City of Baltimore

RECYCLING AND SOLID WASTE MANAGEMENT MASTER PLAN

Task 5 Report

Potential Improvements to the Current Diversion/Recycling System

15 April 2020

Prepared for:

Baltimore City Department of Public Works

Prepared by:

Geosyntec consultants

Columbia, Maryland

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All appendices are provided as MS Excel attachments.

ABBREVIATIONS AND ACRONYMS

Formal names for offices, agencies, institutions, and programs are capitalized; technical terms are in lower case.

ABS	acrylonitrile butadiene styrene (e.g., Lego)
AD	anaerobic digestion; anaerobic digestor
AVAC	automated vacuum collection
BCAA	Baltimore Clean Air Act
BCCF	Baltimore City Compost Facility
BCPS	Baltimore City Public Schools
BCRP	Baltimore City Department of Recreation and Parks
BFWRS	Baltimore Food Waste and Recovery Strategy
BPPF	Baltimore Patapsco Pelletizer Facility
BOS	Baltimore Office of Sustainability
BRC	Baltimore Recycling Center
BRPF	Back River Pelletech Facility
BRWWTP	Back River Wastewater Treatment Plant
BRESCO	Baltimore Refuse Energy Systems Co. (now Wheelabrator)
BSP	Baltimore Sustainability Plan
BZWP	Baltimore Zero Waste Plan
CAP	Baltimore City Climate Action Plan
CAPEX	capital expenditure; capital costs
CASP	covered aerated static pile (composting)
CDL	container deposit law; bottle bill
C&D	construction and demolition
DBO	design-build-operate (contract)
DBFO	design-build-finance-operate (contract)
DHCD	Baltimore City Department of Housing and Community Development
DP3	Baltimore City Disaster Preparedness and Planning Project
DPW	Baltimore City Department of Public Works
EPR	extended producer responsibility
EPS	expanded polystyrene; Styrofoam
FDA	Food and Drug Administration
GHG	greenhouse gas
HDPE	high density polyethylene; no. 2 plastic
HFPA	Healthy Food Priority Area
HHW	household hazardous waste
ICI	industrial, commercial, and institutional (sectors)
ILSR	Institute for Local Self Reliance
LEED	Leadership in Energy and Environmental Design
LMO	last mile organization
LWBB	Less Waste, Better Baltimore (Plan)
L&J	L&J Waste Recycling, LLC
MDE	Maryland Department of the Environment
MDP	maximum diversion potential
MES	Maryland Environmental Service
MFD	multi-family dwelling
MRA	Maryland Recycling Act
MRC	mandated recycled content
MRF	materials recovery facility
MSW	municipal solid waste

MTCO2E	metric tons (tonnes) of carbon dioxide equivalent
NRDC	Natural Resources Defense Council
NMWDA	Northeast Maryland Waste Disposal Authority
NOx	nitrogen oxides
NWTS	Northwest Transfer Station
NTR	non-traditional recyclables
OPEX	operating expenditure; operating costs
O&M	operation and maintenance
PAYT	pay as you throw
PET/PETE	polyethylene terephthalate; no. 1 plastic
PP	polypropylene; no. 5 plastic
PPP/3P/P3	public-private partnership
PSA	public service announcement
PSI	Product Stewardship Institute
PVC	polyvinyl chloride
PWWTP	Patapsco Wastewater Treatment Plant
QRL	Quarantine Road Landfill
RAP	recycled asphalt pavement
RCRA	Resource Conservation and Recovery Act
RECYCLE	Recycling Enhancements to Collection and Yield through Consumer Learning and Education (Act)
RFID	radio-frequency identification
RFP	request for proposals
RNG	renewable natural gas
RORO	roll-on, roll-off container
RRP	resource recovery park (eco-park)
SAYR/SAYT	save as you recycle; save as you throw
SFH	single family home
SMM	sustainable materials management
SOx	sulfur oxides
SSR	single-stream recycling; single-stream recyclables
SSO	source separated organics
SWANA	Solid Waste Association of North America
USDA	United States Department of Agriculture
U.S. EPA	United States Environmental Protection Agency
WARM	Waste Reduction Model (U.S. EPA)
WMRA	Waste Management Recycle America
WTE	waste to energy
WWTP	wastewater treatment plant
ZWA	Zero Waste Associates

1. INTRODUCTION

1.1 Overview and Approach

This Task 5 Report was prepared by Geosyntec Consultants, Inc. of Columbia MD for the City of Baltimore Department of Public Works (DPW) as part of a master planning effort titled the "Less Waste, Better Baltimore" (LWBB) Plan. The LWBB Plan is intended to:

1. Outline a clear and attainable future vision for improving Baltimore City's solid waste and recycling system over both the near- and long-term, with the goal of maximizing waste reduction, reuse/repair, recycling, and sustainable management of materials;
2. Develop actionable strategies to achieve this goal; and
3. Identify potential impacts on existing solid waste management systems, including programmatic and infrastructure needs, investment challenges, and associated policy or regulatory initiatives.

This Report is the eighth in a series of reports developed in support of the LWBB Plan. In previous tasks, an extensive stakeholder engagement and public communication systems was established to engage the community in the master planning effort. Input from the stakeholder engagement process was used to help inform the review of options in Task 5.

In this Report, the capitalized term "City" is used specifically to refer to Baltimore City Government, which includes DPW and other departments and offices (e.g., Planning, Sustainability, and Health) but does not include Baltimore City Public Schools (BCPS). Use of "Baltimore" or the lower case term "city" refers to Baltimore City as a whole. This Report presents potential actions that could be taken by the City, and in particular DPW, to improve the overall waste diversion/recycling system in Baltimore.

Geosyntec's consideration of options for increasing diversion and recycling follows sustainable materials management (SMM) concepts in accordance with U.S. Environmental Protection Agency (EPA) guidance. EPA developed their SMM hierarchy in recognition that no single waste management approach is suitable for managing all materials and waste streams in all circumstances. As such, the hierarchy ranks the various management strategies from most to least environmentally preferred. The EPA's SMM hierarchy is consistent with guidance from the United Nations' Intergovernmental Panel on Climate Change and the European Union, and has been adopted by the Maryland Department of the Environment (MDE) and the U.S. Conference of Mayors. According to the EPA, SMM "aims to use and reuse materials in the most productive and sustainable way across entire lifecycles by minimizing the amount of materials involved, reducing the use of toxic materials, and minimizing overall environmental impacts, while balancing with economic constraints." SMM's holistic approach thus focuses on the impact of materials throughout their life and not only on end-of-life management, which is where solid waste agencies such as DPW typically operate. This presents some constraints in terms of how far "upstream" in the lifecycle use of materials municipal governments and agencies can expect to exert any influence, which is recognized in consideration of options in Task 5.

A further constraint is that solid waste management in Baltimore, like most jurisdictions, operates within two distinct spheres. The City's "sphere of control" represents the portion of the waste stream that is

under their direct control, primarily the residential sector and other entities with waste/recycling services provided by DPW. Recommending changes to programs and systems within this sphere is relatively straightforward and actionable. However, Baltimore also relies on waste management services and facilities that are privately owned and/or are located outside their jurisdictional limits. Although the City does not have direct control over these operations within the commercial sector, they are nonetheless influenced by the City's priorities, policies, and regulations and, therefore, are considered to be within the City's "sphere of influence." Recommending changes to programs and systems within the City's sphere of influence is not as straightforward as for those within their sphere of control.

1.2 Scope and Purpose

Consistent with the methodology outlined above and the scope of work for Task 5, the purpose of this Report is to:

1. Document potential options for the City to consider which, if implemented, would improve waste diversion and recycling rates within the residential and commercial sectors; and
2. Building on promising options, identify specific programs for consideration by the City based on high-level information regarding:
   A. The anticipated level of waste diversion or recycling that could reasonably be expected following their implementation;
   B. Costs and timelines for implementation;
   C. Siting requirements (e.g., whether programs could be located at existing City-owned facilities, or whether new sites would be needed within or outside of city limits);
   D. Job creation potential within the public and private sectors; and
   E. Environmental benefits achieved, measured in terms of lifecycle greenhouse gas (GHG) emission reductions as compared to "business as usual" disposal via landfilling at the City's Quarantine Road Landfill (QRL), or another potential landfill, or incineration at Wheelabrator Baltimore, the waste-to-energy (WTE) facility previously known as BRESCO, or another potential WTE facility.

Review of potential options should also consider contingency planning for unexpected events that could temporarily or permanently interrupt the existing/future system in Baltimore. While adoption of the options for waste diversion and recycling assessed in Task 5 would reduce the City's reliance on disposal infrastructure and thus help build resilience to climate change or other disruptions, contingency planning is more appropriately evaluated in Task 7, which focuses on disposal options for what's left (i.e., material that cannot realistically be diverted under one or more options assessed in Task 5).

1.3 Basis and Guidance for Analysis in Task 5

Several technical and strategic planning documents have been prepared as part of LWBB Plan development to inform and guide the focus of the review of options in Task 5. The City also has multiple planned source reduction, recycling, and waste diversion programs, independent of the LWBB Plan. Programs of direct relevance to Task 5 are outlined in the

Baltimore Food Waste and Recovery Strategy (BFWRS) and the Baltimore Sustainability Plan (BSP), which were prepared by the Baltimore Office of Sustainability (BOS).

Reports Prepared to Date for the LWBB Plan

To date, the following documents have been prepared as part of the LWBB Plan. These form the technical background for Task 5 and also represent the public's input to the master planning effort. All documents listed have been approved by DPW and are posted on the LWBB website.

1. Task 0 – Waste Sort: Geosyntec conducted a two-season waste sort to establish more reliable and up-to-date data on waste characteristics and quantities generated in Baltimore. The Interim Report on Task 0 (22 February 2019) provides data from the winter waste sort conducted in January/February 2019, which assessed residential curbside trash and recycling loads as well as materials disposed of or recycled at drop-off centers by residents and small haulers. The Second Report on Task 0 (26 September 2019) provides data from the summer waste sort conducted in June 2019, which added sorting of commercial trash loads to the waste streams investigated in the winter waste sort.
2. Task 1 – Meetings #1 and #2: To involve residents and other stakeholders in developing the LWBB Plan, DPW solicited community input through facilitated community meetings held on 28 February and 11 March 2019. These meetings provided residents, organizations, businesses, and other stakeholders with the opportunity to identify challenges to improving waste management and diversion in Baltimore and to suggest new options for consideration. Stakeholders were invited to ask questions and provide input at the meetings or to submit their questions/input via a dedicated email address and various online social media platforms, including Facebook, Twitter, and Nextdoor. A summary of ideas shared was provided in the Task 1 – First Report (29 March 2019). Challenges and suggestions were grouped in terms of source reduction, waste collection, recycling, composting, managing what's left, education, health and environmental needs, and enforcement.
3. Task 1 – Online Survey: Parallel to the community meetings, DPW developed an online survey to solicit input from stakeholders. The survey was widely publicized via social media and other outlets. Over 2,000 survey responses were received, which asked respondents how they used the existing waste/recycling system, what issues they identified, and requested thoughts on how to make improvements. As outlined in the Report on Survey Results (18 April 2019), 96% of responders said they would support policies that lead to improved waste reduction, recycling, and reuse, with 86% indicating a willingness to learn how to reduce waste and/or sort waste for new recycling or organics collection programs. A majority of responders agreed that reducing construction and demolition (C&D) waste and expanding opportunities for bulk trash diversion should be encouraged. Challenges and suggestions for improving services were primarily grouped in terms of collection, street sweeping and litter control, better bin allocations, illegal dumping, recycling, composting, plastics, incentives/taxes, education, and the City's 311 service.
4. Task 1 – Meetings #3 and #4: Two additional community meetings were held on 4 and 11 June 2019. At these meetings,

the study team provided an update on input received to date and summarized the current research into options for improving solid waste diversion in Baltimore. Attendees had the opportunity to pose questions or make suggestions regarding the master planning effort. A summary of ideas shared was provided in the Task 1 – Second Report (26 August 2019).

5. Task 3 – Comprehensive Description of Existing Solid Waste Management System: In preparing the Task 3 Report (30 July 2019), Geosyntec reviewed the multifaceted solid waste and recycling programs, services, and facilities operated by DPW and other City and private actors as well as relevant regulations, population and housing projections, governance, finance, and contracts affecting solid waste management and recycling in Baltimore. The review of private actors included infrastructure and facilities in the local region, as defined by a 3-hour truck travel distance from the city. The Report also quantified material flows from the residential and commercial sectors within the city's wasteshed based on data reported by DPW and MDE.
6. Task 4 – Benchmarking: The Task 4 Report (26 September 2019) This study compares the performance of Baltimore's current solid waste management system and services with those in five other U.S. jurisdictions that have either enacted, or are in the process of enacting, meaningful improvements to their waste disposal and recycling rates (e.g., SMM plans, zero waste plans, or circular economy initiatives). Baltimore's master planning effort can learn from the experiences in these other jurisdictions, which are Austin TX, Boston MA, Charleston SC, Charlotte NC, and Portland OR. Areas of comparison included waste collection services, waste management infrastructure and facilities, waste management financials, quantities of waste managed, recycling rates, and waste-related initiatives and regulations. In addition to identifying lessons learned in each of these areas, the study includes a selection of physical infrastructure, policies, and regulatory, programmatic, and economic best practices that the City may consider as part of making improvements to Baltimore's current waste diversion and recycling rates.

Baltimore Sustainability Plan (BSP)

The Baltimore Sustainability Plan was adopted by the City Council in April 2019. The BSP presents three major strategies for improving waste management and recycling in Baltimore with associated action items:

1. Increase the amount of trash that is diverted from landfill or incineration to recycling programs. Specific action items include providing free recycling bins to all residents and increasing commercial recycling; launching an anti-litter, pro-recycling campaign; and creating a plan to achieve zero waste, meaning the City is "working toward or diverting over 90% of discards from landfilling or incineration."
2. Expand the City's Waste to Wealth Initiative (see below). Specific action items include implementing the Baltimore Food Waste and Recovery Strategy (BFWRS), siting a local compost facility, and revising building codes and/or creating ordinances to eliminate waste and encourage reuse of deconstructed building materials.
3. Pursue legislative and policy changes to reduce the waste stream. Specific action items include imposing a fee for plastic bags,

creating a procurement committee to incentivize source reduction, and developing a "save as you throw" (SAYT) program.

Meeting the above goals would require additional funding to be approved by the City Council as well as deviation from DPW's current funding mechanisms in which the provision of collection and disposal services is funded from the City's general fund. Options that fall within these three main action items and that could help the City achieve zero waste goals are emphasized in this Report.

Baltimore Food Waste and Recovery Strategy (BFWRS)

The Baltimore Food Waste and Recovery Strategy was developed in September 2018 in partnership with the Institute for Local Self-Reliance, a non-profit organization based in Washington DC. The BFWRS sets specific goals and outlines strategies for achieving multi-sectorial reductions in food waste, with a target date of 2040 in each case:

1. Commercial: 50% reduction in food waste.
2. Higher Education Institutions: eliminate all food waste.
3. City Government: 90% diversion of food and organic waste from landfill or incineration.
4. Public Education: 90% food and recyclable waste diversion in K-12 schools.
5. Residential: 80% reduction in residential food waste; 100% access to organic waste collection for residents; and 80% diversion of residential food and organic waste from landfill or incineration.

In support of these goals, the BFWRS recommends creation of composting and anaerobic digestion (AD) capacity for processing 100% of Baltimore's organic waste stream, support for the food waste diversion market by ensuring an adequate supply of organic waste is being diverted to compost and AD facilities, and creating a supportive culture for food waste reduction and diversion within City Government.

To meet the above goals, BFWRS outlines over 60 short-, medium-, and long-term strategies to be implemented by the City, many of which would require significant additional funding to be approved. Support from the City Council will be critical to their success, as well as supporting legislation to help "move the needle" on new initiatives. Community support for these initiatives and added costs will also be critical. In this Report, options that could contribute towards meeting the goals of the BFWRS are emphasized. However, it should be recognized that implementing the BFWRS requires initiatives that are much broader than those under the City's direct jurisdiction.

Waste to Wealth Initiative

The Waste-To-Wealth Initiative was developed to help grow Baltimore businesses while reducing overall waste generation. The initiative seeks ways to support local businesses that are using recycled (secondary) materials to make products rather than primary (virgin) materials. The vision is for these businesses to support creation of stable middle-class jobs. The initiative acknowledges that while several businesses in Baltimore have already engaged in innovative reuse and repurposing strategies for a wide variety of secondary materials, particularly C&D debris, they need support from the City. By fostering businesses that seek to capture value from secondary materials before they enter the waste stream, it is hoped the City can stimulate job creation, combat blight, and encourage resident-led greening efforts to revitalize city neighborhoods. The initiative specifically targets three high-value,

primarily non-residential wastes that comprise a significant portion of waste generated in Baltimore. These are food waste, C&D debris, and wood waste. Options that could contribute towards reducing these targeted wastes are emphasized in this Report.

Climate Action Plan (CAP)

To mitigate the severity of future impacts due to climate change, and to adapt to known risks facing a low-lying coastal region, the City is working to instill resilience into vulnerable systems and infrastructure. The Climate Action Plan was developed in November 2012 to reduce Baltimore's GHG emissions by 15% below 2010 levels by 2020 through a range of strategies targeted at reducing consumption of fossil fuels. In the BSP, this goal was updated to 25% reduction by 2020 and 30% by 2025 (relative to 2007). Transportation (30%) and disposal of waste (1%) were identified as significant contributors to overall GHG emissions.

Public services such as solid waste management are vulnerable to changing climate patterns but also offer solutions. Implementing programs to locally process and reuse components of the waste stream could significantly reduce GHG emissions, which complements the City's goals to promote composting and compost use under the BFWRS as well as C&D debris and wood waste in accordance with the Waste to Wealth Initiative. Waste reduction and reuse are central tenets in the BSP's goal to increase diversion, recycling, and composting to move Baltimore further towards zero waste. Sustainably managing materials, including recycling and disposal of materials as close as possible to the point of generation, would help in achieving the City's GHG emissions reduction goals.

Disaster Preparedness and Planning Project (DP3)

The Disaster Preparedness and Planning Project was created in an effort to address existing hazards while simultaneously preparing for predicted hazards due to climate change. An update to the DP3 was adopted by the City in December 2018. With regard to public services, disaster preparedness and distribution of resources, information, and response plans are identified as being key to ensuring public safety and mitigating hazards. A primary goal of the DP3 is to enhance the city's adaptive capacity and build institutional structures that can cope with future conditions that are beyond past experience.

The key impacts of climate change in Baltimore are likely to manifest as increased flooding and storm damage, potentially inundating low-lying properties and disrupting transportation routes. Therefore, where practical, the options reviewed in Task 5 generally steer towards recommending decentralized systems (i.e., a network of small facilities and programs) rather than one centralized system, as decentralized systems are more robust to catastrophic disruption. Smaller impacted facilities can also usually recover more quickly than larger ones.

1.4 Other Relevant Legislation and Key Resources

Baltimore City Legislation and Resolutions

Baltimore Clean Air Act

The Baltimore Clean Air Act (BCAA), introduced as Council Bill 18-0306, was approved by the City Council on 11 February 2019 and signed by then Mayor Pugh on 7 March 2019. The BCAA requires commercial solid waste

incinerators in Baltimore to conduct continuous monitoring of multiple pollutants, including dioxins, furans, nitrogen oxides (NOx), sulfur dioxides (SOx), particulate matter, polycyclic aromatic hydrocarbons, and several heavy metals. It also establishes significantly stricter emission limits for mercury, NOx, SOx, and dioxins/furans than are required under Maryland regulations. Compliance with the BCAA is required starting in September 2020 or January 2022, depending on the specific emission control and/or monitoring system in question. If BRESCO cannot economically comply with the BCAA, it may be forced to close at that time, adding urgency to the need for achieving significant diversion of waste from disposal in the short term.

Expanded Polystyrene Foam Ban

Baltimore City Council passed ordinance 18-0125 in April 2018 banning expanded polystyrene (EPS) foam food containers. The law prohibits the use of EPS (or Styrofoam) as disposable food serviceware or packaging. Items such as foam cups, clamshells, bowls, and plates will thus no longer be allowed in Baltimore. The ban went into effect on 19 October 2019 and applies to all food service facilities, including restaurants, grocery stores, hospital cafeterias, mobile food carts, bars/taverns, market stalls, public and private schools, caterers, special event food vendors, summer camps, bakeries, and congregation kitchens.

Single-Use Plastic Bag Bill

The City Council passed ordinance 19-0401 on 18 November 2019 (signed 13 January 2020) to ban the distribution of single use plastic bags at the point of sale, and place a fee of a nickel for any other type of single use bag, including paper and compostable bags. The program goes into effect one year after the ordinance is enacted.

Zero Waste Resolution

The Judiciary and Legislative Investigations Committee approved 17-022R, a resolution calling for City agencies and experts to meet and begin discussing "the development of a Zero Waste plan for Baltimore that will advance sustainability, public health, and job creation." The resolution was adopted June 2017. A follow-up resolution 18-0086R was adopted in May 2018. In April 2019, an advocacy group led by United Workers, a nonprofit organization based in Baltimore, hired Zero Waste Associates (ZWA) and the ILSR to "assist the City of Baltimore to develop a zero waste scenario for the city's long-range recycling and solid waste management master plan." ZWA and ILSR have worked on a Baltimore Zero Waste Plan (BZWP) under contract to United Workers, independent of this LWBB Plan. Their BZWP aims to make zero waste a key priority to mitigate climate change, reduce climate emissions and other environmental and public health impacts, save money, support economic mobility, create good jobs and small businesses in all sectors of Baltimore, and sustain this work through culture change.

In agreement with DPW, ZWA and Geosyntec have collaborated and shared ideas. Where appropriate, for example, the potential role of the BZWP in helping achieve necessary programmatic or policy changes is highlighted in several sections in this Report. At the time of writing this Task 5 Report, the final BZWP had not been shared by ZWA or ILSR.

Maryland State Legislation

Passed Legislation

A summary of relevant legislation from the 438th Legislative Session (9 January to 8 April 2019) is outlined below.

- SB 370 – Recycling – Office Buildings: Amends Maryland code to require city/county recycling plans to address collection and recycling of recyclable materials from commercial properties that are 150,000 square feet or larger and zoned for office use. This new bill goes into effect on or before 1 October 2021.
- HB 109/SB 285 – Expanded Polystyrene Food Service Products – Prohibitions: Under this bill, polystyrene products are prohibited from being sold or from being distributed by food service in Maryland starting on 1 July 2020.
- HB 510 – Organic Waste – Organics Recycling – Collection and Acceptance for Final Disposal: This bill prohibits the owner/operator of a refuse disposal system from accepting loads of separately collected organic waste (i.e., yard waste and food waste) for final disposal unless the owner/operator provides for the recycling of the organic waste.

Passed during the 2017 Legislative Session, House Bill 124 directs MDE to adopt regulations to specify when a "recycling facility" may operate without a refuse disposal permit and to exempt certain materials that are managed at a recycling facility from being designated as "solid waste." The law also provides that the regulations may include design and operational conditions for recycling facilities to protect the environment and allows for a tiered system of permits or approvals that are based on the type and amount of materials to be managed at a facility. MDE has completed the consultative phase and is currently drafting regulations for review.

MDE is also holding study group meetings to study and make recommendations regarding diversion of yard waste, food residuals, and other organic materials and the status of state infrastructure, as required by House Bill 171 (also passed in the 2017 session). A final report was issued in July 2019.

Recycling at public schools, apartment buildings and condominiums with ten or more dwelling units, and special events held on public property is already required under Maryland law. Specific laws are also in place to prohibit disposal of scrap tires in landfills; make battery manufacturers responsible for collection, transportation, and recycling or disposal of batteries; and require collection and recycling of fluorescent and compact fluorescent lights that contain mercury.

Finally, Maryland has an electronics recycling law that mandates manufacturer responsibility; however, the law is not very strong in terms of assisting jurisdictions with the costs and operational burden of electronics recycling programs. The law has had limited impact statewide and most of the money collected stays with MDE.

Legislation Not Passed or Repealed

The State Legislature has previously considered but not passed bills related to recycling of solar photovoltaics; prohibiting restaurants from providing single-use plastic straws to customers; recycling/diversion of paint; and encouraging recycling of mattresses and box springs. These are listed here as a reminder that they may remain in consideration in upcoming sessions.

In December 2014, MDE published a guidance document titled "Zero Waste Maryland: Maryland's Plan to Reduce, Reuse, and Recycle Nearly All Waste Generated in Maryland by 2040," which set an overall 80% recycling goal and 85% waste diversion goal by 2040. Although the Zero Waste Plan was subsequently repealed, it may be reissued in the future.

Federal Legislation

Winning on Reducing Food Waste Initiative

On 9 April 2019, the U.S. EPA, U.S. Dept. of Agriculture (USDA), and Food and Drug Administration (FDA) issued a federal interagency strategy for reducing food waste, as part of the "Winning on Food Waste" initiative. The strategy includes six priorities to work towards a national goal of reducing food loss and waste by 50% by 2030. The priorities include improving interagency coordination; increasing education and outreach; improving guidance and collaboration with private industry; and encouraging food waste reduction within the federal government.

Udall/Lowenthal Plastic Crisis Legislation Proposal

U.S. Senator Tom Udall (D-NM) and U.S. Representative Alan Lowenthal (D-CA) intend to introduce comprehensive legislation in Fall 2019 to tackle the plastic waste crisis. The announcement made on 18 July 2019 was accompanied by a dozen proposed components, but without actual bill text, for which the lawmakers are seeking input from stakeholders. A summary of the components is provided below, with the full announcement available here.

- Obligations for producers: Producers will be required to design, manage, and finance programs for end-of-life management of their products and packaging as a condition of sale. Producers will help cover the costs of waste management and clean-up, as well as awareness raising measures.
- Nationwide Container Deposit Requirements: Place a national deposit requirement on beverage containers (all materials, including glass, plastic and aluminum).
- Carryout Bag Fee: A fee will be placed on the distribution of available carryout bags (paper bags and non-reusable bags).
- Ban on Certain Plastic Products: Where alternatives are readily available and affordable, the most commonly polluted single-use plastic products will be banned from the market.
- Styrofoam: Ban use of expanded polystyrene.
- Labelling Requirements: Consumer products made from plastic will require clear and standardized labelling which indicates how waste should be disposed and the presence of plastics in the products.
- Awareness-Raising Measures: States will be encouraged to raise consumers' awareness about the negative impact of littering as well as about available re-use systems and waste management option.
- Collection Targets: Set goals for states to collect a high percentage of single-use plastic drink bottles. Set targets to standardize recycling collection across communities and states.
- Requirements: Set requirements for certain products to be made of 100% recyclable materials and others made from a significant percentage post-consumer recycled product.
- Federal Fund: A federal fund will ensure resources are available for pollution reduction, remediation programs and innovation research.
- Protect Local Governments and Political Subdivisions: States that prohibit local governments from implementing measures to reduce plastic products will lose federal funding.

- Encourage Local Government Action: Create Clean Cities Program to use smart technology and social media to help local governments cost-effectively identify pollution hot spots and implement source reduction solutions.

Save Our Seas 2.0 Act

In an effort to further address marine debris, the Save Our Seas 2.0 Act has been introduced in the House and Senate. Among other goals, this bill is intended to strengthen domestic infrastructure to prevent the creation of new marine debris and directs the EPA to develop a strategy within one year to improve waste management and recycling infrastructure, harmonize waste collection and recycling protocols, strengthen markets for recycled plastic, and identify barriers to increasing the collection of recyclable materials. Additionally, it would create a Waste Management Revolving Fund and a Waste Management Infrastructure Grant program.

Congressional Letter to Dept. of Commerce and EPA

On 12 July 2019, over 40 members of Congress signed letters sent to the U.S. Dept. of Commerce and U.S. EPA expressing serious concerns about the state of recycling in the United States and to better understand how they are responding to the impacts of China's "National Sword" policy. The Department of Commerce is mandated under the Resource Conservation and Recovery Act (RCRA) to encourage greater commercialization of proven recycling technology as well as stimulate the development of markets for recycled materials in the United States. RCRA also made EPA the federal leader in the conservation and recovery of materials. The letter requests a reply to several questions about the actions of both EPA and Commerce since China's policy was announced.

Zero Waste Act

The Zero Waste Act was introduced in the U.S. House of Representatives by Representative Ilhan Omar (D-MN) on 25 July 2019 and would establish federal grants to support municipalities in recycling and waste reduction efforts. The program would be carried out by the U.S. EPA and would be funded with up to $250 million from 2020 through 2027.

Similar legislation was previously introduced in 2017 as the "Zero Waste Development and Expansion Act." This legislation has been described as a component of the Green New Deal.

RECYCLE Act

The proposed Recycling Enhancements to Collection and Yield through Consumer Learning and Education (RECYCLE) Act would create a program within the U.S. EPA to bolster recycling education. Sponsored by Senators Rob Portman (R-OH) and Debbie Stabenow (D-MI), RECYCLE would authorize up to $15 million per year over five years in grants to states, tribes, nonprofits, public partnerships, and local governments to ramp up commercial and municipal recycling outreach and education. The EPA would be directed to develop a model recycling toolkit to bolster recycling participation and decrease contamination rates. Where appropriate, the act would also task the EPA with updating guidelines for products containing recycled material more frequently, as well as recommending that federal agencies purchase those items.

Key Resources

Several online resources are available to help local governments and municipalities plan for and implement policies and programs for waste

reduction and recycling initiatives. Links to some key resources are listed below.

U.S. Environmental Protection Agency

The U.S. EPA's "Reduce, Reuse, Recycle" website aims to help residents and communities learn how reducing, reusing, and recycling can help save money, energy, and natural resources. Information is focused on recycling programs managed at the state and local level.

The U.S. EPA also maintains a compendium website "Managing and Transforming Waste Streams: A Tool for Communities," which explores policies and programs that communities can implement to reduce waste disposal and promote waste prevention and materials reuse across multiple waste generation sectors. The website also provides access to example city and county ordinances, language for contract and franchise agreements, analytical tools, and case studies.

Finally, the U.S. EPA's "America Recycles" initiative aims at growing and strengthening the U.S. recycling system through multi-stakeholder collaboration. U.S.-based organizations and jurisdictions are encouraged to sign the America Recycles Pledge. From this initiative, the EPA recently issued the "Status Report: Framework for Advancing the U.S. Recycling System," which focuses on four critical action areas:

1. Promote education and outreach;
2. Enhance materials management infrastructure;
3. Strengthen secondary material markets; and
4. Enhance measurement.

The status report represents the collective thinking and ideas of the America Recycles Workgroup members through June 2019.

Maryland Department of the Environment

MDE's "Waste Diversion" website provides resources for education and outreach, recycling at work and school, and source reduction; a recycling market directory; and links to other recycling websites. The aim is to encourage residents and businesses to recycle more and to recycle correctly.

MD Recycles

MD Recycles is an online directory of recycling and donation resources for residents and businesses. Maintained by NMWDA, the website also provides links to supporting umbrella organizations (e.g., Maryland Recycling Network, National Recycling Coalition) and trade associations (e.g., Appliance Recycling Information Center, Reusable Industrial Packaging Association).

The Recycling Partnership

The Recycling Partnership (RP) is a call to action to improve recycling by putting private dollars to work in communities to invest in systems to protect resources and unlock opportunity through implementing best practices. A key focus of RP's messaging is bringing about behavioral changes to reduce contamination in residential recycling through education, enforcement, harmonization of messaging across all sectors within a MRF-shed, tagging (e.g. "oops" stickers on carts with contamination), and communication

and outreach via events, presentations, and media. The City of Toronto is good case study of a jurisdiction that has worked with RP to improve recycling.

Recycle Across America

Recycle Across America (RAA) is a nonprofit organization dedicated to expediting environmental progress by creating a standardized labeling system for recycling bins to make it easier for people to begin to recycle right, wherever they might be. Additionally, RAA provides educational resources to help people understand the importance of recycling right.

A Better Bin

The Institute of Local Scrap Recycling Industries maintains this website as part of their campaign for strengthening residential recycling across the U.S. The information focuses on the role individuals and communities can play in improving recycling.

Montgomery County, Maryland: Aiming for Zero Waste

Finally, a master planning effort is ongoing in Montgomery County, Maryland termed "Aiming for Zero Waste," which is broadly parallel in its aims and scope to the LWBB Plan. Many opportunities and constraints for encouraging waste reduction and diversion measures in Baltimore are mirrored by those in Montgomery County. As such, reports developed for that master planning effort have relevance to the LWBB Plan.

2. METHODOLOGY

The methods used to objectively assess alternative waste reduction options in this Report are presented below. The major steps used to assess waste reduction/diversion options are:

1. Select waste reduction/diversion options to be analyzed in this Report;
2. Choose metrics by which each option will be assessed;
3. Establish the baseline solid waste management practice to which all options will be compared; and
4. Analyze each option using the selected metrics and the established baseline.

2.1 Stakeholder Input

To ease review of this Report, waste reduction/diversion options have been grouped into categories representing commonality between material types, infrastructure needs, and/or programmatic goals identified by stakeholders during the outreach phases of the LWBB Plan. This grouping is also broadly consistent with the Task 1 Reports summarizing stakeholders' input. The categories are as follows:

- Waste reduction and reuse;
- Diversion of food waste and other organics for composting and/or anerobic digestion;
- Diversion of C&D debris and wood waste;
- Expanded options for bulk trash management and material reuse and repurposing, including through the creation of recovery parks and enhanced drop-off centers;
- Changes in waste collection, including expanded options for recycling to include additional materials;
- Operational and administrative changes to the City's existing services; and
- Education and enforcement measures, including litter control, street sweeping, and cleanup of illegal dumping.

Options for managing what's left (i.e., the residual waste stream that cannot realistically be diverted from disposal) will be the focus of future Task 7 of the LWBB Plan, and thus are not addressed in this Report.

This Report should serve as the foundation for setting goals and measuring outcomes, supporting and performing research and outreach, and securing stable funding. Each report section focuses on options that can be sustained – that is, options that are robust, affordable, practical, and enforceable such that residents and businesses will embrace and support them. Where appropriate, opportunities for collaboration and partnership between the public and the private sectors are discussed in relation to each option.

It is noted that much of the input provided by residents at community meetings and via the online survey related to immediate concerns for improving DPW's solid waste services (e.g., litter control, cleanup of illegal dumping, rat abatement, and improving the 311 service) rather than longer-term aspirations for waste reduction and improved recycling. This suggests that getting waste materials into the existing waste collection system is a more urgent focus in some neighborhoods than

efforts to get materials into the right bin for optimal recycling. As such, although this Report focuses on options for making improvements to waste diversion and recycling, where appropriate the discussion also includes methods/ideas for making immediate improvements to existing services.

2.2 Metrics for Objective Assessment

Six metrics were used to objectively compare each potential waste reduction/diversion option to the existing (baseline) solid waste management system in Baltimore. The baseline solid waste management system currently includes recycling, composting and final disposal via landfilling (mainly at QRL) and incineration (mainly at BRESCO). The six metrics used in this analysis are summarized below.

Reduction/Diversion Potential

Reduction/diversion potential is an estimate of the mass of waste that could potentially be prevented from being generated or, if it is generated, diverted from disposal if an option were to be implemented. Reduction/diversion potential is measured in terms of an option's expected contribution to meeting the City's waste reduction/diversion goals for a particular component of the waste stream (per the BSP and BFWRS, as summarized in Section 2.4). Estimates are based on the baseline solid waste practice in Baltimore (2017 data, see Section 2.3) coupled with best estimates for participation rates, contamination rates, capture rates, etc. for that option based on relevant case studies, technology/program reviews in technical and industry publications, and Geosyntec's professional experience. To the extent possible, reduction/diversion potentials for each option presented herein are generally presented in terms of best case assumptions as well as most likely outcomes. It is recommended that all estimates of performance be confirmed via extensive research and data gathering by the City prior to implementation of any option. All tonnages estimates for reduction/diversion potential are rounded to the nearest 50 tons.

Costs

The cost of any given waste reduction/diversion option includes capital costs, operating costs, wages, and City staffing (generally within DPW). Cost estimates for each option are based on DPW's existing costs supplemented with best estimates and unit prices gathered from Geosyntec's professional experience and online research of publicly available information. For many options considered, costs may vary widely based on implementation strategies. The costs presented herein are therefore conceptual level estimates only. All cost estimates should be confirmed via more extensive research and independent data gathering prior to implementation of any option. All costs are rounded to the nearest $1,000.

Benefits

The benefits associated with any given waste reduction/diversion option include revenues (e.g., sale of compost or recyclables), environmental benefits (for which reductions in GHG emissions are used as the primary surrogate), and potential increases in local employment associated with green collar job creation. Indirect benefits, such as reductions in trash volume/pickup frequency, landfill disposal airspace saved, or synergistic interactions with other system components or options are also qualitatively assessed. Revenues from each option were estimated using data from DPW

supplemented with unit rates obtained from Geosyntec's professional experience, online research, or publicly available information.

