹³

TABLE 2-10
Seattle Public Utilities Residential Customers
Recycling and Disposal Service Costs – 2012

Type	Size	Unit	Frequency	Percent	Households	Monthly Rate	Annual Cost	Cost/Ton
Single-Family								
Micro	12	Gal	Weekly	12%	19,830	\$18.65	\$4,438,063	
Mini	19	Gal	Weekly	28%	45,743	\$22.90	\$12,570,051	
One Can	32	Gal	Weekly	54%	87,758	\$29.80	\$31,382,144	
Two Cans	64	Gal	Weekly	6%	10,152	\$59.65	\$7,267,012	
Totals				100%	163,483	\$28.37	\$55,657,271	\$466
Multi-Family								
Dumpster Service	1	CY	Weekly		132,840	\$11.09	\$17,682,098	\$243

¹²Seattle Public Utilities, Economic Services Section. *Garbage Report - 2nd Quarter 2013*. Report Date: July 29, 2013.

¹³Seattle Public Utilities, Economic Services Section. *Recycling Programs - 2nd Quarter 2013*. Report Date: July 25, 2013. These costs include the average amount SPU pays the recycling processing and collection contractors, which is a total contract price plus or minus a variable amount determined by the market prices received from the sale of the recovered recyclables.



For the dumpster-based garbage service used by multi-family residents, the total costs incurred were estimated \$17.7 million in 2012. These costs equate to an average of \$11.09 per household per month and an average cost of \$243 per ton.¹⁴

Residential customers are charged separately for organics collection and processing services. The costs incurred for these services are presented in Table 2-11.

TABLE 2-11
Seattle Public Utilities Residential Customers
Organics Program Service Costs – 2012

Type	Size	Unit	Frequency	Percent	Households	Monthly Rate	Annual Cost	Cost/Ton
Single-Family								
Can Premises	13	Gal	Weekly	22%	31,961	\$4.95	\$1,898,483	
Can Premises	32	Gal	Weekly	9%	13,912	\$7.45	\$1,243,733	
Can Premises	90	Gal	Weekly	65%	95,883	\$9.50	\$10,930,662	
Totals*				96%	141,756	\$8.27	\$14,072,878	\$172
Multi-Family								
Curb/Alley Service**	32	Gal	Weekly	100%	132,840	\$1.38	\$2,199,830	\$1,165

*4% of SF customers are exempt
 **Assumes 100% subscribe to lowest cost service (32-gallon container - \$27.68 per month). Assumes 32 gallon cart serves 20 units.

As shown, the total costs paid by single-family residential customers for their organics service (collection and processing) were \$14.1 million in 2012. These costs equate to an average monthly rate of \$8.27 per household and an average cost of \$172 per ton of organics managed.

For multi-family residents, the total costs incurred were estimated by assuming that all apartment building owners subscribed to the lowest cost service – namely, a 32-gallon cart collected at the curb or alley on a weekly basis. Based on this assumption, the costs incurred would have been \$2.2 million in 2012, which equate to an average of \$1.38 per household per month and an average cost of \$1,168 per ton.

2.8 Source-Separation Recycling Systems – Conclusions

The following observations are offered with respect to Seattle's residential source-separation recycling system:

- The system requires the delivery of 2.5-weekly curbside collection services to each single-family resident. As waste/recycling collection typically represents the largest cost element

¹⁴The multi-family costs are based on the rate for a 1 cubic yard, uncompacted dumpster container service once per week which serves 17 multi-family households. The SPU reports that this is the most common dumpster service provided to multi-family buildings. The rate charged for this service is \$188.57 per month.



in solid waste management programs, it is not surprising that the cost of providing these services is relatively high.

- The quality of the recyclables and organic wastes recovered through these programs is high due to the fact that these items and materials are kept separate from the waste at the source.
- There is no curbside collection services for the following products and materials:
 - Paints and solvents.
 - Household and landscape chemicals.
 - Needles and syringes.

Based on typical participation rates in household hazardous waste collection days or permanent centers, it is likely that most of these products and materials are being landfilled.

- Residents are required to keep their recyclables, food waste, and other organics separated from their mixed wastes. This approach requires additional work on the part of each resident and, in the case of food waste, causes residents who participate to experience a certain amount of unpleasantness (odors, flies, food-waste-container cleaning and sanitizing, etc.) to participate in the program.
- The streamlining of the Seattle approach by reducing the frequency of waste collection to every-other-week would result in certain items (such as pet waste, diapers, and other used sanitary products) being collected every other week instead of weekly.

3.0 THE MIXED WASTE RECYCLING SYSTEM

3.1 Introduction

As described above, source-separation recycling programs typically require the delivery of two to three collection services per week to each resident to collect (1) recyclables (2) yard wastes and other organics, and (3) mixed waste. They also require that residents participate by keeping their recyclables and organics separated from the waste container at their residence and placing them in separate containers at the curb for collection.

While participation rates have ranged from less than 50 percent in some neighborhoods to over 70 percent in others, no program has yet to achieve 100 percent participation. Program participation for some types of residents, such as those living in multi-family buildings, has been particularly difficult and problematic.

