DISTRICT OF COLUMBIA

COMPOST FEASIBILITY STUDY

April 2017

COMMISSIONED BY:

District of Columbia Department of Public Works

"The Preferred Choice"

PREPARED BY:

RRS

416 LONGSHORE DRIVE
ANN ARBOR, MI 48105
734.996.1361
RECYCLE.COM

TABLE OF CONTENTS

EXECUTIVE SUMMARY

Resource Recycling Systems (RRS) was hired by the District of Columbia Department of Public Works (DC DPW) to complete a composting collection progress and feasibility report. RRS developed an analytical model to address generation and potential capture of source separated organics (SSO[1]) in a curbside program for residents serviced by DC DPW. The report also includes generation rates and potential capture of SSO from commercially serviced multi-family residents, and the industrial, commercial, and institutional (ICI) sector. In addition, the feasibility of a commercial landscaper yard waste drop-off program was assessed. Finally, RRS examined the regional processing capacity of the Washington D.C. area, and the possibility of moving SSO through the transfer stations to a nearby processing facility. At the end of the assessment, RRS provided recommendations of transfer and a roll-out plan for the SSO curbside collections program.

The motivation for the District of Columbia to investigate a composting program stems from the Sustainable Solid Waste Management Amendment Act of 2014. The law sets an 80 percent diversion goal for all solid waste generated in the District from waste to energy (WTE) and landfill by source reduction, reuse, recycling, composting and anaerobic[2] digestion. The law requires that a compost collection feasibility study be conducted and gives authority to the Mayor to establish an organics collection program. This study fulfills the law's requirement for a Compost Collection Progress and Feasibility Report.

Currently, the District is composting between 5,000 and 7,000 tons of leaves collected during leaf pickup season. Leaf composting represents approximately one percent of the total waste that passes through the two DC DPW transfer stations. In addition to leaf composting, approximately 60 tons per year of food waste and garden debris is composted at community gardens located across the District. In 2016, there were 41 community gardens in the District, and the number of gardens is increasing at 25 percent per year.

[1] Source Separated Organics include household food waste, other sources of food waste and yard waste. SSO can also include some paper, wood chips and wood debris.

[2] Anaerobic means in the absence of oxygen, so that anaerobic digestion refers to decomposition without the presence of oxygen.

While there is demand for composting in the area, the regional organics recovery infrastructure has not grown in proportion to this demand. There are only two facilities within 40 miles of the District that accept both food and yard wastes. The Prince George's County facility in Upper Marlboro, Md. accepts 3,600 tons of food waste per year and is currently expanding capacity to accept 8,000 tons of food waste and 60,000 tons of yard waste per year. The other facility in the region is the Balls Ford Composting Facility operated by Freestate Farms in Manassas, Va. This facility is currently permitted to process 50,000 tons of yard waste and pre-consumer plant derived food waste per year, and plans to expand to 80,000 tons per year once permits are approved and phase I of the anaerobic digestion system and advanced aerated composting system comes online in April, 2018. A second expansion that would enable the facility to accept more than 150,000 tons per year of food and yard waste is also planned, but no definitive dates have been set. While the District may be able to work out an agreement with these facilities or other smaller facilities in the region to accept District generated food and yard waste, transfer costs are high at $37/ton or more. Thus, it is economically disadvantageous to transfer organics material collected in the District. Direct hauling of the SSO to a processing facility within the District is preferred. By avoiding transfer and collecting a tipping fee, it is estimated that the District could enable $12.35 million in capital, more than enough to build an in-District composting facility[3].

To address the District's infrastructure limitations, the District is scheduled to complete a co-digestion feasibility study in the FY 2017 to determine appropriate feedstock, suitable pre-processing technologies and associated costs, and the impacts of co-digestion on the operations of DC Water. However, given the ratio of food and yard waste generated in the District, RRS recommends that the District examine a covered Aerated Static Pile (ASP) composting solution for comingled food and yard waste. The advantages of ASP include odor control, vector/nuisance control, speedier material decomposition, better finished material quality and better neighborhood relations. All of these characteristics will make the opportunity to site a composting facility in an urban environment more likely. In addition, other benefits for the District include retaining the carbon value of the SSO, creation of approximately 6-12 fulltime facility operating jobs plus the additional staff required for collection, and circular economy bragging rights. Immediate actions the District can take towards in-District composting include the following:

- Prioritize locating a site for an in-District composting facility,
- Develop permitting and zoning requirements for composting and anaerobic digestion facilities,

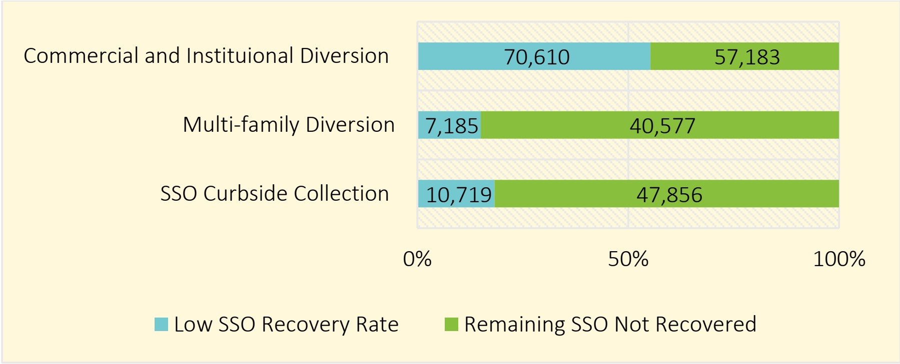
[3] RRS estimates that a ASP facility could generally be constructed for $7 million. Given the urban nature of this project the cost may be more, up to $11 million. A facility ranging in cost between $7 and $11 million on 10 to 20 acres could process 150,000 tons per year. More refined cost and size estimates require an engineering feasibility study.

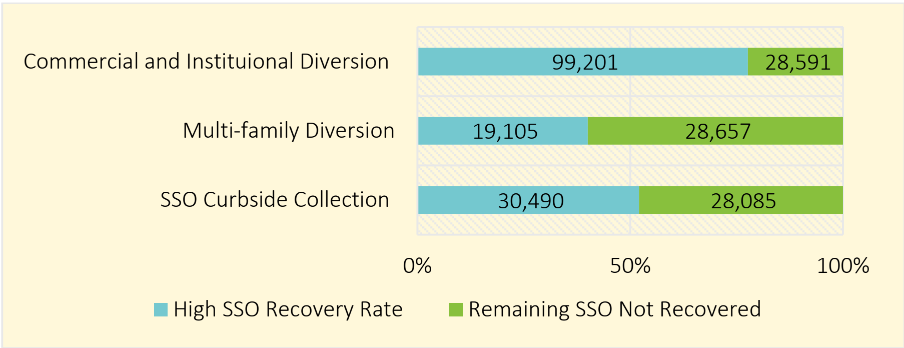
- Revise or repeal existing regulations that prohibit food waste to animal feed and disposal regulations of source separated organics from foodservice establishments, and
- Consider developing a requirement for large quantity food waste generators to compost once a facility is in operation, regulations around yard waste landfill diversion requirements and/or pay-as-you-throw program.

Once these infrastructure limitations are addressed, then the District may be able to capture and compost as much as 148,796 tons of organics per year or 60 percent of generation.

Table E1: Generation and Recovery Potential			
Sector	Generation	Recovery Potential Low	Recovery Potential High
	tons/year	tons/year	tons/year
SSO curbside collection program	21,056 to 59,221	10,719	30,490
Commercial landscapers drop-off potential	13,427	13,427	13,427
Multi-family diversion potential	17,962 to 47,761	7,185	19,105
Commercial and institutional potential	114,365	57,183	85,774
Total generation	166,810 to 234,774		
Total diversion potential		88,513	148,796

Figure E1: Potential SSO Recycling by Sector Low Generation (Top Figure) and High Generation Rates (Bottom Figure)





Commercial and Institutional Diversion in graph includes commercial and institutional diversion and commercial landscape drop-off diversion.

Outlined below is a five-year roll-out plan for SSO curbside collection program:

- Year One and Two – Securing Land for In-District Organics Processing Facility
    - Locate, design and permit a 10 to 20-acre site with an annual throughput capacity of up to 150,000 tons per year.
    - Site and facility construction will begin at the end of Year Two and be completed by the fall of Year Three to allow for collection and accumulation of fall leaves.

- Year Three – Continuation of In-District Infrastructure Development and First Program Roll-out Phase
    - While the District continues to develop the organics processing facility, the District should begin roll-out of food waste and yard waste collection to 33,037 households that are currently serviced by DC DPW[4], covering approximately 30 percent of DC DPW serviced households. During this time, the collected SSO will be direct hauled to a regional composting facility such as Prince George's County or Balls Ford Road Composting Facility. Alternatively, if the District is unable to secure a facility to accept comingled food waste and yard waste, the District should role out yard waste collection only to these households. The alternate roll-out plan would still require direct haul to a regional processing facility. It is recommended that the initial households include both households in the Outer-District area, which includes Wards 3, 4, 5, 7, and 8, and households in the Inner-District area, which includes Wards 1, 2, and 6. The purpose is to capture the differences in generation rates between the Inner-District and Outer-District areas. For example, it is anticipated that Ward 3 will generate substantially higher amounts of yard waste than Ward 6. It is crucial that during the initial roll-out, the District collects

[4] Residents currently serviced by DC DPW include single family residents and multi-family dwellings with three units or fewer.

data on participation rates, set-out rates, truck capacity, route timing, and seasonal variation.

- Year Four – Completion of In-District ASP Facility and Continue Program Roll-Out Phase
    - By year four, it is assumed the District will have completed infrastructure development for a covered ASP composting facility, and SSO will be processed within the District. In year four, the program will expand the SSO curbside collection program to an additional 33,981 DC DPW serviced households, capturing roughly another 30 percent of the DC DPW serviced households. It is clear from studies of other programs across North America that collection of yard waste is crucial in the economic feasibility of an SSO curbside program. Therefore, it is recommended that these additional households should include areas of the District with higher yard waste volume generation rates to ensure the program maintains a high collection tonnage for more reasonable processing costs per ton. In year four, the District should open the composting facility for commercial landscapers to voluntarily drop-off yard waste generated in the District.

- Year Five – Expansion Phase
    - Expand the SSO curbside collection program to include remaining 38,264 households serviced by DC DPW. It is still critical that the District closely monitor the SSO curbside collection program for participation, collection tonnage, truck capacity and efficiency of routes.

Table E2 outlines the net system costs of an SSO curbside collection program in years three, four, and five. It also outlines the total capital costs of containers and trucks. The table provides a cost range (low and high) in relation to low and high SSO generation rates when looking at program parameters including containers by ton, containers by household, and the total capital costs of trucks. The container costs are present regardless of generation, and, therefore, does not vary with generation amount.

Table E2: Net System Costs and Capital Costs			
	Year Three	Year Four	Year Five
Number of trucks required	9 to 13 trucks	14 to 23 trucks	21 to 35 trucks
Total number of staff required	29 to 42 staff	46 to 75 staff	68 to 114 staff
Net system cost with containers by ton	$567 /ton to $283 /ton	$428 /ton to $264 /ton	$453 /ton to $260 /ton
Net system cost with containers by household	$23 /HH to $31 /HH	$37 /HH to $56 /HH	$55 /HH to $84 /HH
Total startup capital cost of containers (accumulative)	$1,306,508	$2,801,672	$4,342,008
Total capital cost of trucks (accumulative)	$1,690,000 to $2,480,000	$2,790,000 to $4,580,000	$4,110,000 to $6,960,000

*HH stands for household. SSO collected the first year of collection (year three of plan) has a direct haul of 2 hours built in to account for the use of an out of District processing facility. Years four and five are assumed to be processed at the in-District composting facility, and the direct haul round trip is reduced to 50 minutes.

Other actions the District should take include the following:

- Continue to invest in community food waste drop off program and community gardens compost program to grow interest/awareness about composting for eventual curbside program,
- Expand composting to all DC public schools (DCPS), encouraging on-site composting for student learning,
- Start backyard composting program. The program should include education for residents such as a how-to class for composting, and could potentially provide vouchers for residents to purchase composting bins,
- Develop and implement household food waste reduction education and outreach campaign and 'grasscycling' campaign, and
- Undertake activities to increase recycling rates in areas of the District with lower recycling rates to ensure success of a composting program in these areas once it is rolled out.

BACKGROUND AND PURPOSE

RRS was hired by the DC DPW to conduct a compost collection progress and feasibility study. The study includes an analytical source separated organics[5] (SSO) curbside collections model for DC DPW serviced households (single-family and multi-family with 3 units or fewer). An analysis of SSO generation and potential capture for the commercially serviced multi-family households, and the industrial, commercial, and institutional (ICI) sector was also conducted. The study also includes a potential drop-off tonnage estimate for yard debris generated by commercial landscapers operating in the District. Finally, the regional processing capacity for SSO is discussed and recommendations on transfer of SSO and a five year roll-out plan are made.

The District spans nearly 70 square miles and is bordered by Montgomery County, Md. to the northwest, Prince George's County, Md. to the east, and Arlington and Alexandria, Va. to the south. More than 7,400 acres of land in the District is dedicated to parks, accounting for about 19 percent of the District's total area. The District has the second highest percentage of acreage of parkland for an urban city in the US[6].

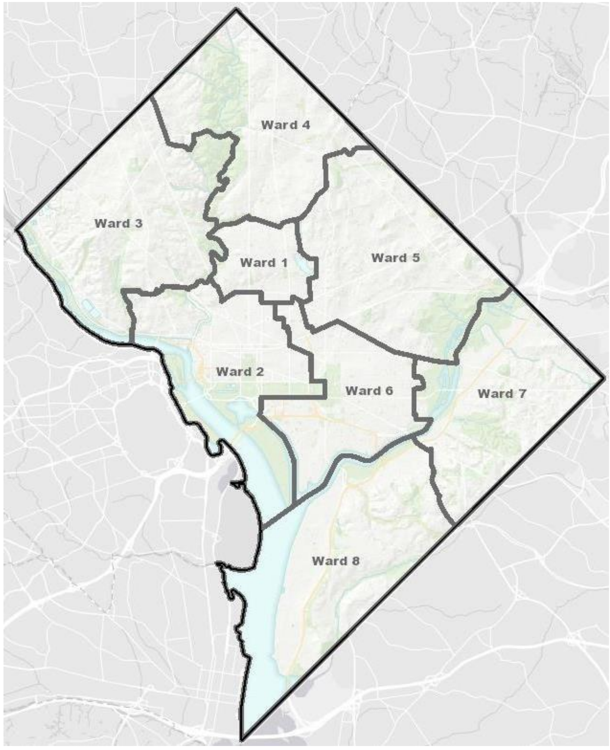
The 2015 U.S. Census Bureau estimates that more than 650,000 people are living in the District spread over eight wards. The wards are broadly divided between the three 'Inner-District wards', Wards 1, 2 and 6 and the five 'Outer-District wards', Wards 3, 4, 5, 7 and 8. Downtown Washington D.C. is in Ward 2, with major landmarks including the National Mall, The White House and the Smithsonian Museums. Georgetown and George Washington Universities are both located in Ward 2. Ward 2 is bordered by Ward 1 and 6. Capitol Hill, the Supreme Court and The Library of Congress are all located in Ward 6. Ward 1 is home to Howard University.