GHG reductions are estimated against the baseline using the U.S. EPA's Waste Reduction Model (WARM) assuming a one-way hauling distance of 20 miles for all local waste management options (e.g. landfill, combustion, recycling, composting). For organics diversion/reduction options, GHG emissions are also compared against an "all landfill" condition to account for the potential scenario in which BRESCO becomes unavailable, after which all non-diverted organics would likely go for landfill disposal. The "all landfill" baseline condition is applied only to organic waste as this waste type generates a high GHG emission potential at landfills through anaerobic degradation and methane generation. GHG reductions can be compared with the goals of the CAP as updated by the BSP, which outlines how the City aims to reduce GHG emissions by 25% by 2020 and 30% by 2025. GHG emissions in Baltimore were estimated at 7,230,859 metric tons (tonnes) of carbon dioxide equivalents (MTCO2E) in 2014.

Job creation estimates only include jobs directly gained by each option (i.e., primary jobs) and do not include changes in downstream employment (i.e., secondary jobs), although it is understood that there would likely be an increase in secondary jobs as a result of implementing many of these options. These estimates also do not account for potential job losses at local landfills and other waste disposal/transfer facilities due to reduced volumes for disposal as it is assumed that these facilities would simply import waste from elsewhere to make up for shortfalls.

All benefits, including GHG offsets, are conceptual level estimates only. Additional independent data collection and research is required to obtain more accurate estimates prior to implementing any option. All monetary benefits in this report (i.e., revenues, wages, and airspace savings) are rounded to the nearest $1,000.

Challenges to Implementation

Potential challenges to implementing any given waste reduction/diversion option include land or infrastructure requirements, the volatility of end markets (e.g., for sale of recyclables), and the City's staffing needs and potential training requirements for new or existing staff. Negative or competing impacts on other waste reduction options are also considered.

Experience

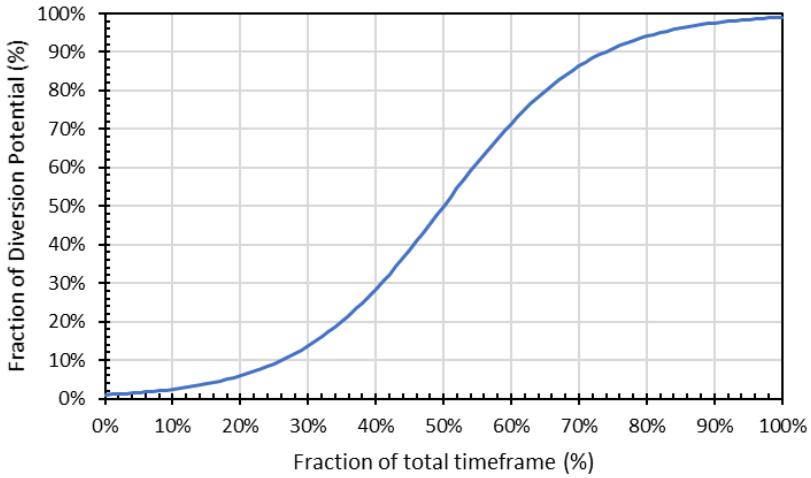
This category highlights the similarities between the options proposed herein and existing programs run by DPW or other City departments/offices. These may include educational and outreach programs, inspection programs, incentive programs, billing mechanisms, staffing requirements/overlap, or other potentially useful experience that the City may have. Local/regional experience within the private industrial, commercial, and institutional (ICI) sectors as well as nonprofits is also important.

Timeline

The timeline associated with post-implementation performance of an option is estimated based on Geosyntec's professional experience, online research, or other publicly available information. Timelines are assessed in terms of the short term (generally, the next 5-10 years), medium term (generally, the next 10-15 years) or long term (generally, the next 15-20 years). The estimated timeline accounts for the expected time lag between program

implementation and seeing noticeable improvements as a result of the affected population responding and adapting to the given option.

To account for the time lag, a simple S-curve is used to model waste diversion or reduction with time, as illustrated in the simplified relationship given in the figure below.



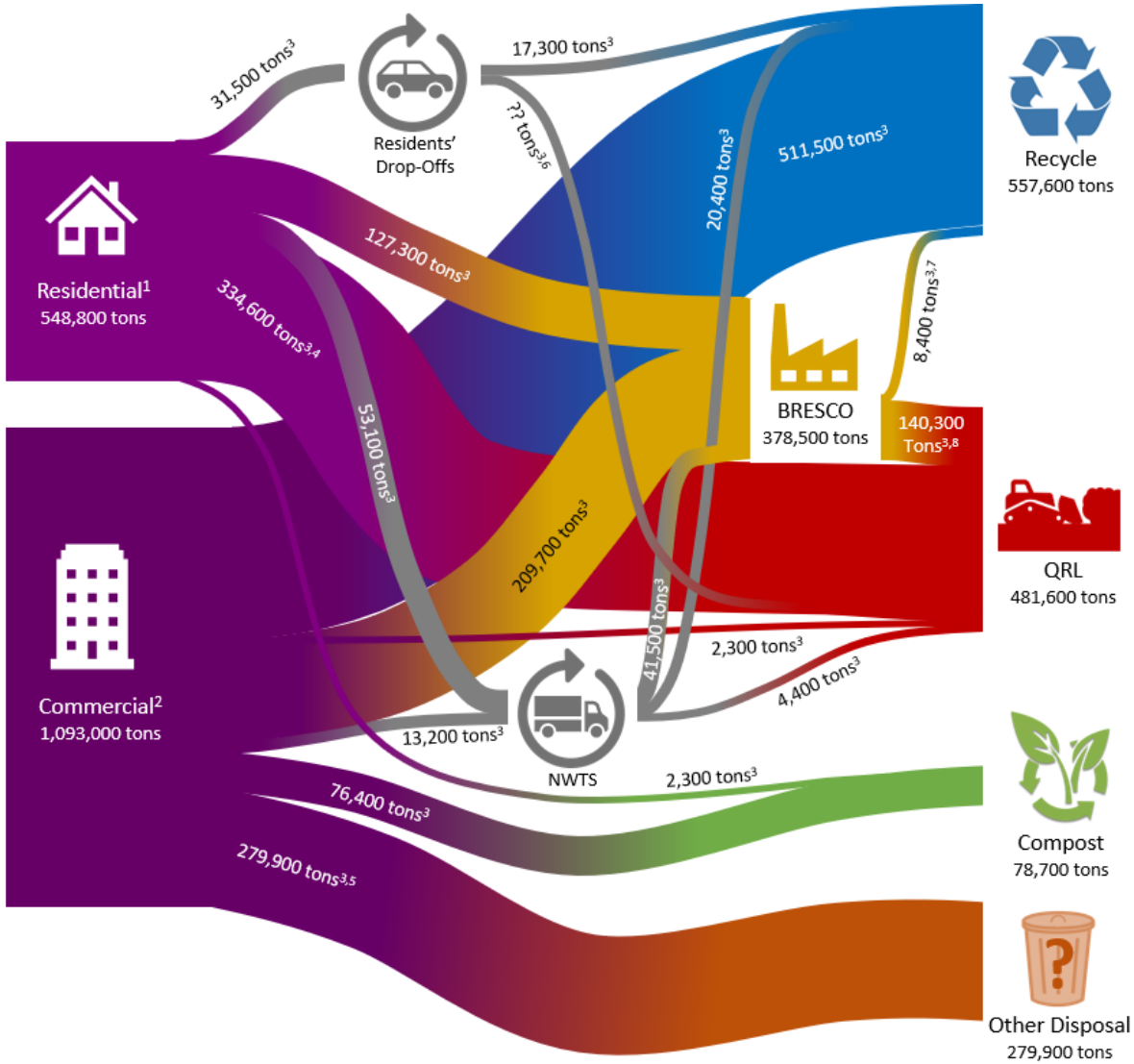
S-curve used to Model Waste Diversion with Time for Phased Options

S-curves like these are commonly used to represent idealized learning curves, with small incremental changes in the early stages followed by rapid growth and then slowed changes as participation rates near saturation near the end of the timeframe of interest. It is assumed that all waste diversion options outlined in this Report would follow this S-curve structure because the volume of waste diverted would be largely dependent on residents and businesses learning about the new system/program, adapting to change, and forming new habits. However, the timeline associated with different options may be radically different. For example, making improvements to residential drop-off centers and the small hauler program would be expected to see rapid benefits within a five-year timeframe. In this case, 100% on the x-axis of the s-curve graph represents five years. On the other hand, fully implementing a residential composting program may take up to 20 years, in which case 100% on the x-axis of the S-curve graph represents 20 years.

For some larger, more complex options (e.g., residential composting), phased implementation is also considered. However, despite being implemented in phases, the overall performance of the program is still estimated using the S-curve model.

2.3 Establishing the Baseline for Analysis

To estimate the diversion potential, costs, benefits, and challenges for each waste diversion option considered in this Report, options must be objectively assessed against the baseline solid waste management practice in Baltimore, primarily existing use of BRESCO and QRL. Specifically, a detailed analysis of the generation and composition of the existing solid waste stream is required to assess potential diversion options. The majority of the information used in this analysis, as well as all references for waste tonnages referenced in this Report, are sourced from the two Task 0 Reports and the Task 3 Report prepared previously for the LWBB project. However, some additional reference material was also used to supplement the analysis in cases where city-specific information was limited. Appendix 1 contains a detailed description of the analysis of the existing waste stream in Baltimore, including all sources, methods, and assumptions used in its development.



Summary of Waste Streams in Baltimore City under the Existing System (modified from LWBB Plan Task 3 Report)

Notes

1. Residential waste is collected by DPW, which includes some waste from Downtown businesses and City Government buildings. However, this also includes mixed waste delivered to QRL by DPW and the Department of Transportation as well as some mixed waste loads delivered to QRL by private haulers.
2. Commercial waste includes commercial, industrial, and institutional waste collected by private haulers.
3. Waste stream tonnage calculations are presented in Appendix 1 of this Report and are based on values from the 2017 MDE MRA report, the 2017 Baltimore City MRA Report, the 2017 BRESCO tonnage report, the 2017 NWTS tonnage report, the 2017 QRL tonnage report, and the 2017 Small Hauler Report.
4. Residential waste flow to QRL includes soil sent to QRL for beneficial reuse.
5. Commercial waste is hauled by private haulers and the City has no way to fully track this waste. It is assumed that much of this waste is C&D debris that haulers take to private facilities (e.g., rubble landfills outside the City).
6. Waste outflows from residents' drop-offs are unknown. It is assumed that DPW sends little if any of this waste to BRESCO.
7. The quantity of recyclables recovered at BRESCO is back-calculated from total metals reported in the 2017 MDE MRA Report and other metals reported in the Baltimore City MRA Report. This value represents back-end scrap recovered from incineration of waste generated within the City.
8. The quantity of WTE ash landfilled at QRL is from the 2017 QRL tonnage report.

Existing Waste Streams

A simplified graphical illustration of the existing waste streams in Baltimore was shown on the previous page. Approximately 548,800 tons of residential waste and 1,093,000 tons of commercial waste were generated in Baltimore in 2017 (1,641,800 tons in total). Of the total waste generated, approximately 747,000 tons (45%) was diverted from final disposal. This value includes the roughly 8,400 tons of backend scrap metal recovered from BRESCO, which is included in the commercial recycled scrap metal category, and the 189,400 tons of recycled soil beneficially reused as daily and intermediate cover material at QRL. 78,700 tons (5%) were composted, 229,800 tons (14%) were incinerated at BRESCO (this value does not include the approximately 8,400 tons of recovered backend scrap or the 140,300 tons of ash landfilled at QRL), 292,200 tons (18%) were landfilled at QRL (including 140,300 tons of ash from BRESCO), and 279,900 tons (17%) were otherwise disposed by commercial haulers in the private system. Based on 2016 statewide data for C&D waste tonnages (approximately 3.2 million tons), it is assumed that the majority of the 279,900 tons of other disposal is C&D waste.

Based on the analysis performed herein, it is estimated that approximately 816,100 tons of waste were disposed in Baltimore in 2017, including 520,800 tons of MSW, 279,900 tons of C&D waste, and 13,200 tons of waste received from small haulers. This disposed waste represents material that is available for diversion under various options in Task 5.

Source (tons)	Fate of Waste (tons)	Waste Type	Total Amount (tons)	Transfer Facility	Destination
Residential (548,800)	Recycled (227,050)	Soil Cover at QRL	189,400	N/A	QRL
		C&D	3,500	N/A	QRL
		SS Recyclables	20,250	NWTS	WMRA
		Non-SS Recyclables	100	NWTS	OTHER
		Dropoff Recyclables	13,800	DROPOFF	WMRA/OTHER
	Compost (2,300)	Organics	2,300	N/A	CAMP SMALL
	Disposed (319,450)	MSW	29,550	NWTS	BRESCO
			3,150	NWTS	QRL
			146,450	N/A	QRL
			127,350	N/A	BRESCO
			50	N/A	COVANTA
		Dropoff MSW	12,900	DROPOFF	QRL*
Commercial (1,093,000)	Recycled (519,950)	Soil	77,400	N/A	OTHER
		C&D	324,000	N/A	OTHER
		SS Recyclables	50	NWTS	OTHER
		Non-SS Recyclables	42,250	N/A	OTHER
		Scrap Metal	68,800	N/A	OTHER
		Other non-MRA Recyclables	7,450	N/A	OTHER
	Compost (76,400)	Organics	30,600	N/A	OTHER
		Sewage Sludge	45,800	N/A	VEOLIA
	Disposed (496,650)	MSW	201,300	N/A	BRESCO
		C&D	279,900	N/A	OTHER
		Small Haulers	11,900	NWTS	BRESCO
			1,250	NWTS	QRL*
		WWTP Grit Screenings	2,300	N/A	QRL

*Values are estimated; waste is assumed to go to QRL for this analysis

Summary of Existing Waste Streams in Baltimore

Composition of the Disposal Waste Stream

The overall composition of the disposal waste stream (brown rows in the table on the previous page, ignoring WWTP grit screenings) was determined using a combination of data from the Task 0 waste sorts and published sources. For consistency in later analyses, waste composition categories were chosen to be consistent with U.S. EPA's WARM software.

MSW

The composition of residential MSW was determined using data from the winter and summer waste sorts performed in January/February and June of 2019 as part of Task 0 for the LWBB project. The composition data for residential MSW is included in Appendix 1.

The composition of commercial MSW was based on the June 2019 waste sort supplemented with data from the U.S. EPA (2013). The assumed composition of commercial MSW is also included in Appendix 1.

C&D Waste

C&D waste composition was estimated using data from the U.S. EPA (2016) for C&D waste generated in the United States in 2014. The assumed composition of C&D waste is included in Appendix 1.

Small Haulers and Drop-off MSW

The composition of small hauler loads and waste received at drop-off centers was determined using data from the winter and summer waste sorts performed January/February and June of 2019 as part of Task 0. The waste composition data for small hauler loads and drop-off centers is included in Appendix 1.

Summary of Disposed Waste Composition and Tonnages

Separating MSW, C&D, small-hauler, and drop-off waste into base components yields the material tonnages in the table overleaf. This breakdown shows a combined total of 163,200 tons of compostable organics (including food, yard waste, and mixed organics), 288,700 tons of C&D waste (including concrete, lumber, asphalt, and drywall), 240,700 tons of traditional recyclables (including paper, plastics, metals, and glass), 5,600 tons of non-traditional recyclables (including bulky waste and carpet), and 117,900 tons of "unclassified" material are disposed of in Baltimore annually.

The 117,900 tons of material under the "unclassified" category includes items that do not fall into previous categories. The composition of this material is largely unknown because it is generally classified as "trash" or "unclassified" in recycling reports with little detail provided. However, this represents material that is hard to recycle using current technologies and includes items such as non-compostable organics, medical waste, composite materials, Styrofoam and contaminated plastic film, and diapers. In Task 5, it is assumed that unclassified materials will continue to require disposal over the long term; in other words, this will comprise the majority of the "what's left" category for evaluation of long-term disposal needs in Task 7.

Category (tons)		Residential Waste (tons)	Commercial Waste (tons)	Total (tons)
Organics (163,200)	Food Waste	65,450	44,050	109,500
	Yard Waste	36,250	15,150	51,400
	Mixed Organics	0	2,300	2,300
Traditional Recyclables (240,700)	Cardboard	24,600	32,350	56,950
	Mixed Paper	18,700	17,600	36,300
	HDPE/PET	12,700	7,550	20,250
	Mixed Plastic	55,150	29,800	84,950
	Aluminum Cans	4,000	2,500	6,500
	Steel Cans	7,650	9,000	16,650
	Mixed Metals	250	300	550
	Glass	9,350	9,200	18,550
C&D (288,700)	Lumber	2,400	22,000	24,400
	Clay Bricks	0	6,350	6,350
	Concrete	2,050	199,300	201,350
	Asphalt Concrete	0	40,200	40,200
	Asphalt Shingles	0	7,150	7,150
	Soil	150	150	300
	Drywall	900	8,050	8,950
Non-Traditional Recyclables (5,600)	Bulk	2,500	2,500	5,000
	Textiles/Carpet	250	250	500
	Other	50	50	100
Unclassified (117,900)	-	77,050	40,850	117,900
Total	-	319,450	496,650	816,100

Estimated Composition of Disposed Waste in Baltimore

2.4 Summary of Reduction and Diversion Goals

The BSP currently sets a goal of increasing waste diversion from landfill and incineration to 90%. As shown above, approximately 1,641,800 tons of waste were generated in Baltimore in 2017 (548,800 tons in the residential sector and 1,093,000 tons in the commercial sector). Of this, approximately 747,000 tons were recycled and 78,700 tons were composted, giving a current overall diversion rate of about 50%. Therefore, to meet the goals of the BSP, the overall diversion rate needs to be increased by about 40% (equivalent to diverting an additional 657,000 tons of currently disposed waste).

As shown in the table opposite, approximately 698,200 tons of disposed material falls into the four main categories listed (i.e., organics, C&D waste, traditional recyclables, and non-traditional recyclables). For the most part, these materials are divertible (e.g., through reuse, donation, and recycling) and they currently account for roughly 43% of Baltimore's waste stream. Therefore, by focusing on these four waste categories, the City should theoretically be able to meet or get close to an overall 90% diversion goal; however, this would require near-universal participation and capture rates from the residential and commercial sector. It is noted that the BFWRS provides specific targets for reduction and diversion of food waste, and these are considered directly within the context of meeting an overall 90% diversion goal.

For this Report, specific reduction and diversion goals for each waste type were set according to the City's current strategic plans (e.g. BFWRS, CAP). Where no City-specific targets were identified (e.g. for C&D waste), published accounts of the experience of other jurisdictions, including those used for benchmarking in Task 4, were used to define reasonably achievable diversion goals.

2.5 Assessment of Options

The remaining chapters of this Report assess options identified by Geosyntec as potentially meeting the criteria for consideration in the Draft and Final Master Plans using the established metrics and baseline conditions. These are as follows:

- Chapters 3 to 6 – Options for reducing and diverting food scraps and other organic waste, traditional recyclables, C&D debris, and non-traditional recyclables, respectively;
- Chapter 7 – Options for developing integrated recycling facilities that target multiple material classes in combination;
- Chapter 8 – Broader strategies and policies for encouraging waste reduction and diversion in Baltimore; and
- Chapter 9 – Other service and administrative changes, including improvements in the City's 311 service, street sweeping, waste collection service, etc.

A summary of the individual contribution that each set of options is expected to make to the overall diversion rate, and thus the quantity of "what's left" for disposal, is provided in Section 10.

In the remainder of this Report, all performance and cost estimates are assessed on the basis that the City's established goals will be met in full. As such, this Report does not directly challenge how "realistic" the goals set by the BSP or BFWRS may be or attempt to estimate participation rates. Rather, this Report aims to provide the City, and DPW in particular, with a detailed accounting of the costs and other challenges that would be entailed in achieving the City's stated goals. For each option presented, suggestions are provided for education/outreach, incentives, enforcement, and legislative measures to boost participation rates. It is acknowledged that meeting goals will require near-universal participation from affected sectors in Baltimore. For example, achieving a residential food waste reduction rate of 80% in accordance with the BFWRS (see Section 3.1) would require every household to reduce food waste generation by 80% on average, an optimistic expectation. Therefore, reduction and diversion totals provided in this Report should be considered upper-bound expectations. For this reason, the summary of findings in Chapter 10 is presented and discussed in terms of the Maximum Diversion Potential (MDP).

Subsequent to this Report, the Draft and Final Master Plans developed in Tasks 8 and 9 of the LWBB Project, respectively, will serve to prioritize options for implementation. As part of the prioritization process, expected rates of participation in any new program(s) will be scrutinized in more detail.

3. FOOD SCRAPS AND ORGANIC WASTE

With approximately 163,200 tons disposed in Baltimore in 2017, organic waste represents the third largest component of the disposal stream (behind C&D waste and traditional recyclables). However, because very little organic waste is currently diverted (the residential diversion rate for organic waste is roughly 2%), there is a lot of room for growth in the City's efforts to reduce, reuse, and divert organic waste. Organic waste may thus represent the "low-hanging fruit" for wholesale solid waste reduction and diversion and, for this reason, options for reduction, reuse, and diversion of food scraps and other organic waste are a key focus of this Report.

3.1 Reducing Food Wastage

Over 110,000 tons of food waste are disposed of annually in Baltimore, representing 13% of the total disposed waste stream. Food waste represents the largest component of compostable material disposed nationally and in Baltimore. Many plans at the federal, state, and local level seek to combat food wastage. These include BFWRS and the "Winning on Reducing Food Waste Federal Interagency Strategy", a collaboration between the USDA, the USEPA, and the FDA which seeks to reduce food wastage in the US by 50% by 2030. For this analysis, the goals laid out in the BFWRS are used to estimate costs, challenges, and benefits of the City's food waste reduction efforts.

Food Wastage in Baltimore

Of the 110,000 tons of food waste disposed of annually in Baltimore, approximately 65,000 tons are residential in origin (i.e., waste collected curbside by DPW from single family homes, small businesses, and government buildings), while 45,000 tons is commercial in origin (i.e., waste collected by private haulers from multifamily units and other businesses). Food-centric establishments such as restaurants and grocery stores often have high food wastage rates.

While individuals and households contribute significantly to food wastage (e.g., by serving larger portions than needed, discarding leftovers, buying unnecessary items that go uneaten, or failing to take note of expiration or "sell by" dates), a potential reason for the large amount of food wastage in Baltimore is a lack of healthy food options. Approximately 146,000 people in Baltimore live in Healthy Food Priority Areas, or HFPAs (see map overleaf from the 2018 Food Environment Report), which are defined as areas where the average healthy food availability index for all food stores is low, the median household income is at or below 185% of the federal poverty level, over 30% of households have no vehicle available, and the distance to a supermarket is more than a quarter mile. Residents living within HFPAs are highly dependent on fast food and convenience stores, which may contribute to more food waste if they are not able to control their own food preparation or portion sizes. It is likely the large amount of packaging on food sold at these establishments also contributes to high reported litter rates in many HFPAs.

City Initiatives to Combat Food Wastage

In September 2018, the City began working with the Natural Resources Defense Council (NRDC) and the Rockefeller Foundation to enact strategies laid out in the BFWRS by establishing the Food Matters pilot food waste management project in which local establishments are

awarded grants of up to $10,000 to support the City's goals of reducing food wastage. To date, eleven applicants have been awarded grants.

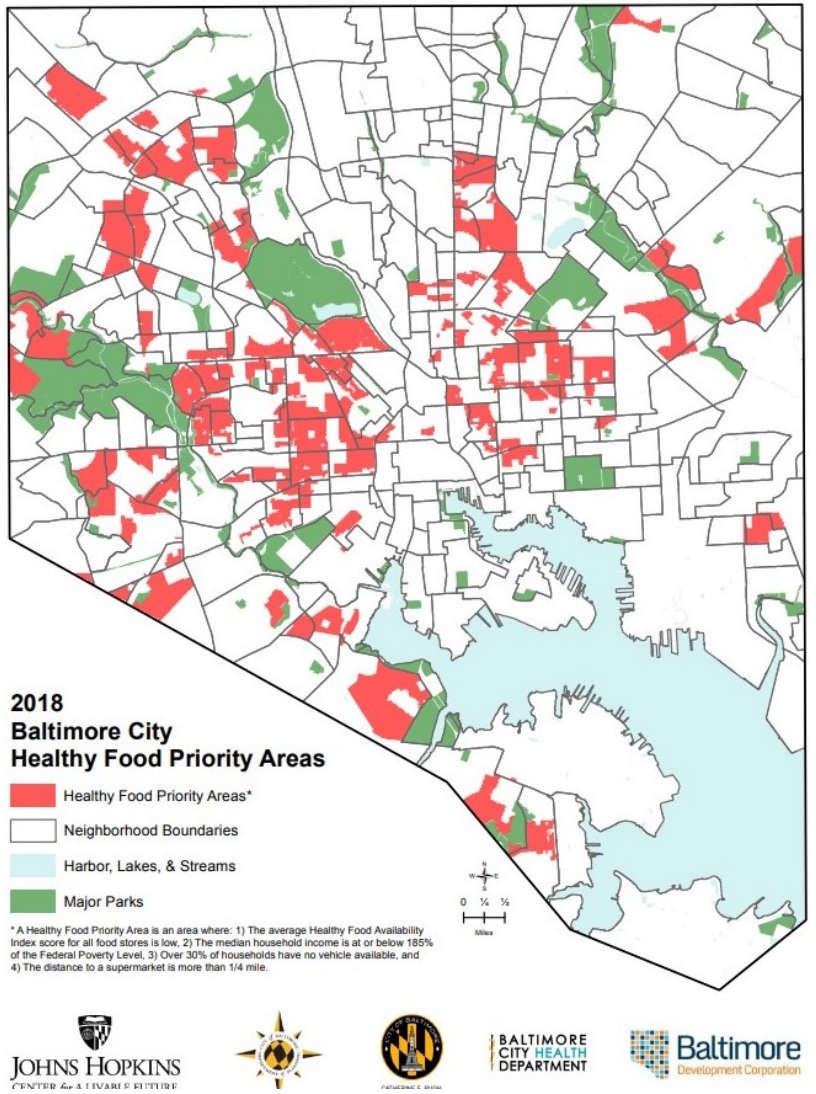
Additionally, in June 2019 the NRDC issued a request for proposals (RFP) for a food waste financing and funding assessment in Baltimore as a way to evaluate opportunities to leverage financing and/or funding strategies to support the food waste reduction strategies laid out in BFWRS.

Donation and Food Rescue Organizations in Baltimore

The largest and most established food rescue/donation organization in Baltimore is the Maryland Food Bank. Other, smaller organizations include Food Rescue Baltimore, the Food Recovery Network, Helping Up Mission, Paul's Place, the Franciscan Center, and Hungry Harvest. As a result of these food rescue/donation efforts, it is estimated that 5,750 tons of food was distributed to food insecure Baltimore residents in 2018 (NRDC 2019).

In addition to major food rescue organizations, there are some other establishments offering possible synergies regarding food waste work in the Baltimore region. These include:

1. Center for Eco Technology: A national non-profit supporting food waste prevention and diversion at the local and state level. They support the development of a wasted food diversion marketplace.
2. Food Rescue US/EAT Management: Operated by a former chef/restaurateur turned food waste consultant. Currently supporting the advancement of the Food Rescue US platform designed to increase food rescue efforts with volunteer support.



Healthy Food Priority Areas in Baltimore (from the City's 2018 Food Environment Report)

Reduction Targets

The BFWRS's reduction and diversion goals are summarized in the table below (first column). The BFWRS does not specifically define "reduction" or "diversion" in the context of the goals set, but establishes a hierarchy of food waste reduction and recovery that prioritizes home composting and community scale composting after source reduction and edible food rescue, but before development of more centralized and larger scale facilities.

Source	Reduction Target (%)	Diversion Target (%)
Commercial	50%	0%
Universities	100%	0%
City Government	0%	90%
Public Schools	0%	90%
Residential	80%	80%

Food Waste Reduction Targets from BFWRS

Only food waste reduction goals are considered in this section, with food waste diversion discussed in Sections 3.2 and 3.3. As shown in the table, separate reduction goals are outlined in BFWRS for commercial waste, universities, and residential waste.

Characterization of Relevant Waste Streams

University Waste

It is noted that the term "university" includes colleges and higher education institutions for the purposes of this Report. University waste is characterized according to the following assumptions:

1. University waste is actually a component of the commercial waste stream as it is collected by private haulers; however, for the purposes of assessing food waste reduction goals from the BFWRS, these two waste streams are assessed independently.
2. University waste is assumed to have the same composition as residential MSW (universities are essentially small residential communities).
3. Generation rates for university waste are assumed to be 40% of the generation rates for residential MSW in Baltimore. This value is based on an assumed food waste generation rate for university students of 150 lbs./student/year and the measured food waste generation rate of approximately 375 lbs./person/year determined from the Task 0 winter and summer waste sorts.
4. The fate of university waste (i.e. the fraction that is landfilled, composted, recycled, or combusted) is assumed to be the same as bulk commercial waste collected within Baltimore.
5. To determine the mass of university waste generated each year, it was estimated that Baltimore universities have approximately 54,738 students in total (from Wikipedia: "List of Colleges and Universities in Baltimore").

Using the assumptions outlined above, it is estimated that there is approximately 3,250 tons of food waste generated in universities each year in Baltimore.

Commercial and Residential Waste

Based on the breakdown shown in Section 2.3, there are approximately 65,449 tons of residential food waste and 40,796 tons of commercial food waste (not counting university waste) generated in Baltimore each year.

Reduction Potential

Applying the reduction targets from BFWRS to the food waste tonnages estimated for the three waste streams of interest gives a reduction potential of 3,250 tons of university food waste, 20,400 tons of commercial food waste, and 48,750 tons of residential food waste (excluding the approximately 2,400 tons of food waste produced at public schools and the approximately 2,100 tons of food waste produced at government offices, for which the food waste reduction target is 0% as outlined above). **This yields a total 72,400 tons of food waste that could be reduced annually if the BFWRS targets are met, which would contribute about 11% of the 657,000 tons targeted under the BSP**. In the remainder of this section, all performance and cost estimates are assessed on the basis that the BFWRS goals are met in full. It is acknowledged this would require very high participation rates from affected sectors (e.g., achieving a residential food waste reduction rate of 80% would require every household in Baltimore to reduce food waste generation by 80% on average, an optimistic expectation).

Options and Strategies

Consistent with strategies outlined in the BFWRS, it is assumed that food waste reduction targets will be met through a combination of food rescue and donation (e.g. via food banks) and true source reduction (e.g. educating consumers to purchase only the amount of food they need and hence generate less food waste). This will require a coordinated effort between the City, local food generators (businesses, universities, and residents), and local food rescue/donation organizations. The NRDC recently commissioned a report titled "Food Rescue in Baltimore: Assessing Current Landscape and Potential Growth" (26 March 2019) from Full Plate Venture LLC and the Maryland Food Bank assessing the current landscape for food rescue in Baltimore and the potential for future growth (referred to herein as the NRDC report). Recommendations from this document as well as those provided in the BFWRS are summarized below:

Recommendations from the BFWRS

Commercial Food Waste Reduction Strategies

The recommendations provided in the BFWRS to reduce commercial food waste in Baltimore by 50% by 2040 are summarized below:

1. Conducting a needs assessment for the city's food recovery system;
2. Creating a "best practices" guide for businesses and institutions that wish to donate edible food in the city;
3. Creating a resource guide for individuals and businesses wishing to use produce "seconds" (i.e. ugly fruit and vegetables);
4. Supporting state legislation that extends liability protection for entities selling recovered food and donors that donate past-date foods;
5. Working with the Maryland Department of Agriculture to include food recovery at the Maryland Buyer-Grower Expo;
6. Creating a public awareness/marketing campaign for businesses around reducing food waste;
7. Supporting local and state legislation that calls for a phased-in food waste and organics landfill ban;
8. Creating and staffing a City government position tasked exclusively with managing food recovery and food waste reduction initiatives;

9. Creating incentive programs for food donation, or businesses sourcing recovered food;
10. Ensuring there are enough community partners to handle the volume of all donated food, and ensuring that these partners are adequately resourced (refrigeration, hauling, etc.);
11. Creating/supporting a waste audit program for commercial food waste producers;
12. Supporting existing business models that sell "seconds" produce and if gaps exist, supporting the creation of a "Vendors Market" for unsold produce from wholesale distributors; and
13. Creating/adapting an entity to coordinate and promote all food recovery activities citywide.

The BFWRS does not estimate how many commercial entities would have to participate to achieve a 50% reduction in food waste generation.

University Food Waste Reduction Strategies

The recommendations provided in BFWRS to reduce food waste from higher education institutions by 100% by 2040 are summarized below:

1. Supporting the development of a Food Recovery Network chapter in every higher education institution in the city;
2. Supporting the completion of waste audits at every higher education institution in the city;
3. Creating a public awareness/marketing campaign around food recovery for colleges and universities;
4. Working with colleges, universities, and institutional food providers to change the culture of campus cafeterias from one of required abundance to "it's ok to run out;"

Residential Food Waste Reduction Strategies

The recommendations provided in BFWRS to reduce residential food waste in Baltimore by 80% by 2040 are summarized below:

1. Creating/supporting a public awareness and education campaign around household food waste;
2. Supporting community-based culinary education programs, with emphasis on food waste reduction;
3. Creating and implementing a voluntary household waste audit program, including incentives for participation;
4. Developing and implementing a system for tracking household food waste; and
5. Distributing "smart" trash cans to all city residents capable of tracking waste weight, creating a positive feedback loop by sending waste data to residents via water bill or other means.

Recommendations from the NRDC Report

The NRDC report recommended the following actions to strengthen the food rescue landscape in Baltimore:

1. Convene meetings of stakeholders in the food rescue system, including the City, food donors, food rescue organizations, last mile organizations (LMOs; these refer to any entities such as shelters, soup kitchens, or food pantries that distribute donated food to food insecure individuals), and clients, on a regular basis to support relationship building and strategic planning;
2. Track food donations received from local sources each year at food rescue organizations to support progress tracking under the BFWRS;

3. Develop, in coordination with other stakeholders, a three to five-year strategic plan for expanding food donations and strengthening the food rescue system;
4. Hire a "sourcer" to cultivate relationships between prospective food donors and food rescue organizations;
5. Develop and distribute food safety guidance for licensed food facilities from the City's Health Department;
6. Develop policies and programs that incentivize food donation;
7. Distribute educational materials on liability protections and tax incentives to food donors;
8. Develop a citywide strategy to recruit the next generation of food rescue volunteers to support the effective training, management, and retention of volunteers in the food rescue system;
9. Develop a coordinated strategy to engage the local philanthropic and business communities to mobilize support for food rescue infrastructure, staffing, and other needs;
10. Identify organizational development resources to strengthen food rescue capacity for fundraising, management, and communications;
11. Evaluate strategies for making donated food more geographically accessible to clients;
12. Evaluate the need for potential technology solutions to connect clients and LMOs;
13. Elevate the voices of food assistance clients by including them in advocacy activities, volunteer opportunities, and community outreach;
14. Work with LMOs to gather input and feedback from clients on an ongoing basis;
15. Conduct a detailed study of the specific food security-related needs of people living with disabilities; and
16. Expand outreach to clients on ways to access food assistance.

Other Tools and Strategies for Reducing Food Wastage

Other strategies for reducing food wastage include:

1. Online food waste reduction tools: The U.S. EPA provides a food waste management cost calculator to estimate the cost competitiveness of alternatives to food waste disposal for food waste generators, including source reduction, donation, composting, and recycling of yellow grease.
2. Food waste tracking: A private company GOODR provides a secure ledger that tracks an organization's surplus food waste from pickup to donation. The company aims to improve an organization's bottom line through charitable donations, reduce GHG emissions, and route edible surplus food to local communities in need. Hartsfield-Jackson Atlanta International Airport currently uses GOODR to help meet its zero-waste target.
3. Mobile Apps: There are a number of smartphone applications meant to connect food rescue agencies with consumers. For example, Food Rescue's ChowMatch matches food donations with food assistance organizations while organizing volunteers to transport the food to those organizations. Another example is the Food for All app available in Boston and New York that allows customers to buy leftovers from restaurants at a discount.

Estimated Costs

Costs associated with constructing and operating food rescue and donation infrastructure would likely be borne by the private sector (e.g. by local businesses) while costs associated with education, outreach, tracking, enforcement, and health monitoring for the program would likely be borne by the City. Only high level cost estimates are provided in this Report; it is expected that more detailed assignment of costs between the public and private sectors for the various food waste reduction and rescue programs included in the BFWRS will be provided by BOS through their Food Matters program. All costs presented herein are in 2019 dollars and do not include financing costs.