Because of the persistent issues associated with resident participation, solid waste managers have continued to explore different approaches to residential curbside recycling. Significant progress has been made over the last 20 years with respect to the development of new machinery and technologies to enhance the recovery of recyclables and organics from mixed waste. These technologies include optical sorting systems, air stream classification, disc screens, and bag-breaking equipment.

As a result, a small but growing number of communities have elected to implement recycling systems that do not require the source separation and separate collection of recyclables and organics, but instead utilize new processing technologies at MRFs to recover recyclables and organics from the mixed waste stream. As described in Section 1, the city of Houston has decided to implement a "One Bin For All" program that will not require its residents to source-separate their recyclables but rather will process all residential waste for the recovery of recyclables at a mixed waste processing facility.¹⁵

The purpose of this section is to present a case study of another community - San José, California - that has embraced the mixed waste collection and processing option for residential recycling for its multi-family residents.

3.2 The San José Mixed Waste Recycling System

3.2.1 Introduction

The City of San José has been a leader in the field of recycling materials from solid waste for over 20 years and was one of the first municipalities in the United States to develop a "Zero Waste Plan." The California Department of Resources Recycling and Recovery (CalRecycle) reported a 74 percent waste diversion rate for the City in 2010.¹⁶

Despite this success, the City found that the achievement of high recycling rates for its multi-family residents presented a persistent problem for a number of reasons. First, effective outreach to this population has been challenging since apartment dwellers are a more transient population with diverse language requirements. In addition, multi-family buildings often suffer from the "tragedy of the commons" problem, where no one takes responsibility for shared trash and recycling areas. For these reasons, the diversion rate achieved by this residential subsector was historically low. For example, in 2003, the City's multi-family collection contractor reported a diversion rate of only 18 percent achieved by the multi-family source-separation recycling program.¹⁷

¹⁵<http://www.recyclingtoday.com/houston-one-bin-for-all-bloomberg-winner.aspx>. Accessed 8-21-13.

¹⁶City of San José Environmental Services Department. *Integrated Waste Management Zero Waste Strategic Plan*. November 2008. http://www.sjrecycles.org/PDFs/ZeroWasteStrategicPlan_complete.pdf.

¹⁷*Ibid.*



To enhance the recovery of recyclables and organics from multi-family residents, the City modified its diversion program for multi-family complexes in 2008 to include the processing of mixed waste generated by these complexes. Instead of sending most multi-family garbage directly to the landfill, the City's collection services contractor – GreenTeam of San Jose – now delivers all the solid waste collected from its multi-family residences to a solid waste processing facility in San José.

It should be noted that the City still provides source-separated recyclables collection services for multi-family residents and that multi-family residents are still encouraged to source-separate their recyclables. The processing of mixed waste from multi-family residences for materials recovery is viewed as adjunct method that enables further recovery and diversion of multi-family residential waste.

It should also be noted that the source-separated recyclables collected from multi-family residents are not processed at the mixed waste processing facility but are taken to a source-separated materials recovery facility (MRF) for processing.

3.2.2 Recyclables and Mixed Waste Collection

The City's contractor – GreenTeam of San Jose – provides recycling and garbage collection services to all of the 100,000 multi-family housing units located in the 3,337 apartment and condominium complexes in San José.¹⁸

The recyclables are collected in a single stream fashion by GreenTeam and are taken to the GreenTeam MRF for processing. The mixed waste collected from multi-family residences is delivered to a MRF owned and operated by GreenWaste for processing.¹⁹

Garbage rates include waste collection as well as once-a-week collection of recycling bins or carts (see Table 3-1). All recyclables go together into the same recycling bin.

The monthly service fee is based on:

- The frequency of collection.
- The number and sizes of all the garbage dumpsters in use at each complex.

¹⁸GreenTeam of San Jose is a local San Francisco Bay Area recycling company providing innovative collection and processing services to the City of San José.

¹⁹GreenWaste is a privately owned and operated recycling and diversion company located in San José that specializes in the collection and processing of residential and commercial trash, yard trimmings, curbside recyclables, food waste and construction and demolition debris.



TABLE 3-1
San José, California
Multi-Family Garbage/Recyclables Collection Rates

Garbage Bin Size (cu yd)	Standard Recycling Bin Size (cu yd)	Number of Collections Per Week (Recycling Collection Once Per Week)				
		1	2	3	4	5
1	1	\$99.20	\$179.65	\$260.13	\$340.62	\$421.11
1.5	1.5	\$124.59	\$228.58	\$332.58	\$436.58	\$540.56
2	2	\$150.64	\$278.17	\$405.70	\$533.20	\$660.71
3	3	\$201.54	\$376.11	\$550.66	\$725.22	\$899.76
4	4	\$252.46	\$474.06	\$695.63	\$917.24	\$1,138.85
5	5	\$303.35	\$571.97	\$840.62	\$1,109.29	\$1,377.92
6	6	\$354.26	\$669.95	\$985.61	\$1,301.29	\$1,616.99
8	8	\$456.05	\$865.83	\$1,275.56	\$1,685.33	\$2,095.09

3.2.3 Mixed Waste Processing

GreenTeam of San Jose delivers the mixed waste collected from multi-family residences in San José to the GreenWaste MRF for processing. Located in the City of San José, this 96,000-square foot facility processes residential and commercial waste, yard trimmings, curbside recyclables, food waste, and construction and demolition (C&D) debris.²⁰

The GreenWaste MRF, which was constructed in 1999, was originally designed to process recyclable materials, yard trimmings, and C&D debris.²¹ In 2008, a massive reconstruction project was undertaken that involved the installation of two side-by-side processing lines – one for source-separated recyclables and another for mixed waste processing. As a result, the MRF is now permitted to process up to 2,000 tons per day of mixed solid waste and single-stream recyclables. The side-by-side design results in reduced costs due to economies of scale and the combined processing of recovered materials from both lines.