The Outer-District wards surround the three Inner-District wards in a semi-circle starting with Ward 3 to the west, circling around clockwise to Ward 4 to the northwest, Ward 5 to the north, Ward 7 to the northeast and Ward 8 to the east (see Figure 1). The Outer-District wards are mostly residential and have considerable greenspace including the United States National Arboretum managed by the U.S. Park Services, Rock Creek Park in Ward 4 and Fort Circle Park in Ward 7.

[5] Source Separated Organics include household food waste, other sources of food waste and yard waste. SSO can also include some paper, wood chips and wood debris.

[6] *2011 City Park Facts*. Trust for Public Land, 2011.

Figure 1: Map of the District of Columbia Wards

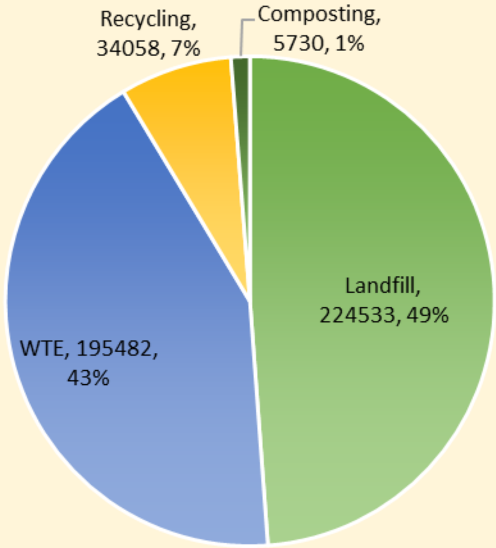


CURRENT OPERATIONS

There are two DC DPW transfer stations in the District, Fort Totten and Benning Road. Fort Totten is the more heavily used transfer station, taking about 60 percent of waste and recycling. Fort Totten allows for residential drop off every day 1 PM - 5 PM, and Saturdays 8 AM – 3 PM.

In FY 2015, 458,932 tons of refuse, recyclables and leaf litter were received at the District-owned transfer stations (Figure 2). Forty-nine percent of the total tonnage coming into the transfer stations went to landfills in Virginia and 43 percent of the total tonnage went to a waste-to-energy (WTE) facility in Lorton, Va. for disposal. Seven percent of the total tonnage coming into the transfer stations was recycled. The leaf litter was 5,729 tons, about one percent of the total tonnage, and was composted at either the ACME Biomass Reduction Facility in Brookeville, Md. or at the Prince George's County Facility, with 95 percent of that going to the ACME Biomass Reduction Facility. In FY 2015, the District spent over $4 million on leaf collection and composting. The majority of the waste and recycling (approximately 63 percent) is brought into the transfer stations by private haulers. The private haulers are servicing the ICI sector as well as multi-family housing in the District with four or more units. There is no estimate on the amount of waste and recycling brought to the transfer stations by private haulers from outside the District. The remaining 37 percent of waste and recycling arriving at the transfer stations is coming from DC DPW haulers who service single-family and multi-family units with three or fewer units. The total waste generation rate of the District is currently unknown. Figure 2 outlines the tonnage of material brought into the two DC DPW transfer stations in 2015.

Figure 2: 2015 Fate of Material Coming into DC DPW Transfer Stations (tons, %)



Source: DC DPW data.

Based on the DC DPW Trakster[7] route data, Wards 1, 2, 3 and 4 recycle on average more than 15 pounds per household per week, while Wards 5, 6, 7 and 8 recycle 15 pounds or less per household per week. Ward 3 features the highest recycling rates, with 21 pounds per household per week (Table 1). Ward 8 recycles the least pounds per household per week out of the eight wards.

[7] Trakster is an optimization routing company.

Table 1: HH Trash and Recycling by Ward

Ward	lbs. Trash/HH/week*	lbs. Recycling/HH/week
1	23	19
2	17	18
3	42	21
4	53	17
5	54	12
6	19	15
7	45	8
8	44	6
Average	37	14

*HH refers to households

In the past several years, the District has made major pushes towards greater sustainability. The Sustainable Solid Waste Management Amendment Act of 2014 was adopted by the District City Council. The Act aims to divert 80 percent of all solid waste generated in the District from waste to energy and landfill by source reduction, reuse, recycling, composting and anaerobic digestion. Separation of recyclables from refuse is mandatory, and separation of food waste and yard waste will be added once a composting collection program is adopted in the District. Private haulers operating in the District are required to deliver source separated materials to recycling or composting facilities, as appropriate. Private haulers will also be responsible for communicating source separation requirements to their customers. In this law, the District has the authority to place mandates on large generators and enact organics landfill diversion requirements. The Mayor may enact a pay-as-you-throw program, subject to the Council's approval. In addition to this, the Sustainable Omnibus Act of 2014 requires disposable foodservice ware used in foodservice establishments to be either recyclable or compostable, effective January 1, 2017. The law also requires the development of source separation education and outreach materials for the District.

SSO COLLECTION

The first portion of this report details the SSO curbside collection model for DC DPW serviced households, including diversion, capital investment, and operating cost estimates. This is followed by generation estimates and potential diversion for commercial multi-family households, the ICI sector, and commercial landscapers.

A review of successful organics programs elsewhere indicates the following program parameters are the most important:

- Co-collection of food waste and yard debris maximizes participation and diversion and is most economical on a cost-per-ton basis.

- Provision of interior household containers and exterior collection carts makes collection more convenient for residents and haulers.

- Use of plastic collection bin liners should be strictly limited to certified compostable bags and used only in the kitchen bin, bucket or pail, keeping in mind that many composting facilities prefer loose collection.

Collection costs can comprise 60-70 percent of total program costs, so selecting the best approach is a key critical element.

PROCESSING

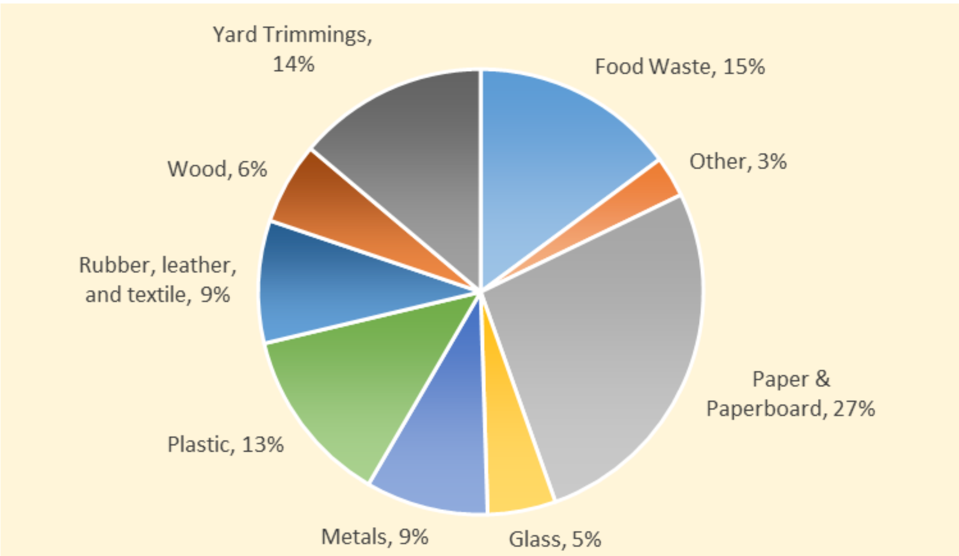
A mix of regulatory, capacity, technology and vendor capability issues relating to processing of food-based organics combine to challenge even the best thought-out organics recovery program. In the long-term, a processing approach that incorporates state-of-the-art technology and a convenient location is desirable. Currently there is limited capacity to compost SSO in the District and surrounding region, and this will need to be considered in the roll-out of any composting program. An analysis of the capability of the current transfer stations to accept SSO and capital cost associated with construction of a new transfer station or improvements to current transfer stations is provided in the transfer stations section.

ORGANICS COLLECTION

SSO is often called "organics" but in actuality, the term "organic waste" includes a variety of biodegradable feedstocks, including yard debris, wood chips, brush, waste wood, manure, household organics[8] (HHO) and some waste paper.

Leaves, grass and brush (or yard debris) are the organic components of the waste stream most often considered for collection at the residential curb. Together with other organics such as food scraps and soiled paper, organics makes up a considerable percentage of the overall residential waste stream. Figure 3 shows typical residential and commercial waste stream characteristics. A U.S. Environmental Protection Agency fact sheet estimates 57.5 percent of yard trimmings were "grasscycled" or composted in 2014, while only 2.8 percent of food scraps were recovered.

Figure 3: Typical Residential and Commercial Waste Stream Composition



Source: U.S. EPA Residential/Commercial Solid Waste Composition (2014)

Collecting one or more types of organic waste from residential sources is an integral part of any composting system. Collection economics are important because collecting organics is generally more than twice the processing cost on a per ton basis.

[8] Household Organics refers to food waste generated inside a residence.

The success of organic waste collection depends on several variables:

- Type/characteristics of organic waste to be collected,
- Type of collection container,
- Seasonal volume fluctuations,
- Available processing capability,
- Volume of material collected/economy of scale, and
- User convenience and participation.

In the appendix, the reader will find more detail on the characteristics of organic waste, common considerations in designing the organics waste stream, frequent issues related to organics collection, composting in the DCPS, types of digestion systems, volume and capacity considerations, process economics, and prevention and recovery solutions for food waste.

PROCESSING TECHNOLOGY

Composting is the most cost effective option for recycling food waste. While composting is a "natural" process, many technologies and engineered approaches are applied to processing food and other organic wastes into marketable compost. These range from low-tech windrowing to sophisticated, capital-intensive digester operations. Each of these techniques is designed to create an environment for reduction and stabilization of organic materials, but vary in their applicability to SSO recovery.

Four technologies are reviewed in Table 2; each has its own advantages and disadvantages pertaining to residentially generated SSO.

Table 2: Processing Type Survey

Technology	Type	Description	Time to finished product	Applicability to SSO
Windrowing	Outdoor open air	Organic material is mixed and formed into long trapezoidal rows. Material is periodically turned and mixed.	3-9 months	Food waste must be adequately mixed with yard debris and bulking agents (wood chips) to balance the carbon-to-nitrogen ratio (C:N) and follow "best practices" for odor prevention.
Static Pile	Outdoor open air	Air is pumped into large pile to speed decomposition.	1-2 years	As above, need to balance the carbon-to-nitrogen ratio (C:N) and follow "best practices" for odor prevention.
Aerated Static Pile	Outdoor, indoor, or in-vessel System	HHO is mixed with higher carbon-content materials, and formed into long cylindrical rows and encased in a plastic bag "sleeve". Air is introduced into the bags.	4-6 months	Popular for animal manures and growing in application for additional high-nitrogen materials. As above, need to balance the carbon-to-nitrogen ratio (C:N) and follow "best practices" for odor prevention.
Anaerobic Digestion	Outdoor enclosed anaerobic	Organic material is typically mixed and warmed in a closed, airtight tank. Microorganisms break down or "digest" organic material without the presence of oxygen, typically for 6 weeks. Energy recovery from methane generation is common.	15-40 days	Household, industrial, institutional, and commercial organics (e.g. food waste) provide excellent nutrient sources in the digester. Not a solution for large amounts of yard waste.

Evaluating the best long-term technology options for the District involves the consideration of:

- Feedstock volume,
- Biological engineering (aerobic versus anaerobic), and
- Access to end-markets.

A detailed discussion of composting technology options, volume and capacity considerations, process economics, prevention solutions, and recovery solutions are presented in the appendix section.

ORGANICS OUTREACH

Experience gained from organics collection efforts elsewhere provides strong support for the following outreach and education recommendations:

- Early and Often: Let residents know what is coming so that they can expect a change. HHO collection is a new concept for many people and will require continual education and frequent reminders.
- Containers: Provision of “kitchen” containers are an effective tool for program roll-out. The container is a good tool for increasing participation since it serves as a visual reminder to separate organics for collection. The right secondary containers (rolling toter carts) that are easy to use and “engineered” (i.e. venting, drainage) also help increase participation.
- Address the “yuck” factor upfront. Help residents understand how to avoid odor and related problems. Post information in a variety of places, including labels on the carts, websites, telephone “hotlines” and other program information sources.
- Emphasize the tremendous diversion/waste reduction opportunity that comes with organics recovery. This helps residents know they are making a difference.

To follow the outreach theme of “early and often”, a dedicated budget should include ample funding in advance of start-up and on an ongoing basis. RRS recommends a level of effort approaching $2/HH/year to cover year-one start-up and roll-out costs, and $1.50/HH/year for ongoing programming[9]. This level of effort is built into the residential organics recovery model described below and will help ensure that participation is maximized and that residents prepare materials properly for collection. This budget also assumes that other community resources such as the media and “stakeholder” groups, will supplement the outreach effort.

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[9] Note that the educational costs outlined here are rough numbers and do not take into account staffing or mailing costs.

SSO CURBSIDE COLLECTION MODELING

A residential organics recovery model for 105,282 households was prepared for the District to analyze the feasibility, cost and roll-out options for different scenarios of an SSO collection program serving single-family and multi-family with three units or less. The model incorporates factors such as organics generation rate, route participation rate (derived from recycling data), compaction ratios, material densities, household pass-by rates, financial terms, labor costs and processing tip fees[10]. The assumptions and results of the model are presented in the following sections.

ASSUMPTIONS AND VARIABLES

Several variables that are part of the assumptions are particularly important. They include:

- Generation Rate for Residential Curbside Collection – Residential organics, including food waste and yard debris, are generated at somewhat predictable rates, although these rates vary based on the range of items accepted in the food waste stream, whether or not brush is included with yard debris, and seasonal variations. Generation rates take into account both the waste generation rate of District residents based on DC DPW data and estimations of food waste generation based up analysis from ReFED[11], a collaborative study on national food waste generation. For the purpose of estimating volumes for the District, two ranges of volume were applied to each scenario for DC DPW serviced households:
    - HHO generation: 200 (low) and 525 (high) pounds per household per year.
    - Yard debris generation: 200 (low) and 600 (high) pounds per household per year.
- Participation Rate – Participation rate is a complicated variable because it addresses participation across the entire year but not specifically on a weekly basis. The participation rate in conjunction with the generation rate determines the total quantity of material that is collected. Educational level and per capita income can affect the level of participation due to more stable living and

[10] Model results on routing, participation, number of trucks, and number of employees is derived from DC trakster data. Estimations of food and yard waste generation rates are derived from ReFED and the 2011 Solid Waste Characterization Study for the District of Columbia. Operating costs, labor costs, tipping fees, and all other budgetary data are based from DC data for FY 15.

[11] ReFED created the Roadmap to Reduce U.S. Food Waste in 2015: http://www.refed.com/?sort=economic-value-per-ton

housing arrangements where convenient access to city services, such as collection programs, are known and considered a basic service that a resident enjoys. Transient population further adversely impacts participation rates due to a lack of education about City services. Participation rate in the model is varied by recycling route based on variations in recycling participation rates observed from the DC DPW Trakster data. A higher participation rate was applied on routes where the routes in that area recycled on average more than 15 pounds per household per week, and a lower participation rate was applied on routes where the routes in that area recycled on average 15 pounds or less per household per week. Where services are provided at "no cost" to District residents the participation rates for SSO and yard waste programs are assumed to be between 30 and 50 percent for food waste and between 50 and 70 percent for yard waste (low and high participation rates respectively). Conversely in situations where residents have to actively choose these programs and make some effort to gain enrollment, the rates of participation only approach 15 and 30 percent for food waste and 30 and 50 percent for yard waste respectively. Also modeled is an exceptionally high participation rate with 50 to 70 percent for food waste and 70 to 90 percent for yard waste.