Potential Costs to the Private Sector

Costs to the private sector would mainly include capital costs (CAPEX) associated with developing additional food rescue and donation infrastructure as well as operating costs (OPEX) for these facilities. Unit CAPEX and OPEX of $687/ton and $3,350/ton/year were estimated based on the Maryland Food Bank's 2018 Annual Report. These unit rates include the asset value of property and equipment (capital), as well as reported operating expenditures on program services, management, and fundraising (operating costs). Using these values, CAPEX of $50 million and annual OPEX of $240 million could be incurred to achieve the full reduction potential of 72,400 tons of food waste per year. However, it is noted that unit OPEX includes the cost of food (the majority of which is likely to come from in-kind donations) and labor (much of which is likely to be provided by volunteers). Assuming high levels of in-kind donations and volunteering, direct costs borne by the program would be considerably lower. At the Maryland Food Bank, for example, the majority of direct costs reported (e.g., personnel, transportation, and administration) are covered by monetary donations from individuals and organizations and grants from foundations and the federal/state government. Additionally, the cost estimates shown here are conservative by assuming that all food waste reduction occurs via food donation programs rather than true source reduction measures (e.g., households reducing the quantity of food purchased). In reality, a combination of true source reduction and food donation will be required to meet the BFWRS goals. Therefore, annual OPEX would be expected to be considerably lower than shown.

Costs to the City

It is not expected that the City would invest in any capital projects as part of implementing food waste reduction strategies. As such, the City's costs would be operational in nature, including administrative costs (i.e., planning, tracking, and enforcement), education and outreach, and health monitoring costs. Estimated OPEX assuming the food waste reduction goals of the BFWRS are met in full are summarized in the table below. Assumptions for unit costs, quantities, and sources of data are included in Appendix 2. It is noted that total costs for this option may be reduced if the City partners with local non-profits and leverages existing infrastructure for health monitoring and outreach.

Item	Total Cost
Admin (Planning, Tracking, Enforcement)	$ 500,000
Education/Outreach	$ 3,080,000
Health Monitoring	$ 1,100,000
Total	**$ 4,680,000**

Estimated Annual Operating Costs to the City of Implementing Food Waste Reduction Program

Indirect Costs

Indirect costs associated with implementing a food waste reduction program, mostly in the form of lost revenues, may include:

1. Reduced tip fees received by DPW at QRL, along with potential job losses due to reduced waste collection and landfilling;
2. Reduced tip fees and potential facility closures and/or job losses at private haulers, transfer stations, and/or composting facilities;
3. Reduced demand for food from local farmers and traders (which may also result in job losses); and
4. Increased need for monetary donations from individuals and businesses to support growing food rescue nonprofits.

Estimated Benefits

While no direct revenues are expected from this option (food would be donated and given away rather than sold), there are expected to be other benefits to the community, including environmental benefits associated with reduced GHG emissions, and indirect benefits to City government, businesses, and residents.

Environmental Benefits

Two baseline waste stream conditions were used to estimate environmental benefits:

1. Actual baseline conditions, assuming material flows in accordance with current conditions shown in Section 2.3; and
2. "All-landfill" baseline conditions, which assumes that BRESCO is not operating and all waste not diverted from disposal would otherwise be sent to landfill.

If the BFWRS targets are met in full, the estimated GHG emission reductions achieved would be about 304,600 MTCO2E annually under current baseline conditions modeled using WARM. This is the equivalent of taking 64,700 passenger vehicles off the road or reducing gasoline consumption by 34.3 million gallons. Under the "all-landfill baseline conditions, it is estimated that GHG emissions would be reduced by 337,200 MTCO2E.

Airspace Savings

Reducing food wastage would reduce the amount of waste going to QRL and BRESCO. DPW charges a tip fee to cover the costs associated with consuming disposal capacity (airspace) at QRL. The value of this airspace can be calculated as the product of the tip fee and the reduced tonnage. This value does not represent a direct revenue, but rather is representative of the cost savings to any entity that reduces food waste disposal. It also represents potential revenue as airspace that DPW could offer to another customer. Using the current tip fee at QRL ($67.50/ton) and the reduction potential for this option (72,400 tons, **a potential airspace savings of $4.89 million could be realized**.

Indirect Benefits

Beyond feeding hungry people and reducing waste disposal, indirect benefits associated with implementing a food waste reduction strategy include:

1. Reducing the volume of residential waste collected (as well as the odor generation and vermin attracting potential of waste put out by households) may allow DPW to reduce trash collection in all or some service areas to a biweekly basis rather than a weekly

basis, or reduce the allowable volume of trash collected per household, allowing each truck to service more homes;

2. Businesses (e.g., supermarkets and restaurants) would save money by reducing spending on food and waste collection;
3. Residents and businesses would save money on food purchases; and
4. Job opportunities at food donation organizations would be increased.

Challenges to Implementation

Challenges to implementation of a food waste reduction strategy include:

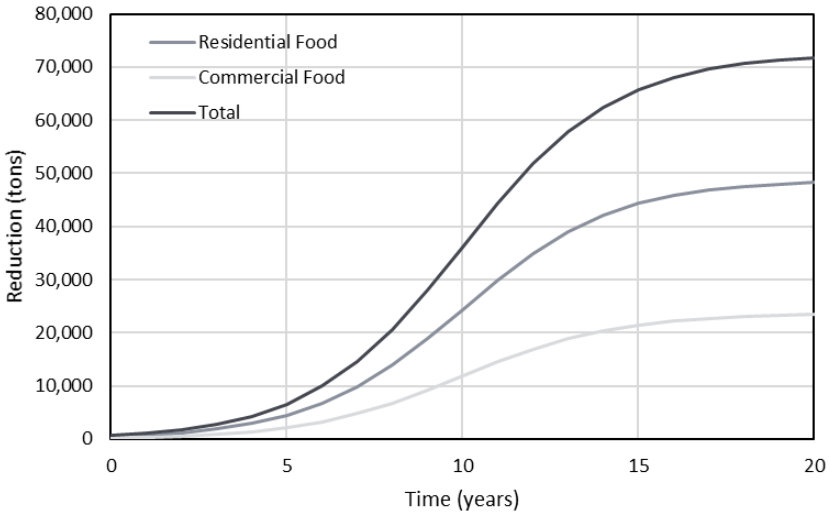
1. Changing the food buying and disposal habits of local businesses and residents would require a long-term commitment to education and outreach by the City;
2. The City may be met by resistance from local farmers and waste disposal/recycling/transfer companies who would see reductions in demand if this policy is implemented; and
3. The City must implement rigorous health and safety programs to ensure that unsafe food is not donated for human consumption.

Experience

The City does have some experience implementing source reduction programs. This experience includes implementing educational programs for source reduction and recycling. DPW earns a 4% reduction credit toward its MRA recycling rate from MDE for implementing multiple programs on their "Source Reduction Checklist."

Timeline

The BFWRS calls for food waste reduction targets to be met by 2040. It is likely that the City would implement food waste reduction targets for government offices and public schools prior to rolling out the program to residents and businesses as a way to "lead from the front." Assuming that the City is able to meet the food waste reduction goals by 2040, the expected timeframe for the program to achieve its maximum potential is estimated as 20 years according to an S-curve function as shown in the figure below.



Estimated Food Waste Reduction in Baltimore with Time

Expected Performance

Expected performance of a food waste reduction program is difficult to gauge because:

- Food waste reduction is difficult to quantify (i.e., it is not easy to measure the amount of waste that is not generated); and
- Many food waste reduction programs have been implemented relatively recently, so very little benchmarking data is available on their performance thus far.

Notwithstanding, data from the Vermont Agency of Natural Resources showed that food rescue nearly tripled in the first four years after implementing the Vermont Universal Recycling Law, which mandates the separation of food and food waste for uses preferable to landfilling (e.g. donation, food for animals, composting, etc.).

3.2 Residential Organics Diversion

Currently, there is no centralized organics diversion program in Baltimore. Organics diversion (mostly composting) is available only through local community collectives, small-scale farm-based initiatives, small-scale privately contracted collection, or personal backyard compost systems. In the LWBB Plan survey provided to stakeholders, 7% of respondents stated they perform some form of backyard composting while 8% participate in a community composting initiative. However, these rates are unlikely to represent citywide averages as survey takers were self-selected and thus more likely to be interested/involved in waste reduction.

The BFWRS has established the goal of providing all residents with access to composting by 2040, and has established food waste diversion targets for different sectors. These goals are used to drive the analysis presented in this section.

Current State of Organics Diversion and Processing

In 2017, approximately 163,000 tons of organic waste was disposed of in Baltimore, with 78,700 tons diverted from disposal. The organic waste diverted from disposal includes 45,800 tons of sewage sludge, 10,700 tons of food waste, 14,500 tons of yard waste, and 7,700 tons of wood material (see Appendix 1). The majority of the organic waste currently diverted is from the commercial sector. Diverted residential organic waste accounted for only 2,300 tons (3%) of organics diversion.

City-Partnered Organics Diversion and Processing

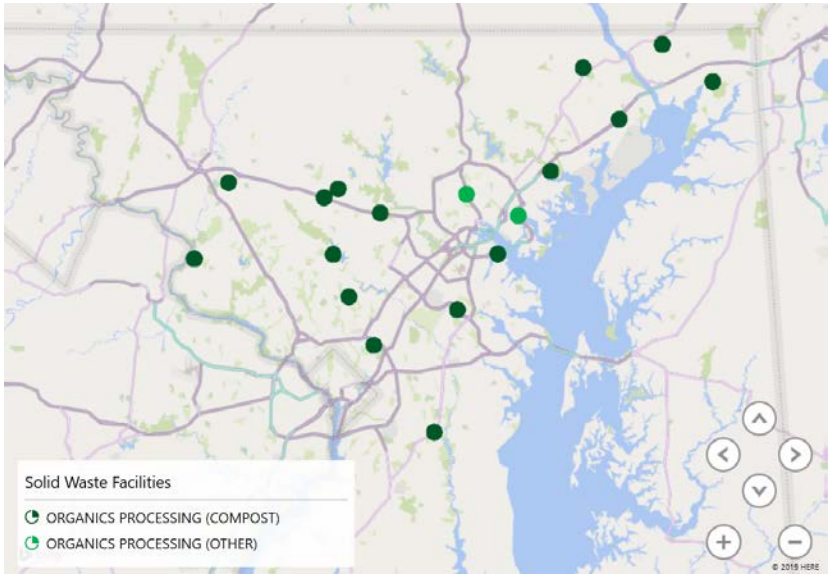
Currently, the City partners with two private companies (Veolia Water North America and Synagro) to process sewage sludge from the two wastewater treatment plants in Baltimore. Approximately 30% of the sewage sludge generated at the Back River Wastewater Treatment Plant (BRWWTP) is composted using an in-vessel process at the Baltimore City Compost Facility (BCCF), located directly adjacent to QRL and operated by Veolia. The remainder of the sludge generated at BRWWTP and all of the sludge generated at the Patapsco Wastewater Treatment Plant (PWWTP) is processed into a pelletized product at the Back River Pelletech Facility (BRPF) and the Baltimore Patapsco Pelletizer (BPPF), both of which are operated by Synagro. The pelletized product is then sold as fertilizer and soil conditioner.

In addition to sewage sludge processing, the Department of Recreation and Parks (BCRP) also operates Camp Small, a 5-acre wood waste collection and recycling yard located in the Jones Falls valley just north of Coldspring Lane at I-83. All logs, branches, wood chips, leaves, and brush collected from parks and street right of ways are processed at Camp Small. Under the Camp Small Zero Waste Initiative, prime logs, wood

chips and brush are sorted and made available for purchase by local residents and businesses. Approximately 7,700 tons of wood waste was processed at Camp Small in 2017.

Local Organics Processing Capacity

In addition to the City-operated facilities described above, multiple large organics processing facilities operate in the local region. The map below presents active composting and other organics processing facilities located within a one-hour travel distance of Baltimore.



Organics Processing Facilities within One-Hour Drive of Baltimore (from Truckshed Database Tool developed for Task 3 Report)

It is likely that these facilities and others like them are responsible for processing the roughly 22,900 tons of organic waste diverted by the commercial sector in 2017. However, most facilities are municipal or county operations that are unlikely to accept significant additional food waste from a large out-of-catchment generator. Notable examples include:

1. Prince George's County Compost Facility: A partnership between Maryland Environmental Service (MES) and the County, this facility is located in Upper Marlboro. The current permitted capacity is 69,000 tons per year of organics (food scraps and yard trimmings). Covered aerated static pile (CASP) composting technology is utilized.
2. Alpha Ridge Landfill: Howard County operates a CASP composting facility at their landfill in Marriottsville. The current permitted capacity is 12,000 tons per year of organics (food scraps and yard trimmings).

Privately operated facilities include Veteran Compost in Harford County (annual capacity of 20,000 tons), West Coast Mushrooms in Cecil County (16,000 tons), and Acme Biomass Reduction in Montgomery County (19,000 tons). Veteran Compost primarily uses CASPs with some vermicomposting, and plans to expand to a new 20,000 ton per year facility in Lothian MD. The exact amounts and types of feedstock currently accepted at these facilities is not known; however, these facilities could potentially accept some food waste from Baltimore.

Small-scale community composting programs also operate within Baltimore. Charm City Farms and Whitelock Community Farm allow local residents to bring food scraps for composting, while the Baltimore Compost Collective provides weekly food scrap collection from homes in South Baltimore and composts the material at the Filbert St. Community Garden in Curtis Bay. Compost Cab provide a home pickup service for

compostables in the Baltimore/Washington area. Mundea, a small private company, offers all-in-one waste management solutions for compost, recyclables, and residual waste. They are currently engaging with Baltimore area restaurants to help reduce their waste stream through composting and recycling.

The BOS has also implemented a small-scale food scrap drop-off service through the "Food Matters" program at the Baltimore Farmers' Market and Bazaar held beneath the Jones Falls Expressway at Holliday and Saratoga Streets. Collected food scraps are used by a tenant farmer to feed pigs. The service is also available at the Waverly Farmers' Market, which operates year round.

Diversion Targets

The BFWRS's reduction and diversion goals are summarized in the table below (second column). Separate diversion goals are provided for City government, public schools, and residential waste. Private school waste is not listed explicitly in the BFWRS and thus is handled as part of commercial waste in this Report.

Source	Reduction Target (%)	Diversion Target (%)
Commercial	50%	0%
Universities	100%	0%
City Government	0%	90%
Public Schools	0%	90%
Residential	80%	80%

Food Waste Diversion Targets from BFWRS

For this analysis, it is assumed that the target diversion rates for residential yard waste are the same as those outlined for food waste by BFWRS. Only food waste and yard waste diversion goals are considered in this section as food waste reduction was already discussed in Section 3.1. However, it is noted that there are likely some potential avenues for food waste reduction through donation from City government and public schools that were not discussed in the previous section due to the fact that the BFWRS did not include specific reduction goals for these two sectors. It is assumed that food waste from City government and public schools would be handled in conjunction with the residential organic waste stream.

Characterization of Relevant Waste Streams

Public Schools Waste

Waste from public schools is characterized according to the following assumptions:

1. The composition and generation rates of public school waste are based on data from a comprehensive 2010 study by the Minnesota Pollution Control Agency. Using the total waste generated and the student population at the studied schools, it is assumed that public school waste is generated at a rate of 0.095 tons per student per year and contains approximately 50% compostable material.
2. The current fate of public school waste (i.e., the fraction that is landfilled, composted, recycled, or combusted) is assumed to be the same as bulk residential waste.
3. To determine the mass of public school waste generated each year in Baltimore, the public school population was estimated to

be 76,180 students using 2018 data from the Maryland Department of Planning.

Using the assumptions outlined above, it is estimated that there is approximately 2,400 tons of food waste generated by public schools each year in Baltimore.

City Government Waste

City government waste is characterized according to the following assumptions:

1. The composition and generation rates of City government waste are assumed to be the same as those for public schools.
2. The fate of City government waste (i.e. the fraction that is landfilled, composted, recycled, and combusted) is assumed to be the same as bulk residential waste.
3. To determine the mass of City government waste generated each year in Baltimore, the number of government employees was estimated to be 66,040 using 2018 data from the Maryland Department of Labor, Licensing and Regulation.

Using the assumptions outlined above, it is estimated that there is approximately 2,100 tons of food waste generated at City government buildings each year.

Residential Waste

Based on the baseline analysis in Section 2.3, there are approximately 60,900 tons of residential food waste (not including public school waste or City government waste) and 36,300 tons of residential yard waste generated in Baltimore each year.

Diversion Potential

Two "Residential Organics" (RO) scenarios are considered for food waste diversion. Scenario RO1 assumes that the City decides not to attempt to implement the food waste reduction targets outlined in the BFWRS but instead opts solely to maximize food waste diversion; as such, organics diversion targets are applied to the full organics waste stream as currently estimated in Section 2.3. Scenario RO2 assumes that the reduction goals outlined in the BFWRS are implemented and met in full, with diversion goals thus applied to the reduced organics waste stream estimated in Section 3.1. In many ways, Scenarios RO1 and RO2 provide boundary conditions for this analysis, with actual performance likely falling somewhere between.

Scenario RO1: BFWRS Reduction Measures are Not Implemented

Applying the diversion targets from the BFWRS to the tonnages estimated for the three waste streams of interest gives a diversion potential of 2,150 tons of public school food waste, 1,900 tons of City government food waste, 48,750 tons of residential food waste, and 29,000 tons of residential yard waste. **This yields a total of 52,800 tons of food waste and 29,000 tons of yard waste that could be diverted annually (81,800 tons total), which would contribute about 12.5% of the 657,000 tons targeted under the BSP.**

Scenario RO2: BFWRS Reduction Measures are Implemented

Applying the diversion targets from BFWRS to the residential food waste stream under this scenario gives a diversion potential of 9,750 tons. The diversion of all other waste streams of interest is as per Scenario RO1. **This yields a total of 13,800 tons of food waste and 29,000 tons of yard waste (42,800 tons total) that could be diverted annually, which would**

contribute about 6.5% of the 657,000 tons targeted under the BSP. Adding in the 72,400 tons of food waste avoided by implementing the BFWRS reduction measures in Section 3.1 results in a total of 115,200 tons of reduced/diverted organic waste under Scenario RO2.

Options and Strategies

Multiple options and strategies exist to work toward organics diversion targets. These include expanding the use of existing organics processing capacity in/around Baltimore, providing curbside collection of source-separated organics (SSO), which includes food waste, yard waste, and other compostable organics such as napkins, and developing new organics processing capacity. It is likely that the City would choose to combine different aspects of these strategies to work toward overall diversion goals. Note that in discussion of future organics processing options beyond backyard or community scale, the generic term "composting" is used to mean any biological process, whether aerobic composting or anaerobic digestion (AD).

Expand Use of Existing Processing Capacity

Expanding the use of existing organics processing capacity is perhaps the easiest way for Baltimore to increase organics diversion. The BFWRS lays out a series of recommendations to expand existing capacity in Baltimore. These include improving access to backyard compost bins to residents, establishing school gardens at public schools to encourage on-site gardening and composting, supporting/incentivizing the creation of community composting locations in Baltimore neighborhoods, and conducting a feasibility study for establishing composting or anaerobic digestion facilities at existing City-owned sites. Options discussed in this subsection rely on consumers processing their own organics or self-delivery of organics for processing by others; as such, their overall efficacy may be limited.

Expand Use of City-Partnered Organics Processing Facilities

The major City-partnered organics processing facilities include BCCF, BRPF, and BPPF (which process sewage sludge) and Camp Small (which processes wood waste). Of these, BCCF and Camp Small would offer the greatest opportunity for expansion to process other organic waste. BCCF could be expanded to accept and compost yard waste or food waste alongside sewage sludge, although facilities designed to process a homogenous, wet feedstock such as sewage sludge often struggle with attempts to add bulkier, heterogenous, and drier feedstock materials. The central location of Camp Small with easy access to major roads makes it a prime site for a new compost facility; however, the property would need to be expanded to offer a yard waste or food waste composting program. The availability of adjacent land for expansion is limited. Alternatively, Camp Small could be relocated to a larger City-owned location.

On-Farm Composting

On-farm composting offers the potential for increasing organics diversion in Baltimore. On-farm composting initiatives generally involve co-composting farm waste (including manure and yard/plant waste) with food waste brought to the farm from outside. However, due to permitting restrictions, regulatory limitations, environmental concerns, odor problems, and feedstock quality issues, opportunities for on-farm composting are currently limited in the area surrounding Baltimore. If on-farm composting is to be considered as a strategy for the City to meet diversion goals, these issues may need to be addressed.

The BOS has already implemented a small-scale food scrap drop-off service at farmers markets through their Food Matters program, which could serve as a vehicle to expand on-farm composting.

Encourage Backyard and Community Composting

Backyard and community composting may be encouraged by the City to help meet diversion goals. However, because of generally low participation rates and the fact that many homes (e.g., rowhouses) do not have adequate space for composting, community-scale and backyard composting are unlikely to meet the City's diversion goals on their own. However, these should be encouraged as part of an integrated organics diversion program. Any food waste that is composted at home or in the local community does not enter the formal waste stream, which would lower overall costs for organics management.

Backyard composting may be encouraged by providing residents with subsidized or complimentary backyard composting units while also implementing education and outreach programs to encourage the practice. City code would also need to be updated to allow for such practice. Based on experience in other jurisdictions (e.g., Frederick County), extensive outreach efforts would be required on the part of the City to encourage widespread use of backyard composters. If backyard composting is encouraged as part of an overall diversion program, success would be difficult to measure as it relies on self-reporting on the part of residents. However, the City could set up an online portal/phone number where residents could self-report, which could be advertised by the City when distributing educational materials and bins. Even if few residents self-report, a widely implemented backyard composting program would help meet diversion goals.

Existing community composting initiatives in Baltimore were described previously. The City may choose to encourage these programs by providing grants or subsidies to local community composting initiatives. The City may also choose to launch urban farming, community garden, or "adopt a lot" programs to turn empty lots into parks and gardens. Encouraging these types of programs would increase both the production and the local demand for compost by increasing residents' access to composting while also increasing the need for compost in newly created green spaces.

In addition to community gardens, the City may also encourage the creation of school gardens at public schools. These gardens can act as hands-on facilities where children can learn about sustainable gardening, waste reduction, and composting.

In-Sink Disposal Units

In-sink disposal units (i.e. garbage disposals) offer an opportunity to process food waste in homes and send it directly into the City's sewerage system for treatment. Treatment processes at BRWWTP including AD can be used to generate valuable byproducts, including biomethane (for energy), compost, and pelletized soil amendments from the ground food waste. As such, the City may wish to encourage the use of in-sink disposal units as a means of increasing diversion rates. However, it should be noted that an analysis would need to be conducted to make sure that the existing sewerage infrastructure and treatment facilities can handle the increased organics load. Further, encouragement of in-sink disposal units for food scraps are not likely to fully meet diversion goals, so can only be considered as part of a larger food waste diversion plan.

Provide and Encourage Curbside Collection of Organics

In addition to expanding organics processing capacity, the City would likely need to initiate a centralized curbside collection program for source-separated organics (SSO). It is envisioned that such a program would collect SSO from City government buildings, public schools, households, and some Downtown businesses and bring it to organics processing facilities (e.g. composting or AD facilities) for processing. In the LWBB Plan survey provided to residents, 66% supported providing curbside collection of organics for composting as an alternative to waste disposal, even if this were to cost more. Additionally, 86% of respondents expressed a willingness to learn how to sort waste for new SSO collection programs. This indicates strong support for developing a SSO collection program.

The BFWRS provides recommendations for the City to implement and encourage an SSO collection program. These include conducting a residential curbside collection pilot program, expanding curbside collection throughout the city (long-term), conducting a feasibility study for pay-as-you-throw (PAYT) and other incentive-based residential waste collection strategies, and implementing a residential food waste ban. Case studies of SSO curbside collection programs reviewed as part of this analysis include:

1. Cambridge MA, which implemented a curbside composting pilot program to 600 homes in 2014, expanding to 25,000 homes (50% of the city) by 2018. Program expansion was backed by a strong marketing campaign and cost the city approximately $1 million.
2. Austin TX, a jurisdiction included in the Task 4 benchmarking study, which initiated a curbside food waste collection program in October 2017 with service to 52,000 households. Half of Austin's curbside customers currently have combined yard trimmings and food waste pick-up while the other half only have collection of yard trimmings. The city plans to continue rolling out combined yard trimmings and food waste pick-up to all customers in 2020. Austin has primarily contracted with a local, privately-owned composting facility to process the combined yard and food waste that is picked up from the residential curbside program. Austin's 2018-2019 budget predicted expenditure of $9.2 million on organics collection and processing.
3. Portland OR, another benchmarked jurisdiction, which has an extensive SSO collection program as part of their mature organics management program that includes 22 composting and AD facilities. However, Portland's current program was considered too large and sophisticated to be a good indicator of costs and issues for a startup SSO operation.

Offer SSO Collection as Part of Curbside Services

This program could be run by DPW as an extension of their existing curbside collection services or contracted out to a private third party. Some options to consider are listed below:

1. Expand separate curbside collection of yard waste: Currently, many residents place their yard waste out in separate bags (DPW allows as many as five bags of leaves per household during weekly trash collection), but yard waste is routinely hauled with trash to BRESCO or QRL. If yard waste was collected separately, it could be easily diverted from disposal. This option would require yard waste to be put out on the curbside (in paper bags or carts/bins) and the addition of a separate weekly collection route (along with recycling and trash pickup).

2. Provide separate curbside collection of SSO: This option would require the addition of a separate weekly collection route (along with recycling and trash pickup) as well as a significant behavioral change from local residents.
3. Offer SSO collection routes to private sector: DPW could choose to divide the city into collection routes/zones and outsource collection of SSO in these zones to private companies. Existing local firms include Waste Neutral, Compost Cab, and Compost Crew. For this option, DPW would have to ensure that enough processing capacity exists in or around Baltimore to process collected SSO.
4. Co-collection of SSO with other waste streams: Under a co-collection program, residents would be provided with clearly marked or brightly colored heavy duty compostable bags in which to collect their SSO. These bags would be collected with trash and brought to a MRF where compostable bags would be removed from the trash stream and separated for composting. Organix Solutions, a private company, currently offers this service to 48 cities in Minnesota. A major drawback with this option is it requires a mixed waste processing facility, which does not currently exist in the local area and would be expensive to develop. Additionally, residents may not like having to purchase a specific type of bag for collection service.

Provide Drop-Off Centers for Food and Yard Waste

Currently, DPW manages five residents' drop-off centers for recyclables. These could be expanded to provide separate drop-off areas for source-separated food and yard waste.

Implement Save-As-You-Throw Program

Implementing a SAYT program (outlined in detail as a policy option in Section 8.2) could either provide a financial incentive for greater recycling and participation in an SSO collection program, or a penalty for not doing so. However, SAYT programs have also been shown to increase contamination in the recycling and organics waste stream as residents are discouraged from using their trash bins. As such, the City would need to implement a citywide enforcement and citation program in coordination with SAYT to reduce contamination in SSO collection bins, which may prove costly.

Implement a Food Waste Disposal Ban

Implementing a food waste disposal ban would encourage residents to participate in an SSO collection program. Banning food waste disposal has been shown to significantly improve participation rates in cities with bans; for example, San Francisco saw its participation rate for organics collection increase from 35% to 90% after implementing an organics disposal ban in 2009. However, implementing a food waste ban would require a coordinated enforcement effort on the part of the City, which may prove costly.

Reduce the Frequency of Trash Pickup

Reducing the frequency of trash pickup while also offering a SSO collection program would encourage residents to throw more into the organics bin. However, as with a SAYT program, reducing the frequency of trash pickup may also have the unintended consequence of increasing contamination in the organics/recycling stream. As such, the City may need to implement an enforcement program in which residents who throw trash into their SSO bins would be fined, which may prove costly to administer and unpopular in practice.

Develop New Organics Processing Capacity

If a centralized SSO collection program is implemented, new local processing capacity would need to be developed to meet the increased demand. Organics processing facilities include composting or AD facilities (in this section, the term "composting" is used interchangeably to mean either process). These facilities may be co-located with other reuse and diversion facilities as part of a resource recovery park (see Section 7.2). The City may increase processing capacity by:

1. Building, permitting, and operating its own organics processing facilities;
2. Partnering with private companies to design, build, and operate organics processing facilities under a public-private partnership (PPP); or
3. Contracting with other existing public or private entities to accept organics for processing.

Section 4.4 provides a summary of these different contracting mechanisms with respect to developing a new materials recovery facility (MRF); the mechanisms would be largely the same for an organics processing facility.

The BFWRS provides guidance on how to expand organics processing in Baltimore. These include conducting a feasibility and cost-benefit analysis for establishing composting or AD facilities at City-owned sites; working with surrounding counties to identify viable locations for small, medium, and large-scale composting and AD facilities; and issuing joint RFPs for private organics management companies to develop processing facilities at selected sites.

City-Owned and Operated Organics Processing Facility

Constructing and operating new organics composting facilities would give the City full control over the fate of collected residential SSO and avoid dependence on a third party for organics processing. However, under this scenario, the City also assumes all responsibility for siting, permitting, constructing, and operating enough facilities to meet the demand of the SSO collection program. These operations could be staffed and managed entirely by DPW or, preferably, in collaboration with other departments such as BCRP. To meet demand for organics processing capacity, the City has two options:

1. Centralized facility: Site, permit, construct, and operate one large facility capable of processing all SSO collected from residential sources as well as City government and public schools. This facility would likely be sited at or near QRL.
2. Decentralized facilities: Site, permit, construct, and operate a series of small facilities to process SSO. These would be distributed around the city and developed sequentially as demand for additional SSO processing capacity builds.

The main advantage of the centralized option is economies of scale, as it would be less expensive in the long term to staff and operate one large facility rather than a series of small facilities. Another advantage is that a large facility requires only one plot of land while a decentralized would require multiple plots of land. Developing multiple facilities also entails more permitting and environmental monitoring effort.

The main advantage of a decentralized approach is redundancy. If there is some problem and one of the facilities has to temporarily (or permanently) shut down, capacity could be relatively easily transferred

to the other facilities. If only one facility is constructed, a temporary or permanent shutdown of the facility would completely eliminate the ability to process organic waste. Decentralized systems are thus more robust to climate change impacts such as flooding or storms. Another advantage of decentralization is that capacity can be scaled up with time to match the demands of the SSO collection program. SSO collection would most likely be rolled out in phases; therefore, constructing a series of small organics processing facilities would allow processing capacity to match demand and require less initial capital and operational funding.

Developing Processing Capacity under a PPP

Developing organics processing capacity under a PPP would allow the City to control siting and construction of processing capacity but transfer responsibility for the day-to-day operation of facilities to a third party. Under this option, the City could work with a state agency such as MES or the NMWDA, or with a local private company, such as Veteran Compost or Bioenergy DevCo (an AD developer based in Columbia, MD). Again, either one large processing facility or a series of smaller facilities could be developed. Under a PPP, the City would typically own the facilities and guarantee a supply of SSO under a "put or pay" contract while paying a tip fee to cover operational expenses (plus a markup) to the operator.

As an (albeit small-scale) example, Philadelphia's Department of Parks and Recreation (DPR) recently issued a request for proposals for a PPP to collect and process about 150 tons of food waste annually. The winning bidder would be responsible for equipping a municipal property to compost food waste from DPR and any outside sources.

Exporting Organics for Processing

Exporting organics for processing by another entity (public or private) outside the city would relieve the City of all responsibility for processing collected SSO. The most likely local entities with whom the City could contract for organics processing again include Veteran Compost or Bioenergy DevCo.

Role of the Baltimore Zero Waste Plan

Active participation in composting is a cornerstone of zero waste planning. The BZWP looks in detail at potential funding mechanisms and incentives for stimulating and supporting composting in Baltimore, particularly by small businesses, community organizations, and nonprofits. Based on information shared to date, the BZWP suggestions include that City contracts for organics collection and/or processing should not just be open to major companies. Instead, there should be requirements for local small businesses and nonprofits to have a set aside of at least 25% of contracts. Other suggestions include providing funding to private small-scale and medium-scale processors to purchase equipment, fund facility upgrades, or other activities to help expand food waste recovery capacity; providing funding for community gardens and farms to support a distributed community composting network; and/or hiring a full-time position within the City to advance a distributed and diverse composting infrastructure.

Overall, this LWBB Plan is neutral in its support for these suggestions at least until details regarding proposed services and costs have been elaborated further. However, it is acknowledged that small-scale, community-based operations may prove to be more efficient and cost-effective than larger operations at achieving the public participation

levels necessary for the BFWRS's goals to be realized. In this case, it would be sensible to fund smaller programs in addition to or instead of developing large-scale systems.

Estimated Costs

In this analysis, the costs associated with SSO collection and composting are presented. Costs associated with SSO collection would most likely be borne directly by the public sector (likely DPW), while costs associated with composting may be borne by the public sector or by a private company through a PPP or other contracting mechanism (in which case composting costs would be borne indirectly by the public sector). Potential cost assignments for the public and private sectors will be discussed further in the Draft Master Plan in Task 8.

It is noted that only a conceptual level cost estimate is presented here. However, in a composting and recycling hearing at the City Council on 7 May 2019, the City Finance Office supported providing curbside composting services to residents, which suggests they have done some financial analysis as the basis of that support. It is recommended that DPW get a copy of their analysis for comparison to that presented herein. In addition, as part of the ongoing Food Matters project, which is a collaboration between the City, NRDC, and the Rockefeller Foundation, the consultant firm RRS recently completed a feasibility study for siting and funding a mid-size composting facility. That report should also be reviewed for comparison to cost estimates presented herein.

Estimated Collection Costs

For this cost analysis, it is assumed that DPW would administer and conduct the collection of SSO from all single family homes (SFH), City government premises (CG), small businesses (SB) currently served by DPW's residential curbside trash and recycling service, and public schools (PS). DPW would continue to provide curbside recycling to SFH and CG, as well as to SB and PS currently served. PS would continue to contract with private haulers for trash collection. SSO collection services would be paid for in the same way as customers currently pay for trash and recycling collection services. However, alternative collection systems involving the public and private sectors in different ways could also be considered.

Scenario Assumptions

To calculate collection costs, two different SSO collection scenarios were considered, which reflect the two food waste reduction strategies RO1 and RO2 outlined previously:

1. Scenario RO1 – Do Not Implement BFWRS; Add SSO collection to existing weekly curbside services: Under this scenario, it is assumed that the BFWRS will not be implemented; therefore, the total quantity of waste generated in all sectors would remain consistent with current levels. Separate collection of SSO would be provided once weekly to SFH, SB, PS, and CG. All other existing curbside trash and/or recycling services would remain weekly. For Scenario RO1, both an optimistic and pessimistic case are evaluated:
    A. Case RO1-A – Optimistic: This case assumes that the collection efficiency on existing routes can be improved sufficiently such that no additional trucks would be required (i.e., DPW's existing collection fleet would be used to provide the additional SSO collection). This may be reasonable given that the total mass of waste to be collected would be broadly

consistent with current levels with only 2,200 tons of SSO from PS added to the over 320,000 tons of waste already handled.

B. Case RO1-B – Pessimistic: This case assumes that collection efficiencies cannot realistically be improved to overcome the more spread out collection routes and longer collection times that may transpire by offering curbside SSO collection in addition to trash and recycling services (i.e., three separate collections would require trucks to travel further and take longer to collect a full load). It is thus assumed that DPW would need to purchase additional trucks to cover SSO collection.

2. Scenario RO2 – Implement BFWRS; Add SSO collection to existing weekly curbside services: Under this scenario, it is assumed that the total quantity of waste generated by SFH and SB would be reduced to reflect the BFWRS targets. SSO collection at SFH, SB, PS, and CG would be provided weekly. Existing curbside recycling and trash collection would remain weekly. Both optimistic and pessimistic cases are evaluated:

   A. Case RO2-A – Optimistic: This case assumes that the collection efficiency on existing routes can be improved sufficiently such that no additional trucks would be required (i.e., DPW's existing collection fleet would be used to provide the additional SSO collection). This may be reasonable considering that the total mass of residential waste collected is expected to decrease by 48,750 tons per year due to food reduction and rescue programs.

   B. Case RO2-B – Pessimistic: This case assumes that collection efficiencies cannot realistically be improved to overcome the more spread out collection routes and longer collection times that may transpire by offering curbside SSO collection in addition to trash and recycling services. It is thus assumed that DPW would need to purchase additional trucks to cover SSO collection.

Capital Expenditure (CAPEX)

CAPEX on SSO collection was estimated based on the following assumptions regarding equipment needs:

1. 32-gal. green bins at a unit cost of $35 would be supplied to each SFH and SB served. It is assumed that there would be approximately 200,000 individual premises served, for a total CAPEX of approximately **$7 million**. For this analysis, it is assumed that no kitchen bins ("caddies") would be provided. Customers would use their own small containers for indoor collection of compostables to transfer to their outside bins.
2. 10-gal. green bins at a unit cost of $20 would be supplied to each PS and CG location for collection from classrooms and offices. One bin per 25 students/employees is assumed, for a total of 5,700 bins with CAPEX of **$114,000**.
3. 64-gal. green bins at a unit cost of $50 would be supplied to each PS and CG for collection of organics in communal dining areas (e.g., cafeterias). It is assumed that one bin would be needed for every 100 students/employees, for a total of 1,420 bins with CAPEX of **$71,000**.
4. Additionally, for bulk consolidation of SSO loads at PS and CG locations, 2-CY dumpsters would be provided at a unit cost of $800. It is assumed that one bin would be needed for every 500

students/employees, for a total of 285 dumpsters and CAPEX of **$228,000**.