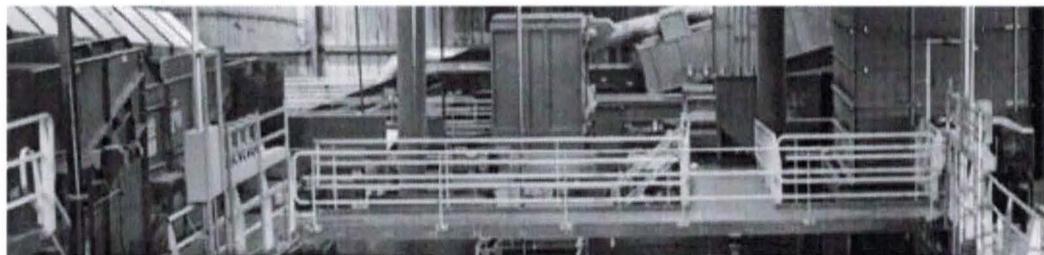


Figure 3-1. GreenWaste Material Recovery Facility (Courtesy: GreenWaste)

²⁰<http://greenwaste.com/about-us/material-recovery-facility-mrf>.

²¹GreenWaste/Zaner Sustainability Report. 2012.

Processing at the facility starts with the manual sorting, which is followed by mechanical processing and then manual sorting of separated materials for quality control. The mechanical sorting equipment and processes include bag breakers, screens, separators, magnets, optical sorters, and an eddy-current separator. The bulk of the wastes and recyclables processed at the MRF come from San José's multi-family residences.

The mixed waste processing line, which can process up to 30 tons per hour, consists of pre-sort stations, a bag breaker, a trommel screen, a drum separator, a polishing screen, and quality-control post-sort stations. To maximize materials recover, mixed recyclables pulled from the MSW line during the pre-sort step are transferred to the pre-sort conveyor of the single-stream line for processing. Unsorted materials, consisting largely of organics, are composted at the Z-Best Composting Facility in Gilroy, California.

At the Z-Best facility, all materials are processed in an enclosed 20,000-square-foot building to remove non-compostable items. The compostable items are then shredded and transported to the composting area where they are ejected into a 350-foot-long bag that houses all the compostable wastes. PVC pipes are also introduced into the bag and used to aerate the compostable materials. Retention time in the bags is about four months, after which the contents are removed, turned, and cured prior to screening. The materials are then transported to a screening system that is used to remove any larger materials, which are then disposed. The smaller compostable materials are stockpiled and cured for an additional four weeks before being screened again.

Samples of compost products are sent monthly to an independent laboratory to be tested for nutrient value, contamination, and pathogen reduction. The organic compost is sold primarily to farmers in the area as well as material yards and landscapers. In 2010, Z-Best sold over 115,000 tons of compost products.

3.2.4 Mixed Waste Diversion Rates

Since the reconstruction project, the GreenWaste MRF has consistently recovered more than 98 percent for recyclable materials and 75 percent of the mixed waste processed at the facility. Under its contract with the City, GreenWaste must achieve a minimum diversion rate of 70 percent for residential solid waste collected from multi-family dwellings.

To ensure contract compliance, GreenWaste is required to conduct semi-annual audits of the program's performance based on a minimum sample size of 40 tons. During the audit, the mixed waste is hand-sorted into four categories: (1) sorted recyclables, (2) compost feedstock, (3) lost tons (due to evaporation of moisture), and (4) residue. The average values based on the results of nine audits are presented in Table 3-2.

As indicated, the City estimates that 22 percent of the mixed waste processed is recovered as sorted recyclables. Another 48 percent of the waste processed is recovered as compost.

**TABLE 3-2
GreenWaste Recovery Multi-Family MSW Sorts
Data Summary***

Facility/Parameter	Tons	Percent of Tons Delivered to GWR
Tons Delivered to GWR	457.21	100%
GreenWaste MRF		
Sorted Recyclables	100.73	22%
GWR Residue	50.84	11%
Compost Feedstock	287.55	63%
GWR Lost Tonnage**	18.09	4%
TOTAL	457.21	100%
Z-Best Composting Facility		
Total Screened Compost	219.69	48%
Z-Best Residue	62.03	14%
Z-Best Lost Tonnage**	5.83	1%
TOTAL	287.55	63%

*Data compiled from nine audits conducted from September 2008 through July 2013.
**Tonnage lost due to moisture evaporation.