- Set Out Rate – An important factor that needs to be determined is how many households will set out organics on a weekly basis. Set out rate is different than participation rate. For example, a participating household may only set out a bin once a month, while their neighbor who also participates may set out a bin once a week. Both households are participating, but can have different set out rates. Furthermore, when set outs are fairly numerous, but the quantity of material set out is small (i.e. five pounds per household per week) then the overall capacity of the collection vehicle is limited not by volume, but by the number of stops a driver can make in a single collection shift. When the quantity of material that is generated is high then the load capacity of the collection truck becomes a limiting factor and determines the number of trucks required to service all participating households or customers. A setout rate of 70 percent was used in this analysis.

- Pass-Bys –The number of pass-bys limits the truck tonnage. For these scenarios, the model assumes that no more than 750 households can be "passed by" on a day by one single truck given the nature of the routes in the District, mostly collection in narrow alleys that require the use of rear loading semi-automated collection trucks. This number is based on the current average number of DC DPW serviced households on a trash route.

- Tip Fee – A $35 per ton tip fee is assumed for organics processing and transfer in the short term. This tip fee is within a range of quoted tip fees from regional facilities. However, it is likely that there will need to be further negotiations to define the transfer and composting cost in the event that this project moves forward. Actual tip fees could be $5 – $10 per ton less if accompanied by a larger tonnage and a longer-term contract for processing and transfer.

- **Number of Trucks** – In general the number of trucks required for collection of organics was calculated by quantifying the anticipated volumes of recovery.

- **Labor Costs –** The following labor costs are built into the operating costs portion of the model:
    - One regular driver per truck at $24.50 per hour,
    - Two loaders per truck at $19.70 per hour per employee,
    - One mechanic and one supervisor for every ten trucks at $28.50 per hour and $37.50 per hour respectively,
    - One fulltime management position for every 20 trucks at a cost of $200,000 per year, and
    - Workman's compensation and staff overhead.
- **Material and Operational Costs –** The following material and operational costs are built into the operating costs portion of the model:
    - Utilities, $500 per year per truck,
    - Vehicle Insurance, $5,500 per year per truck,
    - Fuel and fluids, $9,000 per year per truck,
    - GIS/GPS management, $900 per year per truck,
    - Vehicle repair and maintenance supplies, $4,500 per year per truck,
    - Vehicle tires and roadside service, $500 per year per truck,
    - Accidental payouts, $100 per year per truck,
    - Licenses, $500 per year per truck.
- Education Costs – Includes activities such as brochures, pamphlets, and other educational material or activities that go out to residents in advance of program start up and in the first couple years of the program start up.
    - First year costs: $2.00 per household
    - Second year costs: $1.50 per household

SELECTING A COLLECTION SCENARIO

For each scenario, it is assumed that all households have access to weekly SSO collection, including both yard waste and food waste. RRS assumed that participation rates would vary by recycling route according to the observed recycling participation rates. The costs presented in the three collection scenarios does not include any transfer cost. The costs can be thought of in terms of collection costs with the ability to compost in the District.

The Inner-District Wards 1, 2 and 6 were modeled assuming:

- One kitchen bucket per household,
- One 48-gallon cart per household, and
- 13 cubic yard semi-automated rear load truck.

The Outer-District Wards 3, 4, 5, 7 and 8 were modeled assuming:

- One kitchen bucket per household,
- One 64-gallon cart per household, and
- 16 cubic yard semi-automated rear load truck.

1. Scenario A: Medium participation for curbside collection, a participation rate most likely to occur when services are provided at “no cost” to city residents. Scenario A is referred to as the base case.

2. Scenario B: High participation for curbside collection, a participation rate that occurs when government policies such as organics diversion requirements and pay-as-you-throw programs are implemented, and a strong educational campaign is initiated.

3. Scenario C: Low participation for curbside collection, a participation situation where residents have to actively choose these programs and make some effort to gain enrollment.

SCENARIO A: BASE CASE MEDIUM PARTICIPATION

This scenario is considered the ‘Base Case’ with medium participation, and is used as the baseline for the roll-out period if services are provided at “no cost” to District residents and residents are automatically included in the program (no “opt-in”). For all routes, participation rates are higher for yard waste composting because of the “yuck” factor created by decomposing food in “food waste buckets” and in curbside carts and food waste collection might be less convenient.

Table 3: Scenario Assumptions									
		Routes							
		107-112	207-209	314-330	404-424	508-527	604-618	711-716	813-816
FW participation rate	Med	50%	50%	50%	50%	30%	30%	30%	30%
YW participation rate	Med	70%	70%	70%	70%	50%	50%	50%	50%
Set-out rate	Med	80%	80%	80%	70%	70%	70%	70%	70%

* FW is defined as food waste and YW is defined as yard waste

Table 4: Scenario A, Base Case Medium Participation, Results			
		Low Generation	High Generation
	Food waste diversion (HHO)	4,441 tons	11,657 tons
	Yard waste diversion	6,278 tons	18,833 tons
Program Details	Total SSO diversion	10,719 tons	30,490 tons
	Required number of new trucks	21 trucks	35 trucks
	Net system cost per ton	$552 /ton	$296 /ton
	Net system cost per household	$56 /HH	$86 /HH
	Total staff needed for program	68 staff	114 staff
Capital Costs	Total startup capital cost of containers	$4,342,008	$4,342,008
	Total capital cost of trucks	$4,110,000	$6,960,000
Annualized Costs	Annual cost of program	$6,401,120	$10,414,677
	Annual money saved from landfill/WTE haul and tip fee	($488,661)	($1,390,060)
	Total annual cost of program	$5,912,459	$9,024,618

In this scenario, between 10,719 and 30,490 tons of SSO could be collected per year and would require 21 to 35 new trucks and 68 to 114 new staff for collection, depending on if generation rates are low or high respectively. The net system cost per ton is nearly halved for a high generation rate from $552 per ton if generation rates are low, to $296 per ton if generation rates are high. The reason the cost per ton decreases significantly from low generation to high generation is that the cost of containers, a fixed cost regardless of generation rate, is spread over more tonnage. While the cost per ton decreases from low to high generation rates, the cost per household increases when more SSO is collected. That is because when more SSO is collected, the processing costs increase significantly.

The capital cost of the base case scenario includes the purchase of kitchen buckets, 48 or 64-gallon toter carts, and new collection trucks. The purchase of containers, both kitchen buckets and toter carts, is $4.34 million, and the purchase of trucks for collection would range from $4.11 to $6.96 million.

The annual cost of diverting 10,719 to 30,490 tons of SSO from the landfill and/or waste to energy facility is between $488,661 to $1.39 million, and this cost savings is reflected in the total annual cost of the program of $5.91 to $9.02 million per year. While there is some cost savings in diverting material from the landfill and WTE facility, the amount of diversion is not enough to reduce the Inner-District trash collection from two days per week to one day per week. Only a 3 to 4 cubic yard reduction in volume collection on Inner-District routes is expected based on weekly trash generation rates. However, the current average cubic yards of trash collected per load if the two weekly pickups were collapsed into one is over 20 cubic yards. Since the truck size is limited to 13 cubic yards in the Inner-District, a reduction of 3 to 4 cubic yards from 20 cubic yards still will not be accommodated by the current truck size. Table 5 shows a breakdown of food waste and yard waste collection expected by routes.

It is important to keep in mind that this scenario's generation rates do not fully take into account peak seasons in yard waste generation, such as leaf season. During leaf season, it is assumed that the District may need to rent extra trucks and hire temporary workers to manage the extra load. As a result, it is not anticipated that the District will see a cost reduction in annual leaf pick up during the leaf season.

Table 5: Scenario A by Household

Routes	Participating Households	Food Waste Low, tons/year	Food Waste High, tons/year	Yard Waste Low, tons/year	Yard Waste High, tons/year
107-112	4,199	526	1,382	588	1,763
207-209	2,966	356	934	415	1,246
314-330	9,163	1,303	3,420	1,283	3,848
404-424	9,013	1,021	2,681	1,262	3,785
508-527	5,503	462	1,212	917	2,751
604-618	4,414	447	1,172	736	2,207
711-716	4,787	250	657	798	2,393
813-816	1,678	76	200	280	839

SCENARIO B: HIGH PARTICIPATION

This scenario is considered the high participation analysis. High participation occurs in communities that place significant value on waste reduction and diversion and understand the full circle benefits of composting. Generating a community culture focused on these factors would involve continuous education on the reasons for and benefits of composting, a sense of trust and commitment in the District leadership, and, more than likely, time. Along with a community commitment to composting, convenience of the composting program is essential. Further things government can do to reach high participation levels is to consider programs such as pay-as-you-throw that charge residents based on the amount of garbage they generate, and requiring diversion of organics from the landfills.

Table 6: Scenario B Assumptions									
		Routes							
		107-112	207-209	314-330	404-424	508-527	604-618	711-716	813-816
FW participation rate	High	70%	70%	70%	70%	50%	50%	50%	50%
YW participation rate	High	90%	90%	90%	90%	70%	70%	70%	70%
Set-out rate	High	90%	90%	90%	80%	80%	80%	80%	80%

* FW is defined as food waste and YW is defined as yard waste

Table 7: Scenario B, High Participation Rates, Results			
		Low Generation	High Generation
	Food waste diversion (HHO)	6,547 tons	17,185 tons
	Yard waste diversion	8,383 tons	25,150 tons
Program Details	Organics diversion	14,930 tons	42,335 tons
	Required number of new trucks	24 trucks	49 trucks
	Net system cost per ton	$442 /ton	$289 /ton
	Net system cost per household	$62 /HH	$116 /HH
	Total staff needed for program	79 staff	162 staff
Capital Costs	Total startup capital cost of containers	$4,342,008	$4,342,008
	Total capital cost of trucks	$4,690,000	$9,280,000
Annualized Costs	Annual cost of program	$7,277,077	$14,167,571
	Annual money saved from Landfill haul and tip fee	($680,653)	($1,930,038)
	Total annual cost of program	$6,596,424	$12,237,533

If participation rates are high, 14,930 tons and 42,335 tons of SSO could be diverted from the landfill for low and high generation rates respectively. This would require an additional 24 to 49 trucks and 79 to 162 staff for the curbside collection program. The cost per ton in the low generation rate is $442 per ton, and $289 per ton in the high generation case. One method of ensuring adequate tonnage to reduce cost per ton below $400 per ton is to encourage participation as much as possible. The more participation, the greater the SSO diversion potential, the lower the cost per ton. High generation also keeps costs per ton down, however it should not be relied upon solely to keep cost per ton below $400 because generation rates can vary seasonally while participation rates will not.

SCENARIO C: LOW PARTICIPATION

A low participation scenario may occur if roll-out happens too soon to allow for adequate education of the community and infrastructure to be setup to handle the SSO. A low participation rate could also occur if the program is not convenient (e.g., opt-in) or residents do not understand why composting is valuable to them and their community.

Table 8: Scenario C Assumptions									
		Routes							
		107-112	207-209	314-330	404-424	508-527	604-618	711-716	813-816
FW participation rate	Low	30%	30%	30%	30%	15%	15%	15%	15%
YW participation rate	Low	50%	50%	50%	50%	30%	30%	30%	30%
Set-out rate	Low	70%	70%	70%	60%	60%	60%	60%	60%

* FW is defined as food waste and YW is defined as yard waste

Table 9: Scenario C, Low Participation Rates, Results			
		Low Generation	High Generation
	Food waste diversion (HHO)	2,541 tons	6,670 tons
	Yard waste diversion	4,172 tons	12,516 tons
Program Details	Organics diversion	6,713 tons	19,186 tons
	Required number of new trucks	18 trucks	24 trucks
	Net system cost per ton	$779 /ton	$340 /ton
	Net system cost per household	$50 /HH	$62 /HH
	Total staff needed for program	59 staff	79 staff
Capital Costs	Total startup capital cost of containers	$4,342,008	$4,342,008
	Total capital cost of trucks	$3,690,000	$4,850,000
Annualized Costs	Annual cost of program	$5,532,365	$7,392,449
	Annual money saved from landfill haul and tip fee	($306,051)	($874,709)
	Total annual cost of program	$5,226,315	$6,517,740

If participation and generation rates are low, then 6,713 to 19,186 tons could be collected. The program would require 18 to 24 trucks and 59 to 79 staff. In the low generation, low participation scenario the total tonnage collected is less than 10,000 and as a result the cost per ton is high at $779. Clearly, the District benefits significantly from higher participation to generate enough SSO diversion tonnage to spread out the capital costs. While the cost per ton in the low participation, high generation scenario is $340 per ton, much lower than the low generation case, generation rates vary throughout the year and cannot be relied upon to keep cost per ton down.

OTHER ORGANICS COLLECTION POSSIBILITIES

COMMERCIAL LANDSCAPER DROP OFF PROGRAM

Washington D.C. is known for abundant trees and greenspace. As such, a large amount of yard waste is generated from the ICI sector and generally managed by commercial landscapers. Nearly two-thirds of the organic material is managed by private tree services and would include material such as tree branches, stumps and leaves.

Currently yard debris and bulk waste is dropped off at the Fort Totten transfer station by residents of the District. Bulk collections and drop-off of bulk items includes couches, refrigerators, mattresses, and doors. In FY 2015, residents dropped off 12,382 tons of bulk waste and yard debris to the Fort Totten facility. There is no data collected specifically on the amount of yard waste dropped off by residents at the transfer station. It was also pointed out by many DC DPW employees that they suspect a number of residential drop-offs are actually commercial landscapers posing as residents. The DC DPW employees expressed that there is no justification of turning away drop-offs even if it is apparent the yard waste was generated by a commercial landscaper if a District identification can be presented. In FY 2015, the District spent more than $1.5 million on bulk collections and drop-off.

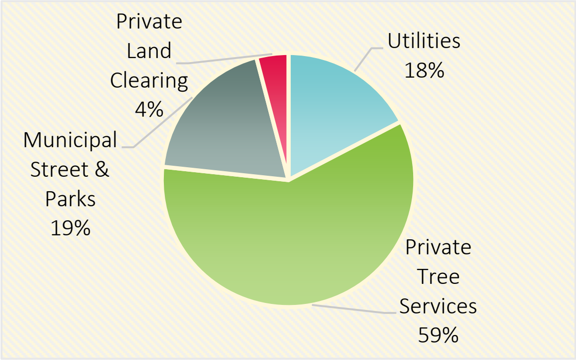
In 2011 a waste characterization study was conducted by ARCADIS/Malcom Pirnie and found that 20 percent of the waste coming to Fort Totten on DC DPW trucks was yard waste. Assuming a similar percentage of yard waste comprises the bulk waste, 2,476 tons of yard waste was collected via the bulk pile in FY 2015. Prince George's County compost facility estimates that 70 percent of yard waste drop-offs are from residents of the county and another 30 percent comes from commercial landscapers. Given that ratio of residential drops-offs to commercial landscaper drop-offs, the yard waste currently being dropped off by District residents would be 1,733 tons per year and commercial landscapers are dropping off 743 tons per year.