5. Scenarios RO1-B and RO2-B requires the addition of 20-CY collection trucks. It is assumed that the number of collection vehicles in the fleet would need to increase by approximately 1.5 times to account for a third organics collection route each week. This is a total of 70 additional trucks. Trucks are assumed to cost $100,000 each for total CAPEX of **$7 million.**

A summary of the assumed CAPEX for each of the four collection scenarios is provided below.

Scenario	32-gal. bin	10-gal. bin	64-gal. bin	2-CY dumpster	20-CY truck	Total CAPEX
RO1-A	X	X	X	X		**$7,412,400**
RO1-B	X	X	X	X	X	**$14,412,400**
RO2-A	X	X	X	X		**$7,412,400**
RO2-B	X	X	X	X	X	**$14,412,400**

Estimated CAPEX for Equipment under SSO Collection Scenarios

Operating Expenditure (OPEX)

It is assumed that OPEX for collection will be borne by the public sector. OPEX for collection was assumed to include both direct collection costs (i.e. the costs of labor and collection vehicles) as well as education and outreach spending. Direct collection costs were assumed to be proportional to the number of collection routes associated with each collection scenario. For all scenarios, three collection routes would be conducted each week (i.e., one each for organics, recycling, and trash). As such, it is assumed that OPEX for all scenarios would increase by 1.5 times (i.e., 3/2) from current levels. Education and outreach costs were calculated using data from Howard County, which spent approximately $3 per household on educational materials (including mailers and brochures) during the recent rollout of its SSO collection program.

Currently, it costs $24,608,000 for DPW to collect trash and recycling from the roughly 200,000 SFHs and other premises served by DPW and $465,000 for administration of the recycling program for a total of $25,064,000 per year. Based on this, it is assumed that SSO collection would include $12,532,000 in direct collection costs and $600,000 in education and outreach spending for a **total OPEX of about $13.1 million per year above current collection expenditure**.

Estimated Organics Processing Costs

For this analysis, it is assumed that the City would build and operate new facilities (either directly or through a PPP) to process the organics collected from the curbside SSO collection program. It is assumed that these would be composting facilities operated as covered aerated static piles (CASPs), the dominant technology used for organics processing in the U.S. However, other composting or AD technologies may be employed if at comparable performance and costs. As such, use of the term "composting facility" in this discussion is for simplicity only and does not imply an endorsement of CASPs over any other technology.

As detailed previously, rather than building and operating new facilities under the cost model presented herein, the City may instead opt to expand existing composting capacity at BCCF and/or Camp Small, encourage backyard and small-scale community-based composting,

and/or partner with a state agency or private firm to process organics. In this case, costs presented here should be used to benchmark expected investments and performance metrics for alternative models.

Composting Facility Assumptions

Costs for development and operation of composting facilities were estimated based on the following assumptions:

1. The capacity of each composting facility developed would be limited to 20,000 tons of compost production (output) per year. This value was chosen based on the upper-bound throughput for successful operations reported by other composting facilities in the mid-Atlantic region. Note that this capacity is significantly smaller than that evaluated by RRS in the Food Matters project, which proposed constructing one facility with approximately 60,000 tons per year throughput capacity.
2. Each facility would comprise ten CASPs each with a capacity of 2,000 tons/year.
3. 70% of facility capacity (i.e., 14,000 tons) would come from SSO collected in Baltimore while the other 30% includes bulking agents (most likely trees and other plant material from BCRP operations and/or yard waste from outside the city) to improve the processing time and quality of generated compost.
4. Facilities would operate eight hours a day, five days a week, 52 weeks a year.
5. Facilities would be sited on four-acre lots. This small size requirement is based on needing a minimum of two acres for every 100 tons/day of processed material with 40% of land used for composting (Savage 2008). However, larger lots would provide more flexibility and scope for expansion if needed.
6. Contamination represents 24% of the incoming organics mass (this material would need to be screened out and landfilled) with 33% becoming compost. The remaining mass is off-gassed as carbon dioxide and other gases (SWOLF, 2017).

Under these assumptions, six composting facilities would be required to process the total expected volume of organics collected under Scenarios RO1-A and RO1-B, while four facilities would be required for Scenarios RO2-A and RO2-B.

Capital Expenditure (CAPEX)

CAPEX was calculated on a per-facility basis for developing a 20,000 ton/year composting facility under the following assumptions:

1. Land acquisition: Lot prices were assumed to be on the order of $100,000 per acre for a total land acquisition cost of **$400,000** per facility. This cost could be avoided if a facility is sited on unused land already owned by the City.
2. Site preparation and engineering: The total cost for engineering, permitting, site preparation, and utility interconnects were assumed at **$470,000** per facility (Geosyntec 2017).
3. Compost system: The cost for each CASP system includes concrete pads, covers, aerators, probes, leachate management, and all other fixed equipment necessary for operation. Per-unit CAPEX was assumed at $140,000, for a total of **$1,400,000** for 10 units per facility (van Haaren, 2009).

4. Equipment: It is assumed that each facility would require at least one front end loader for moving organics and finished compost product, as well as a grinder to break down large items (e.g., stumps). Based on this, total equipment costs would be **$395,000** per facility (van Haaren, 2009).

The expected CAPEX for each composting facility are summarized below.

Line Item	Units	Unit Cost	Quantity	Total CAPEX
Land Acquisition	Acres	$100,000	4	**$400,000**
Site Prep and Eng.	LS	$470,000	1	**$470,000**
Compost System	Each	$140,000	10	**$1,400,000**
Equipment	LS	$395,000	1	**$395,000**
TOTAL				**$2,665,000**

Unit and Total CAPEX for a 20,000 Tons/Year Composting Facility

Operating Expenditure (OPEX)

OPEX was calculated on a per-facility basis for operating a 20,000 ton/year composting facility under the following assumptions:

1. Labor: One full-time supervisor and eight full-time workers would be required at each facility at an hourly rate of $25 and $18, respectively. Based on this, total annual wages are estimated at **$351,500** per facility.
2. Fringe Benefits: It is assumed that the workforce would receive healthcare and other benefits at a cost of 40% of the employee's wages (**$140,600** per facility).
3. Repair and Maintenance: Repair and maintenance costs were estimated at $9 per ton of organics processed per year, for total OPEX of approximately **$180,000** per facility per year (van Haaren, 2009).
4. Utilities and Fuel: Estimated at $2 per ton of organics processed per year for total OPEX of **$40,000** per facility per year.
5. Disposal of Residues: Disposal of residual (i.e., non-compostable and reject) material was estimated at $67.50 per ton, the current tip fee at QRL. Residues are estimated to comprise 24% of all incoming feedstock, or approximately 4,800 tons per year with a total disposal cost of **$324,000** per facility per year.

The expected OPEX for each composting facility is summarized below.

Line Item	Units	Unit Cost	Quantity	Total OPEX
Supervisor	hours	$25	2,080	$52,000
Workers	hours	$18	16,640	$299,500
Fringe	Wages	$351,500	40%	$140,600
Maintenance	tons	$9	20,000	$180,000
Utilities/Fuel	tons	$2	20,000	$40,000
Disposal of Residues	tons	$67.50	4,800	$324,000
TOTAL				**$1,036,100**

Unit and Total OPEX for a 20,000 Tons/Year Composting Facility

Total Estimated Costs

The total estimated costs for all four scenarios are summarized in the table below.

Scenario	SSO Collection[1]		Composting[2]		
	CAPEX	OPEX	# Fac.	CAPEX	OPEX
RO1-A	$7,412,400	$12,532,000	6	$15,990,000	$6,216,900
RO1-B	$14,412,400	$12,532,000	6	$15,990,000	$6,216,900
RO2-A	$7,412,400	$12,532,000	4	$10,660,000	$4,144,600
RO2-B	$14,412,400	$12,532,000	4	$10,660,000	$4,144,600

1. Costs likely to be borne directly by public sector
2. Costs borne by public sector (directly or through PPP) or private sector

Total Annual Costs for Residential Organics Diversion Scenarios

Estimated Benefits

Beyond circular economy benefits of converting organic waste into reusable compost product, specific benefits of SSO collection and composting include direct revenues from the sale of compost, job creation associated with increased collection and new composting facilities, environmental benefits associated with reduced GHG emissions, and indirect benefits to local government, businesses, and residents.

Expected Revenue

Direct revenue is expected only from the sale of compost from composting facilities. Revenues for compost sales are calculated on a per-facility basis under the following assumptions:

1. 33% of the incoming mass of organics becomes compost. The remaining mass is off-gassed as carbon dioxide and other gases or represents contamination in the incoming waste stream (SWOLF, 2017).
2. Compost has a unit weight of approximately 0.4 tons/CY (SWOLF, 2017).
3. High-quality compost generated from combined food and yard waste can sell for roughly $30/CY. This value is based on selling prices for bulk compost at Home Depot, Veteran Compost, and estimates from Improvenet.

Based on these assumptions, a compost facility with an output of 20,000 tons/year should generate roughly 16,500 CY of saleable compost product, offering potential annual revenues of **$495,000** per facility.

Expected Job Creation

Expected job creation was estimated assuming:

1. Personnel requirements for SSO collection would increase depending on the change in the number of collection trucks in the fleet;
2. Two full-time employees would be added for each collection truck added; and
3. Personnel requirements at each compost facility include one full-time supervisor and eight full-time workers.

For simplicity in this evaluation, it is assumed that all workers earn $18/hour. Under these assumptions, the estimated change in labor hours (with equivalent jobs created/lost) and change in wages was estimated for each scenario as indicated in the table overleaf.

Scenario	Change in Labor Hours	Jobs Created	Change in Wages
RO1-A	112,320	54	$2,022,000
RO1-B	403,520	194	$7,263,000
RO2-A	74,880	36	$1,348,000
RO2-B	366,080	176	$6,589,000

Estimated Job Creation/Loss for Residential Organics Diversion Scenarios

Environmental Benefits

The environmental benefits associated with SSO collection and composting were estimated using the EPA computer program, WARM. Two baseline waste stream conditions were used to estimate environmental benefits:

3. Current baseline conditions (see Section 2.3); and
4. "All-landfill" alternative baseline conditions, which assumes that BRESCO is not operating and all waste not diverted from disposal is sent to landfill.

Scenarios RO1-A and RO1-B: Under current baseline conditions, it is estimated that GHG emissions would be reduced by 19,116 MTCO2E, the equivalent of taking 4,060 passenger vehicles off the road or reducing gasoline consumption by 2.15 million gallons. Under the "all-landfill" alternative baseline conditions, it is estimated that GHG emissions would be reduced by 36,955 MTCO2E.

Scenarios RO2-A and RO2-B: Under current baseline conditions, it is estimated that GHG emissions would be reduced by 4,495 MTCO2E, the equivalent of taking 954 vehicles off the road or reducing gasoline consumption by 505,800 gallons. Under the "all-landfill" alternative baseline conditions, it is estimated that GHG emissions would be reduced by 8,944 MTCO2E.

Airspace Savings

Increased organics diversion in Baltimore would reduce the amount of waste going to QRL and BRESCO. Both QRL and BRESCO charge a tip fee to cover the costs associated with consuming airspace (or capacity) of the facility. The value of this airspace/capacity can be calculated as the product of the tip fee and the diverted tonnage. This value does not represent a direct revenue, but rather is representative of the cost savings to the entity that diverted organic waste from disposal. It also represents potential revenue as airspace that DPW could offer to another customer. Using the tip fee at QRL ($67.50) and the diversion potential for this option (i.e., 81,800 tons for Scenario RO1, 42,800 tons for Scenario RO2), airspace savings of **$5,523,000** or **$2,890,000** were calculated for Scenarios RO1 and RO2, respectively.

Indirect Benefits

Indirect benefits associated with SSO collection and composting include the potential to reduce trash pickup to biweekly (particularly under Scenario RO2), thereby reducing neighborhood truck traffic, pollution, and noise, and support for the local/regional composting industry. Compost demand is on the rise in Maryland in part because of state regulations that require the use of compost as a best management practice for stormwater management and erosion and sediment controls at construction sites and newly constructed facilities.

Challenges to Implementation

Challenges to implementation of an SSO collection and processing strategy include:

1. Promoting participation in the program: It may be difficult to persuade residents to separate organics from their waste stream, particularly due to the potential issues associated with food waste (odor, bugs, vermin, etc.).
2. Enforcing participation in the program: It may be hard to meet diversion goals if participation in the program is voluntary only. In the case that the program becomes mandatory, it may be difficult or expensive to enforce participation from the roughly 200,000 participating households.
3. Siting composting facilities in Baltimore: It is estimated that each composting facility would require at least four acres of land (larger lots would be preferable). Large, inexpensive lots may be difficult to procure.
4. Managing compost facilities: DPW does not have much experience managing compost facilities (all composting in Baltimore is currently managed by private companies), although BCRP has more relevant experience managing wood waste at Camp Small. As such, the City may consider partnering with a private company to manage SSO composting under this program.

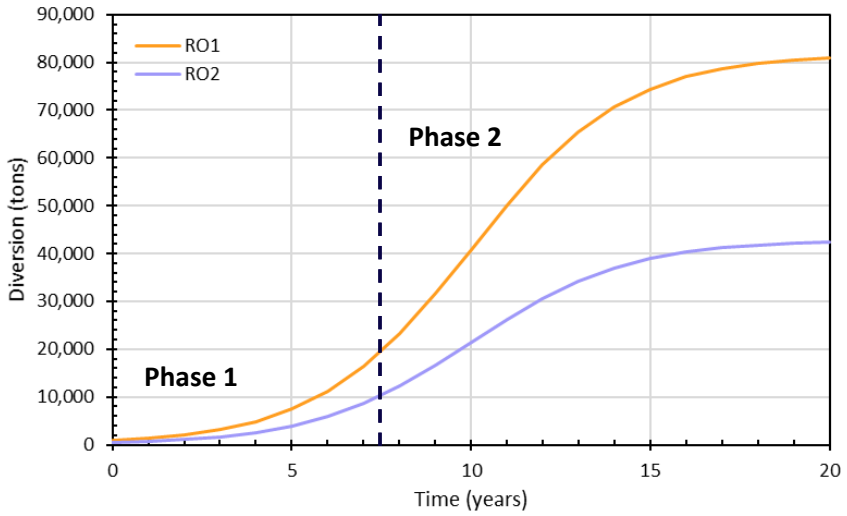
Experience

While the City does not have much experience operating or managing composting facilities, it does have experience running collection programs. This experience includes collecting trash and/or recycling from households, government buildings, small businesses, and public schools. DPW also has most of the collection equipment and staff required to implement an SSO collection program and has experience leading education campaigns to promote recycling.

Timeline

An SSO collection and composting program in Baltimore would most likely be implemented in two phases. A description and estimated timing of these phases is given below:

1. Phase 1: This phase would most likely involve SSO collection from PS and CG, with a small residential pilot SSO collection program. This would be easier for the City to control and enforce and also set an example for other residents (while also teaching the children of those residents to participate in the program). Other residents could be allowed to drop off yard and food waste, and the facility could also take food waste from farmers markets and special events. It is estimated that Phase 1 would take two years to permit and implement and would involve construction of one composting facility. Based on estimates of SSO capture with time (see figure overleaf), Phase 1 would likely last 7-8 years before additional facilities would be required.
2. Phase 2: This phase would involve a step-by-step expansion of SSO collection to more households. It is expected that this phase would be rolled out in stages to different neighborhoods over a roughly ten-year period. Additional composting facilities would be constructed over time as needed to meet demand. Assuming a 20-year total timeframe for this option, Phase 2 would likely take 12-13 years to achieved full SSO capture from all city households.



Estimated SSO Diversion with Time

Expected Performance

Expected performance of an SSO diversion program can be gauged using data from Portland, OR. Portland has had a curbside food and yard waste diversion program with weekly collection since 2011. Prior to this time, Portland offered only yard waste collection on a biweekly basis. Between 2010 and 2018, the amount of organic material collected from the curbside program increased from 523 pounds per household per year to roughly 1,030 pounds per household per year (an increase of roughly 500 pounds per household per year over a nine-year period). If this degree of improvement were extrapolated to Baltimore (where DPW currently collects trash from 200,000 SFH), an increase in organics diversion of 50,000 tons per year may be expected over the same period.

3.3 Commercial Organics Diversion

Commercial waste collection, including from public schools and universities, is currently handled by private haulers in Baltimore. As such, the City has no direct control over commercial organics diversion but can influence diversion rates by implementing a combination of incentives and mandates and/or by supporting legislation at the state level. As discussed in Section 1.4, state legislation enacted under HB 510 in 2019 will prohibit the owner/operator of a disposal facility from accepting loads of separately collected organic waste for final disposal unless they provide for organics recycling. Further mandates on organics diversion may also be enacted in upcoming legislative sessions.

It is assumed that organics diversion in the commercial sector would be achieved through selective policy implementation and enforcement rather than through more direct means (e.g., DPW collecting commercial organics and constructing additional processing capacity). The BFWRS lays out goals for a 50% reduction in commercial food waste generation in Baltimore by 2040 (as discussed in Section 3.1), but does not provide any goals for food waste diversion. As such, for this analysis various policy options that the City could enact are presented and an estimate of the achievable diversion potential is provided for each policy option without considering any set goals or targets.

Current State of Commercial Organics Diversion

In 2017, approximately 30,500 tons of commercially generated organics were diverted from disposal. This number includes approximately 11,000 tons of yard waste, 7,800 tons of wood waste (diverted to Camp Small), and 11,500 tons of food waste. As commercial waste is handled by the private sector, exact destinations for these diverted organics are not

reported; however, the likely destination is private composting facilities near the city (e.g., Veteran Compost).

Diversion Targets

Five different policy options were evaluated for their potential to increase commercial organics diversion. Each option is evaluated under two "Commercial Organics" (CO) scenarios:

1. Scenario CO1: This scenario assumes that the City decides not to attempt to implement the food waste reduction targets outlined in the BFWRS but instead opts solely to maximize food waste diversion (see Section 3.1); therefore, organics diversion targets are applied to the full disposed organics waste stream as currently estimated in Section 2.3.
2. Scenario CO2: This scenario assumes that the reduction goals outlined in the BFWRS are implemented and met in full, with diversion goals thus applied to the reduced organics waste stream.

These two scenarios were chosen to bound the analysis. In reality, it is likely that the City would obtain some percentage of the BFWRS food waste reduction goals between Scenarios CO1 and CO2.

Characterization of Relevant Waste Streams

The disposed commercial organic waste stream is assumed to have the characteristics shown in the table opposite under Scenarios CO1 and CO2 (see Appendix 1 for calculation details).

Scenario	Food Waste		Yard Waste		Total	
	Source-Reduct. (tons)	Disposed (tons)	Source-Reduct. (tons)	Disposed (tons)	Source-Reduct. (tons)	Disposed (tons)
CO1	0	44,050	0	15,150	0	59,200
CO2	23,650	20,400	0	15,150	23,650	35,550

Total Disposed Commercial Organics under Different Scenarios

Options and Strategies

Multiple options and strategies exist to encourage diversion of commercial organics. Options 1 through 5 reflect some examples of these as described below, listed from strictest (least flexible) to least strict (most flexible).

1. Organics Disposal Ban

The first option considered in this analysis is a blanket ban on disposal of all organic waste produced in Baltimore, similar to the Mandatory Recycling and Composting Ordinance No. 100-09 passed by San Francisco, CA in 2009. This option would require the participation of all the city's commercial organics producers. As found in San Francisco, it would require a great deal of education/outreach as well as enforcement to maintain participation. As a large scale ban, it would likely also be implemented gradually in phases.

2. Organics Disposal Ban on Large Commercial Generators

As a way to phase in a blanket ban on commercial organics disposal, or as a standalone policy, the City may consider banning disposal of organics from large commercial entities that generate more than one ton of organics per week. An example ordinance is Massachusetts' Commercial

Food Material Disposal Ban (310 Mass. Code Regs. 19.017). This option would achieve diversion of a large amount of organic waste, but would be a smaller and more manageable program than Option 1 as there are only about 150 facilities in Baltimore generating more than one ton of organics per week (Foster, 2016[1]).

3. Organics Disposal Ban on Very Large Commercial Generators

As with Option 2, an organics disposal ban on very large commercial generators (i.e., those that generate more than two tons of organics per week) could be a way for the City to phase in a blanket commercial organics ban (Option 1) or could be a standalone policy to target large food waste sources. There are about 60 businesses in Baltimore that generate more than two tons of organics per week (Foster, 2016). As an example, the State of New York recently enacted a similar ban on commercial organics disposal beginning in January 2022, after which any establishment that generates more than two tons of food waste per week must separate edible material for donation and arrange for inedible scraps to be taken to an organics recycler within 25 miles.

4. Surcharge Pricing for Organics Disposal

Rather than banning disposal of commercial organics, the City may enact an ordinance to charge a surcharge on disposal of commercial loads containing organics. Under the assumption that all loads of commercial MSW contain organics, the surcharge would apply to all commercial MSW loads collected in Baltimore, regardless of their ultimate disposal destination. The surcharge would be applied to haulers with the assumption that it would be passed along to their customers, the waste generators. This would require significant coordination and administration by the City to determine which haulers are operating within city limits and how much waste they are hauling to assess the appropriate surcharge. As disposal becomes more expensive under the surcharge, the expectation is that generators would elect to reduce their organic waste sent for disposal and/or source separate and divert their organics. This analysis considers the effects of implementing a 20% surcharge on all loads of commercial MSW disposed at QRL and BRESCO.

5. Subsidy/Credit for Organics Diversion

The final option considered is implementing a credit for collection of commercial organic material (i.e., an incentive option as opposed to a punitive option). The City would offer businesses a credit to cover 20% of their organics diversion costs. This would reduce the effective cost of organics disposal for businesses, thereby encouraging them to source separate and divert their organic waste.

Diversion Potential

The estimated diversion potential for each policy option under Scenarios CO1 and CO2 is shown in the table overleaf. Data from Foster (2016) was used to estimate the diversion potential for each option, **with potential contributions ranging from 2,150 tons to 59,200 tons.** A full analysis is included in Appendix 2.

1. Foster, B. "Commercial Composting for Baltimore City," prepared in consultation with the Baltimore Office of Sustainability as part of the author's Master of Public Policy program at the University of Virginia, 4 May 2016. 57pp.

Scenario	Policy Option	Food Waste (tons)	Yard Waste (tons)	Total (tons)
CO1	1	44,050	15,150	59,200
	2	14,000	4,800	18,800
	3	9,500	3,250	12,750
	4	3,200	1,100	4,300
	5	6,300	2,200	8,500
CO2	1	20,400	15,150	35,550
	2	5,250	3,900	9,150
	3	3,550	2,650	6,200
	4	1,250	900	2,150
	5	2,450	1,800	4,250

Diversion Potential for Commercial Organics Diversion Policies

Estimated Costs

In this analysis, the costs associated with SSO collection, composting, and administration are presented. Costs associated with SSO collection and composting would most likely be borne by the private sector, while administrative costs would likely be borne by the City. Potential cost assignments for the public and private sectors will be discussed further in the Draft Master Plan (Task 8).

Estimated Collection Costs

For this analysis, it is assumed that businesses affected by implementing any Option 1 through 5 would contract with private waste haulers to collect SSO.

Capital Expenditure (CAPEX)

Major capital costs for bulk collection of organics from businesses are:

1. 2-CY dumpsters: To estimate the number of dumpsters required for each policy option, it is assumed that each dumpster will be 50% full at pickup, pickup will occur once per week, and the density of organic waste is 700 lbs./CY. Each dumpster is assumed to cost approximately $800 (Bearicuda 2019);
2. 20-CY front-end loader trucks: To estimate the number of trucks required for each policy option, it is assumed that collection occurs five days a week (260 days a year), trucks are 90% full, and the density of organic waste in the trucks is 700 lbs./CY. Each truck is estimated to cost approximately $100,000.

The table below summarizes the estimated CAPEX for each option.

Scenario	Policy Option	2-CY Dumpsters		20-CY Trucks	
		Quant.	Total Cost	Quant.	Total Cost
A	1	3,253	$2,602,400	37	$3,700,000
	2	1,031	$ 824,800	12	$1,200,000
	3	699	$ 559,200	8	$ 800,000
	4	235	$ 188,000	3	$ 300,000
	5	468	$ 374,400	6	$ 600,000
B	1	1,953	$1,562,400	22	$ 2,200,000
	2	503	$ 402,400	6	$ 600,000
	3	339	$ 271,200	4	$ 400,000
	4	118	$ 94,400	2	$ 200,000
	5	234	$ 187,200	3	$ 300,000

Estimated CAPEX for Collection of Commercial Organics

Operating Expenditure (OPEX)

OPEX for collection of commercial organics are assumed to be charged by private haulers in the form of collection fees. It is assumed that all customers would be provided with a suitably-sized dumpster for separated organics with each dumpster emptied once weekly. Fees charged for waste collection by private haulers are generally confidential and thus were not available for assessment of OPEX; therefore, to estimate collection costs it is assumed that private haulers' operating costs would be roughly proportional to those incurred by DPW for collection of residential trash and recycling. In 2018, it cost $24,608,000 for DPW to collect approximately 326,800 tons of material (20,250 tons of recyclables and 306,550 tons of trash). This suggests an average OPEX of $75.30/ton, which is used in this analysis, although it is recognized that additional public services provided by DPW such as bulk trash collection, cleanup of illegal dumping, and street sweeping increase their unit collection costs. OPEX estimates for commercial organics collection are summarized in the table opposite. Details are provided in Appendix 2.

Estimated Composting Costs

For this analysis, it is assumed that commercial organics would be processed at new private facilities either inside or outside Baltimore. The costs associated with composting would be borne by the private sector and passed on to participating businesses as a component of collection fees. For simplicity, composting facility assumptions are the same as those presented in Section 3.2. It is assumed that each composting facility would be dedicated to processing commercial organics and capable of processing 20,000 tons of compost per year. Based on this, between one and five facilities would be required depending on which option is implemented.

Capital cost assumptions for composting facilities are the same as those presented in Section 3.2. It is anticipated that the total CAPEX to develop each composting facility would be approximately $2,665,000.

Operating cost assumptions for composting facilities are the same as those presented in Section 3.2. It is anticipated that the total OPEX for each composting facility would be approximately $1,036,100 per year.

A summary of CAPEX and OPEX for composting under each option is presented in the table below. Details are provided in Appendix 2.

Scenario	Policy	SSO Collection	Composting		
		OPEX	No. Facilities	CAPEX	OPEX
CO1	1	$ 4,457,000	5	$ 13,325,000	$ 5,181,000
	2	$ 1,412,000	2	$ 5,330,000	$ 2,072,000
	3	$ 957,000	1	$ 2,665,000	$ 1,036,000
	4	$ 322,000	1	$ 2,665,000	$ 1,036,000
	5	$ 640,000	1	$ 2,665,000	$ 1,036,000
CO2	1	$ 2,676,000	3	$ 7,995,000	$ 3,108,000
	2	$ 689,000	1	$ 2,665,000	$ 1,036,000
	3	$ 464,294	1	$ 2,665,000	$ 1,036,000
	4	$ 160,841	1	$ 2,665,000	$ 1,036,000
	5	$ 320,175	1	$ 2,665,000	$ 1,036,000

Total Estimated Costs for Commercial Organics Diversion Polices

Estimated Administrative Costs

It is assumed that administrative costs for each policy option would be borne by the City. These are summarized in the table overleaf.

Scenario	Policy	Education and Outreach	Enforcement	Coordination	Subsidy	Total OPEX
CO1	1	$ 100,000	$ 180,000	--	--	$ 280,000
	2	$ 100,000	$ 180,000	--	--	$ 280,000
	3	$ 100,000	$ 180,000	--	--	$ 280,000
	4	$ 100,000	--	$ 60,000	--	$ 160,000
	5	$ 100,000	--	$ 60,000	$ 369,000	$ 529,000
CO2	1	$ 100,000	$ 180,000	--	--	$ 280,000
	2	$ 100,000	$ 180,000	--	--	$ 280,000
	3	$ 100,000	$ 180,000	--	--	$ 280,000
	4	$ 100,000	--	$ 60,000	--	$ 160,000
	5	$ 100,000	--	$ 60,000	$ 299,000	$ 457,000

Estimated Administrative Costs for Commercial Organics Diversion Options

Administrative costs listed in the table include:

1. Education and Outreach: This includes programs designed to inform businesses about the option(s) being implemented and encourage participation. Annual cost assumed at **$100,000** per year (Foster, 2016).
2. Enforcement: The options that include mandatory participation (Options 1 to 3) would require significant enforcement, which would require a minimum of three employees (two inspectors and one analyst) each employed at an annual cost of $60,000 (including benefits) for a total of **$180,000** per year.
3. Coordination: The policy options that do not include mandatory participation (Options 4 and 5) would not require enforcement but would require administration and coordination by one analyst at a cost of **$60,000** per year (including benefits).
4. Subsidies: Option 5 includes subsidies to be paid to participating businesses, calculated as 20% of organics disposal costs. It was assumed that the cost of disposal equals the yearly OPEX for collection and composting plus a 10% markup. This equates to **$340,000** for Scenario CO1 and **$268,500** for Scenario CO2.

Estimated Benefits

Expected benefits from commercial organics collection and composting include:

4. Direct revenues from the sale of compost;
5. Job creation associated with increased collection, operation of new composting facilities, and government administration of the programs;
6. Environmental benefits associated with reduced GHG emissions; and
7. Support of the local composting industry and other local businesses.

Expected Revenues

Direct revenue is expected from the sale of compost from composting facilities as well as from surcharges (under Option 4) and citations resulting from enforcement (under Options 1 to 3). It is assumed that

composting revenues would be collected by the private sector while surcharge and enforcement revenues would be collected by the City.

Assumptions for revenues from compost sales are the same as in Section 3.2. It is anticipated that revenues from the sale of compost produced from commercial organics would be approximately **$495,000** per year per composting facility. Calculation details are provided in Appendix 2.

Citations are expected to generate revenues for the City under policy Options 1 to 3. Citation revenues were estimated based on the following assumptions (based on data from Cleveland, Ohio):

1. A total of 7,800 inspections can be performed per year assuming two inspectors working five days per week, 52 weeks per year and 15 inspections per day.
2. Citations of $500 per violation would be levied on every business found to be out of compliance with the selected policy.
3. Citation frequencies of 10% for Option 1, 5% for Option 2, and 2% for Option 3 are expected.

Under these assumptions, the following citation revenues were calculated for Options 1 to 3 as shown in the table below.

Option	Citation Frequency	Citation Revenue
1	10%	$ 390,000
2	5%	$ 195,000
3	2%	$ 78,000

Estimated Citation Revenues for Commercial Organics Diversion Options

As programs expand, it anticipated that more citations would initially be issued as more businesses are required to participate; however, as policies mature over time and businesses become familiar and accepting of the new reality the overall citation rate should decline. Therefore, citation revenues at the levels indicated in the table should not be assumed to be sustainable over the longer term.

Surcharge Revenues (Option 4 Only)

Surcharge revenues were assumed to be collected from all loads of commercial MSW disposed at BRESCO and QRL under Option 4. The following assumptions were used to calculate expected surcharge revenue:

1. Surcharge revenues would be collected at a rate of 20% of the typical tip fee.
2. The typical tip fee was taken to be $67.50, the current tip fee at QRL, which provides a reasonable basis for analysis. It is recognized that commercial haulers generally directly negotiate their tip fees with BRESCO, which may be significantly lower.
3. The commercial MSW disposal stream in Baltimore is estimated at approximately 210,000 tons (see Appendix 1).
4. Based on the expected amount of waste diverted under Option 4 (4,300 tons under Scenario CO1, 2,150 tons under Scenario CO2) and the amount of food waste reduction under Scenario CO2 (23,650 tons), the amount of waste subject to the surcharge was calculated to be 205,700 tons for Scenario CO1 and 184,200 tons for Scenario CO2.

Under these assumptions, the expected surcharge revenues for the City were calculated to be **$2,777,300** for Scenario CO1 and **$2,486,900** for Scenario CO2.

Expected Job Creation

A summary of the expected job creation for collection and composting as well as administration is shown in the table below.

Scenario	Policy Option	Job Creation	
		Collection + Compost (Private Sector)	Administrative (City)
CO1	1	119	3
	2	42	3
	3	25	3
	4	15	1
	5	21	1
CO2	1	71	3
	2	21	3
	3	17	3
	4	13	1
	5	15	1

Estimated Job Creation for Commercial Organics Diversion Polices

Job creation in the private sector is anticipated due to increased demand for collection and composting while job creation for City employees is anticipated based on increased administrative/inspection needs. Job creation due to implementing commercial organics collection and composting under the different scenarios and policies was calculated using the assumptions outlined in Section 3.2. Administrative job creation was estimated by assuming that three jobs (two inspectors and one analyst) would be created for each option that requires enforcement and one job (analyst) would be required for each option that requires coordination. Administrative jobs are anticipated to pay $20 per hour.

Environmental Benefits

GHG emission offsets associated with implementing commercial organics collection and composting scenarios and policies were estimated using WARM. These are summarized in the table below for each option under current baseline waste disposal conditions. GHG emission offsets for Scenario CO2 include avoided emissions from food waste reduction.

Scenario	Policy Option	Change in GHG Emissions (MTCO2E)	Equiv. Passenger Vehicles	Equiv. Gallons of Gasoline
CO1	1	-1,884	400	212,000
	2	-597	127	67,200
	3	-405	86	45,500
	4	-136	29	15,300
	5	-271	57	30,500
CO2	1	-760	161	85,500
	2	-196	41	22,000
	3	-132	28	14,800
	4	-46	10	5,100
	5	-91	19	10,200

Greenhouse Gas Emission Offsets for Commercial Organics Diversion Polices under Current Baseline Conditions

GHG emissions were also estimated under "all-landfill" alternative baseline conditions, which assumes that BRESCO is not operating and all waste disposal is to landfill. Results are summarized in the table below.

Scenario	Policy Option	Change in GHG Emissions (MTCO2E)	Equiv. Passenger Vehicles	Equiv. Gallons of Gasoline
CO1	1	-31,125	6,608	3,502,300
	2	-9,862	2,094	1,109,700
	3	-6,683	1,419	752,000
	4	-2,247	447	252,800
	5	-4,472	949	503,200
CO2	1	-14,142	2,993	1,591,300
	2	-3,641	771	409,700
	3	-2,454	519	276,100
	4	-849	180	95,600
	5	-1,692	358	190,400

Greenhouse Gas Emission Offsets for Commercial Organics Diversion Polices under "All Landfill" Alternative Baseline Conditions

Based on these results, GHG emissions associated with the use of BRESCO as the baseline condition for organics disposal are less than 10% of what they would be under a hypothetical "all-landfill" condition. This is because disposal of organics in landfills produces methane, a powerful GHG (emissions of which cannot be fully controlled throughout the landfill lifecycle), whereas incinerators convert organics to biogenic carbon dioxide.

Airspace Savings

Increased organics diversion in Baltimore would reduce the amount of waste going to QRL and BRESCO. Both QRL and BRESCO charge a tip fee to cover the costs associated with consuming airspace (or capacity) of the facility. The value of this airspace can be calculated as the product of the tip fee and the diverted tonnage. This value does not represent direct revenue, but rather represents a cost savings to any entity that diverts organic waste from disposal. Using the tip fee at QRL ($67.50) and the previously calculated organics diversion potential for each option, potential airspace savings are presented in the table below.

Scenario	Policy Option	Diversion (tons)	Tip Fee	Potential Airspace Savings
CO1	1	59,200	$ 67.50	$ 3,995,200
	2	18,800	$ 67.50	$ 1,265,900
	3	12,750	$ 67.50	$ 857,900
	4	4,300	$ 67.50	$ 288,400
	5	8,500	$ 67.50	$ 574,000
CO2	1	35,550	$ 67.50	$ 2,399,000
	2	9,150	$ 67.50	$ 618,000
	3	6,200	$ 67.50	$ 416,000
	4	2,150	$ 67.50	$ 144,000
	5	4,250	$ 67.50	$ 287,000

Estimated Airspace Savings for Commercial Organics Diversion Polices

Indirect Benefits

Indirect benefits associated with commercial organics collection and composting include the potential to reduce trash pickup frequency for

participating commercial customers as well as support for the local composting industry and landscapers by providing a steady and reliable source of compost.

Challenges to Implementation

Challenges to successful implementation of a commercial organics disposal policy in Baltimore include:

1. Pushback from local businesses: Options 1 to 3 include organic waste disposal bans that would significantly affect the solid waste disposal habits of most businesses. Adjusting these habits may be costly or difficult for businesses to achieve, especially in the short term. Further, restricted storage space at their premises may be an issue for small businesses needing to separately store organic waste between pickups.
2. Enforcement: Options 1 to 3 would require significant enforcement to keep local businesses engaged in the organics disposal ban. Enforcement may be costly and difficult for the City as it would require hiring and training new inspectors. Enforcing payment of citations would be unpopular with local businesses and haulers. The City also does not have a strong track record of effectively enforcing solid waste disposal practices.
3. Lack of existing local organics disposal capacity: As outlined in the Task 3 Report, there are not currently many composting facilities in the local area. As such, to meet the demand imposed by a commercial organics disposal policy, multiple new facilities would need to be built or organic waste would need to be transported long distances for processing.