3.2.5 Mixed Waste System Costs

An analysis of the costs of the San José mixed waste recycling system is presented in Table 3-3. The service rates charged to multi-family building owners cover the costs of both recyclables and garbage collection and processing. The monthly service fee is based on the frequency of collection and the number and sizes of the garbage containers in use at each complex.

The most popular collection service contracted for by multi-family building owners is a 3-cubic yard (CY) waste container serviced twice a week. The monthly charge for this service (which covers the two weekly waste collection services, two weekly recyclables collection services, and the costs for processing the waste at the GreenWaste MRF) is \$376.11, which equates to \$4,513.32 per year.

A multi-family household in San José generated 0.74 tons of waste (excluding recyclables) in FY2013. Assuming a bulk density of 250 pounds per CY, this equates to 5.92 CY of waste. Therefore, the 3-CY container collected twice per week service would serve about 53 multi-family households, costing each household \$85.64 per year.

The City currently pays GreenWaste \$81.51 to process each ton of MSW at its mixed waste MRF, which equates to \$60.32 per multi-family household per year. Subtracting this



Source-Separation and Mixed Waste Recycling Systems: A Comparative Analysis

amount from the total household cost of \$85.64 leaves \$25.32 per year to cover the four weekly collection services or \$6.33 per collection service per household per year. Since two of the four weekly services are for waste collection, a multi-family household incurs costs of \$60.32 for waste processing and \$12.66 for waste collection for a total of \$72.98 per year or \$6.08 per household per month for waste collection and processing.

Similarly, a monthly cost of \$1.06 per household per month (\$6.33 times 2 divided by 12) is incurred for recyclables collection. In this regard, it should be noted that the cost of processing source-separated recyclables is included with the collection rate. Revenue from the sale of collected materials is kept by Green Team as an incentive to maximize resource recovery.

Collection Service Data	
Dumpster Size (Cu. Yds.)	3
Monthly Service Rate	\$376.11
Annual Service Cost	\$4,513.32
No. Collection Services per Week (2 garbage, 2 recycling)	4
Collection Frequency (times per year)	52
Cubic Yards (CY) Collected per Year:	
MSW	312
Recyclables	312
Total	624
Cost per Cubic Yard (includes processing)	\$7.23
Cost of Collection Services	
Tons MSW Collected per Year from each Multi-Family Household	0.74
Assumed Bulk Density (Lbs/Cu.Yd.)	250
CY of Waste Collected per Year from each Multi-Family Household	5.92
No. of Multi-Family Households served by 3-CY/twice a week service	53
Cost per Multi-Family Household per Year	
Total Cost	\$85.64
Minus MSW Processing Costs	-\$60.32
Collection Costs	\$25.32
Cost for each Collection Service	\$6.33
Cost for MSW Collection (twice a week)	\$12.66
Total MSW Collection/Processing	\$72.98
Cost per Multi-Family Household per Month	
MSW Collection/Processing Cost	\$6.08
Recyclables Collection/Processing Cost	\$1.06

3.2.6 Observations

The following observations are offered with respect to San José's approach to the collection and processing of wastes from multi-family buildings in a mixed waste MRF:



- The City recognized that participation by the apartment building residents in the source-separated recycling program was low – with diversion rates amounting to 18 percent of the waste stream. For this reason, the City decided not to pursue a source-separated approach for organics diversion but instead process the mixed waste stream from apartment buildings for materials and organics recovery.
- This organics collection approach is referred to be "invisible" to the resident and property owner. The placement of a separate organics dumpster at each complex is not required nor is a separate collection service needed. The downside, however, is the production of a lower quality compost due to the contamination of the organics from other components in the mixed waste stream.

4.0 COMPARATIVE ANALYSIS OF SOURCE-SEPARATION RECYCLING AND MIXED WASTE RECYCLING SYSTEMS

4.1 Introduction

The cost and performance data collected for the Seattle source-separation recycling system and the San José mixed waste processing system can be used to conduct a preliminary analysis of the benefits and drawbacks of each system option. Since the San José mixed waste recycling system only processes waste from multi-family residences, the waste diversion and cost analyses presented below only apply to the services provided in each city for multi-family residents.

This section also includes an analysis of the additional air pollution and accident risks associated with the source-separation recycling system option. Both of these negative impacts are directly related to the additional collection vehicles that are used to collect the source-separated recyclables and organics. These impacts are analyzed for source-separated recycling collection services provided to single-family residents in a hypothetical community with 163,500 single-family households.

4.2 Waste Diversion

The diversion rates of the two recycling systems achieved for multi-family residents are presented in Table 4-1. This table includes diversion data for both the source separation and mixed waste diversion programs instituted for multi-family buildings in San José.

As indicated, the source-separation recycling approach in Seattle is achieving a higher materials recycling rate for multi-family residences than the mixed-waste recycling approach implemented in San José. However, as the table indicates, 19 percent of the multi-family waste stream in San José is recovered through the source-separation collection service provided to multi-family buildings before the remaining waste is processed at the mixed waste recycling facility. In this

regard, it is uncertain what portion of these recyclables would be recovered at the mixed waste recycling facility if the source-separation recyclable collection service was not provided. If a decision was made by the City of San José to discontinue the source-separation recycling for multi-family-residents and if 65 percent of the source-separated recyclables were recovered at the mixed waste recycling facility, then the materials recycling rate of the mixed waste recycling system would equal the rate being achieved in Seattle's source-separation recycling system.