If the District opened up the transfer station to allow commercial landscapers to drop-off yard waste, an additional 13,427 tons per year of tree debris is possible[12]. This estimation is based on a 2002 study from the Minnesota Department of Natural Resources and adjusted for changes in length of growing season in the Washington D.C. region.

[12] Minnesota Department of Natural Resources, Urban Tree Residue, Minneapolis, March 2002.

Table 10: Sources of Yard Waste in the District	
Source	Tons per Year
Utilities	2,334
Private Tree Services	7,961
Municipal Street & Parks	2,583
Private Land Clearing	549
Total	13,427

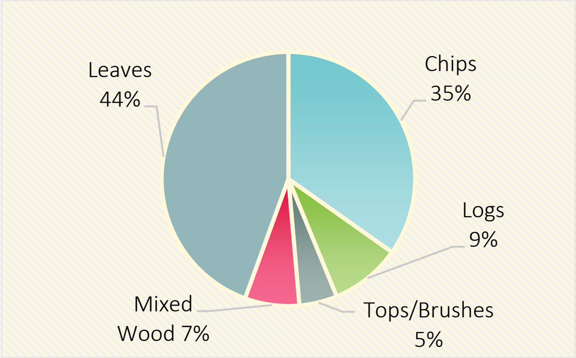
Figure 4: Source of Yard Waste in the District



Source: Minnesota Department of Natural Resources, Urban Tree Residue, Minneapolis, Minnesota March 2002.

Table 11: Wood Type Generation in the District	
Wood Type	Tons per Year
Chips	4,670
Logs	1,208
Tops/Brushes	649
Mixed Wood	932
Leaves	5,968
Total	13,427

Figure 5: Wood Type Generated in the District



Source: Minnesota Department of Natural Resources, Urban Tree Residue, Minneapolis, Minnesota March 2002.

Based on the analysis of the regional composting capacity, there is enough capacity in the region to manage composting 13,427 tons per year of yard waste. In order to transfer it is estimated that the District should set aside 20 square feet for each ton on the tipping floor or drop off area. If the District implemented this drop off program, 258 tons of yard waste would need to be stored per week at one of the transfer stations and would require approximately 5,000 square feet of space.

Table 12: Cost of Transfer from District					
Transfer to	Mileage	Total cost per ton at $0.075 cents/mile	Tipping Fee /ton	Total Transport /ton	Total Transport Cost
Prince George's County	26	$1.95	$35	$36.95	$496,128
Loudoun Composting	42	$3.15	$35	$38.15	$512,240
Harvest Recycled Green Industries	41	$3.08	$35	$38.08	$511,233
ACME	20	$1.50	$32	$33.50	$449,805
Freestate Farms	35	$2.63	$35	$37.63	$505,191

THE INDUSTRIAL, COMMERCIAL AND INSTITUTIONAL SECTOR

The ICI sector includes restaurants, hotels, colleges and universities, schools and grocery stores and suppliers. These sectors can provide excellent opportunity for low contamination collection in what is often referred to as "back door collection" or "back of house collection", referring to collection that occurs in the kitchens of restaurants, schools, colleges and universities. George Washington University is currently managing back door collection at two Starbucks locations on campus and diverting 150 tons per day in coffee grounds from landfill. These organics are being composted at the Prince George's County facility. The Smithsonian, Whole Foods and Mom's Organics are also composting food waste.

Using ReFED supported generation rates, an estimated 114,365 tons per year is generated by the ICI sector. Nearly 80 percent of food waste comes from perishable foods, which include prepared fresh deli items, meats, fruits and vegetables, seafood, milk and dairy, and some grain products such as bread and bakery items. In contrast, non-perishable foods — pastas, canned goods, and highly processed, shelf-stable products — are generally wasted less because they don't spoil as easily. Perishables often get discarded because they are inexpensive and quickly spoil. Pound per pound, fruits and vegetables are among the least expensive and fastest spoiling foods, constituting over 40 percent of total food waste. Conversely, seafood and meats are the two least wasted and most expensive food types.

Food waste derived from consumer-facing businesses and consumers reflects an estimated recovery and recycling rate of less than 10 percent nationally. Composting of food scraps has lagged behind rates achieved for other materials. Food scraps are composed of 70 percent water, requiring transport costs without any corresponding revenues, while the market values for the energy and compost end products made from scraps are relatively low compared to plastics and metals. For these reasons, municipalities and businesses have prioritized recycling schemes for other materials. The following table is an estimated quantity of food waste generated by the ICI sector.

Table 13: ICI generation and Capture				
Industrial				
	# of Employees	Generation tons/year	Potential Recovery 50% tons/year	Potential Recovery 75% tons/year
Bakeries	179	1,208	604	906
Beverage & Tobacco	22	223	112	167
Industrial Totals	201	1,431	716	1,073
Commercial				
Supermarkets and Grocery Stores	6,462	9,692	4,846	7,269
Full Service Restaurants	23,994	35,987	17,994	26,990
Limited Service Restaurants	11,093	12,205	6,103	9,154
Colleges/Universities	37,106	28,954	14,477	21,716
Elementary and Secondary Schools	10,715	3,038	1,519	2,279
Large Hotels	14,349	10,770	5,385	8,078
Assisted Living and Nursing Homes	7,562	2,460	1,230	1,845
Hospitals	28,055	10,226	5,113	7,670
Grocery Store Distributors	683	1,033	517	775
Commercial Total	140,019	114,365	57,183	85,774

Given a 50 percent recovery rate, the District could expect 57,183 tons to 85,774 tons per year in SSO from the commercial and institutional sectors, depending on low or high generation rates respectively. A small portion of organics, under 1,431 tons per year, are generated in the industrial sector and are not included in the estimated capture tonnage. Organics generated via the industrial sector are generally different in nature than the commercial sector, tending to be much higher portions of liquid. As a result, organics from the industrial sector can be extremely difficult to manage and thus are often not included in SSO diversion programs. However, industrial sector organics can be a good feedstock for co-digestion.

COMMERCIALLY SERVICED MULTI-FAMILY DWELLINGS

Multi-family dwellings with more than three units are not serviced by the DC DPW and instead have private haulers for trash and recycling pick up. SSO collection at multi-family dwellings is particularly difficult for a number of reasons including a generally more transient population and difficulty in making the programs convenient for residents. Many residents living in larger apartment buildings may have to walk up and down stairs or take an elevator to get to a trash dumpster. In general, people tend to be less willing to make several trips for garbage, recycling and organics. A transient population requires constant education initiatives that can be expensive. Due to these factors, the capture rate is estimated at 40 percent. For the estimated 163,287 multi-family households, an estimate 7,185 to 19,105 tons per year of food waste could be captured.

Table 14: Multi-Family Food Waste Generation

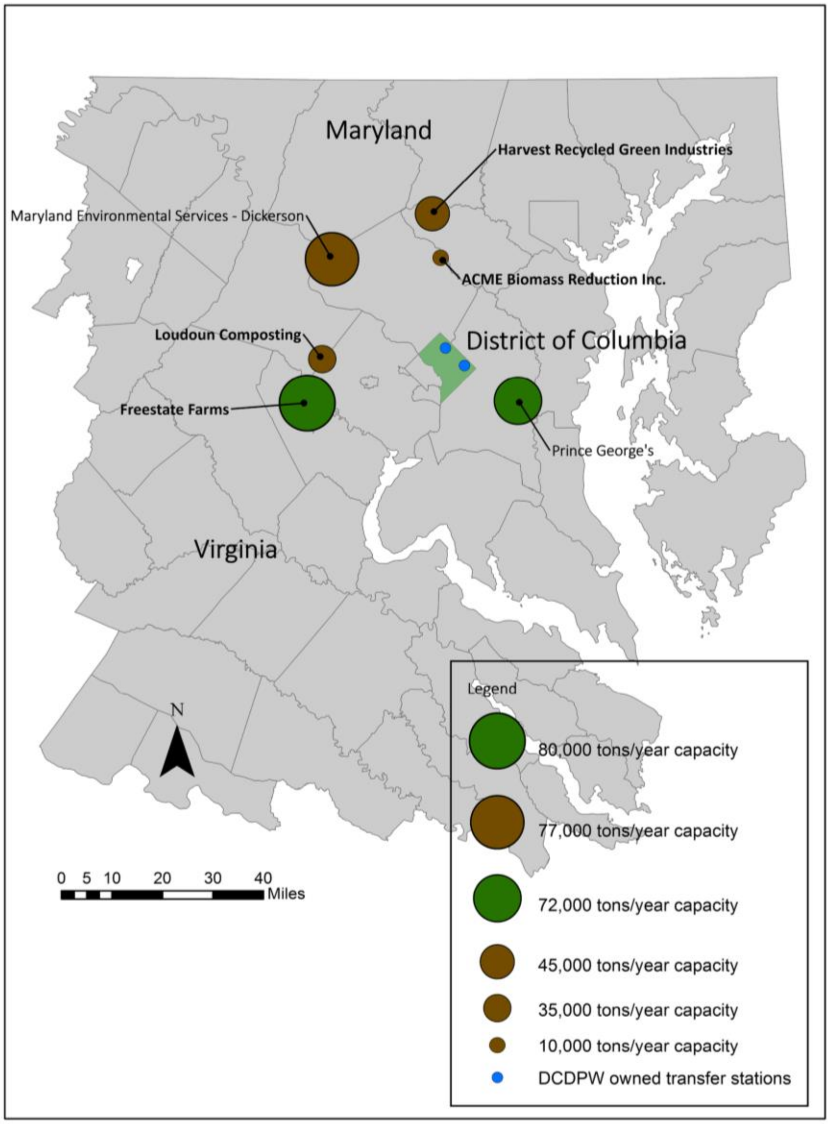
	Generation tons/year	Food Waste Capture tons/year
Low	17,962	7,185
High	47,761	19,105

REGIONAL PROCESSING CAPACITY

A regional study of processing capacity identified six major composting sites in the region within 40 miles of the District. Smaller facilities or facilities more than 40 miles are excluded from this discussion and figure 6, with the exception of Veterans Compost. Of the six major facilities, only two of the facilities currently accept both food waste and yard waste, The Balls Ford Road Composting Facility operated by Freestate Farms in Manassas, Va. and Prince George's County Facility in Upper Marlboro, Md. Only the Freestate Farms facility accepts comingled food waste and yard waste, and currently the facility is only accepting pre-consumer food waste. Prince George's requires separation of the two streams.

Collection of SSO from DC DPW serviced households along with commercially serviced multi-family households, the commercial and institutional sectors, and a commercial landscaper yard waste drop off program could range from 88,513 tons per year to 148,796 tons per year. Of this SSO collection, between 68,808 tons per year (4,441 tons from DC DPW households, 7,185 tons from commercial multi-family, and 57,183 tons from the commercial and institutional sector) to 116,535 tons per year (11,657 tons from DC DPW households, 19,105 tons from commercial multi-family, 85,774 tons from the commercial and institutional sector) is food waste. Prince George's County will only have capacity for 8,000 tons per year food waste and 60,000 tons of yard waste after the expansion. The Balls Ford Road Composting Site operated by Freestate Farms is currently permitted to process 50,000 tons of yard waste and pre-consumer plant derived food waste per year, and plans to expand to 80,000 tons per year once permits are approved and phase I of the anaerobic digestion system and advanced aerated composting system comes online in April, 2018. A second expansion that would enable the facility to accept more than 150,000 tons per year of food and yard waste is planned but no definitive dates have been set. The Balls Ford Road facility may have capacity to accept DC DPW serviced residents with collection of SSO in the range of 10,000 to 30,000 tons per year, but it is unclear how much food waste is allowable, or if yard waste and food waste could be comingled. Therefore, there is limited capacity to compost food waste in the region.

Figure 6: Map of Regional Composting Capacity



Green indicates facility accepts both yard waste and food waste.
Brown indicates facility only accepts yard waste.

Table 15: Regional Processing Capacity								
Facility Name	City	State	Mileage from DC DPW TS	Accepting Food Waste	Accepting Yard Waste	Capacity*	Throughput	Tip Fee
Prince George's	Upper Marlboro	MD	25	Yes	Yes	Expanding to 8,000 tons/year FW & 60,000 tons/year YW	4,000 tons/year FW & 50,000 tons/year YW	$35
Loudoun Composting	Chantilly	VA	42	No	Yes	~45,000 tons/year	–	$35
Harvest Recycled Green Industries	Woodbine	MD	41	No	Yes	~ 30,000 – 40,000 tons/year	–	Based on truck size
ACME	Brookeville	MD	20	No	Yes	10,000	10,000	$32
Balls Ford Road Freestate Farms	Manassas	VA	35	Yes	Yes	80,000	Expanding currently	$35

* FW is defined as food waste and YW is defined as yard waste

TRANSFER STATIONS

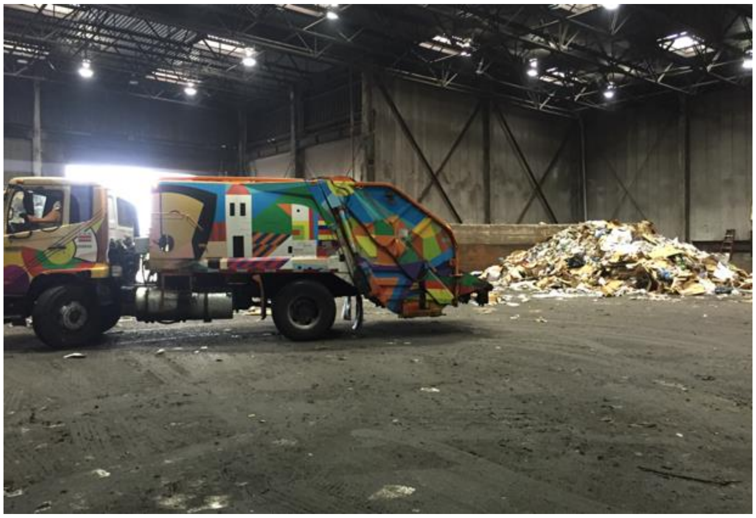
The District operates two transfer stations six days a week. These facilities receive both solid waste and recyclables from DC DPW trucks, private haulers and residents. As facilities that have been in operation for over 30 years, they are badly in need of retrofit for safe and more efficient operation. Repair costs to bring these facilities up to modern standards have been identified by 4tell Solutions, LP in a property conditions report dated October 16, 2014. A brief description of the facilities follows:

- Benning Road Facility
  - The facility is located in the western portion of Ward 7, and borders the Anacostia River.
  - The facility operates two overlapping 8-hour shifts per day with 8 to 20 employees per shift.
  - Throughput around 180,300 tons per year.
  - The site is 6.9 acres, and the tip floor 28,561 square feet.
  - The property conditions report found the elevated concrete decks where waste is tipped by haulers and roof over collections area to be in fair to poor condition, the steel supporting in good condition and the exterior of the building in poor condition.
  - Since the property condition assessment was completed, the stormwater system and roadway and ramp repairs have been made at Benning Road. The booster pump was also replaced in FY 2014.