Experience

The City has good experience administering recycling programs but limited experience enacting and enforcing bans. This experience includes:

1. Administration of the recycling program: This includes collection, education and community outreach, and sponsoring local recycling initiatives.
2. Performing inspections: The Department of Housing and Community Development enforces exterior sanitation issues and DPW organizes thousands of site visits and inspections annually as part of the rat abatement program.
3. Polystyrene ban: The City enacted a ban on polystyrene food containers in 2018; however, this policy is new and the City's success rate at enforcing the ban is untested at present.

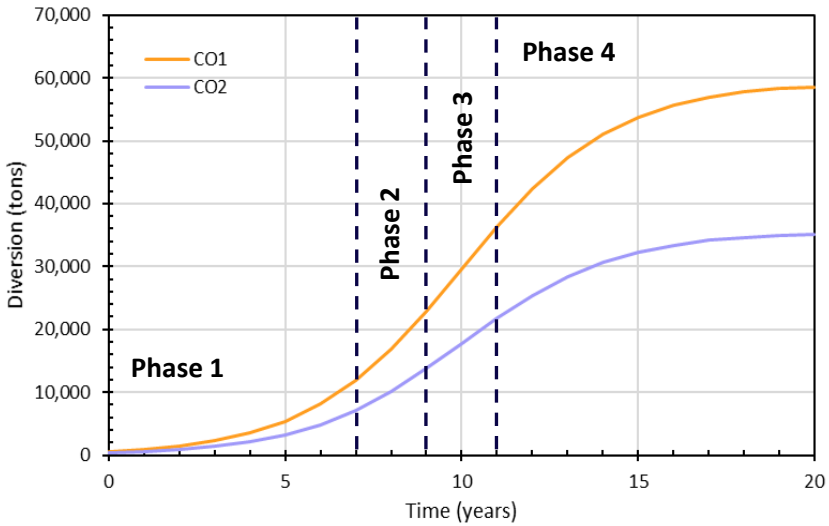
Timeline

Enacting a commercial organics diversion policy in Baltimore would most likely need to be implemented in phases. A conceptual description and estimated timing of these phases is given below. It is estimated that the full diversion potential of this policy could be met within a 20-year timeframe from the onset of Phase 1:

1. Phase 1 would most likely consist of a combination of Options 4 and 5 (i.e., a surcharge on waste disposal and a subsidy for businesses with separate organics collection). Surcharge revenues from Option 4 could be used to fund the subsidies offered as part of Option 5. Based on the estimates of commercial organics capture with time (see figure overleaf), it is

estimated that Phase 1 would last approximately 7 years to achieve the combined diversion potential of Options 4 and 5.

2. Phase 2 would most likely be implementing Option 3 (i.e., a disposal ban on businesses producing more than two tons per week of organic waste). During Phase 2, it is anticipated that the City would still allow businesses that generate less than two tons per week of organics to participate in the Phase 1 program. It is anticipated that Phase 2 would last approximately two years before moving to Phase 3.
3. Phase 3 would be implementing Option 2, extending the disposal ban to businesses producing more than one ton per week of organic waste. During Phase 3, it is anticipated that the City would still allow businesses that generate less than one ton per week of organics to participate in the Phase 1 program. It is anticipated that Phase 3 would last approximately two years before moving to Phase 4.
4. Phase 4 would be implementation of Option 1, a blanket ban on disposal of commercial organics. This final policy would be made permanent following implementation.



Estimated Commercial Organics Diversion with Time

Expected Performance

Expected performance of a commercial organics diversion program can be assessed by comparing to similar programs in other cities. However, many of these programs are still in their early stages, so it is difficult to gauge their success at this time. Example programs in other cities include:

1. Austin, TX: Austin implemented a program in October 2018 requiring all food businesses (including restaurants, bars, farmers markets, grocery stores, etc.) to divert organic materials from landfills with proposed fines between $100 - $2,000 per day for non-compliant businesses. This program built on a previous

policy, implemented in 2016, that required all large businesses (15,000 square feet or larger) to divert organics from the landfill.

2. New York, NY: New York City implemented a program effective in February 2019 requiring all restaurants with floor areas greater than 15,000 square feet, chain establishments with at least 100 locations, and food retailers with at least 25,000 square feet of floor space to divert food scraps from disposal. This program builds on the original program (which targeted about 275 of the city's largest food waste generators) which was implemented in January 2017.
3. Portland, OR: Portland recently announced a phased commercial organics program targeting commercial generators of more than 1,000 pounds of organics per week by 2020, generators of more than 500 pounds per week by 2021, and generators of more than 250 pounds per week by 2022. The program will require source separation and donation or processing of organics.

4. TRADITIONAL RECYCLABLES

4.1 General Overview and Outlook

In the context of this Report, traditional recyclables are considered to be materials that are widely accepted in DPW's single-stream curbside collection program, including mixed paper, cardboard, plastics (in particular plastic no. 1, or PET/PETE, and plastic no. 2, or HDPE), aluminum cans, steel cans, and glass. Because these items are accepted as single-stream recyclables (SSR), the shorthand term SSR is used to describe traditional recyclables in this chapter.

Based on extrapolation of data from the Task 0 winter and summer waste sorts conducted for the LWBB Plan (see Section 2.3), SSR comprises about 240,700 tons of the nearly 825,000 tons in the disposed waste stream in Baltimore annually, or about 30% of total disposed tonnage. Therefore, recovery of additional SSR could significantly contribute to working toward the BSP's goal of 90% waste diversion.

As discussed in the community outreach meetings, as well as through online feedback and the LWBB survey, the general sentiment amongst stakeholders was that recycling should be as convenient as trash disposal, and made universally available. Over 84% of survey responders supported increasing access to recycling, suggesting programs such as providing free recycling bins/carts to every single family home (SFH) and helping multi-family buildings with implementing recycling. In light of this, Chapter 4 sequentially examines improving DPW's existing curbside SSR program (Section 4.2), expanding access to recycling to the currently unserved population (Section 4.3), and then modifying/expanding the SSR processing capacity in and around Baltimore (Section 4.4). Prior to that, however, the remainder of this introductory section on SSR provides a cautionary review of the status of the recycling industry and issues surrounding the secondary materials markets.

Metrics for Measuring Performance

In looking at SSR tonnages and expectations for recovery, it is important to recognize that packaging has been subjected to significant "light-weighting" in recent years, that is a significant amount of packaging has been replaced by lighter alternatives. For example, glass beer bottles have been replaced by aluminum bottles and recyclable plastic laundry detergent bottles have been replaced by non-recyclable plastic pouches. In addition, packaging itself has decreased in weight, with single-use water bottles and aluminum beverage containers now constructed with 40% less plastic and aluminum than in previous years. As such, it should be expected that total SSR tonnages will naturally decrease with time. A new metric for measuring the performance of recycling programs that moves away from tonnage and focuses on lifecycle carbon footprint or secondary material value is needed. The need for a new paradigm is widely accepted in the recycling industry. For example, in their T-6.4 Technical Policy (2018), the Solid Waste Association of North America (SWANA) addresses some issues and makes suggestions for a new standard; however, to date, a new methodology has not been agreed upon by the U.S. EPA or the industry. Therefore, in this Report the primary metric for measuring SSR diversion rates remains tonnage.

The ever-evolving nature of SSR materials will require lists of acceptable materials in curbside programs to be reexamined periodically and adjusted to account for light-weighting and other changes to minimize contamination and capitalize on the most valuable commodities within the recycle stream. Ideally, acceptable materials should be restricted to

those for which there is a market demand that is geographically reasonable, economically feasible, and consistently available.

Impact of China's "National Sword" Policy

Notwithstanding the apparently large potential for significant diversion of additional SSR in Baltimore, it is important to stress that the U.S. recycling industry has faced increasing challenges in the face of drastically reduced imports of SSR by China and, subsequently, other countries. In 2013, China launched a temporary customs program called "Operation Green Fence" aimed at increasing environmental quality by reducing waste importation and contamination in recyclable materials. In 2017, China announced more stringent restrictions under the "National Sword" policy, which banned the import of several recyclable materials from all countries (including mixed paper and mixed plastics) starting in January 2018, and reduced the limit on contamination in scrap metal and recyclable materials not banned to 0.5% effective March 2018. This limit is extremely difficult and costly for U.S. MRFs to meet. Since August 2018, China has also imposed tariffs on many recyclables specifically from the U.S., including cardboard and other recovered fiber as well as metals and plastics.

The effect of National Sword on pricing has been catastrophic: based on monthly updates from Resource Recycling, for example, mixed paper selling for over $85/ton in January 2017 is now worthless (trading at -$2/ton in August 2019), while the national average for cardboard is currently about $28/ton, down from $70/ton a year ago and $180/ton in July 2017. Prices for plastic PET bottles have held relatively firm; however, natural (clear) HDPE plastic is currently trading at about $0.20/lb., down from $0.39/lb. a year ago and a high of over $0.52/lb. in October 2014.

According to a September 2019 report by SWANA titled "Resetting Curbside Recycling Programs in the Wake of China," National Sword has resulted in a 50% reduction in revenues from the sale of recovered recyclables in the U.S., equivalent to about $400 million a year. This is estimated to have increased the cost for U.S. households with weekly curbside collection by about $6.85 per month. SSR contamination levels reported at MRFs typically range from 15-25% (contamination levels in Baltimore reported by WMRA are about 20%; estimates from the Task 0 winter and summer waste sorts suggest 15%), which is costing curbside recycling programs over $1 billion per year on a national basis.

In the wake of National Sword, Baltimore's current recycling services may need to be amended through force majeure provisions as this is a global situation. SWANA, for example, has suggested that certain resets to curbside recycling programs could result in cost savings to offset the cost increases resulting from National Sword. These include switching from weekly to biweekly SSR collection or switching glass recycling (a notable contaminator in SSR and thus contributor to higher costs) from curbside collection to drop-off center recycling only. However, in the context of this Report, which is investigating options for increasing collection of SSR rather than on streamlining/reducing recycling efforts, such actions are not directly explored. For this reason, Chapter 4 mainly examines potential options for expanding access to recycling, noting increased costs for doing so. Notwithstanding, diverting more materials to recycling streams is only half the battle: there must be demand for these materials and contamination levels must be low enough to allow the recycling industry to meet end users' quality controls without entailing excessive processing costs. Therefore, it is important to realize that many of the options outlined in Chapter 4 may not be financially viable unless new technologies are developed, global recycling markets recover

significantly, and/or new domestic demand is stimulated. This may include chemical recycling as discussed in Section 6.3. Predicting the evolution of recycling markets and technologies over the next several years is not possible, and the City is cautioned to carefully examine up-to-date industry trends and market outlooks before making any meaningful investments in additional SSR collection and processing.

To recycle correctly, consumers must receive regular, accurate, and clear information on what is acceptable and the streams into which different materials are to be separated. Education efforts (as discussed in Section 8.1) will be critical to achieving a sustainable increase in SSR recovery. A positive development is that a bill advanced in Congress this year to increase funding for the U.S. EPA through the end of 2020 also directed the agency to develop a national recycling strategy addressing harmonized labeling, public education, and other factors. Language in the bill requires EPA to work with for-profit companies, nonprofit groups, state and local governments, and other stakeholders. Initial recommendations for voluntary action are expected by early 2020. If enacted, suggested changes in federal tax policy to incentivize use of recycled rather than virgin materials and plans for a national infrastructure investment program to include solid waste and recycling could also improve the outlook for SSR recovery.

Source Reduction and Reuse of Recyclables

More impactful and valuable than goals for increasing recycling are source reduction goals, that is preventing these materials from entering the waste stream in the first place or developing true closed-loop systems for material reuse. This requires changes in the design, manufacture, purchase, and use of products; eliminating excessive layers of packaging; and laws/incentives for consumers to have the option to choose reusable rather than single-use products and guide behavioral changes (e.g., eating in at restaurants using washable cups, plates, and utensils rather than buying take-out in single-use containers and bags, or allowing consumers to bring their own reusable containers for food take-out service or leftovers). Source reduction goals are generally best achieved by implementing extended producer responsibility (EPR), product take-back programs, and bans or restrictions on the use of single-use products, especially in the retail and food service sectors. This must be coupled with offering realistic alternatives to banned items; educational programs to educate consumers on why programs/bans have been implemented and what is expected from individuals for these programs/bans to succeed; and a willingness on the part of the City to inspect and enforce. Chapter 8 deals extensively with options related to reduction and reuse measures, included education/outreach (Section 8.1) and support for City and Maryland legislative efforts (Section 8.6). Improving enforcement is addressed in Section 9.2.

In summary, similar to the issue of light-weighting, when looking at long-term SSR tonnages and expectations for recovery rates, it is important to recognize the impact that successful source reduction measures would have on decreasing the SSR stream.

4.2 Improved Curbside Collection

Current System for Residential SSR Collection

DPW provides weekly curbside SSR collection to single-family residences in Baltimore (as well as public housing, some public schools, and some small businesses in the Downtown area that pay DPW for recycling collection). Under the City's residential One PLUS ONE program, there is no maximum amount of recyclable material that can be collected from

each household. Materials accepted in the SSR collection program include aluminum and steel/tin cans, cardboard, glass containers, mixed paper, and plastic bottles and jars. A full listing of currently acceptable and unacceptable materials is available here.

In 2017, DPW reported collecting 20,250 tons of SSR via their curbside collection program. In combination with SSR dropped off at residents' drop-off centers (approximately 13,800 tons in 2017), the average recycling rate for residential SSR in Baltimore is approximately 16.8% (see summary calculation in the table below).

SSR Component	Disposed (tons)	Recycled (tons)	Recycling Rate
Cardboard	24,600	16,600	40.2%
Mixed Paper	18,700	5,100	21.5%
HDPE/PET	12,700	1,150	8.3%
Mixed Plastic	55,200	1,300	2.3%
Aluminum Cans	4,000	300	7.1%
Steel Cans	7,650	450	5.5%
Glass	9,350	1,750	15.8%
TOTAL	**132,200**	**26,650**	**16.8%**

Disposal and Recycling Data for Residential SSR

Options and Strategies

There are multiple strategies that the City could employ to improve SSR diversion. These include revising bin allocations and sizes, revising collection frequency for trash and SSR, implementing dual or multi-stream recycling, or implementing a save-as-you-throw (SAYT) program.

Revise Bin Size and Allocation

DPW currently provides one green 65-gal. (default) or 35-gal. (upon request) trash cart to all SFHs free of charge, while yellow 18-gal. or 25-gal. recycling bins need to be purchased for a small fee (although households are free to use their own recycling bins, paper bags or cardboard boxes). Some options for revising this current bin allocation are provided below:

1. Reduce the default size of the trash bin to 35-gal., which may encourage people to improve their recycling habits to avoid overfilling their trash.
2. Provide the existing recycling bins for free to all SFH, which would encourage more residents to participate in the recycling program.
3. Increase the size of the recycling bin to 65-gal. Increasing the size of the recycling bin (particularly if trash bins are simultaneously reduced in size) may encourage residents to recycle more material. This could be achieved by switching the current green trash carts to recycling and issuing new smaller trash carts; however, this may be difficult to communicate and enforce, and would require stickers to re-identify the green carts as recycling.
4. Changing bin colors. Currently, trash bins are green, a color many stakeholders complained is more commonly associated with organics or recyclables, while recycling bins are yellow. Changing the recycling bin color to blue and the trash bin color to black or brown may more closely match perceptions, which may increase participation in the recycling program.

Revise Collection Frequency

By increasing the frequency of residential curbside SSR collection and/or reducing the frequency of trash collection, the City may be able to encourage greater participation in the recycling program. Additionally, if the City were to provide for separate residential organics collection (see Section 3.2), the volume of collected trash, and hence the collection frequency needed for trash, would be reduced.

Cities that have implemented a biweekly trash collection program in addition to weekly SSO collection include Portland, OR; Toronto, ON; and Brattleboro, VT.

Implement Dual- or Multi-Stream Recycling

Switching from a SSR program to a dual- or multi-stream recycling program has the potential to significantly reduce contamination levels in collected recyclables. It may also slightly reduce the need for post-collection processing of recyclables at a MRF. As such, switching to dual or multi-stream recycling could lead to significant efficiencies by reducing post-collection processing costs and increasing recovery of higher value recyclables. As part of this option, DPW could consider refusing to pick up improperly sorted trash and recyclables. If recyclables and trash are pre-sorted by residents, it would be relatively easy for collection workers to identify contamination in different bins. Such a system would place responsibility for contamination directly on residents, encouraging improved recycling habits. However, it may also lead to increased complaints from residents and additional staff hours to resolve these complaints. Additionally, the total mass of recyclables collected would likely reduce as some residents may not be willing to put in the extra levels of effort to sort the material.

Some options to consider for implementing a dual- or multi-stream recycling program include:

1. Separating glass from other recyclables: Glass shards can lead to contamination of other recyclables such as cardboard in SSR. Additionally, glass is abrasive and damaging to MRF equipment, and has a very low commodity price (it generally costs money to send glass to market). As, such separating glass from other recyclables could significantly reduce contamination levels and improve MRF performance, resulting in lower handling costs.
2. Separating paper/cardboard from other recyclables: Because they are soft and absorptive, paper and cardboard are highly susceptible to contamination in SSR recycling streams. By mandating separate collection of paper/cardboard, the City could reduce contamination and post-collection processing costs, resulting in lower handling costs.

1) Separating waste into multiple categories, such as paper/cardboard, glass, plastic/metals, organic waste, and household trash. This technique is used successfully in some European countries (e.g., Germany) and Japan to reduce contamination in the recycling stream. As an extreme example, some communities in Japan mandate separation of waste/recycling into as many as 30 categories prior to collection.

Implement Save-as-you-Throw Program

Implementing a SAYT program (outlined in detail in Section 8.2) would not only encourage greater recycling but would also encourage residents to participate in an organics collection program. However, SAYT programs have been reported to increase contamination in the recycling stream as residents are discouraged from using their trash bins. As such,

the City would likely need to implement a strict enforcement or citation program in coordination with SAYT, at least in the short term, to reduce contamination in recycling loads.

Diversion Potential

No specific diversion goals are provided in the BSP for residential SSR, although the BSP calls for 90% diversion of all waste from landfill or incineration as part of a zero waste initiative. As such, a target diversion rate of 90% is applied to all residential SSR except mixed paper and mixed plastic. For these waste groups, a lower diversion target of 50% is applied to reflect that recycling these materials can be challenging (indeed, although included in this section, recycling of these two groups may be more appropriately considered in relation to chemical recycling options for hard-to-recycle materials in Section 6.2). A summary of the total diversion potential by material is included in the table below.

Material	Diversion Target	Diversion Potential (tons)
Cardboard	90%	20,450
Mixed Paper	50%	6,800
HDPE/PET	90%	11,350
Mixed Plastic	50%	26,950
Aluminum Cans	90%	3,550
Steel Cans	90%	6,850
Glass	90%	8,250
TOTAL	-	**84,200**

Maximum Diversion Potential for Residential SSR

As shown in the table, the maximum diversion potential of all SSR is estimated at **84,200 tons per year, which if achieved in full would contribute about 13% of the 657,000 tons targeted under the BSP.**

Estimated Costs and Benefits

Estimated Costs

The estimated costs associated with implementing each improved SSR collection option are given below. In this analysis, it is assumed that these costs would be borne by the City as expansion of DPW's current services. However, some costs could be transferred to the private sector, either directly or via a PPP. Potential cost assignments for the public and private sectors will be discussed further in the Draft Master Plan (Task 8).

1. Option 1 - Revise Bin Size and Allocation: For this option, it is assumed that the City would purchase new 35-gal. black or brown trash carts for allocation to each SFH. It is further assumed that the green 65-gal. green carts currently allocated for trash would be reallocated to SSR collection. As such, the only cost to the City is the new trash carts. It is assumed that there are approximately 200,000 SFH in Baltimore and that these carts would cost $35 each (Hyder, 2012) for a total cost of **$7 million.**
2. Option 2 - Revise Collection Frequency: For this option, it is assumed that DPW would reduce trash collection to biweekly while keeping weekly recycling collection. This option would likely only be feasible if the City also implements a separate SSO collection program (see Section 3.2) as SSO collection would result in a smaller volume of trash and would remove the main odor-generating and vermin-attracting components. By

switching to biweekly trash collection, it is assumed that collection costs would be reduced from the current level. Currently, it costs $24,608,000 for DPW to provide trash collection and recycling. By reducing trash collection to biweekly, DPW would only perform three collections every two weeks as opposed to the current four collections performed in a two-week timeframe. As such, it is assumed that collection costs under this option would be 75% of current levels, for an **estimated savings of $6.2 million per year.** One potential indirect cost associated with this option is potential job losses within DPW caused by decreased collection frequency and thus reduced need for collection workers.

3. Option 3 - Implement Dual or Multi-Stream Recycling: For this option, it is assumed that multi-stream recycling is implemented with three categories of recyclables: paper/cardboard, glass, and metals/plastics. It is assumed that DPW's existing truck fleet could be used to implement the multi-stream recycling approach. However, collection costs would be increased as the number of separate pickups would triple (alternatively, DPW could invest in trucks with split beds to minimize long-term collection costs, however, capital costs would increase). For this option, the total mass of material collected is expected to be the same as under the current system (although it is likely that recycling volumes may decrease slightly as some residents may choose not to participate in a multi-stream recycling program). Due to the increased number of collections, it is expected that collection costs would increase by 50% for a total of **$12.3 million per year**.
4. Option 4 - Implement SAYT: For this option, it is assumed that DPW would offer each SFH a standard 35-gal. bin for recycling and an option of four different cart sizes for trash collection. All recycling bins would be offered free of charge (for a total cost of **$7 million** as per Option 1), while residents would be charged different amounts for different sized trash carts. It is assumed that the City would use the same rate schedule for bins as currently used by Austin, TX, as summarized in the table below.

Trash Cart Size	Monthly Rate
24-gal.	$18.55
35-gal.	$19.80
65-gal.	$24.95
95-gal.	$43.50

Monthly Rates for Trash Carts under SAYT Program

Assuming that the there are approximately 200,000 SFH and that the average resident chooses to use a 65-gal. cart, DPW could expect to generate revenues of **$59.9 million per year** from an SAYT program to pay for SSR recycling and trash collection, but would lose equivalent allocations under the general fund (i.e., net revenue would be zero). It is noted that as more residents choose to downsize containers, thus theoretically improving waste diversion rates, DPW would see increasingly less revenue under this model.

Estimated Benefits

Cost offsets expected from each option were described previously. The other benefits considered as part of each option include environmental benefits (estimated using the diversion potential and U.S. EPA program, WARM) and airspace savings

at QRL (estimated using the expected diversion potential and the current tip fee of $67.50 per ton). A summary of the expected benefits is included in the table below.

Benefit	Parameter	Option	Value (per year)
Cost Offset/ Revenue	Revenue or Cost Offset	1	--
		2	$ 6.2 million
		3	--
		4	$ 59.9 million[1]
GHG Reduction	MTCO2E	Max.	-194,250
	Equiv. Vehicle Miles		41,200
	Equiv. Gal. Gasoline		21.9 million
Airspace Savings	Airspace Savings	Max.	$ 5.7 million

1. Net revenues would likely be negligible because DPW would lose allocations from the City's general fund.

Summary of Expected Benefits of Improved SSR Collection Options

Additional indirect benefits include the potential for increased employment (either for recycling inspections or for additional collection routes required for multi-stream recycling (under Option 3) and separate SSO collection (under Option 2).

Challenges to Implementation

Some of the expected challenges to implementation of improved curbside collection are listed below.

1. Public pushback: Public resistance would be expected for all four options. Many residents would likely protest smaller trash bins and less frequent trash collection as these options would reduce the amount of trash that residents are able to put out for collection. Residents are also unlikely to welcome the responsibility of source separation of recyclables associated with multi-stream recycling or the added direct costs associated with a SAYT program.
2. Contamination of the recycling stream: Options 1, 2, and 4 are likely to increase contamination levels in the recycling stream, as residents are encouraged to put out less trash and recycle more material.
3. Vermin: If Options 1, 2 or 4 are implemented, residents may put loose trash bags out with their trash for pickup. Putting out uncontained trash bags is likely to attract rats and flies.

Experience

The City has plenty of experience with most of the options discussed in this section. For example, DPW currently operates numerous collection programs. Reducing trash pickup frequency and/or implementing multi-stream recycling should be relatively simple for DPW to implement from an experience perspective. DPW also currently performs thousands of inspections annually as part of the rat abatement program. Such experience could be useful if inspections are required to enforce participation in a multi-stream recycling program.

Timeline

It is assumed that Options 1, 2, and 4 could be implemented relatively quickly, likely within five years as these options would require relatively little educational outreach (although Option 4 would require some time to alert citizens to the need to choose their desired bin size). Options 1, 2, and 4 are also likely to yield improved

diversion results relatively quickly, as these options are designed to force changes in recycling behavior (either through monetary incentives or by physically limiting the amount of trash that may be thrown out). Option 3, however, would require additional planning and educational outreach prior to implementation because this option relies heavily on changing habits and behaviors. It is likely that Option 3 would take between five and ten years to realize significant changes in diversion.

4.3 Expanded Access to Recycling

Current System for Commercial SSR Collection

Collection of recyclables from MFDs and most businesses in Baltimore is provided by private haulers. In 2017, about 42,300 tons of SSR were diverted from disposal in the private system for an average recycling rate of 24.4% (see summary calculation in the table below).

SSR Component	Disposed (tons)	Recycled (tons)	Recycling Rate
Cardboard	32,350	16,200	33.3%
Mixed Paper	17,600	12,200	40.9%
HDPE/PET	7,550	100	1.4%
Mixed Plastic	29,800	1,600	5.1%
Aluminum Cans	2,500	250	10.0%
Steel Cans	9,000	2,750	23.3%
Glass	9,250	1,750	16.0%
TOTAL	**108,050**	**34,850**	**24.4%**

Disposal and Recycling Data for SSR in Commercial Sector

Options and Strategies

While the City currently provides curbside collection of SSR to SFH, public housing, and some small businesses and public schools, there are still many opportunities to expand this recycling network and increase the overall recycling rate. These opportunities include expanding services to private multi-family dwellings (MFDs), providing mobile collection units for traditional recyclables and other materials, increasing collection from public spaces and special events, and helping to improve recycling services to businesses.

Extend Curbside Collection to Multi-Family Dwellings

Currently, residents in MFDs rely on private haulers contracted by landlords for trash and recycling services. Reportedly, private haulers periodically reject recycling loads from MFDs and/or stop services altogether due to contamination issues (generally, because they may be fined or have their loads rejected at receiving MRFs if contamination is too high). This leads to inconsistent collection and contributes to low participation in recycling programs among MFD residents. By extending recycling services to MFDs, DPW could improve collection by creating a more stable recycling environment. However, this may cause contention with existing haulers who would lose out on this business.

One way that the City could provide recycling collection to MFDs is to provide recycling dumpsters for apartments and condominiums and "recycling buddies" (i.e., sturdy, large capacity bags for recycling collection and storage). Weekly emptying of recycling dumpsters would likely be needed.

Design Guidance/Codes for Multi-Family Dwellings

To improve recycling collection from MFDs, the City could issue guidance on how new developments or redevelopments must consider design of waste collection areas, including provision for diversion capacity and placement of waste containers. These design guidelines could provide direction to property developers and owners on how to incorporate recycling collection infrastructure into multi-family developments to make recycling as easily accessible to residents as trash receptacles. According to information shared to date, developing such guidelines is a key focus of the BZWP, independent of the LWBB Plan. The LWBB Plan broadly supports the BZWP in developing these guidelines, details of which should be elaborated in therein. For this reason, this option is not discussed further in this Report.

Provide Mobile Collection Units

The City could consider provision of mobile collection of recyclables and other materials using a modified trailer or truck. While DPW currently accepts these materials at residents' drop-off centers, residents must have the means to physically transport these materials. Provision of a more convenient way to accept these materials may encourage additional diversion.

Examples of jurisdictions that offer mobile recycling services include Polk County, NC, which provides mobile units for collection of traditional recyclables several days per week, and Pinellas County, FL, which conducts mobile collection events for HHW and electronics. As part of their service, Pinellas County also operates a "Haz-to-Go" truck which can be scheduled by civic groups or homeowner associations and/or can be made available in conjunction with neighborhood yard sales and seasonal clean up events.

Improve Recycling in Public Spaces

Some stakeholders requested that more public trash and recycling cans be provided on streets, in parks, and in other public areas. In this regard, rather than simply provide a larger number of cans in more places, all of which would require additional emptying by collection crews, DPW could look for ways to embrace the smart transformation of waste operations in public spaces that many other U.S. cities have implemented. Not only does this keep streets noticeably cleaner, streets are calmer as fewer collection events mean less trash truck congestion and vehicle emissions.

Examples of smart collection systems for public spaces include:

1. Vacuum Collection: An automated vacuum collection system (AVAC) transports waste at high speed through underground pneumatic tubes to a collection station where it is compacted and sealed in a roll-on, roll-off (RORO) container. When the RORO is full it is transported away and emptied. The process begins with the deposit of trash into intake hatches or portholes, which may be specialized for waste, recycling, or compost. Portholes can be located in public areas and on private property where the owner has opted in. AVAC technology is widely used internationally but U.S. adoption has been slow. AVAC systems are expensive but highly efficient. Manufacturers include Logiwaste (Sweden), Envac (Sweden), and MariMatic (Finland).
2. Underground Vault System: Underground vaults are large (up to 6-CY) trash containers buried about 10-ft beneath the pavement. The units include a sensor that tells the collection vendor when the trash container is full and needs collection. The portion of the trash bin above ground looks like a regular trash or recycling receptacle but is fitted with a trap door that leads to the

underground vault. A specially-designed truck attaches a crane to a bell housing on the top of the bin then hoists and dumps the vault into the truck, which has an onboard compactor. Kissimmee, FL has installed six vault systems since 2018. Vendors include Underground Refuse Systems (Orlando, FL) and Van Dyk Recycling Solutions (Norwalk, CT).

3. Smart Cans: These are compacting or non-compacting public trash cans that wirelessly communicate their real-time status and notify collection crews when they are full and ready to be emptied. Compacting models (which are generally solar powered) can increase a can's effective capacity by up to five times. Smart cans help streamline waste management operations (which reduces GHG emissions), increase productivity by enabling public works employees who previously handled only trash collection to be reassigned to higher priority tasks, and keep public areas clean. A well-known, pioneering brand is the solar powered, compacting bin manufactured by U.S. company Bigbelly Solar. Several Bigbelly units are already in place in downtown Baltimore. Other smart can manufacturers include Victor Stanley (Dundalk, MD), which offers solar-powered public litter and recycling receptacles marketed under the brand "Relay" that are equipped with sensors to measure fullness and alert the owner when the cans are ready for collection, and ECUBE, which offers solar-powered trash compactors that communicate fullness in real time. DPW has already deployed 64 ECUBE smart cans in South Baltimore. DPW also already sources traditional public trash cans from Victor Stanley. Relay cans can also be equipped with scales in the bottom to measure the weight of the contents, detect rummaging, track tonnage, and alert DPW if something very heavy is deposited. More than 1,000 Relay cans have been deployed in Pittsburgh, PA. Newer models to be released later in 2019 will be able to detect pedestrian activity; air, light, and chemical pollution; odor; noise (e.g., gunfire, construction, and outdoor nuisances); and localized climate conditions (e.g., ambient temperature, humidity, and snow depth). An alternative system focused on recycling is available from SourceReCycle (Centerville, VA). This system uses a smart recycling container marketed as "SmartBox" to collect real-time data to track all recycling activity and help increase recycling and reduce contamination rates. The SmartBox can be configured for commercial and/or residential implementation and can assimilate recycling data on an individual, municipal, and state level.

Special Event Recycling

This type of program targets vendors or organizations using public streets, parks, arenas, community centers, and other facilities for concerts, festivals, or other special localized events. This program complements a public space recycling program as described above. Recycling plans for special events held on public land are mandated under Maryland law. Organizers of special events in Baltimore are required to get a permit, which provides an opportunity for the City to ensure that appropriate waste management and recycling provisions are made. Permitting requirements could be supported with educational materials and brochures designed to help event planners and attendees understand how special events can implement recycling programs.

While DPW currently provides cleaning services, trash removal, and recycling services to qualifying events (if their services are requested),

there is a range of additional support that DPW could provide to event organizers. This includes providing advice on setting up a recycling plan, provision of bins and containers, or developing self-assessment guides to help organizers manage and minimize waste generated at events (e.g., by requiring that food and drink vendors minimize single use serviceware).

Expanding Recycling Services to the Commercial Sector

The City may choose to expand recycling services to the commercial sector in order to increase diversion of traditional recyclables. In fact, this will soon be mandated by law for certain businesses. In March 2019, the Maryland state legislature passed a law (SB 370) to require county recycling plans to address collection and recycling of recyclable materials from office buildings that are 150,000 square feet or larger. Methods to expand recycling services include:

1. Public Service: DPW could provide curbside collection of traditional recyclables from businesses. This would require the addition of separate weekly collection routes for commercial recyclables along with DPW's existing recycling and trash pickups.
2. Franchising: The City could offer commercial recycling collection routes to the private sector. The City could choose to divide Baltimore into collection routes/zones and offer to contract collection of Commercial recyclables in these zones to private companies. For this option, the City would need to ensure that sufficient processing capacity exists in or around Baltimore to process collected recyclables.

Programs could be phased in based on customer size and type, starting with larger businesses and institutions.

Diversion Potential

No specific diversion goals have been established for commercial sector recycling, although the BSP calls for 90% diversion of all waste from landfill or incineration as part of a zero waste initiative. As such, a target diversion rate of 90% is assigned to all recyclables except mixed paper and mixed plastic, which are assigned 50% diversion targets to reflect current difficulties in their recycling (see previous discussion in relation to residential SSR in Section 4.2).

A summary of the total diversion potential by material is included in the table below, with the maximum diversion potential of all SSR estimated at **69,300 tons per year, which if achieved in full would contribute about 10.5% of the 657,000 tons targeted under the BSP.**

Material	Diversion Target	Diversion Potential (tons)
Cardboard	90%	27,500
Mixed Paper	50%	2,700
HDPE/PET	90%	6,800
Mixed Plastic	50%	14,100
Aluminum Cans	90%	2,250
Steel Cans	90%	7,850
Glass	90%	8,100
TOTAL	-	**69,300**

Maximum Diversion Potential for SSR in Commercial Sector

Estimated Costs and Benefits

Estimated Costs

The estimated costs associated with implementing each of the options considered to expand access to recycling are given below. For costing purposes in this analysis, it is assumed that these costs would be borne by the City. However, some/most of these costs could be transferred to the private sector, either directly or via a PPP. Potential cost assignments between the public and private sectors will be discussed further in the Draft Master Plan (Task 8).

1. Option 1: Expand curbside recycling collection to MFDs: The average curbside recycling set out per household is estimated at 0.1 tons per household based on 2017 data for households served by DPW (20,246 tons collected from approximately 200,000 households in 2017). According to the Department of Housing and Community Development, there are 97,200 housing units in MFDs in Baltimore. Using the average household recycling rate, this equates to an additional 9,850 tons of traditional recyclables potentially available for collection from MFDs. It is assumed that collection costs would be directly related to the volume of material collected. In 2017, DPW collected approximately 326,800 tons of material (20,250 tons of recyclables and 306,550 tons of trash) for a total collection cost of $24,608,000 (equivalent to $75.30/ton). Therefore, the additional cost of collecting recyclables from MFDs is estimated to be **$740,000 per year**. For this option, additional collection trucks and collection bins for MFDs would be needed. It is estimated an additional 7 trucks would be required at a unit cost of $100,000 per truck and an additional 540 2-CY collection bins would be needed at a unit cost of $800 per bin. This yields total **CAPEX of $1.1 million**. The number of required trucks and bins is based on the density, collection, and capacity assumptions presented in Section 3.3. Further, it is estimated that two additional workers would be employed per truck (labor costs were captured in the OPEX estimate above).
2. Option 2: Provide mobile collection units: CAPEX for this option includes the trucks and trailers necessary to provide mobile collection units. Assuming three mobile collection units (consisting of one truck and one trailer each) are purchased at a cost of $50,000 each, total **CAPEX of $150,000** is estimated. Assuming that each truck would employ one full-time operator/driver at a cost of $50,000, total **OPEX of $150,000 per year** is estimated. There would also be some minimal cost for public outreach regarding rollout of the mobile collection units.
3. Option 3: Improve recycling in public spaces: For this option, it is assumed that the City would place an additional 2,000 compacting recycling smart cans in public spaces. Assuming a unit cost of $4,100 per compactor (as recently paid by Millbrae, CA for Bigbelly units), total **CAPEX of $8.2 million** is estimated for this option. Installing solar powered compactors would also allow DPW to empty trash bins on a less frequent basis, lowering collection costs. In Millbrae, installation of Bigbelly compactors reduced collection costs by 50%. DPW may expect similar OPEX reductions from implementing this option.
4. Option 4: Special event recycling: For this option, it is assumed that DPW would review permits, provide advice on setting up recycling plans, and offer self-assessment guides to event organizers. It is estimated that this would require one part-time

employee with **OPEX of $30,000 per year** assuming wages and fringe benefits of $25/hour. Little/no CAPEX is required for this option.