TABLE 4-1
Comparative Analysis of Diversion Rates for Recycling Systems in Seattle and San José for Multi-Family Residences

Parameter	Source-Separation Recycling (Seattle)	Mixed Waste and Source-Separation Recycling (San José)		
		Mixed Waste Recycling	Source-Separation Recycling	Total
WASTE DIVERSION				
Materials Recycling	30%	18%	19%	37%
Organics Composting	3%	39%	0	39%
TOTAL	33%	57%	19%	76%

There are two benefits that the mixed waste recycling system option provides that are not provided by the source-separated recycling system option. The first benefit is the ability to divert organic wastes from multi-family residences. In this regard, the diversion rate for organics from multi-family households in Seattle was 3 percent compared to 39 percent in San José. As a result, the total diversion rate for multi-family residential complexes for the San José mixed waste recycling system (57%) is significantly higher than the 33 percent diversion rate achieved by the Seattle source-separated recycling system.

The second benefit is the potential for the mixed waste recycling system to produce a “Process-Engineered Fuel” (PEF). PEFs are different from the refuse-derived fuels (RDF) that have historically been produced and combusted in RDF-based waste-to-energy (WTE) systems in that they meet the "legitimacy criteria" established by the United States Environmental Protection Agency (EPA) for the recovery of non-hazardous secondary materials from MSW that are subsequently burned in combustion units.²²

According to the EPA, PEFs are classified as a non-hazardous secondary material (rather than as solid wastes) if:

- The material has been sufficiently processed to produce a fuel or ingredient product that meets the legitimacy criteria.

²²<http://www.epa.gov/epawaste/nonhaz/define/index.htm>. Accessed 9-11-2013.



- The material that has been determined through a case-by-case petition process not to have been discarded and to be indistinguishable in all relevant aspects from a fuel product.
- The material has been identified as a categorical non-waste fuel. Materials that have received a categorical non-waste determination from the Agency are listed in 40 CFR 241.3(b) and include:
 - Scrap tires that are managed under established tire collection programs.
 - Resinated wood.
 - Coal refuse that has been recovered from legacy piles and processed in the same manner as currently-generated coal refuse;

Legitimacy criteria for non-hazardous secondary materials used as a fuel in combustion units require that the non-hazardous secondary material must be managed as a valuable commodity based on the following factors:

- The storage of the non-hazardous secondary material prior to use must not exceed reasonable time frames.
- Where there is an analogous fuel, the non-hazardous secondary material must be managed in a manner consistent with the analogous fuel or otherwise be adequately contained to prevent releases to the environment.
- If there is no analogous fuel, the non-hazardous secondary material must be adequately contained so as to prevent releases to the environment.
- The non-hazardous secondary material must have a meaningful heating value and be used as a fuel in a combustion unit that recovers energy.
- The non-hazardous secondary material must contain contaminants at levels comparable in concentration to or lower than those in traditional fuels which the combustion unit is designed to burn. Such comparison is to be based on a direct comparison of the contaminant levels in the non-hazardous secondary material to the traditional fuel itself.

PEFs that meet the EPA regulations can be combusted in existing industrial or utility boilers. Importantly, while these boilers would have be subject to the section 112 Clean Air Act requirements, they would not have to meet the more stringent EPA section 129 Clean Air Act requirements which apply to WTE facilities. For both of these reason, the recovery of PEFs from MSW should have significantly lower associated costs than traditional WTE systems.

These provisions are codified in the non-hazardous secondary material (NHSM) regulations under the Resource Conservation and Recovery Act (RCRA) (40 CFR Part 241).

4.3 System Costs

The costs associated with the multi-family source-separated recycling system in Seattle and the mixed waste recycling system in San José are compared in Table 4-2.

TABLE 4-2
Source-Separation and Mixed Waste Processing Systems
Comparison of Costs for Multi-Family Customers

Alternative	Source-Separation Recycling		Mixed Waste Processing	
	Monthly Costs To Building Owner	\$/HH/Mo. ¹	Monthly Costs To Building Owner	\$/HH/Mo. ²
Waste/Recyclables Collection and Processing	\$188.57	\$11.09	\$376.11	\$6.08
Organics Collection and Processing ³	\$27.68	\$1.38		
Total		\$12.47		

¹Based on a monthly rate of \$188.57 charged by SPU for the weekly servicing of a 1 cubic-yard dumpster container. This service is reported by SPU to be the most common service contracted for by multi-family building owners. In 2012, a total of 50,497 tons of waste were collected for disposal from the city of Seattle's 6,000 apartment buildings containing 132,840 apartment units. Assuming a bulky density for non-compacted apartment waste of 250 Lbs/CY, these numbers translate to 17 pounds/apartment unit/week or 0.06 CY/apartment unit/week. An 1-cubic-yard dumpster would therefore serve a building containing 17 apartment units.

²See Table 3.3 for the derivation of this cost.