- Fort Totten Facility
  - The facility is located on the border of Wards 4 and 5.
  - The facility operates three overlapping 8-hours shifts per day with 12 to 30 employees per shift.
  - Throughput around 275,800 tons per year. Also accepts resident bulk, trash and recycling drop off.
  - The site is 6.6 acres, and the tip floor 43,642 square feet.
  - While it is the smaller of the two transfer stations, Fort Totten handles 60 percent of the waste from the District. As a result, Fort Totten has major space limitations.
  - The property conditions report found Fort Totten to be in better condition than Benning Road, giving everything except the roof a fair to good condition report. The roof of the office building was the only portion of the facility to receive a poor condition rating.

- Reno Facility
    - Reno is a small holding facility used for leaves during the fall and salt during the winter.

Figure 7: Benning Road Transfer Station Tipping Floor



Both Fort Totten and Benning Road are arranged the same way with the load-out area located directly below the tipping floor.

Figure 8: Fort Totten Transfer Station Tipping Floor

CURRENT TRANSFER STATION OPERATIONS

Table 16 shows the transfer station capital and operating costs, trucking costs and tip fee costs for transferring SSO out of the District to processing facilities. The cost of operations of a transfer station receiving SSO has been determined to be $33.70 per ton with an additional $2.00 per ton for trucking 40 miles. A distance of 40 miles was chosen based on the distance to several possible regional processing facilities identified earlier in the report. The capital cost assumes a new facility. A new facility would require a base area of 4,000 square feet plus an additional 20 square feet of tipping floor space for each ton of waste received in a day (assuming the waste will be temporarily piled six feet high on the tipping floor). If the District were to receive and transfer SSO from single-family, multi-family (all unit sizes) and the ICI sector, the new transfer station would require 13,000 to 17,000 square feet of tipping floor space. In addition to the tipping floor, a typical transfer station requires a site between five and ten acres and should have class A road for both an entrance and separate exit. In general, amortization of the building occurs over 20 years, station equipment at 10 years and rolling stock at 8 years. Looking forward, a detailed capital cost assessment for using the existing transfer station for SSO could result in renovating one of the existing facilities at a lower cost than building new. An additional 8,000 to 13,000 square feet would need to be added to the tipping floor at a current transfer station such as Fort Totten.

Table 16: Transfer Station Cost Performance	
Transfer station capital cost	$2,295,000
Transfer station capital cost (annualized)	$238,678
Transfer station operating cost (annualized)	$540,150
Total annual transfer station cost	$778,828
Management allowance (10% of total cost)	$155,766
Total annual transfer station facility cost	$934,594
Total facility cost ($ /ton)	$33.70
Total transportation cost ($0.075/ton-mile, and 40 miles)	$2.99
Total SSO transfer cost ($ /ton)	$36.70

Transfer Costs do not include the costs of demolition work at the Benning Road Transfer Station.

The costs for transfer in the District are high in comparison to other similar facilities operated in different parts of the country. A more usual cost for an efficient transfer operation for waste would range from $10 to $15 per ton. It would be anticipated that because transfer of SSO is somewhat more complicated because of the high moisture content of the material that the costs would be closer to the $15 per ton end of the range. With cross-contamination problems already in evidence, adding SSO to the floor would likely make contamination worse.

SSO/YARD WASTE AND TRANSFER

The cost of transfer ($36.70 per ton) and the other benefits (e.g. retaining the carbon value of the SSO, jobs, circular economy bragging rights) of carrying out organics processing within the District suggests serious consideration should be made for developing a composting or anaerobic digestion facility as close to the generators as possible. If this facility were located within the District, collection vehicles could direct haul to the facility, landscapers and residents both could drop-off at the same locations and residents and local growers could similarly purchase finished compost to complete the recovery cycle.

Table 17: Processing Facility Cost and Additional Capital Analysis		
	Transfer	No Transfer
Transfer cost	$37 /ton	$0 /ton
SSO processing tip fee	$35 /ton	$35 /ton
Total SSO processing cost	$72 /ton	$35 /ton
Additional processing capital cost ($ /ton)	$0 /ton	$37 /ton
Additional processing capital	$0	$5.0 million
Total processing capital	$7.35 million[13]	$12.35 million

An SSO input of 25,000 tons per year with a $35 per ton tip fee will allow for substantial investment in composting infrastructure of $5 million. In addition to the capital generated via the tip fee, $7 million can be generated by avoiding transfer costs of SSO. An ASP facility capable of processing 150,000 tons per on a 10-20 acre site could typically be constructed for $7 million. However, considering the urban nature of this project the cost of the facility may be up to $11 million. With the $7 million not spent on the transfer of SSO, and another $5 million generated from the tip fee, the total capital DC could generate for an ASP facility may be up to $12 million. With a total of up to $12 million, this investment seems sufficient for the implementation of a composting facility, even in the circumstance that the facility is 150% of the $7 million dollar estimate (see recommendation section for more detail on covered aerated static pile recommendation). A more precise evaluation of cost of facility would require an engineering feasibility study. Overall, this type of facility investment could very well be undertaken as part of a public-private partnership of the sort often employed to create investment opportunities in recycling facilities.

RECOMMENDATIONS

As outlined in the previous section, transfer of SSO is not recommended. Rather it is recommended that the District focus on locating an in-District site for a composting facility. Benefits to composting within the District include money saved on transfer, retaining the carbon value of the SSO, creation of approximately 6-12 fulltime jobs in operating the facility plus the additional staff required for collection, and circular economy bragging rights. An in-District composting facility will also grow awareness and provide systems and compost for both large and small-scale generators, landscapers and growers.

[13] The amortization time period is 20 years at 4% interest.

This will most likely require the District to address permitting and zoning requirements for composting and anaerobic digestion facilities. A five-year roll-out plan for a composting collection program is recommended below. Year one of the plan involves composting facility site selection and/or identifying necessary upgrades to transfer stations. Year two of the plan involves initiation of construction and/or renovations. Collection of SSO from DC DPW serviced households should begin in year three, and roll-out of collection will take two additional years to complete.

REGULATION RECOMMENDATIONS

A number of existing District regulations need to be modified or updated to encourage composting and the recovery of organics in the District while ensuring the District is clean, safe and healthy.

- Food Waste Disposal by Foodservice Establishments
    - Current D.C. regulation requires residents and businesses in the District to dispose of food waste by grinding it and flushing it down the sanitary sewer (i.e., in-sink disposal systems), or by first draining the liquid portion before storing in "wrapped" bins for co-collection with rubbish[14]. Thus, existing regulations prohibit foodservice establishments from setting out source separated food waste for collection for composting.

- Siting and Permitting Guidelines for Composting and Anaerobic Digestion Facilities
    - To attract well-run composting and anaerobic digestion facilities to the District, the District needs to develop clear rules and guidelines specific to the siting, design and operation of these facility types. Many states have taken steps to streamline the siting and permitting process to encourage these types of facilities and have posted the requirements on the US Composting Council and the American Biogas Council websites to make this information readily available to the industry sector.[15] Additionally, New York and many other states have implemented small scale exemptions to permitting requirements to encourage community or small scale composting.

- Contracting
    - The Sustainable Solid Waste Management Amendment Act of 2014 limits the length of contracts the Mayor can sign for processing material to ten years. The District may want to consider lengthening the allowable term for contracts with

[14] 21 DCMR §704.2 and §704.3

[15] U.S. Composting Council State Composting Regulations. http://compostingcouncil.org/state-compost-regulations-map/

anaerobic digestion, recycling, and composting facilities to ensure the best terms and encourage the development of these facilities in or near the District.

- Animal Feed
    - While the U.S. Environmental Protection Agency considers sending food waste to animal feed an important option for recycling food waste, current D.C. regulations prohibit the transportation or collection of food waste for animal feed[16].

COMPOSTING FACILITY RECOMMENDATIONS

A covered aerated static pile (ASP) composting facility is the recommended composting method for the District. ASP composting is the most cost efficient and simplest composting method for large volumes of organic waste. It is especially suited for co-collected yard debris and food waste. ASP can be done indoors, outdoors in a windrow composting operation or in a totally enclosed in-vessel system. It uses an aeration system to push and/or pull air through the composting mass. Inducing airflow into the organics pile helps to maintain aerobic conditions such as moisture level and temperature that are ideal for the microbial populations, allowing for maximized degradation efficiency and minimization of pathogens. Unlike windrow facilities that require turning of the pile, ASP does not due to the air flow through the pile, which reduces the operational costs of the facility. In addition, covering the compost for aeration provides an added benefit of odor minimization, lowering the impact of the facility on surrounding neighbors. It is anticipated that a minimum of 10 acres, assuming careful siting and a plan to use roads off site for some of the circulation, and a maximum of 20 acres will be required to operate a covered ASP facility. It is common for an ASP facility to have 6-12 full-time employees including a manager, supervisor, operators and maintenance staff.

PROGRAM IMPLEMENTATION

Implementation scheduling is critical to overall program success. Requiring District users to participate too soon, before infrastructure is fully built-out, runs the risk of self-serving economic behavior which result in excessive tip fees or capacity shortfalls. Therefore, a staged implementation schedule is critical. A five-year plan is recommended in which the first year is dedicated to identifying land and securing contracts for construction of a compost facility. Construction should commence in year two. The following three years is the roll-out of the residential composting collection program. The collection roll-out only considers generation rates and costs of residents serviced by DC DPW, and does not include multi-family units of four or more or the ICI sector. The roll-out also assumes that in-District composting infrastructure will not be

[16] 21 DCMR § 704.1

complete in the first year of collection, which is year three of plan, so that SSO collected in year three will need to be direct hauled to a processing facility out of the District. It is assumed that composting will occur within the District for year four and five. Such a tentative schedule is presented below:

Land Acquisition and Contracting

- Year 1 – Selection and acquisition of composting site within the District; begin contracting for construction.
- Year 2 – Complete contracting of composting facility and begin initial stages of construction.

Residential

- Year 3 – Roll-out to 33,037 households currently serviced by DC DPW with direct haul to processing facility while construction of in-District composting facility continues.
- Year 4 – Roll-out to 33,981 additional households currently serviced by DC DPW with in-District composting begun.
- Year 5 – Roll-out to remaining 38,264 households currently serviced by DC DPW.

Other considerations:

- It will be important for the District to modify the DPW master campus plan[17] to accommodate any compost collection trucks that are purchased, minus the number of trash trucks that may be retired once trash routes are re-routed as part of this implementation; the decrease in trash trucks and routes is unknown at this time.

- Similarly, while staffing numbers for the SSO collections program are estimated, that does not necessarily mean all new hires. Current trash and recycling route staff may be allocated to the compost routes. However, it is not anticipated that there will be a significant staff reduction in trash routes. While trash tonnages will be reduced with an SSO program, the reduction in trash may not be enough to significantly reduce the number of routes. A definitive answer will only be known with a comprehensive route efficiency analysis.

YEARS ONE AND TWO

In year one, the District will need to conduct a composting site siting analysis in order to move forward with an in-District facility and secure contracting. In year two, construction of an in-District

[17] A conceptualized campus on West Virginia Avenue that would improve and optimize DPW's operations to be more healthy, sustainable, and effective, as well as create a number of amenities for nearby residents. http://planning.dc.gov/public-works-campus

composting facility should be commenced with the plan to complete the project by the fall of year three.

YEAR THREE ROLL-OUT

RRS utilized the 'Base Case' scenario in this analysis regarding a roll-out strategy. In year three, RRS proposes a composting roll-out to roughly a third of households currently serviced by DC DPW. It is recommended that the initial participating households includes areas of the city with both high and low yard waste generation rates. Generally, it is anticipated that the Outer-District areas will generate more yard waste than the Inner-District areas. It is also recommended that the program begins working with high recycling participating routes, routes with average recycling rates greater than 15 pounds per household per week, at first to ensure early program success.

The District will need to direct haul the SSO to a regional processing facility in year three (first year of collection), while the in-District composting facility is being constructed. In the model, the direct haul is estimated to include 2 hours of round-trip time for each collection truck. It is crucial in the initial roll-out to gather sufficient participation rates, collection tonnages of SSO, set-out rate, route times and truck capacity to optimize the routing and roll-out of the program.

While a set ward for the roll-out is not provided, it is recommended that in year three the program will focus on areas of the District that have high yard waste generation rates. Ward 3 accounts for 44 percent of the total tonnage of material collected during leaf season, far outpacing all other wards. Also, recycling routes focused around Ward 3 have the highest recycling pounds per household per week of all recycling routes. Therefore, a roll-out that includes some households in Ward 3 would provide a baseline for high collection tonnage in the Outer-District wards. Another suggestion is to include an Inner-District ward with higher population densities. It is expected that the yard waste generation would be less in the Inner-District area based on the decreased tonnage of material collected during leaf season. Rolling out a composting program to households in the Inner-District area would provide a baseline for lower yard waste generation rates collection tonnages. Along with rolling out curbside collection, the District should promote backyard composting by potentially offering discounts or vouchers to purchase necessary equipment and educational information on composting on website.

Table 21: Year Three System Performance

	Low Generation	High Generation
Number of trucks required	9 trucks	13 trucks
Total staff needed for program	29 staff	43 staff
Annual FW tons collected	1,749 tons/year	4,592 tons/year
Annual YW tons collected	2,018 tons/Year	6,055 tons/year
Organics diversion total	3,768 tons/Year	10,647 tons/year

* FW is defined as food waste and YW is defined as yard waste

An SSO curbside collection program that includes 33,037 households will require 9 to 13 trucks and will collect between 1,749 to 4,592 tons of food waste and 2,018 to 6,055 tons of yard waste. It is estimated based on truck dimensions of 8 feet by 25 feet that a typical parking space for the trucks is 13 feet by 30 feet so that each truck requires 390 square feet to park plus an addition 390 square feet in moving space Therefore each truck requires 780 square feet for a total required space to store trucks of approximately 7,000 to 10,000 square feet. Additionally, 29 to 43 staff would be required for the collections program.

Table 22: Year Three System Costs			
		Low Generation	High Generation
Annual Costs	Truck collection cost	$2,135,277	$3,084,289
	Annualized container collection cost	$277,074	$277,074
	Education cost	$39,835	$39,835
	Processing cost	$131,867	$372,641
	Landfill avoided savings	($171,766)	($485,392)
	Net annual cost	**$2,412,287**	**$3,288,448**
Annual Costs per Ton	Truck collection cost per ton	$567 /ton	$290 /ton
	Annualized container collection cost per ton	$74 /ton	$26 /ton
	Education cost per ton	$11 /ton	$4 /ton
	Processing cost per ton	$35 /ton	$35 /ton
	Landfill avoided savings per ton	($46) /ton	($46) /ton
	Net cost per ton	**$640 /ton**	**$309 /ton**
Per Household	**Net cost per Household**	**$23 /HH**	**$31 /HH**
Capital Cost	Capital costs of trucks	$1,690,00	$2,480,000
	Capital cost of containers	$1,306,508	$1,306,508

*Note this is the cost of the roll-out to households assuming a 2-hour round trip direct haul to a processing facility and a tip fee of $35.

The cost of purchasing containers, annualized container collection costs, processing cost per ton and cost of education all remain the same regardless of generation rate. However, the per ton cost estimates decrease significantly with the high generation model. This is important to note because it highlights the value of collecting yard waste, a major component of the organics program, in the curbside organics program. The cost per household for the initial roll-out to 33,037 households is between $23 and $31 including the container cost.