5. Option 5: Expand recycling services to entire commercial sector: As with Option 1, a unit collection cost of $75.30 per ton is assumed. For this option, the full diversion potential of 69,300 tons per year is assumed for a total **OPEX of $5.2 million per year**. For this option, an additional 43 trucks at a unit cost of $100,000 per truck and 3,810 bins at a unit cost of $800 per bin would be required, for a total **CAPEX of $7.3 million**. The number of trucks and bins required is estimated based on the density, collection, and capacity assumptions presented in Section 3.3. It is estimated that two additional workers would be employed per truck (labor costs were captured in the OPEX estimate above).

Estimated Benefits

Cost offsets expected from each option were described previously. The other benefits considered as part of expanding access to recycling include environmental benefits (estimated using the expected diversion potential and the U.S. EPA program WARM), airspace savings at QRL (estimated using the expected diversion potential and the current tip fee at QRL of $67.50 per ton), and potential job creation. A summary of expected benefits is provided in the table opposite.

Benefit	Parameter	Option	Value (per year)
Cost Offset/ Revenue	Cost Offset	1	--
		2	--
		3	50% OPEX reduction
		4	--
		5	--
GHG Reduction	MTCO2E	Max.	-155,500
	Equiv. Vehicle Miles		33,000
	Equiv. Gal. Gasoline		17.5 million
Job Creation	Jobs	1	14
		2	3
		3	--
		4	0.5
		5	86
Airspace	Airspace Savings	Max.	$ 4.7 million

Summary of Expected Benefits of Expanded SSR Collection Options

Challenges to Implementation

Some of the expected challenges to implementing expanding access to recycling are listed below.

1. Promoting participation in the program: It may be difficult to improve the recycling habits of local MFD residents and businesses sufficiently to reach the diversion potential. Significant education and outreach would be required to improve participation.
2. Enforcing participation in the program: It may be hard to meet diversion goals if the program is voluntary only. In the case that

the program becomes mandatory, it may be difficult or expensive to enforce participation.

3. Contamination of the recycling stream: Expanding recycling to previously unserved sectors may result in an increase in contamination until new participants can be educated about what can and cannot be recycled.

Experience

The City has plenty of experience with most of the options included in this section. For example, DPW currently operates residential curbside collection programs. Extending collection to MFDs and businesses should thus be relatively straightforward. In addition, DPW already operates solar compactors smart cans (i.e., Bigbelly and ECUBE) in public spaces and is familiar with these systems. Finally, DPW already supports special events recycling. Expansion of this program (e.g. by providing advice for recycling plans and self-assessment guides to organizers) should be relatively easy to implement.

Timeline

It is assumed that Options 2, 3, and 4 could be implemented relatively quickly, likely within five years, as these options would require little change in recycling behavior (i.e., they would simply provide greater opportunity for recycling to occur). Options 1 and 5, however, would require additional planning and educational outreach prior to implementation as these options require changes in behavior and habits to achieve full diversion potential. They would also require DPW to map out additional collection routes, perform additional collection runs, purchase additional trucks and bins/dumpsters, and/or develop a franchising program for private sector participation, all of which would require significant planning. It may be that starting with Option 1 and then transitioning to Option 5 would be optimal for phasing in wholesale commercial recycling services. It is assumed that Options 1 and 5 would take between 10-15 years to realize significant increases in diversion.

4.4 Increased Processing Capacity

Overview of MRF Operations

SSR sorting and processing is performed at a materials recovery facility (MRF), which involves manual and automated recycling in a multi-stage process in which the "lowest-hanging fruit" are picked first before removing successively more difficult materials in subsequent stages. When materials arrive at a MRF, bulky, heavy items and obvious trash are typically removed on the tipping floor. The remainder is placed on conveyors where easily recovered items are removed manually and/or mechanically (i.e., magnets remove metals, eddy current separators remove aluminum, etc.). The next stage usually involves removal of materials according to size and weight via disc screeners. These are enclosed floors lined with rows of rotating discs of differing shapes and sizes designed to create a wave action in the material flow. Large, flat objects like cardboard sheets and boxes are sent to the top of the material where they are easily removed by manual pickers. Small, light objects like office paper and newsprint are separated by means of air pressure from air knives, clarifiers, and cyclones. The residue then passes through a rotating trommel designed to remove dirt, small particles, and other non-recyclable materials. The remaining material consists of colored glass, cullet, ceramics, and plastics. Traditionally, these are the

materials that are removed and sorted (according to material type and color) by means of light spectrophotometry and optical sensors.

Current Status of SSR Processing

The City currently contracts exclusively with Waste Management Recycle America (WMRA) for processing of collected recyclables. WMRA operates a MRF in Elkridge, MD serving the greater Baltimore-Washington metro area. The WMRA facility has been in operation since 2006 and employs about 170 people. Using a combination of manual labor and automated sorting technologies, the MRF separates mixed recyclables into base components of recyclable paper, cardboard, different classes of plastics, glass, and aluminum and steel cans. Separated materials are then baled and shipped worldwide (although WMRA reports that plastics are currently shipped only within the U.S. and that they look to sell all materials domestically where possible). The facility currently processes about 18,000 tons of SSR every month (i.e., over 200,000 tons annually). The facility's maximum operable throughput is not known.

Currently, all recyclables collected in DPW's residential curbside recycling program as well as all mixed recyclables and hard plastic collected at residents' drop-off facilities are sent to WMRA. In 2017, DPW sent a total of 21,550 tons to WMRA, which comprises less than 10% of the MRF's total processing throughput. In 2017, DPW paid a total of $561,702 for recycling at WMRA for an average effective tip fee of $26.07 per ton. In the first five months of 2018, DPW paid $579,669 to WMRA for recycling of SSR for an effective tip fee of $60.59 per ton. Effective tip fees in 2019 and 2020 are expected to be higher. This dramatic increase in the effective tip fee is the result of the crash in the U.S. recycling market caused by China's National Sword policy, as discussed in Section 4.1.

Two other local recycling facilities that are not currently under contract with the City for processing SSR but that could potentially do so are:

1. Baltimore Recycling Center (BRC), a private MRF and transfer station that accepts wood, cardboard, aggregates, metal, plastics, and concrete for recycling. In 2016, BRC accepted approximately 195,200 tons of material. Although it is not known how much of that was SSR materials, it is suspected that wood and concrete recycling dominates. The current posted gate fee for this facility is $75/ton.
2. L&J Waste Recycling, LLC (L&J), a private MRF that accepts aggregates, metals, wood, SSR, and gypsum/drywall for recycling and reuse. In 2016, L&J accepted and processed approximately 30,100 tons of material. The quantity of SSR in that total is not known, nor are the facility's tip fee or maximum processing capacity for SSR.

Using the Truckshed Database Tool developed for Task 3 of the LWBB Plan, which lists locations and details of all regional waste management facilities, Geosyntec could not identify any other local MRFs within a one-hour truck drive from Baltimore.

Potential for Additional SSR Recovery

Currently, DPW diverts about 20,200 tons of SSR for recycling at WMRA. Based on analysis in Section 4.2, a maximum of about 84,200 additional tons of SSR could be diverted if the options for improving DPW's existing curbside SSR collection are enacted to their fullest extent. Similarly, based on analysis in Section 4.3, a maximum of about 69,300 additional tons of SSR could be diverted if the options for expanding access to SSR collection in the commercial sector are enacted to their fullest extent.

Combined, this represents the potential for an additional 153,500 tons of SSR for processing. At WMRA's current effective fee of about $61/ton, this would cost an additional $9.33 million per year to process; however, at such large volumes a better rate may be negotiable (if WMRA even has the capacity to handle such an increased volume and handle contamination issues). Further, it is recognized that improved/expanded SSR collection would be rolled out in phases such that maximum quantities of SSR would only be collected after several years. Nevertheless, this dollar value serves as the basis for comparison for any options for processing SSR independent of WMRA.

Increasing SSR Processing Capacity

The timeline for increasing SSR processing capacity will be controlled primarily by the timelines for implementing improved or expanded SSR collection services as described in Sections 4.2 and 4.3.

In this review, it is assumed that short-term options would be needed to handle the additional 153,500 tons that could be recovered from improved/expanded collection services. These options focus on expanding existing processing capacity. However, it is assumed that medium- to long-term options would need to handle the 20,200 tons of SSR already collected plus the additional 153,500 tons that could be recovered from improved/expanded collection services, for a combined SSR stream of about 173,700 tons (i.e., it would not make sense to keep sending SSR to WMRA or other private facilities if the City develops or sponsors development of new processing facilities).

Short-Term Options

Option S1 – Process Additional SSR

Invest in Improving Existing MRFs

Both BRC and L&J are older facilities that focus on providing recycling services to bulk customers, mainly in the construction industry. They are not equipped to handle high volumes of SSR. Further, the changing composition of SSR and markets for recovered materials requires MRFs to make regular upgrades to include newer technology into their facilities. Older MRFs that, for example, were designed to handle the materials that were more common before the collapse of newspapers and the boom in e-commerce generally cannot handle modern SSR streams or meet strict contamination limits. While older facilities may be retrofitting with new technology, this is unlikely to be economical for the owners of BRC or L&J unless the City was willing to help fund the upgrades. The only advantage in entering into negotiations with BRC or L&J to modify their facilities to take all or some of the expanded SSR stream would be if WMRA cannot accept a greater quantity of SSR, which is unlikely, or as leverage in negotiating tip fees.

Expand Contract with WMRA

WMRA is a modern MRF that commenced operation in 2006 and is dedicated to processing SSR. WMRA has made several investments in new technology in recent years, including optical technology to sort plastics and anti-wrapping screens reduce downtime. The facility leverages the resources of Waste Management, Inc., a Fortune 500 company. As such, it is unlikely to need or be willing to enter into joint financing with the City for future technology upgrades or increased

throughput but would rather look to secure long-term commitments on tonnage in return for making investments in expanding capacity and sorting technology.

Expected Costs and Benefits

As stated previously, the expected costs associated with continued use of WMRA for processing of additional recyclables is **$61 per ton**. Assuming that the City sends its total combined SSR stream to WMRA, this results in a total cost of **$10.6 million per year**.

This option is not expected to have any tangible benefits for the City (i.e. no changes in employment or revenue).

Medium- to Long-Term Options

Option ML1: Construct New Centralized MRF

The City may decide to develop a new centralized MRF (either directly or by entering into an agreement with the private sector) to process SSR locally at a lower cost than offered by WMRA. This could be considered even in the short term, but given WMRA's experience and leverage in the market, it seems unlikely this would provide a more cost-effective solution, when considering all capital costs and marketing experience needed.

Regardless of future contracting terms with WMRA, if the City is fully successful at achieving the additional SSR recovery envisioned in Sections 4.2 and 4.3, then at some point over the medium to long term the size of the SSR stream would likely exceed the processing capacity at WMRA, which has little room for significant expansion at its current location. This would trigger the need for new SSR processing capacity.

Potential Contracting Mechanisms

The simplest contractual mechanism would be for the City to develop the new MRF and include the facility under the existing portfolio of assets and services administered by DPW, or create a new division or public enterprise for project delivery (design-build-transfer contract) and operation. Financing would likely take the form of a bond issue with capital cost repayments and operating expenses covered through fees levied for services.

An alternative is for the MRF to be developed and operated by the private sector. Private companies finance and develop projects most effectively when there is a market return on their investment to enable the company to grow and hire. As such, they are incentivized to find mechanisms to lower the cost of capital as well as capital and operating expenses. At a minimum, a privately funded facility would require the City to enter into a contract that would establish a unit rate service fee (e.g. $/ton) and minimum quantities of acceptably clean materials that would be delivered for processing (e.g. a "put-or-pay" contract, where a specified fee would be paid to the MRF regardless of the quantity of SSR delivered).

The primary benefit of private sector ownership is that it would not tie the City into facility financing or operational risk, which eliminates long-term liability. In addition, there is the assumption that a qualified private sector operator would bring expertise and experience from their other successful operations to bear on any facility or program developed in Baltimore. The primary drawback of private sector ownership and operation is the risk that issues outside the City's control (i.e., financing, operations, loss of end markets, etc.) can result in temporary or permanent disruptions in service, including rejection of recycling loads and related penalties. Private projects are fully subject to market forces

(i.e., unprofitable projects are shut down). It should be noted that this is not an insignificant risk, since during the past 10 years financial returns in the waste processing and recycling sector have been uncertain and a significant number of MRFs and other waste processing facilities have closed due to financial failure.

Finally, a public-private partnership (PPP, 3P, or P3) is a cooperative arrangement for collaborative infrastructure development or service delivery between one or more public and private sectors, typically of a long-term nature. A relevant local PPP example is the Baltimore City Composting Facility, which is operated through a partnership between the City, Northeast Maryland Waste Disposal Authority (NMWDA), and Veolia Water North America. Maryland Environmental Service (MES) also operates solid waste facilities in partnership with local governments, including the Prince George's County composting facility in Upper Marlboro. Common themes of PPPs are the sharing of risk and the use of private finance leveraging public bond ratings. A PPP typically involves a private entity to finance, construct, and manage a facility over its projected lifespan or some other specified period in return for a promised steam of payments directly from the public entity or indirectly from users. Typically, these payments include contribution of some or all of capital development costs, public backing of debt issuance, and minimum guaranteed payments for services.

While there are many PPP mechanisms used in a wide variety of programs and projects, the design-build-operate (DBO) model is most relevant here. Under the DBO approach, a private sector company would compete for an integrated single contract or concession, but title to the MRF would remain with the City (or would be transferred after a set period). This creates a single point of responsibility for design and construction and can speed project delivery by facilitating the overlap of the design and construction phases and the urgency of transitioning to the operating phase of the project (when the DBO contractor starts generating revenue). A potential benefit of DBOs is lower costs: when project planning, design, construction, and operation are handled together from the outset, there are more opportunities for efficiency. DBOs also help lower risks, as control of the project remains in the hands of the owner while responsibility for performance and compliance are with the DBO partner. Both the owner and DBO partner can manage risk and liability through performance guarantees, insurance, the development of maximum total project cost guarantees early on, and the implementation of quality assurance and control processes.

Expected CAPEX and OPEX

Based on a 2017 study for Frederick County, MD using data from four different sources, **Geosyntec estimated CAPEX of about $40 million for developing a large MRF in an urban setting with nominal 200,000 tons/year processing capacity**. **OPEX was estimated at $45-$55/ton**; however, this estimate preceded National Sword. As noted above, **WMRA currently charges the City about $61/ton**, a more likely long-term cost associated with meeting tighter constraints on material quality.

Expected Benefits

The primary benefits associated with a large, centralized MRF are revenue and job creation. The unit price for recovered traditional recyclables has decreased dramatically in recent years and currently stands somewhere in the range of $20-$30 per ton. For this analysis, it is assumed that a centralized MRF could realize 85% recovery of traditional recyclables (i.e. a 15% rejection rate) and that recovered recyclables

could be sold for $26 per ton (although it is noted that the value of recyclables may continue to decline). Using the assumed throughput of 173,700 tons per year, **total revenues are expected to be approximately $3.8 million per year**.

It is estimated that a MRF will employ approximately 0.03 people per ton per day processed. Assuming 173,700 tons per year, this equates to **21 full time workers**.

Option ML2: Construct Decentralized "Mini-MRFs"

As an alternative to developing a new centralized MRF, the City may instead opt to develop a system of "mini-MRFs" to process SSR locally at a lower cost than can be offered by WMRA. This option offers flexibility, as the City can choose to construct some mini-MRFs while continuing to send excess recyclables to WMRA for processing. Various contracting mechanisms are available for mini-MRF development, including those previously discussed with reference to developing a large-scale centralized MRF. Regardless of the contracting mechanism adopted, the City's exposure to capital and/or other risks would be far lower from supporting a mini-MRF approach rather than developing (or directly supporting private development of) a large centrally located MRF in Baltimore. Similar to suggestions for organics processing in Chapter 3, any involvement by the City in new SSR processing capacity would be better directed at supporting a decentralized approach in which processing capacity can be added incrementally as supported demonstrably by supply and demand data.

Mini-MRFs could be developed by community organizations in collaboration with experienced small haulers and licensed contractors, with the City potentially providing small business development grants. This approach could start with one or two smaller facilities (each of which could be equipped to handle a limited range of SSR materials only) and be expanded only after the sustained success of additional SSR collection and processing has been demonstrated. Decentralized systems are more robust to consumer dynamics, fluctuations in the SSR stream, and potential impacts of climate change.

Mini-MRFs could be built throughout Baltimore to reduce transportation and hauling costs and engage residents on a neighborhood level. Due to their small operational footprint, mini-MRFs can relatively easily be installed within disused/abandoned warehouses or industrial buildings. With a smaller system, haulers would develop relationships with residents while mini-MRFs would also provide a source of jobs for the local community. Shorter haul routes could even allow investment in smaller trucks (ideally non-compacting) to reduce contamination and produce a higher quality product.

DPW has been in contact with Closed Loop Partners, an investment firm working on building the circular economy, regarding a mini-MRF system designed by Revolution Systems. The system is small (it can fit in spaces as small as 5,000 square feet) and processes between one and ten tons per hour of material. The system relies predominantly on manual sorting and can accommodate recovery of as many as 12 different commodities. Revolution Systems provides the mini-MRF system, installation, training, and even consulting services. Closed Loop Partners provide support with central management systems and contracts for shipping materials to end markets.

Expected CAPEX and OPEX

CAPEX and OPEX estimates presented here are based on information from Closed Loop Partners and Revolution Systems for their mini-MRF

technology. Assuming an average throughput of 5-6 tons per hour, an eight-hour work day, and 260 working days per year, it would take **16 mini-MRFs** spread throughout Baltimore to process the 173,700 tons/year SSR stream (i.e., 20,200 tons already collected plus the full diversion potential of 153,500 tons/year associated with improved curbside collection and expanded access to recycling). Each mini-MRF system would cost approximately $1 million and would be built on a half-acre lot (at $100,000 per lot), preferably a disused warehouse or industrial building that can be repurposed. **This puts individual CAPEX at $1.1 million and total CAPEX at $17.6 million**.

It is assumed that each mini-MRF would employ about 10 people: one supervisor plus nine workers at an average annual salary (including fringe benefits) of $50,000. Each facility would incur an additional $150,000 per year in costs for central management support, utilities, and maintenance. As such, the **unit OPEX for each min-MRF system is estimated at $650,000/year with total OPEX at $10.4 million/year** for the entire system of 16 mini-MRFs. This equates to about $60/ton of throughput capacity, which is competitive with what WMRA currently charges to accept SSR.

Expected Benefits

The primary benefits associated with a system of small mini-MRFs are revenue and job creation. The unit price for recovered traditional recyclables has decreased dramatically in recent years and currently stands somewhere in the range of $20-$30 per ton. For this analysis, it is assumed that a centralized MRF could realize 85% recovery of traditional recyclables (i.e., a 15% rejection rate) and that recovered recyclables could be sold for $26 per ton (although it is noted that the value of recyclables may continue to decline). Using the assumed throughput of 173,700 tons per year, **total revenues are expected to be approximately $3.8 million per year**.

It is estimated that each mini-MRF would employ ten full time employees. Assuming 16 mini-MRFs are built throughout Baltimore over time, this equates to **160 full time workers**.

5. CONSTRUCTION AND DEMOLITION (C&D) WASTE

C&D waste represents the single largest component of the waste stream for disposal, comprising about 288,700 tons of the nearly 825,000 tons in the disposal waste stream in Baltimore in 2017 (about 35% of total disposal). Although the C&D waste stream is highly diverse, major material categories tracked for discussion in Chapter 5 only include lumber, clay bricks, concrete, asphalt, shingles, soil, and drywall. Concrete dominates the C&D disposal stream, accounting for over 200,000 tons (69%), followed by asphalt at about 40,000 tons (14%).

C&D waste from commercial sources dwarfs that from residential sources, accounting for about 283,000 tons (98%); therefore, only reduction and diversion of C&D waste from commercial sources is discussed in this chapter. C&D waste from the residential sector primarily enters the waste steam via the small hauler programs at QRL and NWTS. Recovery of some of this material could be achieved in conjunction with proposed upgrades to DPW's drop-off centers to provide more opportunities for diversion of bulky waste (see discussion in Section 7.1).

The data suggests that the potential for reducing and diverting C&D waste is high. However, the recycling rate for C&D waste is already high, at about 48%, indicating that much of the easily recoverable C&D waste is already being diverted. Additional recovery would thus need to target harder-to-recycle materials (e.g., bulky composites that are difficult to separate into base components or items that are contaminated with asbestos, grease, lead paint, etc.), which would inevitably incur higher processing costs than those reported by existing C&D recyclers. To put this in perspective, the current posted gate fee at the Baltimore Recycling Center (BRC), a private MRF that accepts wood, aggregates, metals, and concrete, is $75 per ton.

Currently, the City lacks specific guidance on reduction or diversion targets for C&D waste; however, recovery of C&D waste and wood are key components of Baltimore's Waste-to-Wealth Initiative. Recovery of additional C&D waste could significantly contribute to meeting the BSP's overall goal of 90% waste diversion.

5.1 Reuse of C&D Waste

There is currently large support for reduction and reuse of C&D waste in amongst stakeholders. In the LWBB survey, 90% of respondents favored policies that would encourage reduced waste from demolition and construction projects. As such, C&D waste reduction is an important waste reduction strategy for the City.

Existing C&D Reuse and Reduction

It is difficult to estimate exactly how much C&D waste reduction is already occurring in Baltimore. However, multiple deconstruction and building materials reuse centers currently exist in the city, indicating that at least some source reduction and reuse of C&D material is occurring. Popular deconstruction and building materials reuse centers include Second Chance, the Loading Dock, and Habitat for Humanity of the Chesapeake. A full list can be found at MDrecycles.org Each center reports diverting hundreds to thousands of tons from disposal annually.

Additionally, the USDA sponsored Baltimore Wood Project, a collaboration between federal, City, and private partners, seeks to reuse

both "fresh cut" (i.e., from trees) wood waste and wood waste from deconstruction. Camp Small currently participates in this project.

Additional Reuse Potential

The only waste stream relevant to this analysis is commercial C&D waste as the mass of residential C&D waste currently collected is minimal. Based on the analyses performed in Section 2.3, the commercial C&D waste stream has the following characteristics:

Commercial C&D Materials	Disposed (tons)	Recycled (tons)	Total (tons)	Recycled (%)
Concrete	199,300	228,250	427,550	53.4%
Asphalt Concrete	40,200	46,550	86,750	53.7%
Asphalt Shingles	7,150	8,250	15,400	53.6%
Clay Bricks	**6,350**	7,300	13,650	53.7%
Lumber	**22,000**	30,700	52,700	58.3%
Scrap Metal	**0**	60,400	60,400	100%
Drywall	8,050	8,250	16,300	50.6%
Soil	150	77,400	77,550	100%
TOTAL	283,200	467,100	750,300	62.3%

Characteristics of the Commercial C&D Waste Stream in Baltimore

Of the materials listed, only lumber, clay bricks, and scrap metal can realistically be salvaged and reused. These are often found as complete structures (e.g., fireplaces), wood floors, or salvageable pieces of structural wood and steel. However, scrap metal already has a recycling rate of almost 100%, meaning that only clay bricks and lumber would be available for reuse. Under these assumptions, the **annual reuse potential for C&D waste is calculated to be 28,350 tons**.

Options and Strategies

Multiple policy options and strategies exist to encourage C&D waste reuse. These include City-mandated deconstruction of existing structures, establishing an architectural salvage program, and encouraging green construction.

Deconstruction Policy

Legislation that mandates all construction projects to "deconstruct" rather than "demolish" existing structures would reduce C&D waste generation and encourage reuse. Capacity for deconstruction and reuse of salvaged building materials already exists in Baltimore, which is home to multiple deconstruction companies and building materials reuse centers (e.g. Second Chance, the Loading Dock, Habitat for Humanity of the Chesapeake) as well as the Baltimore Wood Project.)

According to information shared to date, developing a deconstruction policy is a key focus of the BZWP, developed independent of the LWBB Plan. Additional details regarding the design and implementation of a deconstruction policy are expected therein.

Architectural Salvage Program

An architectural salvage program may be implemented in coordination with mandated deconstruction of existing structures to encourage reuse of building materials. An architectural salvage program could be implemented as an online database (similar in concept to dating apps such as "match.com") to match potential buyers with companies offering salvaged building materials. City facilities and/or existing resale companies could hold the material while it is advertised.

Green Construction Policy

A green construction policy would require new construction or major remodeling of existing buildings meet certain environmental and sustainability standards. The best known example is the Leadership in Energy and Environmental Design (LEED) green building certification program, developed by the nonprofit U.S. Green Building Council and used worldwide as an objective measure of achievement. A green construction policy in Baltimore could also promote facilities certified as TRUE Zero Waste and encourage others to be certified.

Baltimore already has a green building code and, based on information shared to date, further development of green construction policies will be a key focus of the BZWP. Specific details are expected in that document, and thus not elaborated in this Report.

Estimated Costs and Benefits

Estimated Costs

Potential costs were analyzed for both strategies presented above (i.e., mandated deconstruction and an architectural salvage program). These costs are likely to be borne by the City with programs administered by DPW or the Department of Housing and Community Development (DHCD). However, potential cost assignments between the public and private sectors will be further discussed in the Draft Master Plan in Task 8.

Option 1: Mandated Deconstruction of Existing Structures

The expected costs for this option were developed using the following assumptions:

1. The program would require that 100% of clay bricks and lumber generated during deconstruction of existing structures be repurposed or reused.
2. Enforcement of the program would require hiring of one full time inspector at a cost of $60,000 per year, including fringe benefits (estimated at 40% of salary).
3. Coordination of the program would require hiring of one full time analyst at a cost of $60,000 per year, including fringe benefits (estimated at 40% of salary).
4. Educational and outreach activities would cost a total of $10,000 per year.
5. The City would collect citations from businesses that do not comply with the program. The dollar value of these citations was not quantified but may help to offset some of the expected costs for the program.
6. No CAPEX is expected.

For this option, total OPEX is calculated to be **$130,000 per year**.

Option 2: Architectural Salvage Program

The main cost for coordinating an architectural salvage program would be to set up and maintain a database to match potential buyers with companies offering salvaged building materials. This would likely require one full time analyst at a cost of $60,000 per year (including fringe benefits). If this program is run in coordination with a mandated deconstruction program, it is likely that only one analyst would be required to coordinate the two programs. As such, additional costs associated with this option may be **negligible**.

Estimated Benefits

The primary benefits associated with this option are increased employment (job creation), environmental benefits associated with increased diversion (GHG reductions), and airspace savings associated with reducing the amount of waste disposed at QRL and other C&D landfills outside of the city. Job creation estimates were calculated based on employment estimates (see cost assumptions) while GHG emissions reductions were estimated using the U.S. EPA's tool, WARM. Airspace savings were calculated as the product of the QRL tip fee ($67.50) and the reduction potential for the program. A summary is provided in the table below.

Benefit	Parameter	Value
Jobs	Jobs	2
	Wages	$85,700
GHG Reduction	MTCO2E	-24,998
	Equiv. Vehicles	5,307
	Equiv. Gal. Gasoline	2,813,000
Airspace Savings	Airspace Savings	$1.9 million

Summary of Expected Benefits of C&D Reduction Programs

Challenges and Experience

Challenges to Implementation

Some of the challenges to implementation of this option are listed below:

1. Pushback from local demolition companies: Some companies, especially smaller firms without skilled deconstructionists on staff, may fear a loss of business if deconstruction rather than demolition is mandated for all construction projects.
2. Lack of demand for reused/repurposed C&D debris: If the City implements this program too quickly, the supply of salvaged materials and items may outpace demand. This is particularly true if the architectural salvage program is not well advertised. Demand can be stimulated through enforcing green construction policies that mandate the use of salvaged materials in all building projects in the city.
3. Lack of experience in regulating C&D waste: The City does not have much experience directly regulating C&D waste, which is predominantly handled by the state and affects the private sector currently.

Experience

The City has some relevant experience with respect to implementing the programs proposed in this section. This experience includes:

1. Education/Outreach: The City currently coordinates education and outreach for residential recycling and source reduction. This experience would be translatable to producing education and outreach materials for C&D waste reduction programs.
2. Inspections: The City currently conducts thousands of commercial and residential construction project inspections per year. The existing construction permit inspection program could be expanded relatively easily to include a deconstruction program.

Timeline

It is expected that the City will be able to achieve C&D waste reduction targets relatively quickly (i.e., within 5-10 years) because only two material types are targeted (lumber and clay bricks) and Baltimore already has a fairly robust deconstruction and salvage system in place. However, the expected performance of such a program is difficult to gauge because it is not easy to measure waste that is not generated or directly managed by the City. Comparable programs for C&D waste reuse (e.g., in Portland, OR and Milwaukee, WI) are relatively new, so limited data is available.

5.2 C&D Diversion

Current State of C&D Diversion

In 2017, approximately 608,000 tons of C&D waste were generated in Baltimore. Of this, 325,000 tons were recycled and 283,000 were disposed, for a total C&D recycling rate of 53.5%. C&D waste is handled predominantly by the private sector, so it is often unclear exactly what materials are being recycled and where. However, there are numerous private C&D transfer stations, MRFs, and landfills in and around the city.

Existing C&D Recycling and Disposal Facilities

The Task 3 Report for the LWBB project provides a summary of the existing C&D recycling facilities in Baltimore and the surrounding area. These include:

1. Baltimore Recycling Center, LLC (BRC): Located within city limits, this facility accepted 195,200 tons of mostly C&D waste in 2016.
2. L&J Waste Recycling, LLC (L&J): Located within city limits, this facility accepted 30,100 tons of mostly C&D waste in 2016.
3. Days Cove Rubble Landfill: This C&D landfill is located in Baltimore County and accepted 187,400 tons in 2016.
4. Honeygo Run Reclamation Center: This C&D landfill is located in Baltimore County and accepted 207,800 tons in 2016.

Review of Potential Material Markets

The main components of the C&D waste stream are concrete, asphalt concrete, asphalt shingles, clay bricks, lumber, scrap metal, drywall (sheetrock), and soil. A brief description of the size of the waste stream and recycling markets for each of these materials is included below. Calculation details are provided in Appendix 1.

Concrete and Asphalt Concrete

Approximately 228,300 tons (53%) of asphalt concrete (i.e., paving) and concrete were recycled in 2017. Crushed concrete and asphalt concrete may be recycled in several ways:

1. Incorporating it as coarse aggregate into fresh concrete for use in recycled asphalt pavement (RAP) or sale to contractors or the general public for construction jobs (all local roads in Maryland are required to be constructed with the maximum practical amount of RAP);
2. Substituting it for limestone aggregate as a foundation material for roadway pavement;
3. Using it for stabilizing soil for subbase pavement layers;
4. Placing it under pipes as a bedding material; and

5. Incorporating it into landscape materials (e.g., in paver stones, as a base material for pavements, or to replace rip rap in gabion retaining walls).

Shingles

About 8,300 tons (54%) of asphalt shingles were recycled in 2017. Asphalt shingles may be recycled by:

1. Processing them into dry granular pieces that can then be used to manufacture hot mix asphalt;
2. Grinding them up and applying them for dust control on rural roads; and
3. Processing them to make recycled-shingle cold patch for filling potholes on paved roads.

Clay Bricks

7,300 tons of clay bricks are recycled annually in Baltimore. Clay bricks may be recycled by:

1. Grinding them into gravel-size pieces for use as ground cover or a substitute for mulch;
2. Crushing them into powder for use on baseball diamonds, running tracks, or tennis courts;
3. Incorporating them into backyard landscaping; and
4. Using them to produce new bricks.

Wood

About 23,400 tons (54%) of wood waste was recycled in 2017. Recovered C&D wood can be recycled in the following ways:

1. Grinding it to produce woodchips for landscaping and other applications; and
2. Converting it into biochar, which has uses in agriculture, environmental remediation, and as a non-soil carbon product for animal feed or building products.

Scrap Metal

It is estimated that 60,400 tons (effectively 100%) of scrap metal were recycled in 2017. Ferrous and non-ferrous metals may be sold directly into the recycling market after they are separated from other materials.

Drywall

About 8,300 tons (51%) of drywall were recycled in 2017. Drywall may be recycled in the following ways:

1. Clean drywall scraps (from construction) may be recovered and used to make more drywall; and
2. Gypsum from old drywall (from demolition) may be used as a soil amendment to improve soil drainage and plant growth.

Soil and Other C&D Fines

About 190,000 tons of soil were diverted for beneficial use as daily cover at QRL in 2017. A further 77,400 tons of soil from the commercial sector were recycled, which means almost all of the soil waste generated was recycled. Soil and other C&D fines may be recycled in the following ways:

1. Application as daily cover at landfill sites;
2. Fill material on construction projects; and
3. Agricultural amendment.

Diversion Targets

The BSP calls upon the City to revise codes and/or create ordinances to eliminate waste and maximize reuse of deconstructed building materials. However, it does not include specific targets for reuse or diversion of C&D waste (only a 90% overall diversion goal is stipulated). As such, for this analysis, two different "Construction and Demolition" (CD) diversion scenarios were considered:

1. Scenario CD1: 90% diversion of C&D waste with no previous source reduction.
2. Scenario CD2: 90% diversion of C&D waste with source reduction as described in Section 5.1.

Relevant Waste Streams

The commercial C&D waste stream currently going for disposal has the baseline characteristics shown in the table opposite (top) for Scenarios CD1 and CD2.

Diversion Potential

The 90% diversion potential for each C&D waste material category under Scenarios CD1 and CD2 is shown in the table opposite (bottom). Scrap metal and soil were not considered for this analysis because the current recycling rate for these materials is nearly 100%, indicating that there is negligible scope to improve current recycling practices. Clay bricks and lumber are eliminated from diversion under Scenario CD2 as they are expected to be reused. Clay bricks were also not included in Scenario CD1 because the market for clay brick recycling is very limited.

Commercial C&D Materials	Waste Stream for Processing (tons)	Potential Reuse (tons)	Waste Stream For Processing (tons)
	Scenario CD1	Scenario CD2	
Concrete	199,300		199,300
Asphalt Concrete	40,200		40,200
Asphalt Shingles	7,150		7,150
Clay Bricks	6,350	6,350	0
Lumber	22,000	22,000	0
Scrap Metal	0		0
Drywall	8,050		8,050
Soil	150		150
TOTAL	283,200	28,350	254,850

Baseline C&D Waste Streams under Different Scenarios

Scenario	Target	Material Type	Tons Diverted
CD1	90% Diversion with no Previous Source Reduction	Concrete	156,550
		Asphalt Concrete	31,550
		Asphalt Shingles	5,600
		Lumber	16,750
		Drywall	6,400
		TOTAL	**216,850**
CD2	90% Diversion Following Source Reduction Measures	Concrete	156,550
		Asphalt Concrete	31,550
		Asphalt Shingles	5,600
		Lumber	--
		Drywall	6,400
		TOTAL	**200,100**

Summary of Diversion Potential for C&D Waste

Options and Strategies

Multiple policy options and strategies exist to improve C&D debris diversion in Baltimore. These include implementing mandated diversion targets for C&D waste, implementing mandated deconstruction of existing structures, implementing an architectural salvage program, requiring deposits as part of permitting, and requiring green construction certification. Several of these policies/programs have overlap with C&D reuse as previously discussed in Section 5.1, which also refers here. In all cases, developing new/additional C&D processing capacity would be needed to handle the additional 200,000 tons or more of potentially diverted materials. This would most likely entail developing a new large-scale C&D materials recovery facility (MRF) in the local area. Implementing a combination of the following options would be optimal for the City's overall strategy to improve C&D waste diversion.

Potential Policies Options

Potential policies and incentives for increasing C&D waste diversion are described below.

Mandatory Diversion Ordinance

One policy option available to the City is to pass an ordinance requiring construction and demolition projects to divert a certain percentage of their waste from disposal. Such a policy would require significant enforcement to ensure compliance. Citations could be used to discourage companies from ignoring the ordinance.

According to information shared to date, developing a C&D waste diversion ordinance in Baltimore is a key focus of the BZWP. As such, this option is not elaborated further in this Report.

Deposits as Part of Permitting

The City could require deposits as part of the permitting process for new construction and demolition projects. These deposits would be returned when contractors provide documentation showing that the project has met a designated diversion threshold. Again, it is understood this policy option is a key focus of the BZWP and so is not elaborated further.