³The monthly rate charged by SPU for the weekly servicing of a 32-gallon container. SPU estimates that this size container can serve as many as 20 apartment units.

As indicated, the monthly rate charge by SPU for the weekly servicing of a 1-CY container is \$188.57. In 2012, a total of 50,497 tons of waste were collected for disposal from the city of Seattle's 6,000 apartment buildings containing 132,840 apartment units. Assuming a bulky density for non-compacted apartment waste of 250 pounds (lbs.) per CY, these numbers equate to 15 lbs./apartment unit/week or 0.06 CY/apartment unit/week. Therefore, a 1-CY container would serve a building containing 17 apartment units.²³ Dividing the monthly rate of \$188.57 by the 17 units served results in an equivalent cost of \$11.09 per multi-family unit per month.

For organics collection, SPU indicates that a 32-gallon container serviced weekly can serve up to 20 apartment units. Therefore, the monthly cost of \$27.88 equates to a cost of \$1.38 per apartment unit per month.

Based on this analysis, the equivalent rate charged per apartment unit for garbage, recyclables, and organics collection services in Seattle appears to be on the order of \$12.47 per unit per month.

The monthly rate charged by the city of San José for the twice-weekly servicing of a 3-cubic-yard dumpster utilized by a multi-family building is \$376.11. Based on the data and calculations provided in Table 3-3, these costs equate to \$6.08 per household per month.

²³In light of the 6,000 apartment buildings in Seattle, the average apartment building has 22 units.



Based on this preliminary analysis, it appears that the source-separated recycling system costs for multi-family households in Seattle are significantly higher than the corresponding mixed waste recycling system costs for multi-family households in San José. The likely reason is the costs of the extra curbside collection services provided in Seattle to collect the source-separated recyclables and organics.

4.4 **Air Pollution Impacts**

This section presents a generic analysis of the air pollution impacts for a community of 163,500 single-family households (similar in size to Seattle). The analysis is predicated on the scenario in which a community is considering the implementation of either a source-separated recycling system or a mixed waste recycling system to serve its single-family households. If the mixed waste processing system option is selected, the community would not have to provide an additional weekly collection services to collect source-separated organics and an additional bi-weekly collection service to collect single stream recyclables.

Historically, the recycling of materials and organics from MSW is generally viewed as being beneficial to the environment due to the energy savings associated with recycling as well as the conservation of natural resources. The impact of source-separated recycling systems on the local environment of communities participating in these programs, however, can be deleterious due to the air emissions generated by the additional collection services required by these systems.

For example, the collection of solid wastes from single-family residences historically has been accomplished by the provision of a single weekly collection service. Typically, one diesel-fueled refuse collection vehicle can serve on the order of 800 single-family households per day, or 4,000 households per week assuming a five-day work week. To serve a community with 163,500 single-family households would require the dispatching of approximately 41 collection vehicles on a weekly basis. The air emissions resulting from these collection vehicles include nitrous oxides, particulates, carbon monoxide, non-methane hydrocarbons, and carbon dioxide. As indicated in Table 4-3, the quantities of air pollutants emitted from 41 collection vehicles servicing 163,500 single-family households range from 1,627 pounds of particulates to 5.8 million pounds of carbon dioxide per year.²⁴

²⁴It should be noted that these emission estimates are based on the assumption that the collection vehicles will utilize diesel fuel.

TABLE 4-3
Air Pollution Impacts of Additional Source-Separation Collection Services

	Nitrogen Oxides	Particulates	Non-Methane Hydrocarbons	Carbon Monoxide	Carbon Dioxide
Collection Vehicles Emissions (Diesel Fuel)					
Grams/Mile ¹	25.27	0.7	0.875	0.912	2,552.17
Garbage Collection (Weekly)					
Households Served Per Truck	4,000	4,000	4,000	4,000	4,000
Waste Collected (Tons)	1,480	1,480	1,480	1,480	1,480
Miles Per Year	25,000	25,000	25,000	25,000	25,000
Megagrams Per Year	0.632	0.018	0.022	0.023	63.80
Pounds Per Year	1,393	40	48.500	50.700	140,655
Pounds of Emissions Per Ton of Waste Collected	0.941	0.027	0.033	0.034	95.037
Pounds of Emissions Per Household Served	0.348	0.010	0.012	0.013	35.164
Organics Collection (Weekly)					
Households Served Per Truck	4,000	4,000	4,000	4,000	4,000
Organics Collected (Tons)	2,240	2,240	2,240	2,240	2,240
Miles Per Year	25,000	25,000	25,000	25,000	25,000
Megagrams Per Year	0.632	0.018	0.022	0.023	63.80
Pounds Per Year	1,393	40	48.500	50.700	140,655
Pounds of Emissions Per Ton of Waste Collected	0.622	0.018	0.022	0.023	62.792
Pounds of Emissions Per Household Served	0.348	0.010	0.012	0.013	35.164
Recyclables Collection (Every Other Week)					
Households Served Per Truck	4,000	4,000	4,000	4,000	4,000
Recyclables Collected (Tons)	1,440	1,440	1,440	1,440	1,440
Miles Per Year	12,500	12,500	12,500	12,500	12,500
Megagrams Per Year	0.316	0.009	0.011	0.011	31.90
Pounds Per Year	697	20	24	25	70,328
Pounds of Emissions Per Ton of Waste Collected	0.484	0.014	0.017	0.018	48.839
Pounds of Emissions Per Household Served	0.174	0.005	0.006	0.006	17.582
Air Pollution Impacts - Additional SSR Collection Services²					
Total - All Three Services (lbs./yr)	142,783	4,067	4,971	5,197	14,417,138
Total - Garbage Collection Only (lbs./yr)	57,113	1,627	1,989	2,079	5,766,855
Added Air Emissions - Source-Separation Recycling (lbs./yr)	85,670	2,440	2,983	3,118	8,650,283
Passenger Cars:					
Grams/Mile ³	1.39	N/A	2.8	20.9	415.8
Miles Per Year	12,500	12,500	12,500	12,500	12,500
Pounds Per Year	38.3		77.1	575.4	11,448
Added Passenger Car Equivalents Due to SSR System	2,239		39	5	756