A crucial component to cost in year three is that it includes cost of a 2-hour round trip direct haul to a regional processing facility. By not transferring the annual cost of the program in the case of low generation is reduced by nearly half a million dollars. This cost reduction translates to a decrease from $23 per household to $18 per household. The cost per ton decrease from $640 to $514 per ton. There is not significant cost savings in the case of high generation because there are enough trucks to collect the higher volumes and still direct haul, which is driven by the upper limit on the number of household pickups per truck. What this means is that trucks will complete routes early and will have excess time for direct haul in the wards that were selected for startup. This reinforces the recommendation to collect abundant data in year one to optimize routes and the final number of trucks that will be needed when the program is fully implemented.

YEAR FOUR ROLL-OUT

In year four, an additional 33,981 DC DPW serviced households should be added into the roll-out, so that roughly 60 percent of the DC DPW serviced households would be included in the collection program. Because of the economic benefit of collecting yard waste with food waste, it is most economical to add these additional households in the higher yard waste generating areas of the city, before including more households in the higher density regions of the District where yard waste generation rates are most likely lower.

Table 23: Year Four System Performance

	Low Generation	High Generation
Number of trucks required	14 trucks	23 trucks
Total staff needed for program	43 staff	72 staff
Annual FW tons collected	3,021 tons/year	7,930 tons/year
Annual YW tons collected	4,078 tons/year	12,234 tons/year
Organics diversion	7,099 tons/year	20,164 tons/year

* FW is defined as food waste and YW is defined as yard waste

By year four, the District will need to dedicate 14 to 23 trucks to collecting SSO and the annual organics collection could be anywhere from 7,099 to nearly 20,164 tons per year, double the collection from year one. The large difference is due largely to the uncertainty in yard waste generation rates. To store the trucks, approximately 10,000 to 18,000 square feet in parking is required, and 43 to 72 staff are needed for the collections program.

Table 24: Year Four System Costs			
		Low Generation	High Generation
Annual Cost	Truck collection cost	$3,321,542	$5,456,820
	Annualized container collection cost	$594,157	$594,157
	Education cost	$77,799	$77,799
	Processing cost	$ 248,459	$705,728
	Landfill avoided savings	$323,636	$919,261
	Net annual cost	**$3,918,322**	**$5,915,243**
Annual Cost per Ton	Truck collection cost per ton	$468 /ton	$271 /ton
	Annualized container collection cost per ton	$84 /ton	$29 /ton
	Education cost per ton	$11 /ton	$4 /ton
	Processing cost per ton	$35 /ton	$35 /ton
	Landfill avoided savings per ton	($46) /ton	($46) /ton
	Net cost per ton	**$552 /ton**	**$293 /ton**
Per Household	**Net cost per Household**	**$37 /HH**	**$56 /HH**
Capital Cost	Capital costs of trucks	$2,790,00	$4,580,000
	Capital cost of containers	$2,801,672	$2,801,672

It is also in year four, when the District composting facility is operating, that starting the commercial landscaper yard waste drop-off program is recommended. Commercial landscapers should be instructed to drop-off material at the new composting facility following the same or similar schedule to the residential drop-off that currently exists at Fort Totten. As mentioned in a previous section, a yard waste drop-off program would require approximately 5,000 square feet of space at one of the existing transfer stations. Given the current space limitations and capital improvement needs of both Fort Totten and Benning Road, it is not recommended to collect yard-waste for composting at the transfer stations. Additionally, starting the drop-off program at the transfer stations and then later moving it to a different location will cause confusion that could affect the success of the program.

YEAR FIVE ROLL-OUT

In year five, the SSO curbside program should be rolled out to all 105,282 households currently serviced by DC DPW. When this occurs, the program will look like the base case scenario presented earlier. The tables below outline more detail on the program in year five.

Table 25: Year Five System Performance		
Number of trucks required	21 Trucks	35 Trucks
Total staff needed for program	68 staff	114 staff
Annual FW tons collected	4,441 tons/year	11,657 tons/year
Annual YW tons collected	6,278 tons/year	18,833 tons/year
Organics diversion	10,719 tons/year	30,490 tons/year

* FW is defined as food waste and YW is defined as yard waste

In year five, 21 to 35 trucks would be needed to collect 10,719 to 30,490 tons of SSO per year. Approximately 68 to 114 employees would be needed to operate the collections program. The trucks would require 16,000 to 27,000 square feet in parking space.

Table 24: Year Five System Costs			
		Low Generation	High Generation
Annual Cost	Truck collection cost	$4,982,314	$7,303,856
	Annualized container collection cost	$920,820	$920,820
	Education cost	$122,835	$122,835
	Processing cost	$375,151	$1,067,166
	Landfill avoided savings	$488,661	$1,390,060
	Net annual cost	**$5,912,459**	**$9,024,618**
Annual Cost per Ton	Truck collection cost per ton	$465 /Ton	$272 /Ton
	Annualized container collection cost per ton	$86 /Ton	$30 /Ton
	Education cost per ton	$11 /Ton	$4 /Ton
	Processing cost per ton	$35 /Ton	$35 /Ton
	Landfill avoided savings per ton	($46) /ton	($46) /ton
	Net cost per ton	**$552 /Ton**	**$296 /Ton**
Per Household	**Net cost per Household**	**$56 /HHLD**	**$86 /HHLD**
Capital Cost	Capital costs of trucks	$ 4,110,000	$6,960,000
	Capital cost of containers	$4,342,008	$4,342,008

In year three, the District can expect a total cost of the SSO curbside program to be between $5.91 and $9.02 million to operate, again assuming in-District composting. That cost works out to be between $56 to $86 per household and $552 to $296 per ton for low and high generation respectively. The total capital cost of trucks and containers ranges from $8.45 to $11.30, plus the additional capital of constructing the composting facility.

CONCLUSIONS

During the review of the District's solid waste and recycling operations in preparation to analyze the feasibility of SSO, the following conclusions and concerns were identified:

- **Costs are High and Efficiencies Are Low** – In comparison to operations of a similar nature performed nationwide, District operating costs tend to be as much as 100% higher. Semi-automated operated trucks with three workers predominate. Collection industry standards (both public and private) evolved more than ten years ago toward single drivers with automated lifts on the trucks, and thus it is not possible to compare the District's collection costs with the surrounding, more suburban communities. Similar staffing levels were observed at transfer stations and result in the same kind of cost increases. It will not be possible for the District to move to fully-automated trucks due to limited collection space in alleys.

- **SSO and Yard Waste Should Not Be Transferred** – With transfer costs higher than $35/ton, a shortage of close processing sites and general traffic congestion, direct haul of SSO and yard waste to a processing facility is recommended.

- **Covered Aerated Static Pile (ASP) Composting is Preferred** - ASP provides substantial advantages to the District as it pursues an organics recovery strategy. Among these advantages are: odor control, vector/nuisance control, speedier material decomposition, better finished material quality, ability to receive a more diverse (high carbon and woody materials from YW) supply of material and better neighborhood relations. All of these characteristics will make the opportunity to site a composting facility in an urban environment more likely. A large scale centralized facility coupled with community garden/backyard systems result in a program that will close the loop for the District, grow awareness and provide systems and compost for both large and small-scale generators, landscapers and growers.

- **Residential Co-Collection of SSO and Yard Waste is Recommended** – Residentially derived SSO comes in very small quantities. It is more cost effective to collect this material in a circumstance where the District is already collecting similar yard waste materials and can easily integrate the smaller amount of SSO into the existing container. In fact, because of the natural porosity of the yard waste, SSO often "soaks" into the yard waste matrix and appears to have no additional impact on volume. Of course, weight does go up because of the higher moisture content of SSO.

- **Seasonal Volume Fluctuations Related to Early Spring Yard Cleanup and Seasonal Leaf Collection –** Seasonal leaf collection utilizing a cart based system with additional material in bags or bundles will require additional seasonal trucks and seasonal workers to handle these volumes. These crews may be reallocated from the street based leaf collection program that is currently in place. A nine-month collection cycle results in staffing reallocation for organics collections crews during winter months.

APPENDIX

ORGANICS WASTE CHARACTERISTICS

Management activities, including source reduction, source separation, collection, pre-processing, composting and end product uses are affected by the mix and volume of organic materials collected. Table A1 summarizes key material characteristics.

Table A1: Organic Waste Categories and Description

Organic Type	C:N Ratio*	% Moisture	Density (loose) lbs/CY	Volume (lbs/HH/year)
Food	15:1	Variable	400-800	400-600
Yard Debris				
Grass, weeds	20:1	10-50%	400-800	1000
Brush	250:1	40-50%	250-500	300
Leaves	40:1 (green) 80:1 (dry)	10-50%	150-700	200-300
Wood Lumber Sawdust/wood chips	500:1 (also high in lignin)	5-25%	250-500	
Other				
Non-recyclable paper	50:1		150-250	Varies
Diapers, sanitary items				Varies
Composites (plastic/fiber)				
Ag residue/dry straw	100:1			N.A
Biosolids Cow manure Pet feces Wastewater sludges	20:1			120 dry lbs/capita/yr

*Carbon to nitrogen (C:N) ratio indicates nutrient balance of materials as a microbe food source. Higher amounts of carbon take longer to break down. Typically, wood waste requires grinding. The increased surface area of smaller particles encourages quicker breakdown and increases the availability of carbon. These volumes are based on national values.

DESIGNING THE ORGANICS WASTE STREAM

Collection of SSO from residential sources, although still rare in the United States, is growing in popularity as more and more communities seek to increase their overall recovery levels. Canadian communities have had more experience and hence these programs provide important data and lessons learned. Still, SSO collection programs throughout North America vary considerably in terms of which wastes are allowed for collection. Basically, collection approaches fall into the following categories as listed in Table A2:

Table A2: Organics Collection Systems		
Collection System	Criteria	Advantages/Disadvantages
HHO alone	Cost	(-) High cost per ton due to truck inefficiencies
	Participation/ diversion	(+) Allows wider range of processing options (anaerobic digestion)
	Technical challenges	(-) Requires non-recyclable paper in order to avoid winter freezing and summer "yuck" factors
HHO plus yard debris (SSO)	Cost	(+) Lower cost per to collect
	Participation/ diversion	(+) Higher participation/diversion tonnage
	Technical challenges	(-) Seasonal nature of yard waste generation will create huge fluctuations in material flow
Addition of paper products	Cost	(+) Marginal cost of paper collection is low
	Participation/ diversion	(+) Higher diversion because there is a recovery option for non-recyclable fiber
	Technical challenges	(-) Increase potential for contamination at compost site and distraction from other recycling programs
Co-collection with other stream	Cost	(+) Most cost-effective means of collecting HHO and kitchen non-recyclable paper because it uses same vehicles as recycling program
	Participation/ diversion	(+) Easy to match with existing programs because they will be on same day
	Technical challenges	(-) Truck modifications will be required in order to limit contamination to "clean" recyclables

Acceptable items in the food or "kitchen waste" category vary from program to program. Some programs accept only food scraps including meat, bones and dairy while other programs allow paperboard in addition to their collection of kitchen waste. For example, Takoma, Md. conducted a curbside HHO collection pilot study in which residents were able to compost food scraps including meat, dairy, bones and pizza boxes. Compost Cab, a private food waste compost collector that operates in Maryland, Virginia and the District, prohibits meat, dairy and compostable packaging from their collection.

HHO only collection programs are quite rare. Typically, these limited collection programs generate insufficient material for economic collection. Other programs have shown that most successful programs find a means of co-collecting HHO with another larger volume material (e.g., SSO). In some cases, split packer trucks are used where one of the collection chambers is configured for municipal solid waste and the other for HHO. In other situations, particularly those where commingling seemed desirable, co-collection with yard debris provides an effective cost outcome.

In addition, carbon based bulking agents are needed as part of the composting process. Bulking agents create spacing within the compost pile whereby oxygenated air can travel. This flow enables the composting to continue in an aerobic manner, without the odor and handling problems that can occur in circumstances where the composting process becomes anaerobic. In addition, woody materials can contribute needed carbon to the process to enable more effective breakdown of highly nitrogenous materials like HHO and grass. Where possible the addition of yard debris based bulking agent sources like tree trimmings or brush can be very useful in the processing environment.

BENEFITS OF YARD DEBRIS COLLECTION

Many communities have implemented yard debris collection programs (frequently at the curbside) as part of an overall ethic of maximizing recovery or as part of outright landfill disposal bans. Over the course of the last twenty years, composting of yard debris in large scale environments has become relatively successful and commonplace. Although generation and disposal behavior of yard debris is not evenly distributed throughout the year, both private and public sector facilities have learned how to manage the fluctuations of yearly flow.

Three benefits derive from yard debris recycling. First, an awareness of the benefits of organics recycling and composting will begin to spread amongst residents and businesses from both the customer and the service provider perspective. Second, a collection and processing infrastructure will grow that will eventually create a portion of the recovery capability for SSO. Third, in residential circumstances the availability of routine, majority of the year and large scale collection system creates a system that allows smaller volumes of SSO to “piggy back” on existing collection programs with little marginal cost impacts. Therefore, step one in the development of a composting program for the District should incorporate yard debris.

In addition, the physical characteristics of yard debris (relatively bulky and 50 percent moisture content or less) create a situation that facilitates the “bulking” of the wetter and “slimier” HHO stream. This characteristic is useful for both the collectors (in circumstances where HHO and yard debris streams can be combined into one container) and the processors who also benefit from being able to handle a more solid material. HHO alone at its collection point has a moisture content that ranges from 80 – 90 percent. Only the lightest handling will prevent this material from becoming a liquid sludge.

The greatest benefit of the co-collection of yard debris with HHO is economic. Throughout the year there simply isn’t enough HHO material to justify a separate collection route. It is impossible for a conventional collection vehicle to stop at enough households in a day to fill its collection body. So, without the capability of co-collection of some other compatible materials the program costs would be prohibitive.

SEASONAL GENERATION OF YARD DEBRIS

The amount of yard debris generated in the District varies by season. Up to 60 percent of yard clippings consist of grass and weeds are collected in the growing season from April through November.[18] The overall amount of leaves can appear larger than grass as it arrives in a shorter time period (October – January). Brush from pruning and storm damage occurs primarily at two peak times (spring and fall). Moderate quantities of brush accumulate in the summer and winter months.

Changes in weather, landscape practices and population can alter yard debris volumes from year to year. In addition, the overall maturity and number of trees can have a dramatic effect on overall yard debris generation. To successfully handle fluctuations, collection routes must be sized to accommodate estimated peak capacity or additional collection capacity must be implemented to handle peak volumes.

Low yard waste generation presents difficulties in many SSO curbside collection programs. Without yard waste, organics generation is often too low to make collection during the winter economically feasible. Furthermore, food waste alone in carts, which has a higher water content, is subject to freezing during the winter months. Ann Arbor, Mich. stops organics collection from December to March due to the low yard waste generation. Further south, the City of Arlington, Va. is testing out year round yard waste collection for the first time in 2016. Fairfax, Va. provides year round yard waste collection to all residents, but only processes yard waste for composting from March 1 through December 24. With the exception of Christmas trees, between December 25[t] and the end of February, the small amount of yard waste generated is disposed of as trash.