Expand C&D Recycling Capacity

There are three main options available to the City to increase C&D processing capacity:

1. Construct and operate a MRF: This would allow the City to implement full control over all aspects of C&D recycling. However, it would also force the City to bear all the responsibility for any operational issues.
2. Construct a MRF in coordination with a private company under a PPP: With this option, the City would own the facility while the private company would operate it.
3. Allow private companies to expand existing facilities and/or develop a new MRF: Baltimore is already home to at least two large operational C&D MRFs (BRC and L&J). If increased C&D recycling is mandated, it is likely that private companies could expand capacity without any help or direction from the City.

A review of potential contracting mechanisms for different private or public sector capacity development options was provided with regard to a MRF for traditional recyclables in Section 4.4. The same considerations and expected challenges and benefits apply equally for a C&D MRF. It is

noted that the MRF could be co-located with other diversion and reuse facilities as part of a resource recovery park (see Section 7.2).

Assuming that sufficient policies and programs can be implemented to push more C&D waste from disposal to diversion, the remainder of Section 5.2 outlines the expected costs, benefits, challenges, and timeline for developing a C&D MRF.

Estimated Costs

In this analysis, the costs associated with constructing a large centralized C&D MRF are presented. It is assumed the costs associated with MRF construction and operation would most likely be borne by the private sector while costs associated with administration and enforcement of C&D recycling policies would be borne by the City. Potential cost assignments between the public and private sectors will be further discussed in the Draft Master Plan (Task 8).

Materials Recovery Facility Costs

The general assumptions used to calculate CAPEX and OPEX for a C&D MRF under Scenarios CD1 and CD2 are included below:

1. The MRF size is expected to be a function of the total disposed mass of material and the required diversion rate. For both Scenario CD1 and CD2, the MRF is anticipated to process 100% of the current C&D waste disposal stream (after accounting for reuse in Scenario CD2). This equates to a required throughput capacity of 283,200 tons per year for Scenario CD1 and 254,850 tons per year for Scenario CD2. The MRF is intended to process C&D waste with 90% diversion of targeted materials as discussed previously.
2. The MRF will operate eight hours a day, five days a week, 52 weeks a year.
3. Land requirements are estimated based on the size of the recently constructed Sun 14 Recycling Facility in Davie, FL, which processes 125 tons of C&D material per hour (260,000 tons per year) on a 15-acre parcel of land. Based on this, a nominal 15-acre lot would be needed for both Scenarios CD1 and CD2.
4. Lot prices in Baltimore were assumed to be on the order of $100,000 per acre.
5. Site development and equipment costs were estimated on a unit price basis from the Sun 14 facility, which cost $14 million to construct operates at a unit cost of about $55/ton on an annualized basis. An additional lump sum cost of $5 million in access/transportation improvements is assumed for both scenarios.
6. A total labor requirement of 30 people was assumed under both scenarios based on the workforce at the Sun 14 facility, with an average annual cost of $50,000 per employee (including fringe benefits).
7. A unit operation and maintenance (O&M) cost of $50 per ton was assumed (based on a 2017 study for Frederick County, MD).
8. Any waste that is not recycled in the MRF is anticipated to be landfilled following processing. A landfill disposal cost of $67.50 per ton was assumed based on the current tip fee at QRL.

CAPEX

Using the above assumptions, the expected CAPEX under Scenarios CD1 and CD2 are summarized in the table overleaf.

Item	Scenario CD1	Scenario CD2
Land Acquisition	$1.5 million	$1.5 million
Site Development and Equipment	$15.6 million	$14.0 million
Access and Transportation	$5.0 million	$5.0 million
TOTAL	**$22.1 million**	**$20.5 million**

Estimated CAPEX for C&D MRF Development

OPEX

Using the previous assumptions, the expected annual OPEX under Scenarios CD1 and CD2 are given in the table below.

Item	Scenario CD1	Scenario CD2
Wages	$1.5 million	$1.5 million
O&M	$14.2 million	$12.7 million
Disposal Cost	$4.5 million	$3.7 million
TOTAL	**$20.2 million**	**$17.9 million**

Estimated Annual OPEX for C&D MRF

Program Administration Costs

It is assumed that the City would require all construction and demolition projects in Baltimore to meet diversion targets. As such, the major cost to the City would be enforcement of this policy. For this analysis, it is assumed that enforcement would require two full time inspectors and one analyst for a total of three full time employees. Assuming that each employee costs $60,000 per year (including fringe benefits), the anticipated administrative costs for Scenarios CD1 and CD2 are **$180,000 per year**.

Estimated Benefits

Expected benefits from diversion of C&D waste include direct revenues from the MRF tip fee and sale of recyclable material, job creation associated with the C&D MRF operation and diversion policy enforcement, and environmental benefits associated with reduced GHG emissions.

Expected Revenue

Revenues from the C&D MRF would be collected by the facility operator, likely the private sector. Revenues from the C&D MRF include the tip fee as well as the sale of recyclables. The assumed tip fee for the MRF is $75/ton based on the current gate fee at BRC, while bulk C&D recyclables recovered at the MRF are assumed to sell for approximately $15/ton (i.e., half of the $30/ton estimated in a 2017 study for Frederick County MD, which accounts for the absence of scrap metal in the input C&D waste stream in Baltimore). Under these assumptions, the direct revenue expected at a C&D MRF under Scenarios CD1 and CD2 are summarized in the table below.

Item	Scenario CD1	Scenario CD2
Tip Fee	$21.2 million	$19.1 million
Sale of Recyclables	$3.3 million	$3 million
TOTAL	**$24.5 million**	**$22.1 million**

Estimated Annual Revenue for C&D MRF

Expected Job Creation

Expected job creation at the C&D MRF is estimated using the following assumptions:

1. Personnel requirements at the C&D MRF assume 30 people total under both scenarios; and
2. Average annual salaries are assumed at $36,000 per employee (excluding fringe benefits).

Under these assumptions, the estimated change in labor hours and wages is estimated for each scenario in the table below.

Scenario	Change in Labor Hours	Change in Jobs	Change in Wages
CD1	62,400	30	$1.1 million
CD2	62,400	30	$1.1 million

Estimated Job Creation Potential for C&D MRF

In addition to the 30 jobs expected to be created at the MRF, it is estimated that the City would employ three people under both scenarios to coordinate and enforce participation in the program.

Environmental Benefits

The environmental benefits associated with C&D waste diversion were estimated using the U.S. EPA's WARM software. As maximum diverted tonnages are not dissimilar, the environmental benefits for Scenarios CD1 and CD2 are essentially equal. **If the maximum C&D diversion potential described in this section is achieved, GHG emissions could be reduced by about 32,700 MTCO2E annually.** This is roughly equivalent to taking 6,950 passenger cars off the road or consuming 3.7 million fewer gallons of gasoline annually.

Airspace Savings

Increased C&D diversion would reduce the amount of waste going to QRL and C&D landfills outside the city. Landfills charge a tip fee to cover the costs associated with consuming airspace (or permitted disposal capacity). The value of this airspace can thus be calculated as the product of the tip fee and the diverted tonnage. This value does not represent a direct revenue, but rather represents a cost savings to any entity that diverts C&D waste from disposal. Using the tip fee at QRL ($67.50) and the diversion potential for this option (216,800 tons for Scenario CD1, 200,100 tons for Scenario CD2), **airspace savings of $14.6 million or $13.5 million were calculated for Scenarios CD1 or CD2, respectively**.

Challenges to Implementation

Challenges to implementation of a C&D waste diversion strategy include:

1. Promoting participation in the program: Depending on the selected policy option, it may be difficult to encourage participation in the C&D diversion program.
2. Enforcing participation in the program: It would be hard to meet diversion goals if the program is voluntary only. If the C&D diversion program is mandatory, however, it may be difficult or expensive to enforce participation at every construction and demolition project in the city.
3. Locating a C&D MRF in Baltimore: It is estimated that the C&D MRF would require about 15 acres of land. However, large, inexpensive lots in locations with convenient transportation links are hard to come by.

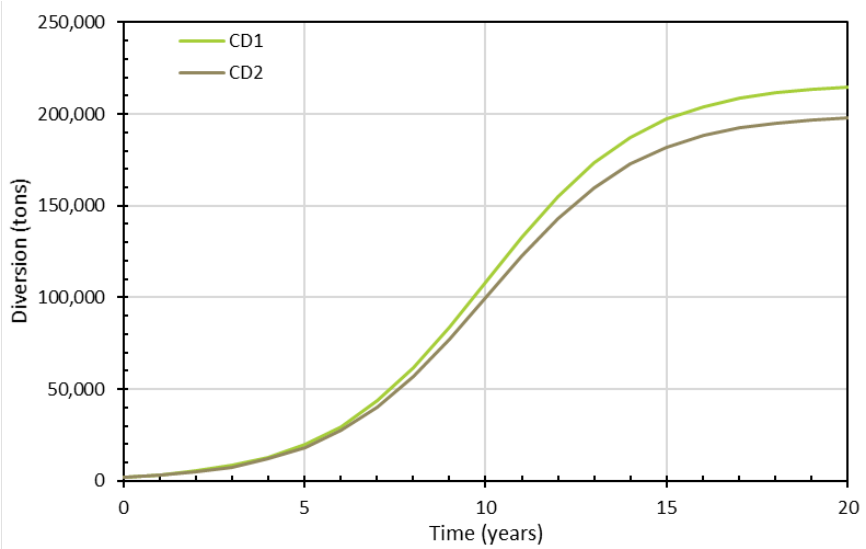
4. MRF operations: If the City decides to construct and operate the C&D MRF (rather than allowing the private sector to do it), the City does not have any experience operating a MRF.

Experience

While the City does not have much experience operating or managing a C&D MRF, it does have experience running education and enforcement programs, including education campaigns for the City's recycling program and a ban on use of expanded polystyrene. The City currently conducts thousands of construction permit inspections as well as home/yard inspections as part of the rat abatement program. This experience could be useful for conducting inspections of C&D diversion and recycling at demolition and construction projects.

Timeline

Implementation of a C&D diversion program could take several years to complete (the estimated timeframe is approximately 20 years to reach full diversion potential) and would likely be enforced in phases. Initial phases may involve slowly increasing the C&D waste diversion target (e.g., begin the program mandating 50% diversion from construction and demolition sites and then work up to 90%) or imposing size-based criteria for compliance with the program (e.g., begin by imposing diversion targets on projects valued at $1,000,000 or more and then gradually expand the program to include smaller projects). The expected C&D diversion for Baltimore is shown in the figure opposite. In accordance with general assumptions on phasing, this assumes that C&D diversion will follow an S-curve.



Estimated C&D Waste Diversion with Time

Expected Performance

Expected performance of a C&D waste diversion program can be gauged using data from four C&D MRFs operated by Waste Management, Inc. in southern Florida (Palm Beach and Broward Counties). As of 2017, these four C&D MRFs achieved a combined average recycling rate of 71% for material accepted at the facility. The maximum recycling rate achieved was 93% at the Sun 3 facility in Fort Lauderdale. Based on this, it seems that a diversion rate of 90% is achievable.

6. NON-TRADITIONAL RECYCLABLES

Chapter 6 essentially covers all classes of recyclable and potentially recyclable materials that do not comprise traditional recycling streams and thus are not covered in previous chapters. The non-traditional recyclables (NTR) stream is highly diverse, comprising bulk trash (e.g., furniture, homewares, appliances, electronics, etc.) as well as mattresses, carpet, textiles, porcelain/ceramics, batteries, and other materials that are currently not recycled widely. Based on a breakdown of the waste disposal stream in Baltimore (see Section 2.3), the NTR stream comprises a very small component of the total, contributing only about 5,600 tons (<1%) of the nearly 825,000 tons of waste disposed of annually in Baltimore. By far the largest NTR component is bulk waste at over 5,000 tons/year. For this reason, Chapter 6 focuses mainly on bulk trash reduction, reuse, and recycling measures.

DPW already provides recycling of other materials that are often classified as NTR. For example, DPW currently sends all the scrap metal (including appliances) and scrap tires recovered at QRL, NWTS, and the residents' drop-off centers to Auston Contracting, Inc., a recycling facility located in Joppa, MD (landfill disposal of tires is not permitted in Maryland). In 2017, DPW sent approximately 100 tons of scrap tires and 400 tons of appliances and scrap metal to this facility. DPW also separates out electronics and electrical equipment and sends these items to local recyclers. In 2017, DPW recycled about 86 tons of these items.

The data show that implementing NTR diversion programs would have a negligible impact on waste diversion tonnages or achievement of the BSP 90% overall waste diversion goal. Nevertheless, NTR recovery programs driven by small businesses and community organizations are key opportunities identified in Baltimore's Waste-to-Wealth Initiative. In addition, while NTR represents a small proportion of the total waste stream by mass, many items (notably bulk trash and mattresses) are difficult to handle and occupy a lot of space in waste trucks and landfills. Bulk trash is also highly visible in the community and comprises items found in illegal dumping incidents, so offering alternatives that the community are invested in may help reduce illegal dumping. Improving recycling and reuse of bulk trash is also important in changing the public's mindset toward waste diversion and reduction generally. In support of this rationale, in the LWBB survey provided to stakeholders, 62% of respondents favored adding additional opportunities for curbside bulk trash collection; 78% favored adding additional opportunities to donate or recycle mattresses, box springs, housewares, and furniture; and 48% favored adding additional opportunities to buy secondhand items. For these reasons, improving collection, recycling, and reuse of bulk trash and other NTR items is an important component of the LWBB master planning effort.

Note that the NTR recycling programs described in this chapter could be developed as standalone initiatives, or could be provided as part of upgrades to residents' drop-off centers (see Section 7.1) or development of a large integrated resource recovery park or eco-park (see Section 7.2). Costs and practicality constraints would be broadly similar in either case.

6.1 Bulk Trash Collection and Diversion

Bulk trash generally consists of broken/unwanted furniture, homewares, electronics, and appliances (white goods). By their nature, these items tend to have a lot of air pockets and thus are often difficult to handle and occupy a lot of space in collection containers and waste trucks. Handling

and storage difficulties are thus important considerations in devising bulk trash collection and diversion programs.

Current State of Bulk Trash Collection and Recycling

Currently, bulk trash collection is coordinated via DPW's quadrant system in the city and occurs once per month at all serviced residential locations. To arrange for bulk trash collection, residents must make a 311 service request two to three months prior to their desired collection date. Materials accepted for bulk collection include furniture, appliances, and tires (without rims). Alternatively, residents may choose to leave their bulk trash at one of DPW's five residents' drop-off centers.

In 2017, only 24 tons (0.5%) of bulk trash were recycled while approximately 5,050 tons were disposed of (an estimated 2,750 tons were landfilled at QRL and 2,300 tons were incinerated at BRESCO). Appliances accounted for the majority of all recycled bulk trash. Note that these reported tonnages do not include bulk trash contained in illegal dumping incidents.

Reduction/Diversion Potential

It is assumed that the City will be able to achieve a source reduction rate of 50% by encouraging reuse and donations and a recycling rate of 60% for bulk trash (based on San Francisco, CA, which achieved a bulk trash recycling rate of 63% in FY2015). **This equates to about 2,550 tons of material available for reduction and 1,500 tons available for diversion.**

Options and Strategies

The City has a variety of potential policy options and strategies to encourage diversion and reuse of bulk waste. These include:

1. Option 1: Investing in programs that turn waste into art. The City could donate abandoned buildings and bulk waste material to artists, sculptors, and recycling innovators to organize shows and contests that encourage the reuse of bulk waste materials.
2. Option 2: Fix-It/Repair Clinics. The City could help to fund clinics where residents can learn how to repair broken electronics, homewares, appliances, bikes, etc. rather than throwing them away. Fix-It Clinics are currently used as a way to reduce bulk trash in many cities across the country, including Austin, TX, Flagstaff, AZ, Minneapolis, MN, and San Diego, CA. The Baltimore Tool Library also holds fix it fairs a few times a year. These clinics are usually staffed by volunteers with skills to share, gained either professionally or through hobbies, and so are free of charge for attendees, although donations may be encouraged. Fix-It Clinics may be hosted by the City, local nonprofits, local businesses, or some combination of private and public entities. In Baltimore, clinics could be offered in coordination with, or in a similar manner to GROW centers, which offer tips and materials for greening and landscaping.
3. Option 3: Collecting bulk waste for donation (curbside and at residents' drop-off locations). DPW currently recycles or disposes of bulk trash collected at residents' drop-off locations and via curbside collection. Working with local charitable and reuse organizations (e.g. the Salvation Army, Goodwill, Habitat

for Humanity ReStores) to offer donation of bulk items might encourage more participation in the program.

4. Option 4: Charging residents for bulk waste collection. This would encourage reuse, repurposing, and resale of bulk items, although it could lead to increases in illegal dumping. As an example, Seattle, WA currently charges residents $30 per item collected and $38 for items with refrigerants.
5. Option 5: Reducing the amount of bulk trash that can be collected via curbside collection. The City already limits the amount of bulk waste per household to three items per household per month. However, this could be reduced to encourage residents to pursue other options (such as donation). Currently, many other cities (e.g. Washington DC and San Francisco, CA) have limits on the amount of bulk waste collected per household in order to reduce disposal of bulk waste.
6. Option 6: Constructing a large, accessible recycling center where residents can drop off their bulk waste for reuse or diversion. This facility would not need to be open every day, but its opening hours would need to be clearly communicated to residents to encourage recycling. This facility could be part of an expanded network of Residents' drop-off facilities (See Section 7.1). A good example is the "ReUse Store" operated by Austin, TX.

Estimated Costs and Benefits

Estimated Costs

The City spent over $1 million on bulk trash collection in 2018 (note that this does not include spending on illegal dumping). This value is expected to change depending on the policy options implemented by the City. A summary of expected changes in bulk trash management costs is shown below (all costs are assumed to be borne by the public sector):

1. Education and Outreach for all Options: If the City were to run an education campaign to help improve reuse, donation, and recycling of bulk waste, it would likely cost $10,000 to $50,000 per year depending on the scale of the education program.
2. Option 1: Investing in a waste-to-art program would result in minimal expenditure on the part of the City. Such a program would likely cost less than $50,000 per year.
3. Option 2: The City could partner with existing organizations or operate their own fix-it/repair clinics. Clinics could be organized similar to the Baltimore GROW centers as pop-up centers hosted in City-owned spaces and public schools. It is anticipated that the City would spend less than $20,000 per year on each clinic offered, including rent and information campaigns.
4. Option 3: If the City can partner with entities that accept donations of bulk items (e.g. the Salvation Army, Goodwill, Habitat ReStores, Vietnam Veterans of America, etc.), this policy is not likely to cost very much to implement.
5. Option 4: If the City implements charges for bulk waste pickup, it would need to hire at least one analyst and potentially a team of inspectors to enforce the charges. However, this cost could be offset by income from charges. As such, cost changes are assumed to be neutral. As an indirect cost, however, this program could increase illegal dumping in the city.
6. Option 5: Reducing collection frequency would result in operational cost savings for DPW. Cost savings are likely to be

proportional to the reduction in collection frequency. As an indirect cost, however, this program may increase illegal dumping.

7. Option 6: Constructing a new recycling center for bulk waste is likely to be expensive. However, expanding existing facilities (e.g. residents' drop-off facilities) to handle bulk waste for donation or diversion may be a more affordable option. A detailed cost breakdown for this option is included in Section 7.1.

One mechanism to help pay for more bulk trash pickup or to expand services for bulk trash diversion is to charge a "Clean City Fee" to local businesses. Glendale, AZ and Austin, TX have enacted such fee programs.

Estimated Benefits

The policy options described above are likely to increase employment at local charitable and reuse facilities. However, changes in employment are not quantified here as many reuse facilities rely on volunteer labor.

In addition to employment benefits, reusing and recycling bulk waste would result in environmental benefits. Using the U.S. EPA's WARM software, and modeling bulk waste as 50% mixed plastic and 50% mixed metal, it was estimated that **GHG emissions would be reduced by 11,394 MTCO2E annually** if the full diversion potential is met (i.e. 2,550 tons reduced and 1,500 tons diverted). This is equivalent to removing 2,400 passenger vehicles from the roads or saving 1.3 million gallons of gasoline annually.

Finally, reusing and recycling bulk material would result in meaningful landfill airspace savings. Annual airspace savings were calculated to be **$276,750** as the product of the QRL tip fee ($67.50) and the maximum reduction/diversion potential for the program.

Challenges and Experience

Challenges to Implementation

There are multiple potential challenges that the City would face in attempting to expand source reduction and diversion of bulk trash. These include:

1. Identifying and sourcing recycling facilities or expanding existing resident drop-off facilities (due to space constraints) to include bulk waste may be difficult.
2. Some residents may be resistant to donating or reusing bulk trash, which would require extensive education and outreach campaigns to change behavior.
3. Some residents lack vehicles (or large enough vehicles) to transport bulky items.
4. Placing a value limit on bulk trash disposal would be difficult and would require hiring and training of multiple inspectors.
5. An increase in bulk trash disposal fees or a reduction in the frequency of bulk trash collection may result in an increase in illegal dumping.

Experience

The City has extensive experience applicable to bulk trash collection, reduction, and diversion. This includes experience running education campaigns for source reduction and diversion of SSR and reducing littering, performing bulk waste collection services, and policies limiting the amount of bulk waste to three items

per household per month. In addition, DPW currently performs residential inspections as part of the rat abatement program. This experience could be used to hire and train inspectors for a bulk trash program.

Timeline

Most options outlined in this section have few timing constraints and could be implemented at the City's discretion within the next 5-10 years.

6.2 Targeted Recycling Programs

The programs outlined in this section target individual components of the waste stream that are not widely recycled under the current system. These NTR materials fall outside the definition of bulk trash in this Report. Although each material class offers negligible tonnage in terms of its contribution to meeting overall diversion goals, they tend to be highly visible in the community. Improving recycling and reuse of these materials is thus important in changing the public's mindset toward waste diversion and reduction.

Targeted recycling of NTR materials forms an integral part of zero waste programs or the circular economy, which defines recyclables as commodities and recycling as processing rather than waste management. Successful implementation of NTR recycling programs requires public policy and enforcement; government, community, and corporate commitment; financial incentives/stimulation; and changes in consumer behavior. Establishing extended producer responsibility (EPR) or product take-back programs are also important methods for reducing NTR waste generation. As such, while this section deals mainly with programmatic developments, strategies for encouraging waste reduction and recycling discussed in Chapter 8 also refer.

For all NTR categories listed in this section, Geosyntec's general opinion is that the City should advocate to the state legislature to develop EPR programs that would provide funding for take-back and recycling of products by manufacturers. In the short term, the City should investigate the feasibility of developing targeted recycling programs, potentially through a nonprofit or community organization or by working with existing vendors, who are identified along with national support organizations in each subsection below (where available). Collection and diversion of large items such as mattresses, carpets and electronics could also be addressed as part of bulk waste recycling as discussed previously in Section 6.1.

For all NTR materials discussed in this section, it is also noted that residents can already access information about local recycling options at MDrecycles.org, which provides a list of recyclers/reuse organizations in the state (including those that pick up items).

Mattresses and Box Springs

Currently, little to no recycling of mattresses or box springs occurs in Baltimore. These items are generally collected as bulk trash or taken to drop-off centers from where they are disposed of as trash at QRL or BRESCO. While mattress recycling is not currently mandated, it is noted that the 2019 Maryland legislative session introduced but did not pass a bill (HB0502) that would have required mattresses and box springs to be diverted from waste disposal/incineration streams. The now-repealed 2014 Zero Waste Maryland Plan also included an initiative to establish EPR programs for mattresses to help fund their diversion. As such, it is

reasonable to assume that recycling mandates for mattresses and box springs may be passed relatively soon.

Organizations Involved

Nationally, the Mattress Recycling Council, a nonprofit organization formed by the mattress industry, supports statewide mattress recycling efforts in states that have enacted mattress/box spring recycling laws (currently, California, Connecticut, and Rhode Island). These three states levy consumer fees of between $9 and $16 on new mattress purchases to fund their recycling programs and offer residents a small monetary incentive of between $1 and $3 to bring a mattress to a recycling drop-off center.

Massachusetts offers grants to municipalities for mattress recycling and has three organizations involved in recycling on a state contract. Vendors may be selected to either accept mattresses on a per-unit basis or provide collection container rental and hauling. Grants are available in the order of $10 per mattress for recycling delivered to the vendor facility. Additional charges may be incurred by the jurisdiction for the rental of a container for storage and transportation to the facility.

Currently, three local firms (Turbo Haul in Annapolis Junction and American Mattress and NOVA Services in Baltimore) collect and recycle mattresses.

Summary of Expected Benefits and Challenges

According to MRC, more than 50,000 mattresses end up in U.S. landfills each day, even though more than 80% of a used mattress's components can be recycled. Benefits of recycling mattresses and box springs are to keep these difficult to manage, bulky materials from consuming landfill airspace and reduce GHG emissions through recycling metal springs, conversion of polyurethane foam into carpet padding, recycling cotton/wool and other textile present, and shredding wood frames for reuse in particleboard manufacture or as biomass. There is potential for job creation through hauling and recycling mattresses.

Challenges are that mattresses and box springs are not easy to disassemble into recyclable components and there are potential health risks from exposure (i.e. bed bugs). Experienced hands-on labor is required. There are currently very few local processors of mattresses. Providing mattress and box spring recycling at DPW facilities would require a dedicated storage space to keep them dry and clean.

Carpets and Rugs

Used carpet and rugs are currently considered bulk trash in Baltimore. Similar to mattresses, the now-repealed 2014 Zero Waste Maryland Plan included an initiative to establish EPR programs to help fund diversion of carpets.

Organizations Involved

A national nonprofit Carpet America Recovery Effort (CARE) was created to advance market-based solutions that increase landfill diversion and recycling of post-consumer carpet. CARE administers the California Carpet Stewardship Program, for example, which generates funding through a fee of 33 cents levied per square yard of carpet sold. The program seeks ways to support development of end markets for recycled carpet products, underwrite collection and transfer of carpet to/from drop-off sites, and for promotion and education.

While no local vendors for recycling carpets could be identified, carpets and rugs in good condition can be donated to a number of outlets in

Baltimore, including Habitat for Humanity, the Loading Dock, and Second Chance.

Summary of Expected Benefits and Challenges

Carpets have been identified as priority items for diversion from disposal by the Product Stewardship Institute (PSI) as they are a bulky and difficult to manage material. Avoided disposal would decrease GHG emissions and preserve landfill airspace. There is potential for job creation through hauling and recycling carpets. However, it may be challenging to find industry partners that accept waste carpet and guarantee recycling. Providing carpet recycling at DPW facilities would require a dedicated storage space to keep them dry and clean.

Textiles

The U.S. EPA estimates that over 16 million tons of clothing and textile waste were generated in 2015, with only 15% recycled. Based on the estimated national population in 2015, this equates to per-capita clothing and textile waste generation of approximately 100 pounds annually.

Organizations Involved

Baltimore like many municipalities generally relies on nonprofit organizations such as Goodwill Stores to collect and resell used clothing in good condition. Other nonprofits such as Planet Aid and St. Vincent de Paul offer drop-off bins in parking lots. Mid-Atlantic Clothing Recycling, a professional clothing recycling company, also provides bins in Maryland.

Simple Recycling is a for-profit recycler that partners with municipalities to provide collection of textiles at events and through curbside programs. The materials are graded and sorted based on quality and condition, with the top quality materials resold to local thrift outlets, mid-grade materials exported to international markets, and "unusable" residuals processed for raw material (e.g., as ceiling insulation fabric). Austin, TX has entered into a contract in which Simple Recycling provides curbside collection of textiles for all curbside customers who receive municipal trash and recycling services, and pays the city $20 per ton of material collected.

Threadcycle is a public education campaign established in King County, WA to encourage residents to donate all used clothing, shoes, and linens for reuse and recycling. About 20% of items are donated for resale at nonprofit stores with the remainder sold to secondhand clothing brokers and recyclers.

Summary of Expected Benefits and Challenges

As described above, there are several ways to divert clothing and textiles from disposal that do not require active participation or direct management of programs by the City. Curbside collection programs offer benefits above drop-off donation bins in terms of minimizing the amount of time that materials are left out. Although donation bins are easy ways to offer textile recycling to residents, unmanned and overflowing donation bins can become a dumping ground for unwanted household goods. Recovery of secondhand clothes for resale avoids new consumption, while avoided disposal of unwearable clothes would decrease GHG emissions and preserve landfill airspace. There is potential for job creation through collection, sorting, and shipping of recovered textiles.

Porcelain and Ceramics

Porcelain and ceramic items such as toilets, urinals, bathtubs, sinks, bidets, tiles, and countertops can be reused or recycled. Porcelain and

ceramics are formed from fired clay soils; these items are thus typically recycled by crushing, after which the dry granules can be added as a feedstock or dry aggregate in asphalt or concrete. Metal and plastic components can be separated and recycled.

Organizations Involved

It is not known whether local C&D waste recycling facilities such as BRC and L&J recycle ceramics and porcelain. No dedicated local vendors could be identified. However, similar to other bulky items, items in good condition can be donated to a number of outlets in Baltimore, including Habitat for Humanity, the Loading Dock, and Second Chance.

Summary of Expected Benefits and Challenges

A ceramic recycling program for bathroom fixtures could be combined with programs that promote water conservation, such as rebates for low-flush toilets where residents are provided with a rebate for recycling and replacing less efficient models. These fixtures could be collected along with bulky or scrap metal items and stored at a residents' drop-off center until there are sufficient quantities to haul to a processor. However, storage could be an issue as they are bulky and heavy.

Batteries

Maryland enacted a law in 1993 requiring mercuric oxide battery manufacturers be responsible for the collection, transportation, and recycling or disposal of these batteries sold or offered for promotional purposes in the state.

It is estimated that more than 90% of the lead-acid batteries sold in Maryland are recycled and reused for new batteries. Both the plastic cases and the electrolyte are also reclaimed and reprocessed for use in new batteries. DPW accepts lead-acid batteries at no charge at its residents' drop-off centers.

Similar to the mercuric oxide battery EPR law, the most effective way to divert lithium ion and other batteries from the waste disposal stream is for the state to enact an EPR law. This would typically include levying a refundable fee on new battery sales to provide a monetary incentive to return the battery (or the battery it is replacing) for recycling. While the City should advocate for an EPR law as the optimal approach for minimizing battery waste, other options are available. A well-known nationwide service is the battery recycling program Call2Recycle.

6.3 Hard-to-Recycle Materials

The approaches outlined for recovering and recycling traditional SSR materials in Chapter 4 or the bulky materials comprising NTR waste streams in Section 6.1 cannot realistically be extended to recovering the complex stream of plastic films, chip packets, candy wrappers, synthetic fibers, and low grade plastics/mixed plastic packaging in SSR or NTR waste streams. NTR materials typically comprise residues (contamination) in curbside SSR loads, which are separated out at MRFs and sent for disposal, or else directly enter the trash stream at source. To date, the most difficult aspect of recycling these materials has been finding a processor and/or end user. This has been solved to an increasing extent by the emergence of commercial-scale chemical recycling, which is discussed herein as the primary means of diverting hard-to-recycle materials. It is noted that chemical recycling could also help divert myriad other waste items such as cigarette butts that currently comprise the "unclassified" category assumed to be unrecyclable in Section 2.3. Despite the emerging technologies discussed below, some of which can process "unrecyclable" materials, for the

purposes of this Report it is assumed that meaningful diversion of materials from the over 130,000 tons/year of the unclassified disposal waste stream remains impractical.

A brief discussion of chemical recycling is given below. Given the nature of the materials sought by chemical recyclers – primarily mixed plastics with some mixed fibers, both of which comprise part of the "traditional" curbside recycling stream – these technologies could have been discussed in Chapter 4. However, given the overlap with some non-traditional curbside recyclables (e.g., carpets, mattress fluff) and the fundamental changes to existing curbside recycling contracts that would be needed for the City to access the chemical recycling market, it was considered these technologies are better discussed as part of this discussion on expanding recycling services to NTR waste streams.

Chemical Recycling

Chemical recycling refers to processes that break down waste materials into their chemical constituents and convert them into useful products such as basic chemicals and/or polymers for new plastics or fuels. According to a recent state-of-the-practice report by Closed Loop Partners, chemical recycling comprises three primary technologies: purification, decomposition, or conversion (or some combination thereof). This class of technologies could help meet the fast-growing demand for recycled plastics. Companies such as Unilever, Procter and Gamble, PepsiCo, L'Oréal, and Danone are among those that have set ambitious goals to ensure all plastic packaging is reusable, recyclable or compostable. However, demand for recycled plastics is rapidly outpacing supply – in the U.S., the current supply of post-consumer recycled plastics can meet only 6% of demand. This suggests a robust market exists if feedstock materials can be cost effectively collected, sorted, and shipped to chemical recyclers. The City has an opportunity here in that DPW already manages a waste stream containing materials that are not currently widely recyclable (and thus incur disposal costs) but for which there may be high future demand at robust prices.

Many chemical recycling options exist for processing hard-to-recycle materials, although a disproportionate number are unproven start-ups with unknown funding reserves and backing and that lack long-term experience beyond pilot scale applications. Scalability remains a significant issue. Nevertheless, examples of companies and organizations that the City could consider collaborating with to process hard-to-recycle materials are listed below. Some companies incorporate material collection and shipping as part of an integrated service. Most are focused on plastics.

1. TerraCycle: An innovative recycling company in New Jersey based around the concept of eliminating the idea of waste by recycling the unrecyclable, TerraCycle has purportedly found ways to recycle and repurpose a wide range of hard-to-recycle materials. They have partnered with major consumer brands, retailers, manufacturers, municipalities, and small businesses in over 20 countries to develop over 60 unique recycling programs for items such as coffee capsules, pens, plastic gloves, and cigarette butts. A TerraCycle cigarette butt recycling program already exists in Baltimore. TerraCycle works with partners to develop tailored collection systems, although their Zero Waste Box Program is the typical mechanism. Boxes specific to a particular brand or material are purchased and placed in appropriate locations. Once the box is full, it can be shipped to

the processing facility to be repurposed. The cost of the box includes the shipping, return shipping, and processing.

2. Green Mantra: This Canadian company is a clean technology leader that produces value-added synthetic waxes, polymer additives, and other chemicals from hard-to-recycle plastic film and grocery bags. They tout themselves as the first company in the world to upcycle post-consumer and post-industrial recycled plastics into synthetic polymers.
3. Renewology: This company offers commercial scale systems using a depolymerization process this is optimized for converting low value post-consumer plastic waste (i.e., nos. 3 to 7 plastics) into high value petrochemical products.
4. Plastic Film Recycling: This organization is supported by the Flexible Film Recycling Group of the American Chemistry Council (ACC). Their goal is to double plastic film recycling to two billion pounds by 2020. To achieve this goal, they are working to increase access to and participation in plastic film recycling for both consumers and businesses. The ACC reports that regulations to make chemical recycling easier are in progress in Maryland.
5. Loop Industries: Based in Canada, this depolymerization technology upcycles all types of waste PET and polyester into high purity PET suitable for use in food-grade packaging and water bottles. This includes the PET plastic found in carpets and opaque/colored bottles, which are traditionally harder to recycle than clear resins.
6. Reclaimed EcoEnergy: This technology reclaims carbon from nos. 1 to 7 plastics (no sorting required) by combining carbon with hydrogen using a controlled eco-cavitation process to form long-chain hydrocarbons. The technology recovers about 70% of carbon in feedstock plastics. Based in Toronto, Canada the firm operates a small pilot project that it claims is scalable to 200 tons/day.
7. Agilyx: Based in Oregon, this firm's technology converts mixed plastics feedstock into custom products such as olefins, naphthalenes, paraffins and waxes, and carbon solids. They aim to provide a full supply chain solution.
8. New Hope Energy: Founded in 2008, this firm mechanically and chemically recycles various plastics into high quality petroleum products using a patented heat exchange vessel system. Their conversion technology can take all plastic products, including high/low density polyethylene, polystyrene, and polypropylene. Mixed colors are acceptable. The firm will also accept bulk PET, polyvinyl chloride (PVC), and acrylonitrile butadiene styrene (ABS), but only mechanically recycles these products. They operate a continuous feed multiple unit production plant at their headquarters in Tyler, TX.
9. Enerkem: Based in Montréal, Enerkem's technology converts non-recyclable trash (generally, bulk rejects from mechanical-biological processing) into syngas and then into cellulosic ethanol, methanol, and other renewable chemicals. According to the firm, their standard modular facility can generate about 10 million gallons of transportation biofuels or renewable chemicals for every 110,000 dry tons of waste input. Enerkem operates a 350 tons/day commercial facility in Edmonton, Alberta as well as a pilot facility in Quebec.

10. Telfer, Inc.: A small company based in Indiana. Telfer (no website) dismantled two old power plants to rebuild a pilot plant near Chicago, IL that uses poor quality (reject) plastics as feedstock. The plant vaporizes plastics (with a 95% conversion rate) into usable petroleum. Char can be sent back through the system to minimize waste.