¹Inform. Greening Garbage Trucks: New Technologies for Cleaner Air. 2003.
²Total emissions are estimated for a community with 163,500 single-family residents. It is estimated that 41 collection vehicles are needed to provide a weekly collection service to this number of single-family residences.
³U.S. Environmental Protection Agency. Consumer Information: Emission Facts. April 2000.



As described above, source-separated recycling systems require the provision of one or more additional collection services per week to each single-family residence. If organics are collected on a weekly basis and recyclables are collected every-other-week, an equivalent of 1.5 additional collection services are needed to collect the source-separated recyclables and organics.²⁵ As a result, the following quantities of air pollutants would be added to the local air shed each year due to the provision of these additional collection services.

- Nitrogen Oxides - 85,670 pounds
- Particulates - 2,440 pounds
- Non-Methane Hydrocarbons - 2,983 pounds
- Carbon Monoxide - 3,118 pounds
- Carbon Dioxide - 8.65 million pounds.

Depending on the pollutant under consideration, these additional emissions are equivalent to adding up the emissions of up to 2,239 passenger cars – each traveling 12,500 miles per year – to the local air shed.

4.5 **Accident Risks**

This section presents a generic, preliminary analysis of the accident risks associated with the delivery of additional collection services to collect source-separated organics and recyclables for a community of 163,500 single-family households.

As stated above, the analysis is conducted for a hypothetical case in which a community is considering the implementation of either a source-separated recycling system or a mixed waste processing system - to serve its single-family households. If the mixed waste processing system option is selected, the community would not have to provide an additional weekly collection services to collect source-separated organics and an additional bi-weekly collection service to collect single stream recyclables.

The risks of truck accidents are also increased with the provision of additional collection services to collect source-separated recyclables and organics. In this regard, the National Transportation Safety Board (NTSB) published a safety study on crashes involving single-unit trucks in 2013.²⁶

According to the study, there are 8.22 million single-unit trucks registered in the United States, which travel more than 110.7 billion miles each year.²⁷ As shown in Figure 4-1, refuse collection trucks are defined as "Class Seven" single-unit trucks.

²⁵For the purpose of this analysis, it was assumed that each collection vehicle would service the same number of households served for waste collection - namely 800 households per crew per day - and would travel the same number of miles per year (25,000).

²⁶National Transportation Safety Board. 2013. *Crashes Involving Single-Unit Trucks that Resulted in Injuries and Deaths*. Safety Study NTSB/SS-13/01. Washington, DC.