GRASS

Grass is one of the main constituents of a typical urban yard debris stream. On average in a mature, treed city, grass can be as much as 40 percent of the entire yard debris stream. Its total quantity varies from season to season depending on seasonal weather variations. The quantity of material available for collection at the curbside is affected by household behavior in three main ways. First, many homeowners own "mulching" mowers that are designed to leave grass clippings on the lawn as they fall during mowing. Second, in the same manner homeowners who participate in backyard composting programs might collect their clippings but keep them for their own compost generations. Finally, homeowners that have their yard cut by grass cutting services generally require their contractors to remove whatever yard clippings are left on the lawn as part of their

[18] *National Gardening Association.*

service. Therefore, households that fall into any of these three categories do not contribute substantially to the grass portion of the yard debris stream. However, the balance of households probably contributes fairly significantly to the yard debris stream requiring processing at a composting facility.

Reducing the amount of grass in the waste stream minimizes the odor potential. Grass collected in plastic bags may become odorous even before it is picked up at the curb. Kraft paper bags are suggested for curbside collected grasses as they reduce the odor potential and are compostable at the compost site. These measures create better circumstances at the composting facilities that are receiving these materials and should be encouraged. Overall, as a high nitrogen feedstock, grass is the least desirable of all yard debris streams. Therefore, any activity that enables the program to reduce this material creates a better environment for a successful composting system.

BRUSH

Management approaches for brush from community to community are inconsistent. Although brush is a small fraction of any program (5-10 percent) it creates some management difficulties. Some ban brush from collections entirely, others limit collections to certain diameter of stem (size of a thumb) and other provide curbside grinding services for larger limbs. The most effective programs focus on limiting this stream to diameters that are sufficient to manage in the collection vehicle without grinding at the curb. Then the commingled mass of yard debris is size reduced in preparation for composting at the site.

When collected in combination with HHO, brush may be desirable at the processing site. The woody component (in chipped form) helps the compost process by providing carbon for microbes and enhancing aeration. Where brush is collected, some form of chipping will be required. Woody materials do not break down at the same rate as grass and leaves unless its' surface area can be increased. An increased surface area makes the carbon in the wood much more available and consequently enables quicker decomposition. In circumstances where the brush is collected commingled with grass and/or leaves, typically the entire commingled mass of material will need to be run through a grinder to ensure the brush is properly chipped. The grinding requirement, especially when it includes grass, has a significant cost impact on the operation.

LEAVES

Leaves are the largest fraction of urban yard debris generation. Especially in cities like Washington D.C. that have a mature stock of deciduous trees, this stream can become quite overwhelming. Even the leaves that fall from the trees in the tree lawn (which in many cases are municipal responsibilities for management) can generate sufficient quantities of material to have negative effect on streets maintenance, storm sewers and sanitary sewers. Where the balance of a homeowner's leaves are pushed onto the street, the management difficulties can become quite extreme. Major public sector efforts have been undertaken in an attempt to minimize the effect of leaves on the combined sewer systems or storm water systems. These efforts have become more concerted in the last ten years as more and more wastewater treatment plants (WWTPs) have become biochemical oxygen demand (BOD) constrained. Simply put, keeping the leaves out of the sewer can delay the expenditure of hundreds of millions of dollars in treatment facility capability. Communities where these issues are a concern have implemented cart based leaf collection with additional material in compostable bags when they have yard waste and HHO cart based organics collection systems.

Leaves also have a high quantity of available carbon, which is essential for maintaining a good compost "recipe" with an appropriate carbon to nitrogen (C:N) ratio. They also provide significant bulking capability that enables the free flow of air that is necessary to provide the composting mass with aerobic break down conditions. Leaves do not require size reduction and can be immediately windrowed or piled up in preparation for composting. This is one of the critical material types from the overall yard debris stream that is desirable.

PAPER

Although not a yard debris material, non-recyclable paper is frequently targeted as part of a household generated organics program. This non-recyclable paper such as tissues and paper towels can add significantly to overall recovery if it is successfully targeted by an organics collection program. Non-recyclable household paper can have some challenging physical characteristics that are important to understand from a collection perspective.

Paper composts more slowly than other organic wastes and should be ground in order to make its carbon available. Paper mixed with higher moisture content materials (e.g., SSOs) alone takes on a "paper mache" type texture that does not allow for the free flow of gases inhibiting efficient composting and can be responsible for creating odors during processing. As wet paper tends to clump, it is important to add bulking agents (wood chips or leaves) to maintain air space. Although paper is slow to compost, when mixed with high nitrogen wastes such as food, it can be managed successfully. Wax-coated boxes for carrying produce are not significant composting problems. Wax will compost and is not found in the finished material and some wax formulations have passed ASTM standards for BPI certified compostable. Some paperboard is coated with polyethylene to make it resistant to breakdown (such as frozen food containers) and should not be added to compost as it will not readily breakdown and may cause contamination issues.

ISSUES RELATED TO BROADER ORGANICS COLLECTION PROGRAMS

The following issues arise as the range of collected organics is widened beyond residential SSO. Commentary regarding potential solutions follows each issue.

Issue #1: Adding grass clippings during the summer months could cause odor problems during the collection and processing process.

Grass provides an excellent nitrogen source at the compost site when properly handled (immediate incorporation into windrows). This very characteristic also can lead to terrific odor problems. Residents can be encouraged to "grass cycle" or mulch, however, if a weekly yard debris program is in place, grass must be handled appropriately. Use of an aerated collection toter cart or Kraft paper bags can be helpful in reducing odors. In addition, standards that require collection vehicles to be unloaded nightly will also limit the impact of grass related odors.

Issue #2: Adding brush could increase the contamination levels of the compost site.

Brush collection can be done with grass and leaves or managed separately with residential wood waste. Brush programs are often very popular with the public and the volumes collected can be significant. Unfortunately, the separate collection and chipping of brush is labor intensive and can be expensive on a cost-per-ton basis.

Contamination from non-compostable twine, nylon, rope, textile strips and wire used to bind the brush together is also a problem. This material needs to be separated from the yard debris and reduced in size as much as possible. Most shredders and grinders are equipped with ferrous recovery magnets, so some wire can be recovered this way. Screening of these materials can be somewhat problematic so residents should be asked to bundle brush with compostable twine.

Issue #3: SSO materials must be put out for collection in containers with closeable tops to prevent plastic film bags being ripped apart by raccoons, dogs or rats.

The choice of containers and bags for use with a collection program can have a tremendous impact on system design and ultimate success or failure. Most SSO programs offer some type of indoor "kitchen" bucket for use on the counter or under the sink. The small container transports SSOs to the garage or outdoors where the food is transferred to a secondary, larger container.

Issues regarding odors and the cleaning of household containers may impact whether a resident will continue to participate in the program or not. Some communities like the City of Cambridge, Md., which began a pilot program in 2014, supplied participating residents with an indoor kitchen bin and compostable bags, citing the bags as key to increasing participation by helping residents overcome the "yuck" factor. Cambridge also supplied residents with a 12- or 21-gallon curbside bin[19]. Providing residents with compostable bags may not be realistic for all programs. The City of

[19]Mail, Randi, Hoffman, Everett. *City of Cambridge, MA Department of Public Works, Curbside Organics Collection from Residents Phase 2 Report*. 2015.

Madison, Wis. began piloting a curbside food waste collection program in 2011, and has been steadily expanding the program. Up until July, 2016 residents were supplied with compostable bags free of charge. However, due to budget constraints, Madison now provides information on where residents can purchase compostable bags. In surveys conducted during the City of Alexandria's food waste collection pilot study, residents nearly unanimously reported that lidded storage containers did not attract rodents or pest even when kept outside[20].

Issue #4: During peak yard debris generation periods (fall and spring) residents will produce more yard debris than can be filled in a 95-gallon cart.

Even if a 64- to 95-gallon container is provided, it may not be of sufficient volume to contain all yard debris that is generated during the peak spring and fall seasons. The most popular choice to gather overflow yard debris is Kraft paper bags. Brush can be collected separately in bundles. Residents should not be allowed to use conventional plastic yard debris bags as they are not compostable and are deemed a contaminate in the composting process. Overall, the contamination of the final compost product and the additional difficulties with odor generation suggest that conventional plastic bags should be totally banned from the proposed program.

COMPOSTABLE PLASTIC BAGS FOR SSO

Compostable plastic bags can play an important role in helping residents overcome the "yuck" factor associated with residential food collection. Like every option, the use of compostable bags has pros and cons:

Pro: Bags reduce the clean-up issues or freezing of kitchen wastes in the tote containers left outside during winter months.

Pro: Compostable bags can breakdown during the compost process and minimize contamination in the finished compost. As a result, the finished compost has a higher value than if the program used standard film plastic bags (e.g. low-density polyethylene bags). Bags are available for kitchen "buckets" or up to 32-gallon transfer containers. Compostable bags would not be practical or affordable for lining large toter carts.

Pro: Some of the more recent compostable bags on the market for collection of yard debris are far less costly than Kraft paper bags, wax and plastic lined Kraft paper bags, and starch-based compostable bags. In fact, some of the compostable plastic bags are falling below 150 percent of the cost of traditional film plastic bags. Quality starch/plastic bags are still around 200 percent or double the price of traditional film plastic bags. Paper based bags can be even more expensive.

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[20] City of Alexandria's Pilot Food Composting Collection presentation. Mike Clem

Con: Some compostable plastic bags on the market do not actually compost in a timely manner and will cause finished compost to contain small bits of unscreenable plastic pieces. It is extremely important to field test the compostable bags using the precise compost technology chosen for the program prior to purchasing these bags for the public. Alternatively, program managers can choose to rely on an existing labeling system for "approved" bags. Some compostable bags will perform well in certain technologies but not others. A pilot program could verify the composability of various compostable bags to be used. In the first year of a program, various bags could be tested for performance on the street and in the compost facility.

Con: Several regional facilities in the Maryland and Virginia area have expressed hesitation on compostable bags and prefer to receive SSO loose. Part of facility's hesitation comes from the above mentioned con that the compostable bags will not degrade in a timely manner. Additionally, although many residents want to help out their local unit of government or not-for-profit operator by purchasing the more expensive compostable bags, a large percentage of the residents will continue using the lower cost plastic film bags that will not compost. Further complicating matters is consumer confusion on the difference between bags labeled as compostable, which generally can be composted in a timely fashion in a composting facility, and bags labeled as biodegradable. Biodegradable bags can take years to fully breakdown, and are not suitable in composting facilities. The composting programs of San Francisco and Toronto provides residents with a detailed description on the difference between compostable and biodegradable plastics.

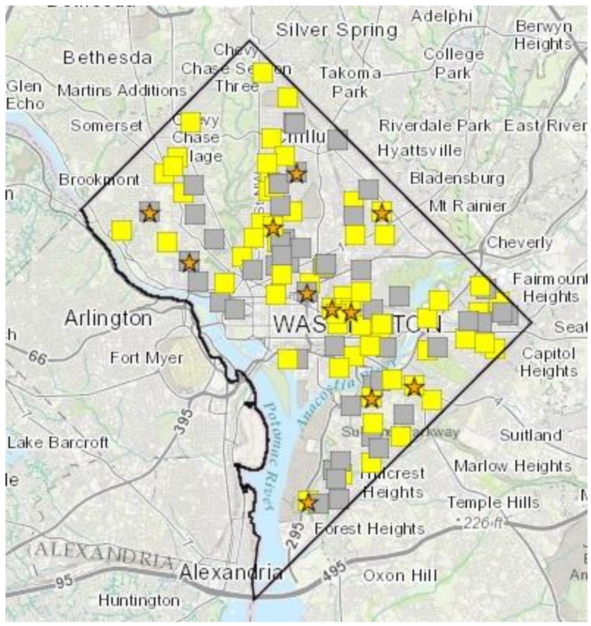
Some programs require residents to purchase compostable bags from local grocery or hardware stores, so that the additional cost of the compostable bags is born by the resident and not by the operators of the system/municipality. Alternatively, they simply will not participate regularly in the organics program or potentially will not participate at all if too much effort or cost is required.

Con: Providing compostable plastic bags for yard debris can be expensive. Additional economic analysis should be done before undertaking compostable bags for handling the seasonal peak times for yard debris in the spring and fall.

DISTRICT OF COLUMBIA SCHOOLS

Under the DC Healthy Schools Act of 2010, the DC Department of General Services must ensure schools are healthy, safe places to learn. Part of this includes promoting programs on recycling and composting. DCPS can opt-in for organics recovery service. In FY 2015, the DCPS diverted 252 tons of organic waste from incinerators and landfill. The organic waste is sent to the Western Branch Composting Facility in Upper Marlboro, which is in Prince George's County. There are also 11 DCPS schools with on-site compost bins where students can learn about composting.

Figure A1: Map of Organics Recovery Potential for DC Public Schools



Schools with composting are show in yellow. Schools without composting are shown in gray.
Stars indicate schools with on-site composting.

TYPES OF PROCESSING SYSTEMS

In general, composting technologies can be classified as in-vessel or outdoor based systems. In an in-vessel based system the material is biologically degraded in an enclosed vessel. An outside based system allows the material to be exposed to the ambient environment. Both systems provide oxygen, generate sufficient temperatures and allow water and carbon dioxide to escape from the composting material. Many composting systems use a combination of in-vessel and outdoor approaches to create a marketable end product. Enclosed static piles and the Ag-bag system would be two examples of this kind of combination. The following technologies are representative of commercially available methods of digesting/composting organic wastes.

BACKYARD COMPOSTING

Backyard composting and community composting can be an easy and inexpensive way municipalities can generate enthusiasm toward composting. One of the most challenging aspects of starting a composting program and an essential component for success is getting residents to understand the value they personally receive from composting. An ideal means of demonstrating value is by providing incentives for residents to compost in their backyard or nearby community garden. Many cities in the U.S. promote composting by offering discounts or vouchers to purchase the equipment necessary to start. For example, the City of San Diego, Calif. offers a year round voucher program where residents can get one of three styles of bins at a discount. The District is already taking steps to promote community composting through their community gardens program.

WINDROW COMPOSTING

Windrowing is the simplest form of compost technology. It is being used throughout the U.S. for composting simple organics such as yard debris. Windrowing is an effective and reliable compost technology for simple wastes and is the least expensive method to biologically treat organic wastes. However, windrowing has the potential to generate odors if “best practices” aren’t employed.

Organic wastes can be composted by arranging layers of size reduced organic wastes and brush chips/wood chips into a pile. The pile is called a windrow and is constructed in order to maximize aerobic microbial activity by creating sufficient mass to both generate and maintain the heat necessary to promote microbial growth and material breakdown. Windrows are typically six to eight feet wide, and as long as possible within space constraints.

Once the pile is established, special machines turn and mix the windrow on a regular basis. Windrows can be turned by a front-end loader, but this turning approach is less efficient then using a windrow turning machine. Many windrow-turning machines are available to windrow compost and they vary considerably in size, capacity, style and price. Windrow turning machines typically vary in price between $100,000 and $750,000.

STATIC PILE COMPOSTING

Static pile composting is similar to windrowing. Rather than aerating the feedstock mixture with a mechanical turning machine, the mixture is usually aerated by means of forcing or sucking air through the windrow or compost pile. Although most static piles are aerated with fans and blowers, simple unaerated static piles can also be used efficiently to compost organic wastes. Oxygenation is accomplished in unaerated static piles by increasing the amount of bulking agent in the compost mixture and by keeping compost piles smaller. This allows for the free flow of oxygen throughout the compost pile without fans or blowers. Unaerated static piles are less expensive to maintain, but take longer to complete the composting process; thus, a larger area (pad) for the storage of composting material is needed which in turn contributes to higher facility capital costs.

Since 1976 the static pile method of composting has been accepted by a number of waste treatment facilities throughout the U.S. Most of these facilities compost sewage sludge mixed with bulking agents of one form or another. The following cities are using static pile technology: Philadelphia, Pa.; Bangor, Maine; Lexington, Ky.; Columbus, Ohio; and Durham, N.H.

AERATED STATIC PILE (ASP) COMPOSTING

Aerated static pile (ASP) composting is the most cost efficient and simplest composting method for large volumes of organic waste. It is especially suited for yard debris, food waste and livestock manure. ASP can be done indoors, outdoors in a windrow composting operation or totally enclosed in-vessel composting. It uses an aeration system to push and/or pull air through the composting mass. Inducing airflow into the organics pile helps to maintain aerobic conditions such as moisture level and temperature that are ideal for the microbial populations, allowing for maximized degradation efficiency and minimization of pathogens. Unlike windrow facilities that require turning of the pile, ASP does not due to the air flow through the pile, which reduces the operational costs of the facility. In addition, covering the compost for aeration provides an added benefit of odor reduction, lowering the impact of the facility on surrounding neighbors.

ANAEROBIC DIGESTION

Anaerobic digestion (AD) is a natural process in which organic materials are broken down by microorganisms in the absence of oxygen. AD treatment systems have been used for decades as a way to stabilize municipal solids and as a form of treatment for high-strength organic waste. A benefit of AD processes, as compared with aerobic processes, is the production of methane-rich biogas which is readily captured. The biogas can be utilized to offset heat or electricity demands and can result in an additional revenue source. In addition to biogas, the end product of the AD process is a digested, stabilized material called digestate, which has nutrient value and can be applied as a low analysis fertilizer. When evaluating AD systems for feasibility it is critical to consider the end uses and/or disposal of the biogas and digestate end products.

AD requires a few key conditions, including an environment without oxygen, optimum temperatures (which vary depending on the specific process), and the proper nutrients. Based on the Eureka Recycling sample data, the residential SSO has a carbon to nitrogen (C:N) ratio ranging between 24.6 and 32.7, which is consistent with the optimum range for digestion between 20 and 30[21]. The commercial SSO characterization showed more variable and lower C:N ratios ranging from 9.2 to 22.9. Given the long detention times in anaerobic systems (on the order of 15 days), the fluctuations in the C:N ratios will likely even out in the reactor. Other concerns are large amounts of yard waste, especially brush and woody material. Woody waste contains high amounts of lignin, a compound most anaerobes are unable to degrade.

[21]RIS International, Ltd. Feasibility of Generating Green Power through Anaerobic Digestion of Garden Refuse from the Sacramento Area. <http://www.nerc.org/documents/sacramento_feasibility_study.pdf> April, 2002.

AD processes are typically classified as wet digestion (or low solids) and dry digestion (high solids). Some references even note a medium-solids system[22]. While the solids concentration threshold between the wet digestion and dry digestion varies from reference to reference, generally wet digestion systems have solids concentrations of 10-15 percent or less. The wet and dry AD systems involve different treatment components, but generally, the biogas quality and quantity produced is similar. The description of the AD alternatives includes more information about wet and dry AD systems; however, primary differences between the two systems are summarized below.

- The two systems require different energy inputs. Wet digestion processes require more energy input, using up to 50 percent of the energy generated, whereas dry digestion processes use only 20 to 30 percent of the energy generated.
- Wet systems have been in use for decades for treatment of municipal biosolids. Dry systems are newer and there are limited U.S. installations.
- Wet systems require the input of water or another wet waste stream. Dry systems, depending on the waste characteristics, may require the input of a bulking material (grass, brush, or woody) to increase the solids concentration and allow percolation of liquid.
- Dry systems require more costly conveyance equipment because standard pumps cannot be used.
- Wet systems require larger storage and heating equipment.

Although popular in Europe and initially frequently utilized for North American on-farm installations, high solid digesters have had difficulty achieving their predicted gas yields using SSO. A number of operators and observers who have focused on SSO digestion in the field at larger volumes find that the combination of operational cost, input requirements, and energy production are not consistent with low solid digestion.[23]

CO-DIGESTION

Solids from sewage sludge are already anaerobically digested at many publicly owned treatment works (POTW) facilities to generate methane and a solid residual as part of the standard secondary treatment process. The methane gas can be used as a source of energy (often for plant operations)

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[22]Verma, Shefali. Anaerobic Digestion of Biodegradable Organics in Municipal Solid Wastes <http://www.seas.columbia.edu/earth/vermathesis.pdf?, May 2002.

[20]Brandon Moffat, personal communication. 3/14/2016.

and the solid residual (biosolids) can be composted to produce a soil amendment. If there is excess capacity in the digester system, food waste can be added to generate more energy. In California alone there are almost 140 POTW facilities that utilize anaerobic digesters, with an estimated excess capacity of 15-30%. An excess capacity at a POTW facility can occur when utility districts overestimate development or when large industries leave the area. For example, East Bay Municipal Utility District's (EBMUD) main treatment plant has an excess capacity because canneries that previously resided in the Bay Area relocated resulting in the facility receiving less wastewater than estimated when it was constructed.

Overall, co-digestion at POTW facilities works well because in many cases the anaerobic digesters already exist and are under-utilized and operational expertise is already in place. In addition, facilities are located in urban areas thus facilitating lower transportation costs and the pre-digestion of food waste can reduce the overall odor production during the composting phase.

The DC Water's Blue Plains Advanced Wastewater Treatment Plant currently treats sewage sludge by removing debris and grit, dewatering and treating with lime to remove harmful organisms and reduce odor before selling as biosolids to farmers to be applied to fertilize land. However, DC Water has a biosolids management program that looks to construct new anaerobic digesters to manage odor, reduce sludge volume and destroy pathogenic organisms. Currently DC Water is still in the process of determining if co-digestion is economically feasible at Blue Plains. The facility is currently generating Class A biosolids at about 31 percent solids and producing 450 wet tons per day (wtpd). If the facility accepted outside wastes, Blue Plains would be able to accept 70 dry tons per day (dtpd) or 450 wtpd at 15 percent solids. A co-digestion feasibility study is scheduled to be undertaken in FY 2017.

VOLUME/CAPACITY CONSIDERATIONS

Composting is an enterprise that has considerable scales of economies when it comes to capital investment. Indeed, some technology options such as anaerobic digestion require daily feedstock volumes of 100 tons. Conversely, windrow and static pile operations can be operated inexpensively with low technology while processing small incoming volumes.

Biological parameters play an essential role in the design of biological reduction technologies. All engineering aspects of compost facilities revolve around the biological parameters necessary for microbial reduction and the need to maintain final compost quality. Product quality considerations include such items as particle size, organic content and biochemical nutrients in the feedstocks.

PROCESS ECONOMICS

The cost estimates for capital and operating portions of the composting technologies discussed here are based on a variety of actual operations that have been viewed by the Project Team over a number of years. The accuracy of these estimates is consistent with conceptual engineering cost opinions and has been prepared for the purpose of comparing the suitability of a range of technologies for composting organic materials from the District. In order to further refine these costs, significant additional work will need to be carried out to identify appropriate sites, actual equipment costs, personnel requirements and energy costs. A critical factor in the economics will be the value of the final material(s).

Table A3 compares the debt service and operating and maintenance (O&M) cost for various technologies. The table expresses this information on a per ton basis so that all comparisons can be measured against tipping fees quoted to the project for acceptance, transfer and composting of organics from the District. Estimates on the value of finished compost and revenues have been made to show the expected tipping fees.

Table A3: Costs for Various Technologies

Compost System	Debt Service $/ton	O&M $/ton	Gross	Revenue	Required Tip Fee	Site Requirements
Backyard	N/A	N/A	N/A	N/A	N/A	N/A
Windrowing	4	54	58	$12 - $20	46	20 - 25 acres
Static Pile	5	55	60	$12 - $20	48	20 - 25 acres
Aerated Static Pile (ASP)	6	55	61	$12 - $20	49	10 - 25 acres
Wet Anaerobic Digestion	26	65	91	$22 - $26	69	5 - 10 acres
Dry Anaerobic Digestion	47	48	95	$18 - $23	77	5 - 10 acres
Co-Digestion	46	55	101	$10-$15	91	5 - 10 acres

No transfer costs have been assumed in the forgoing analysis. It is further assumed that normal odor, dust and debris problems of windrowing would be acceptable at chosen site. A silo digester produces considerably more methane and results in a higher revenue stream than the low-cost container anaerobic system.

Table A-3 should be used to understand the comparative rank of various technologies regarding capital costs (debt service) and operating costs. It is expected that the actual capital cost for any organics technology chosen will differ from those shown in this table, because actual costs are very project specific. For instance, if the composting site will be in an urban environment, the actual costs of land and odor control technology could be significantly higher. This will also increase the costs for site work, odor control equipment and land costs. If a transferring operation is necessary to compost processed materials in a more rural site; this could also increase the capital and operating costs.

PREVENTION SOLUTIONS

According to ReFED, nearly 80 percent of all food waste is generated in homes or consumer-facing businesses. The most cost effective method of reducing food waste is to stop waste from occurring in the first place. ReFED outlines 12 solutions to prevention success.

Table A4: Prevention Solutions	
Packaging, Produce and Portions	Standardized data labeling
	Packaging adjustments
	Spoilage prevention packaging
	Produce specifications
	Smaller plates
	Trayless dining
Operational & Supply Chain Efficiency	Waste tracking and analytics
	Cold chain management
	Improved inventory management
	Secondary resellers
	Manufacturing line optimization
Consumer Education	Consumer education campaigns

The three main sections of prevention include adjustments to packaging, produce and portions, operational and supply chain efficiency and consumer education. Adjustments to packaging, produce and portions include standardizing data labeling to avoid consumer confusion on expiration date which can result in good food being thrown out. Other important considerations in packaging are packing size and packaging to prevent food from spoiling. Produce specification refers to gaining acceptance with using "imperfect produce" or produce that may have a different size, shape or color than consumers are familiar with. Often the use of imperfect produce can provide cost savings. Finally, adjusting to smaller plate sizes and eliminating trays to avoid too much food waste at restaurants will prevent food waste generation.

The next component to food waste prevention is operational and supply chain efficiency. At the base of this prevention component is waste tracking and analytics. By tracking waste, it can be managed and eliminated. For example, collecting information on weights to identify the amount of food tossed out during food preparation. Waste tracking can be as simple as recording the information by hand to using sophisticated mobile applications. Along with tracking waste, improvements in tracking a products average remaining shelf-life could provide grocers with the means of streamlining inventory to prevent items from sitting on the shelf too long. Cold chain management refers to increasing the use of direct point-to-point perishables food shipments from farmers to retailers to reduce the number of stops in transit. Improved inventory management involves optimizing equipment operating conditions to find the most efficient run settings. By modifying production to minimize sporadic waste generation, food waste can be prevented. Finally, to prevent good food from going to the landfill, dedicated markets should be created to sell discounted groceries of less desirable produce, such as the imperfect produce mentioned above.

Consumer education is a key component of prevention, and a solution the District could start implementing today. The education component should include information on better use of leftovers and teaching consumers how to minimize spoilage by properly storing food in the refrigerator. An added component to starting at the education piece is that once aware of the food waste issues, consumers can place pressure on businesses and manufacturers to operate more responsibly.

RECOVERY SOLUTIONS

After prevention methods are implemented, the next step in the food waste reduction hierarchy is recovery. Recovery involves redistributing food to people and ReFED provides seven solutions to redistribution success.

Tables A5: Recovery Solutions

Donation Infrastructure	Donation matching software
	Donation storage and handling
	Donation transportation
	Value-added processing
Donation Policy	Donation and liability education
	Standardized donation regulations
	Donation tax incentives

A huge hurdle to food recovery is connecting the food donors with recipients. Donation matching software can be utilized to establish the most efficient means of connecting food donating businesses such as restaurants with food accepting groups such as nonprofits. Expanding temperature controlled infrastructure and providing small-scale transportation infrastructure for local recovery and long-haul transport can help get the food donations to their recipients in a timely fashion. Finally, consideration of freezing or jarring unused food for later donation is another method of improving food recovery. Another major obstacle for food donation is concern from donors such as restaurants on liability if donated food causes illness. The federal Good Samaritan Food Donation Act protects donors and recipients from civil or criminal liability short of gross negligence and misconduct. Another component to protecting donors and recipients is standardizing local and state health department regulations for safe handling and donation of food through federal policy. Finally, tax incentives can play a key role in promoting participation in food donation programs.

ANALYSIS

ORGANICS GENERATION (ANALYSIS)

This analysis evaluates the amount of SSO that could be captured from each DC DPW household based on several factors. First, a low and a high generation rate is used in order to provide a range of total tonnage that might be expected during collection. This is done separately for both HHO and yard debris so that the economics of collection for either stream can be evaluated independently. Second, the participation rates are varied by collection routes according to analyzed recycling participation rates. Finally, material available is evaluated both in terms of annual as well as weekly generation in order to facilitate the calculation of the required number of trucks. The model also utilizes total number of households per route using the current recycling route data so that recovery can be evaluated on a ward-by-ward basis.

TRUCK CALCULATION (ANALYSIS)

Once the overall amount of organics collected is modeled, the necessary number of weekly collection routes can be calculated. Again, because there is both a high and a low tonnage amount available, it is possible to separately evaluate the number of trucks needed for both high and low recovery assumptions. The model also has the capability to show the number of trucks needed by neighborhood based on recycling truck route information provided by DC DPW. The total number of trucks needed for collection is calculated by dividing the number of routes by five (for the number of days in a week) and rounding up to the nearest truck. Although routes are forced to end after a minimum number of pass-bys (important in situations where only household organics are collected), there is a simplifying assumption made that each route requires an entire day.

CONTAINER CALCULATION (ANALYSIS)

It is assumed that all of the residents of the District will be given a cart and a kitchen “bucket”. This information is used to calculate capital and operating costs for these containers.

COLLECTION COST DETAIL (ANALYSIS)

A summary capital and operating cost analysis that utilizes information from DC DPW’s costs for operating collection vehicles, required routes and trucks calculated as part of the previous worksheets and containers calculated as part of the previous worksheets. Capital costs of all investments are designed to be amortized over the life of the capital asset. Costs for replacement containers are assumed to be part of the annual operating costs while the initial costs for containers purchases are capitalized along with the purchase costs of collection vehicles. Education costs are handled similarly, with startup education costs capitalized and yearly costs shown as part of the operating costs. All operating costs are shown in today’s dollars and are not inflated for future years.

MANAGING CHANGE IN A RESOURCE-CONSTRAINED WORLD

RRS is a consultancy with a vision. We see a world where resources are managed to maximize economic and social benefit while minimizing environmental impact. A world where abundance keeps pace with societal needs.

We have assembled a unique team of strategists, engineers, economists and communications specialists with core strengths in materials and recovery, coupled with expertise in life cycle management and applied sustainable design. These experts operate confidently across the supply chain, identifying the most leveraged opportunities to affect change, and developing pathways to long-term value.

RRS has been working toward this vision since 1986. Our clients are leaders in materials management, and in partnership we have achieved outstanding results. We remain nimble and responsive, providing informed, innovative, actionable solutions to the sustainability challenges of our time.