Source-Separation and Mixed Waste Recycling Systems: A Comparative Analysis

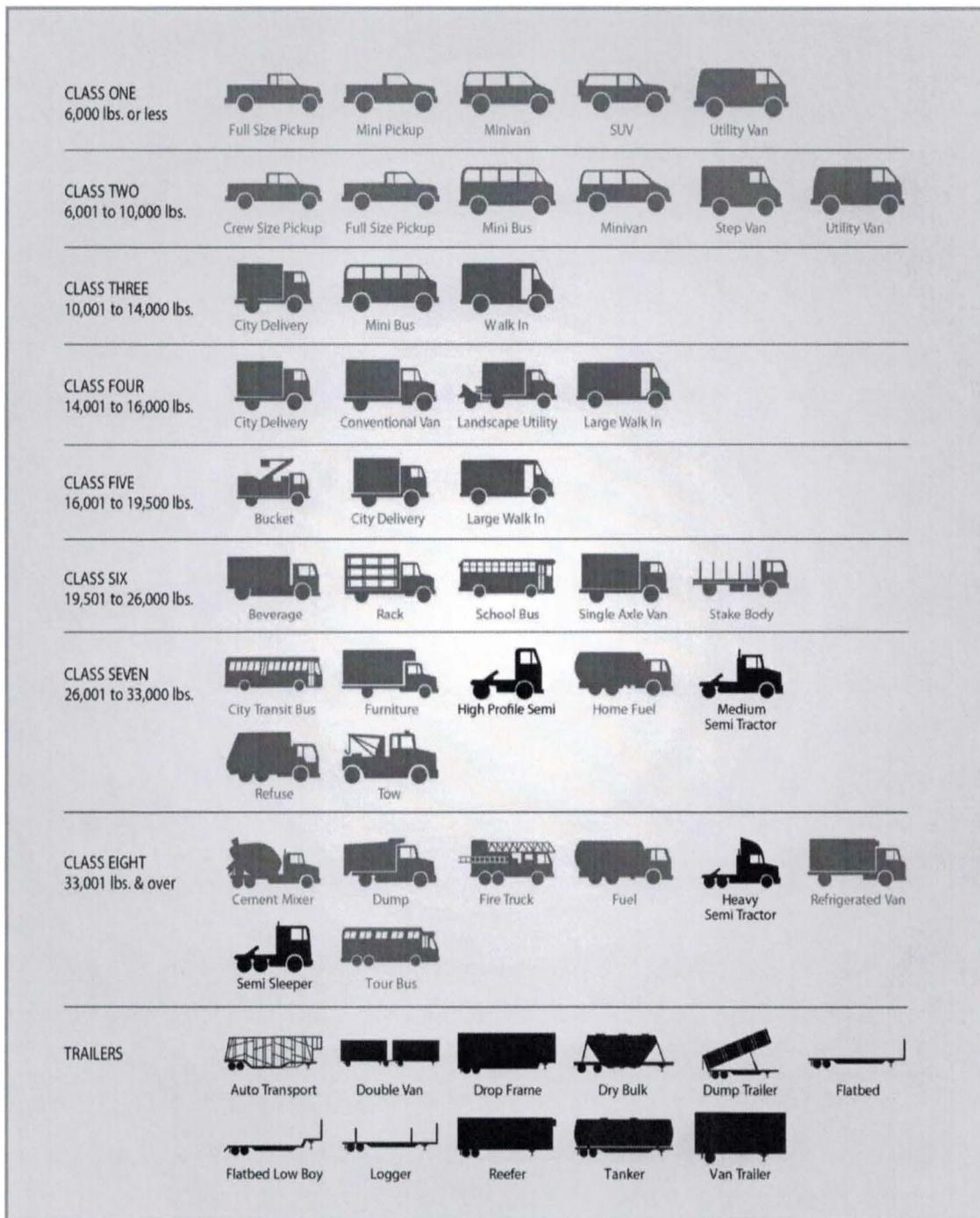


Figure 4-1. NTSB – Single-Unit Truck Classifications

²⁷Single-unit trucks are large trucks (gross vehicle weight rating over 10,000 pounds) with typically non-detachable cargo units that have all axles attached to a single frame. Tractor-trailers are defined as large trucks that have a connection enabling them to pull semi-trailers (no front axles).

Data from the NTSB report are presented in Table 4-4. As indicated, single-unit trucks have historically been involved in 0.112 accidents per million miles traveled.

Parameter	Data
Average Number of Accidents per Year (2005-2009)	12,354
Miles traveled (millions)	110,700
Accidents per million miles traveled	0.112

The additional curbside collection services required to collect source-separated organics on a weekly basis and recyclables every other week from 163,500 single family homes would require that these single-unit trucks travel an extra 1.575 million miles on community roads every year. In light of the NTSB study data, these additional truck miles would result in additional truck accident risks of 0.18 accidents per year in the local community (see Table 4-5).

Parameter	Number of Trucks	Miles/Year	Total Miles/Year
Source-Separation Recycling – Additional Truck Miles			
Organics Collection	41	25,000	1,025,000
Recyclables Collection	22	25,000	550,000
TOTAL			1,575,000
Accidents per Million Miles Traveled			0.11
Additional Accident Risks per Year – SSR System			0.18

5.0 CONCLUSIONS

Based on the analyses presented in this report, the following conclusions can be drawn with respect to the benefits and drawbacks of source-separated recycling versus mixed waste recycling systems:

- Both systems can achieve high diversion rates for residential wastes – on the order of 50 to 70 percent – of the residential waste stream. However, the mixed waste recycling system is able to achieve higher diversion rates for multi-family residential complexes due to its ability to divert significantly higher quantities of organics generated by multi-family residents.
- The source-separation recycling system recovers higher quality recyclables than the mixed waste recycling system. It is unclear what impact the difference in the quality of recovered

recyclables has on the market prices received for the recovered recyclables. Both systems appear to be able to market the recovered recyclables.

- The source-separated recycling system produces a higher quality compost from the recovered organics. It is unclear what impact the difference in compost quality has on the market prices received for the compost. Both systems appear to be able to market the compost produced from the recovered organics.
- The costs of the source-separated recycling system appear to be significantly higher than the mixed waste recycling system for multi-family residents due to the need to provide additional curbside collection services to residents.
- Because of the additional curbside collection services needed for source-separated organics and recyclables, the source-separated recycling system has a detrimental impact on the local air shed and results in additional truck accident risks to the local community.
- The source-separated recycling system is more inconvenient for residents and results in a higher degree of unpleasantness associated with organics diversion due to odors and vector issues.
- Finally, the mixed waste recycling system has the potential to produce a process-engineered fuel from the non-recyclable portion of the mixed waste stream that can be marketed to industries and utilities and can potentially displace the use of fossil fuels for electricity and heating.



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