Note that inclusion of a company/organization in the above listing is not an endorsement of any particular technology. In addition, given the proprietary nature of chemical recycling technologies, it is often difficult to ascertain what the waste products and emissions associated with each process are. It is important to verify that byproducts and emissions are being properly managed and disclosed transparently before entering into an agreement with a technology vendor.

Diversion Potential

Currently, the diversion rate of non-traditional recyclables in Baltimore is negligible and limited to small-scale diversion of bulky waste items. Although the immediate diversion potential is limited, chemical recycling could be used to recycle the nearly 600 tons per year of carpets and other non-bulky NTR materials.

More significantly, review of SSR data in Section 4.2 shows that the current disposal stream in Baltimore contains about 53,800 tons of mixed plastics and about 13,600 tons of mixed paper. Chemical recycling could contribute to meeting the 50% diversion goals established for these materials in this Report or, eventually, to meeting the BSP's overall 90% diversion goal.

Adding Hard-to-Recycle Materials to Collection Programs

To collect hard-to-recycle materials for delivery to a processor, a practical option to consider is developing a permanent drop-off facility for these materials as a component of an upgraded residents' drop-off center (see Section 7.1) or a multi-purpose resource recovery park or eco-park (see Section 7.2). A good national example of this approach is the "Center for Hard to Recycle Materials" (CHaRM) in Atlanta, GA.

Alternatively, adding some of these materials to improved/expanded SSR collection programs (see Sections 4.2 and 4.3) could be a viable strategy. This would need to be considered in the context of existing or future recycling contracts for delivery of SSR to a MRF. Contracts could be expanded to accommodate new materials, with the MRF separating these materials for shipping to chemical recyclers. Depending on their respective appetite for risk, either the City or the MRF operator would negotiate with the chemical recycler to structure a contract for delivery of materials.

As cautioned with regard to expanding SSR collection programs in Chapter 4, for any contract with a chemical recycler to be sustainable there must be sufficient long-term demand for their products and sufficient ability on the part of the City and/or partner MRF to maintain feedstock volumes and quality. Technologies must be carefully vetted to ensure that feedstock specifications can be met. Contamination levels will need to be managed to meet quality controls without entailing excessive costs. Notwithstanding impressive innovations and the promise of expanded demand, predicting the evolution of recycling markets and technologies over the next several years is not possible. The City should carefully examine up-to-date industry trends, market outlooks, and proposed contract terms before accepting any offers.

7. INTEGRATED WASTE DIVERSION AND RECYCLING FACILITIES

Previous chapters reviewed potential expansion of existing recycling programs in Baltimore to collect and process a larger quantity of materials from a wider range of sources. The discussion was grouped around material classes (i.e., organics, traditional and non-traditional recyclables, and C&D waste), with the default assumption being that these recycle streams would be handled independently from each other. However, options exist that can combine collection and/or processing capabilities in a single location, offering economies of scale and more efficient operation. These options are reviewed in this chapter. It is noted that diversion potential, costs, benefits, and challenges are generally amalgamations of previous estimates and thus are only discussed briefly, with direct references made to previous analyses.

7.1 Residents' Drop-Off Centers

To encourage greater participation in recycling, DPW could expand/overhaul their residents' drop-off centers and/or the small hauler program. Expansion of these facilities/programs may involve constructing new drop-off centers (DOCs), increasing the number of products accepted at existing DOCs, increasing recycling of products dropped off at DOCs, or any combination thereof.

Overview of Current Programs

Brief summaries of the resident's DOCs and the small hauler program are provided below. For more information, the LWBB Plan's Task 3 Report contains a detailed summary of both.

1. DPW currently operates five waste and recycling DOCs around the city. These accept bulk trash, commingled recycling, rigid plastics, scrap metal, scrap tires, appliances, waste oil and antifreeze, electronics, and oyster shells. An additional three smaller DOCs only accept commingled recyclable items. Of the material brought to DOCs in 2017, approximately 12,900 tons was sent for disposal with 13,800 tons recycled.
2. The small hauler program allows small commercial waste haulers to dump at QRL or NWTS for a reduced tip fee compared with large commercial haulers. In 2017, 13,200 tons were received from licensed small haulers.

A summary of major types and quantities of waste materials disposed at DOCs by residents and small haulers is given in the table below.

Waste Category	Material	DOCs (tons)	Small Haulers (tons)	Total (tons)
Organics	Yard Waste	250	250	500
C&D Material	Scrap Metal	300	300	600
	Concrete	2,050	2,100	4,150
	Lumber	2,400	2,400	4,800
	Drywall	900	900	1,800
	Soil	150	150	300
Trad. Recycl.	Cardboard	50	50	100
Non-Traditional Recyclables	Mixed Electronics	50	50	100
	Carpet/Textiles	250	250	500
	Bulk Trash	2,500	2,550	5,050
Unclassified	-	4,050	4,150	8,200

Composition and Quantities of Waste Disposed at Drop-Off Centers

Options and Strategies

Two policy options available to expand the DOCs and licensed small hauler program are outlined below.

Option 1: Develop New Capacity

This option would require DPW to either construct new facilities for both residents and small haulers to drop off waste, or expand existing DOCs to allow small haulers to use them in addition to QRL and NWTS. As most existing DOCs are on fairly compact lots, it seems unlikely that these locations could be expanded sufficiently to allow small hauler use (this would require a truck scale and larger throughput capacity, amongst other upgrades). As such, it is assumed that developing new capacity would require the construction of new DOCs. However, rather than standalone facilities, it is noted that new drop-off capacity could be constructed as part of a resource recovery park (see Section 7.2).

Option 2: Expand Reuse and Diversion at Existing Facilities

This option would require reconfiguration of existing DOCs to allow for a larger number of materials to be handled and diverted. This would require increased staffing to direct residents and haulers to the correct location for each material. Additional materials to consider for acceptance include non-traditional recyclable/divertible items such as mattresses, carpet, furniture, homewares, textiles, household hazardous waste, and ceramics/porcelain, as well as items that are currently accepted but are not separated (e.g., C&D waste, bulky waste, food scraps and other organics, appliances with large amounts of rigid plastic, and yard waste). This option could include a materials exchange network/partnership that would allow drop-off facilities to partner with nonprofits to expand donation of items such as bicycles, musical instruments, books, clothes, etc. (see discussion in Section 8.5).

Diversion Potential

The diversion potential associated with expanding DOCs and the small hauler program depends on the specific strategies applied by the City. An estimate of the diversion potential for each of the two options presented is included below.

1. Option 1: Currently, it is estimated that 13,200 tons of trash is collected annually at the two DOCs that service small haulers (QRL and NWTS) with a further 26,700 tons collected at the other five DOCs. This equates to roughly 5,000 tons per year per location. Therefore, it is estimated that an additional 5,000 tons of material could be collected at each new DOC constructed. Using the current diversion rate at DOCs (52%), each additional facility could result in additional diversion of **2,600 tons**.
2. Option 2: Of the material currently disposed at DOCs, it is estimated that 17,900 tons (68.5%) is potentially divertible (i.e., all except "unclassified" material). Assuming a 90% diversion goal in accordance with the BSP, it is estimated that an additional **16,100 tons** could be diverted annually.

Estimated Costs and Benefits

Estimated Costs

Potential costs were analyzed for both options presented above. These costs are expected to be borne by the City. However, cost assignments between the public and private sectors will be further discussed in the Draft Master Plan in Task 8.

Option 1: Develop New Facilities

For this analysis, it was assumed that **three additional facilities** would be built if Option 1 is implemented. The expected costs for this option were developed on a per-facility basis as follows:

1. **CAPEX for DOC construction between $3 and $5 million**. This assumes a six-bay facility managing SSR, yard waste, C&D, MSW, and NTR materials plus a reuse center. CAPEX includes land acquisition and permitting for a 3-5 acre tract (HDR, 2019).
2. **Annual OPEX is expected to be $300,000 to $400,000 per facility**. This includes wages for five full-time employees to run the facility at $50,000 per employee (including fringe benefits), operation and maintenance at $50,000, and educational costs at $10,000. In addition, it is expected the City would need one full-time analyst at $60,000 (including fringe benefits) to keep track of the additional collected material.

This yields total expected CAPEX of $9 to $15 million and $1.1 million in total annual OPEX to build and operate three additional DOCs.

Option 2: Expand Reuse and Diversion at Existing Facilities

The expected costs for this option were developed assuming that there are no space limitations at selected DOCs such that expanding diversion and reuse activities can occur on their existing footprint. For this analysis, it was assumed that all **five existing facilities** would be expanded if this option is implemented. Under these assumptions, the following costs were developed:

1. CAPEX requirements are expected to be minimal, mainly consisting of purchasing additional dumpsters (at nominal $800 unit cost) and ROROs to store additional divertible material. It is assumed that four additional ROROs would be required for each location at a unit cost of $10,000. **This gives a total CAPEX of $200,000.**
2. Annual OPEX is expected to rise as a result of increased labor demand at the expanded DOCs. It is anticipated that one additional full-time employee would be required at each facility (with wages and fringe benefits of $50,000) to help keep residents and small haulers organized (i.e. to make sure that everything goes in the correct area). Additionally, one analyst (with wages and fringe benefits of $60,000) is expected to be required to keep track of the additional collected material. Finally, education and outreach is expected to cost $10,000 per facility for a total of $50,000. **This gives total annual OPEX of $360,000.**

Estimated Benefits

The primary benefits associated with each option are increased employment (job creation), environmental benefits associated with GHG emission reductions from increased diversion, and airspace savings associated with decreased disposal. A summary of benefits is provided in the table overleaf, calculated as follows:

1. Job creation estimates were calculated based on employment estimates (see cost assumptions);
2. GHG emissions reductions were estimated using the U.S. EPA software tool WARM; and
3. Airspace savings were calculated as the product of the QRL tip fee ($67.50) and the reduction potential for each option.

Benefit	Parameter	Option 1	Option 2
Jobs	Labor Hours	37,440	12,480
	No. of Jobs	18	6
	Wages	$660,000	$220,000
GHG Reduction	MTCO2E	-8,800	-25,800
	Equiv. Vehicles	1,900	5,500
	Equiv. Gal. Gasoline	988,000	2.9 million
Airspace Savings	Airspace Savings	$526,500	$1,090,000

Summary of Benefits for Expanding Drop-Off Capacity

Challenges to Implementation

Aside from funding, challenges to expanding DOC capacity are relatively minor. If new DOCs are built, DPW would have to acquire relatively large tracts of land, which could be expensive and difficult unless the City already owns suitable land. Existing facilities may not have sufficient space to expand, in which case DPW would have to buy adjacent land. To construct or expand DOCs, DPW would also have to permit the new facilities/expansions through MDE and update the City's Ten-Year Solid Waste Management Plan. Outreach efforts would be needed to change the DOC usage habits of residents and small haulers. Any expansion to include NTR materials would suffer the same challenges as identified for those recycling programs, namely that an end-user or processor would need to have demand for the new recycle stream.

Experience and Timeline

Expected time constraints on implementation of either DOC option are minor, mainly related to land purchase and potential permitting delays.

DPW currently has considerable experience with operation of DOCs and the small hauler program. Expansion of the DOCs and/or small hauler program should thus be relatively simple.

7.2 Resource Recovery Park (Eco-Park)

Resource recovery parks (RRPs), also known as eco-parks, are large multi-reuse and diversion centers that may include several waste handling and processing facilities in a single location, including MRFs for processing SSR and C&D lines, organics processing (e.g. composting/AD), bulk waste reuse, areas for handling and sorting hard-to-recycle materials (e.g., CHaRM), and residents' trash and recycling drop-offs. In some cases, a RRP may also house an energy recovery facility; for example, biogas produced from an AD plant may be cleaned and processed for pipeline distribution as renewable natural gas (RNG) or utilized directly in engines or turbines to generate electricity. Many RRPs may also co-locate retail businesses specializing in reused materials and educational centers.

Jurisdictions that have successfully constructed integrated RRPs include Monterey, CA, Kent County, MI, Phoenix, AZ, and Tacoma, WA.

Options and Strategies

The most practical option available for construction of an RRP would be to co-locate individual reuse and diversion facilities (as previously described in Chapters 3 through 6) in one large centralized location. The location of this facility would be subject to an extensive siting and feasibility study, although optimally it should be located close to QRL to minimize transportation of process residuals.

For this analysis, an RRP is assumed to have sufficient space for:

1. Reuse facilities, such as a food bank, C&D salvage and reuse center, a thrift store, and a fix-it/repair clinic;
2. A composting facility sized to process all residential organics;
3. A MRF sized for processing all curbside SSR;
4. A MRF sized for processing all C&D waste; and
5. A residents' drop-off center also serving small haulers, sized to operate at twice the average capacity of the existing DOCs.

It is noted that developing the RRP with fewer/different components would change its overall processing capacity and costs accordingly.

Diversion Potential

The diversion potential for an RRP is assumed to be the sum of the diversion potential for its four main components, ignoring the minor tonnage diversion that would be achieved by smaller reuse facilities. A summary of the expected diversion is given in the table below, along with the relevant referring section of this Report.

Component	Diversion Potential (tons)	Report Section
Compost Facility	14,000*	3.2
MRF for SSR processing	153,500**	4.4
MRF for C&D processing	216,850	5.2
Residents' Drop-Off Center	7,150	7.1
TOTAL	**391,500**	-

Notes:

* excluding bulking materials

** maximum diversion potential for all SSR components

Diversion Potential for Integrated Resource Recovery Park

Estimated Costs and Benefits

Estimated Costs

The costs associated with constructing an RRP are broadly similar to those associated with constructing each individual facility. Some savings may be achieved through economies of scale; however, this is ignored here for the sake of conservatism. Costs are expected to be borne by the City or shared with the private sector via a PPP. However, a fully privately funded and operated option may be feasible. A summary of expected costs is provided in the table below.

Component Facility of RRP	CAPEX	Annual OPEX
Compost Facility	$ 2.7 million	$ 1.0 million
MRF for SSR processing	$ 40 million	$ 10.6 million
MRF for C&D processing	$ 22.1 million	$ 20.3 million
Residents' Drop-Off Center	$ 8 million	$ 740,000
TOTAL	**$ 72.8 million**	**$ 32.7 million**

Expected CAPEX and OPEX for an Integrated Resource Recovery Park

For comparison, a private company Fiberight operates an RRP serving over 100 communities in Maine. The facility features a state-of-the-art MRF with backend processing of some recovered materials and organics composting. The facility opened in April 2019 and can process 180,000 tons annually. CAPEX incurred was about $70 million.

Estimated Benefits

The primary benefits associated with developing an RRP are direct revenues from sale of compost product and recovered recyclables, increased employment (job creation),

environmental benefits associated with increased diversion (GHG reductions), and airspace savings associated with decreased disposal at QRL and BRESCO.

Job creation estimates were calculated based on employment estimates for each individual facility that comprises the RRP (see cost assumptions in assessment of individual facilities). GHG emissions reductions were estimated using WARM. Airspace savings were calculated as the product of the QRL tip fee ($67.50) and the reduction potential for the component facility in question. A summary is provided in the table below.

Benefit	Parameter	Value
Revenues	Direct Revenue	$ 25.0 million
Jobs	Net Labor Hours	87,400
	Net Jobs	42
	Net Wages	$ 2.1 million
GHG Reduction	MTCO2E	-388,500
	Equiv. Vehicles	82,500
	Equiv. Gal. Gasoline	43.7 million
Airspace Savings	Airspace Savings	$ 26.4 million

Expected Benefits of an Integrated Resource Recovery Park

The primary indirect benefits associated with developing an RRP include reduced transportation costs (monetary and environmental) for shipping waste, recovered materials, and residuals between facilities and improved communication and collaboration between facility personnel and users at the RRP, resulting in potentially higher diversion rates.

Challenges to Implementation

The main challenges to developing a RRP are listed below:

1. Land acquisition: Estimated land requirements would be about four acres for a composting facility, 25 acres for an SSR MRF, 15 acres for a C&D MRF, and one acre for a residents' drop-off facility, for a minimum of 45 acres. Finding a single plot of this size in a convenient location in Baltimore is likely to be difficult, with several permitting challenges.
2. Managing processing facilities: The City does not have much experience with operating these types of facilities. As such, the City may wish to have a private company manage these facilities as part of a PPP or other contract (see Section 4.4 for discussion of potential contracting mechanisms).

Experience and Timeline

DPW has some experience with large-scale waste management operations from QRL and NWTS, and is experienced at handling residents and small haulers at DOCs. Managing an RRP should not be much different from a logistical perspective; however, the City does not have much experience managing MRFs or composting facilities (except BCRP's mulching and composting operations at Camp Small), making the day-to-day operations of these facilities potentially challenging.

Obtaining permit approval for a multi-purpose facility handling large quantities of waste with potentially large air and effluent emissions would be expensive and time consuming, especially considering local resistance to such a facility regarding truck traffic, noise and other nuisances. Although the RRP could be developed in phases, it would likely take 5-10 years to build out.

8. ENCOURAGING WASTE REDUCTION AND RECYCLING

Chapters 3 to 7 of this Report examine options to increase diversion and recycling of specific material classes from the current disposal waste stream, focusing on facilities and networks (i.e., "hard" infrastructure) and programmatic changes (i.e., "soft" infrastructure) that would need to be implemented by the City and the private sector in order to achieve the waste reduction and diversion goals of the BSP. While many soft infrastructure options are susceptible to underperforming on diversion/recycling rates, hard infrastructure options are often sensitive to cost overages. In both cases, however, options are highly sensitive to rates of participation and engagement amongst stakeholders. Therefore, Chapter 8 examines policies and strategies that could be enacted by the City to promote and increase waste reduction and diversion across multiple material classes and stakeholder sectors.

In reviewing policies and strategies for consideration in Chapter 8, reduction efforts are paramount, as waste that is not generated in the first place does not enter the waste stream and thus does not incur a processing or disposal cost. Just as a "nega-watt" is a concept used in the energy market to describe a megawatt of power saved by increasing efficiency or reducing consumption, waste reduction policies and strategies could be thought of in terms of "nega-tons" of waste avoided. However, nega-tons by their nature are difficult to quantify; as a result, this chapter provides more of a qualitative than quantitative assessment of waste reduction initiatives. To address unavoidable waste, policies and strategies aimed at improving the level and effectiveness of participation in the various waste diversion and recycling programs outlined in previous chapters are also reviewed. These policies and strategies generally work by making it easier and more meaningful for residents and businesses to participate in programs.

Encouraging waste reduction and recycling through policy changes and strategic initiatives are key goals of the BSP. It is noted that reducing waste generation and increasing diversion and recycling to levels envisioned in this Report will require major political action and behavioral changes across all socioeconomic sectors in Baltimore to reduce waste from consumers, manufacturers, restaurants and bars, grocery stores, online vendors, and other businesses. Leadership from all branches of City government will be essential, particularly the Mayor's Office and City Council, as DPW and other departments/offices cannot execute the changes needed on their own. Indeed, with regard to the options discussed in Chapter 8, the role of DPW and other departments/offices would generally be to help implement regulations and policy initiatives enacted by City Hall, although they could also play a central role in public-private partnerships (PPPs) to develop new recycling and diversion capacity. This is especially pertinent to the discussion in Section 8.6.

8.1 Education and Outreach

Educating residents and businesses on the importance of waste reduction, reuse, recycling, and composting is a key factor for achieving the goals of the BSP. In the online survey conducted for the LWBB Plan, 96% of responders said they would support policies that lead to improved waste reduction, recycling, and reuse.

Food Waste Reduction and Composting

In the online survey, 86% of responders also indicated a willingness to learn how to reduce waste and/or sort waste for new recycling or organics collection programs. This is important in the context of the BFWRS, which was developed to set specific goals and strategies for achieving multi-sectorial reductions in food waste by 2040. The BFWRS outlines over 60 short-, medium-, and long-term strategies to be implemented by the City, including education and outreach efforts.

Specific suggestions from survey responders for education and outreach efforts that the City could undertake to reduce food waste include:

1. Conduct an educational campaign about composting, including in schools.
2. Educate residents on the difference between "Sell By," "Use By," and "Best By" to reduce food waste.
3. Educate residents about purchasing food more sustainably.
4. Educate restaurants on decreasing waste (e.g., food, paper napkins, plastic utensils, takeout containers).

Other Waste Reduction and Recycling Measures

As described in the Task 3 Report, the City already has several outreach and educational programs to inform residents of single-family and multi-family properties, businesses, and schools about proper management of solid waste including reducing, reusing, and recycling. Nevertheless, key improvements suggested by survey responders include:

1. The City needs to offer more general public education on recycling rules and how to reduce waste. Key reasons cited for why many residents don't separate recyclables from trash is that they don't know how to do so or why it is important.
2. The City also needs to overcome social and cultural barriers to recycling (i.e., the perception that recycling is something "other" people do). This could be done by developing advertising campaigns for TV, social media, and outdoor spaces (e.g., buses and bus shelters and in a variety of languages).
3. Many residents are also unsure as to what is recyclable, particularly what types of plastics and food packaging are recyclable. 73% of survey responders requested the City to provide more literature that focuses on waste reduction, reuse, and recycling.

Other suggestions from the survey for education and outreach efforts that the City could undertake include:

1. Identify all public and private recycling locations/resources and list them on the DPW webpage along with opening hours and other pertinent information.
2. Include up-to-date recycling requirements, opportunities, and resources in all mailings from the City (e.g., tax and water bills, jury duty summons, etc.).
3. Hold an educational campaign about the environmental impact of waste and the impact of waste on children's futures.
4. Educate the public through art shows using recovered materials.
5. Train and hire youth or unemployed adults to conduct door-to-door campaigns every year to educate households on recycling.

6. Engage schools, churches, businesses, organizations, and government in educational campaigns, including those aimed at addressing climate change such as Drawdown Buy-In.
7. Engage celebrities, athletes, and local stadiums to support and promote recycling, including getting stadiums to promote game days as zero waste events. As an example, the Phoenix Suns partnered with Republic Services to promote recycling and conduct education events during halftime.
8. Empower community/neighborhood associations and block captains as waste management experts so that they can lead their communities in waste reduction, recycling, and composting. Block captains could be paid to encourage their involvement.
9. Provide education on recycling to seniors so they are more likely to participate.
10. Improve communications and publicity, and train DPW staff to better support and inspire residents (e.g., improve online information dashboard, train office and field/truck staff on customer engagement and how to sort waste and why it matters).

A good example of an online recycling resource and messaging tool is Recycle Smart (https://recyclesmartma.org), an initiative of the Massachusetts Department of Environmental Protection. The easy-to-use online tool features a "recyclopedia" that residents can use to find if a specific material or product is recyclable in their community. Tools such as this that empower individuals to make better decisions have proven effective at increasing participation rates. There is also increasing evidence that focusing on positive aspects of recycling (i.e., "this used product can be reborn as a new product") rather than emphasizing negative environmental outcomes from not recycling leads to higher participation and lower contamination rates.

Role of the Baltimore Zero Waste Plan

Education and outreach efforts in support of achieving zero waste goals are a key focus of the Baltimore Zero Waste Plan (BZWP), developed independent of the LWBB Plan. According to information shared to date, the BZWP intends to advocate for:

1. Providing many levels of education from what can be reused, recycled, or composted to involvement in planning for new infrastructure (including billboards, bus and truck wraps, social media, radio, and TV public service announcements).
2. Educating and empowering youth on how they can help implement zero waste at home and at school and encourage them to promote zero waste programs.
3. Asking anchor institutions (e.g., universities, hospitality, and shopping areas) to lead the way on embracing zero waste, reducing wasting and reusing, recycling and composting more.
4. Providing outreach and education for home and on-site organics recovery, including sharing expertise among community-based composters about what works and what doesn't.
5. Providing grants to zero waste social enterprises, entrepreneurs, mission-based recyclers, composters, digesters, and reuse organizations to help foster the culture change needed to

achieve zero waste, such as the Baltimore Compost Collaborative in Curtis Bay.

6. Establishing Zero Waste Block leaders to teach residents about recycling and organics recovery, host party kits with reusable cups, plates, cutlery, etc., and provide an outlet for community-based social marketing.
7. Building on existing spaces for zero waste education (e.g. United Workers Leadership School, Share Baltimore Learning Exchange, Association of Community Lands Trust, and the City Planning Academy).

This LWBB Plan broadly supports the BZWP in advocating for these education and outreach initiatives, details of which should be elaborated therein.

8.2 Usage-Pricing Models (Save as You Throw)

A usage-based variable fees model, also known as trash metering, unit pricing, or variable rate pricing) is a system for disposing of waste in which users are charged a rate based on how much waste they present for collection. Waste is measured by weight or size while units are identified using different types of bags, tags, stickers, containers, or even electronic ID tagging systems. Typically, services for waste diversion such as recycling and composting are provided free of direct charges where usage-pricing systems are implemented for trash collection.

Different models exist depending on the region and municipality. The best known usage-pricing model for waste services is "pay as you throw" (PAYT), also known as "save as you throw" (SAYT) or "save as you recycle" (SAYR). For the most part, larger municipalities use volume-based PAYT systems, typically cart-based, while smaller municipalities utilize bag or tag systems. However, the choice of system seems to be based more on regional trends and the availability of supporting services rather than on any specific documented performance differences between these approaches. A SAYT program is explicitly called for in the BSP; therefore, in the remainder of this section, the acronym SATY is used universally to refer to a usage-pricing model.

Potential Benefits

Advocates point out that SAYT can contribute to economic stability, environmental sustainability, and equity as residents are charged based on the amount of waste they dispose of. SAYT is based on two guiding principles of environmental policy: the polluter pays principle and the shared responsibility concept. Advantages are generally grouped as:

1. Environmental: SAYT is a method of increasing waste separation and recycling, as well as encouraging waste minimization. The intent is to drive down the amount of materials routinely disposed in the trash stream by changing consumers' habits (e.g., avoiding single-use items or products with lots of unrecyclable packaging) and raising the amount of material diverted to recycling and composting programs. Results can include energy savings from transportation, increases in material recovery from recycling, and emissions reductions from landfills and WTE incinerators. SAYT programs also indirectly encourage producers to develop more efficient designs and environmentally friendly product lifecycles.
2. Economic: The two most traditional approaches to disposing of MSW are a flat-rate system or municipal taxes (Baltimore's current system). All users pay the same amount regardless of how much waste they present for pickup, meaning there is no

incentive to reduce waste. With SAYT, waste management services are treated like other utilities such as electricity or water that are charged by unit of consumption. Some or all of the costs of waste management can thus be removed from taxes, providing more independence in the management and financing of residential waste services.

3. Social: Under SAYT, waste collections costs are distributed more fairly among the population, and in proportion to the amount of waste each user generates. This eliminates effective subsidies on larger waste generator, such that SAYT is said to promote community sustainability.

It is important to note that SAYT is a mechanism for changing the way that residents pay for waste services, with the goal of stimulating them to reduce trash generation as a means of saving money. SAYT is not a mechanism in itself for changing the way in which waste and recycling services are provided. For example, implementation of a new curbside organics collection program or changes in the way that curbside recycling services are provided are not directly affected by how the City would charge for these services. In other words, the City can achieve the goals of waste reduction and diversion outlined in this Report without implementing a SAYT program.

Implementation Options and Timeframes

SAYT is a relatively flexible option that can be implemented in a number of ways. For example, the City could implement a full SAYT program where residents pay for all trash set out for collection using specially marked bags, bag tags, or variable sized containers. Alternatively, a hybrid or partial SAYT program could require residents to pay additional fees only when setting out more trash than can fit in their standard issue green cart. Residents would be required to buy special colored/marked SAYT bags or stickers at gas stations or grocery, convenience, and hardware stores. Only official SAYT bags would be accepted by trash collectors or for drop off at residents' convenience centers.

The City has the option to administer a SAYT program directly or to contract with a private organization such as WasteZero to administer the program.

A SAYT program could be implemented in the short- to medium-term and sustained over the long term.

Challenges and Costs

Because SAYT is not a waste reduction or diversion program *per se* but rather a change in how residents pay for those programs, assigning direct costs to SAYT is not straightforward. A review of SAYT charges in other U.S. jurisdictions revealed that fees varied markedly; this likely has much to do with difficulties in understanding exactly what is and is not included in the published fee structure. Overall, the City should expect low to moderate additional costs associated with the need for increased promotion and education, to address the potential increase in the volume of calls during initial roll-out periods, and to address the need for additional enforcement. Assessing fees for waste management on a direct usage basis rather than as a flat service charge or a line item on a property tax bill adds administrative costs and complexity to a residential waste collection program. A full SAYT program with multiple cart sizes and different bag/sticker options would require considerable resources to administer, including a system for storing and exchanging carts and billing. A partial or hybrid PAYT program is less complex, but nevertheless both full and partial SAYT programs would draw on more time from

DPW's curbside collection staff to scan carts and bags and tag for non-compliance, which could affect collection efficiency.

Currently, residents are unaware of the true cost of waste disposal, and the City's current waste limits are relatively generous at 96-gal. per week per household under the One PLUS ONE Program. Although SAYT was often mentioned as a mechanism for increasing recycling and reducing waste by survey respondents, equal numbers of survey responses (41%) agreed and disagreed on their willingness to pay for trash services based on the amount of trash set out for disposal. At best, public support for transitioning to a usage-pricing model is thus likely to be muted. Strong pushback from some quarters is likely, given that public resistance is common whenever a change to an established municipal service is proposed. A recent study by the Massachusetts Department of Environmental Protection recommended making SAYT programs revenue-neutral by reducing taxes at the same time as introducing trash fees so residents don't see the latter as a new cost.

A concern expressed by many survey responders was not to increase taxes or add new costs for trash and recycling pickup as this would incentivize illegal dumping. Another concern is SAYT programs being considered a tax on low-income communities, which tend to purchase more packaged food items. In general, however, jurisdictions that have implemented SAYT practices do not report increased litter, open burning, or illegal dumping, especially when SAYT pricing is combined with easier recycling and composting. Paying for trash collection while recycling for free may also encourage residents to put more material into recycle bins, leading to increased contamination rates and lowering the value of recycle loads unless extensive education and enforcement efforts are made. It is difficult to find objective data to confirm or refute this concern. Most importantly, the costs of other programs must be covered by SAYT revenues if the City's current model of funding solid waste services from the general fund is to be replaced by a usage-pricing model; therefore, SAYT fees would need to be structured so the that City can recover administration costs and still generate sufficient revenue to support diversion programs. It is critical to recognize that the goal of SAYT is to decrease waste set outs and increase recycling loads; therefore, the City would need to consider how basing funding for collection services on a waste stream that is expected to decrease over time would impact the overall system. There would also be increases in recyclable and organic collection costs with increased tonnages, although this would be partially offset by increased revenue from additional tonnage of recyclables diverted and a decrease in trash transfer and disposal costs.

Overall, this LWBB Plan is neutral in its support for SAYT. Significant new research and a detailed business case would need to be undertaken to investigate how implementing a SAYT program would impact the City's solid waste funding structure. Nonetheless, a brief estimate of SAYT pricing in the context of improving the City's curbside recycling program was provided in Section 4.2.

Experience

The City does not use any type of SAYT system and thus does not have any direct experience of usage-based pricing for waste collection services. However, DPW provides water and wastewater services and billing under a usage-based model.

Two jurisdictions studied as part of the benchmarking effort in Task 4 of the LWBB Plan (i.e., Austin, TX and Portland, OR) have mature SAYT

programs. Both offer a tiered service fee structure based on the number and/or size of bins/carts set out.

Role of the Baltimore Zero Waste Plan

SAYT is a cornerstone of zero waste planning; as such, the BZWP includes pivoting to a SAYT program in Baltimore. Based on information shared to date, the BZWP suggests adopting a metered collection service with three carts allocated per household (one size for recycling and organics and a smaller size for trash, with additional services available for a fee). The SAYT program could be set up with different schedules for collection of trash, recycling, and organics (e.g., recycling and organics every week, trash every other week).

8.3 Waste Reduction in Public Schools

Exposing students in grade and high schools to the ideals of waste reduction and diversion at a young age should mean that they are seasoned recyclers and composters by the time they establish their own residences. This will be vital for sustaining the goals of waste reduction and diversion over the long term.

Improving Public Schools Recycling

Baltimore City Public Schools (BCPS) responsible for compliance with MDE's mandates for recycling. Recycling services are currently provided by DPW at some public schools. Overall, the City has a high level of control and influence over the performance of recycling efforts at schools. Improving recycling at public schools is a direct goal of the BSP.

Given that recycling services are provided at some public schools (others do not have their own recycling programs due to cost restrictions), the goals to improve recycling at public schools should be focused on increasing school sign-ups into the program, increasing participation within each school, and decreasing contamination rates. In this regard, several survey responders suggested that students should be targeted in education campaigns and competitions to reduce littering and improve their consumer habits and recycling practices (e.g., build/support student mentorship programs, equip schools with books about reuse and recycling, and/or coordinate trips to recycling centers). It was also suggested that students could participate in recycling competitions that offer gift cards or other rewards for participation.

MDE offers school educators copies of interdisciplinary activity lessons for Grades K-9. The activity lessons cover topics such as recycling, source reduction, landfills, composting, reuse, ecosystem cycles, hazardous waste, and buy recycled. MDE also hosts an annual "Rethink Recycling" Sculpture Contest held at their headquarters in Baltimore. The contest gives Maryland high school students the opportunity to be innovative and create a sculpture made from recyclable or reused materials. Judges select an overall winning sculpture along with individual recognition for creativity, workmanship and use of materials. The winning prizes include an award as well as possible national recognition and television news airtime. Corporations and non-profit organizations sponsor prizes for all contest entrants, such as gift cards, tablets, and laptops. The link to MDE's website in Section 1.4 provides more details on education and outreach resources available from the State.

Developing a Public Schools Composting Program

Setting up composting services for food waste in school cafeterias/ kitchens was widely supported by survey responders and is a direct goal of the BFWRS. Schools serve several thousand meals a day, while many

students bring their own packed lunches. However, it is noted that expanding recovery of food waste to public schools would not contribute substantively to the City's overall food waste reduction because the amount of material recovered is expected to be modest, no more than about 2,200 tons/year (see Section 3.2). However, collection of food waste from public schools is considered to be of high value due to its qualitative benefits and the additional educational advantages offered.

Implementing food waste reduction and composting programs at public schools are an integral part of the analyses on organic waste diversion in Sections 3.1 and 3.2, respectively. It is recognized that costs, including collection costs and costs for ongoing educational programs, may be difficult to absorb by school budgets, and thus the City may opt to phase in composting programs over several years unless separate funding can be secured. As benchmark examples, a school cafeteria recycling pilot program at about 20 grade and high schools in Kansas is reported to cost up to $500 per month per school. Closer to home, Urbana Highschool in Frederick County recently implemented a small-scale food waste recovery and composting program and may have some relevant cost data and other experience to share.

8.4 Incentive Programs

Incentives for recycling can take many forms. For example:

1. Cities and counties in California that meet certain criteria are established by the Department of Resources Recycling and Recovery as a Recycling Market Development Zone (RMDZ). California's RMDZ program combines recycling with economic development to fuel new businesses, expand existing ones, create jobs, and divert valuable material from landfills. The RMDZ program provides loans, technical assistance, and product marketing to businesses that use recyclable materials to manufacture their products within a RMDZ.
2. Some municipal incentive programs reward waste reduction and recycling efforts by larger waste generators and haulers by offering reduced disposal fees at landfills or annual recycling rebates or credits.
3. At a household level, people could be provided a discounted collection rate for proper and consistent use of their recycling bin. This could be linked to tiered pricing within a SAYT program.
4. Grants could be provided to communities to support programs and actions to reduce waste and increase participation in diversion programs.
5. Incentives can also serve to support private waste processors or independent contractors to pick up litter or cleanup illegal dumping.

In the context of this LWBB Plan, however, the discussion in this section is mainly focused on the use of cash or other rewards to serve as direct incentives for encouraging residents and businesses to divert waste from disposal.

Cash and Rewards for Recycling

The success of any incentive program is difficult to measure as it is difficult to directly attribute the program to changes in recycling behavior. However, given DPW's relatively modest outreach and education program, spending some additional funds on an incentive program may be warranted.

The City could consider developing their own program; for example, a survey responder suggested implementing a "Baltimore's Environmental Best" program rewarding businesses and other organizations that work to reduce waste in the city to inspire residents, businesses, and community organizations to start or continue their work. In deciding how to develop an incentives program, it is important to reward good behavior not the absence of bad behavior.

Overall, it would probably be simpler for the City to sign up with an existing national recycling rewards program. Two notable examples are described below.

Verde (Recycling Perks)

https://verdeoutreach.com/

Launched in 2011, this program aims to increase participation in recycling by providing incentives through a simple points system. Residents sign up for free and start earning points every time they set their single-stream recyclable bin out, which is recorded using radio-frequency identification (RFID) technology. Points can be used to earn discounts and freebies at local restaurants, stores, and activities. Participating jurisdictions include Chesapeake City, VA, where the company is based, as well as several other cities and counties in Virginia and the southeastern U.S. Using data analysis, Verde can make determinations about which household has recycled, how often, and how that relates to key demographic information. With these elements in place, they can strategically market to areas of low participation and relate use of local rewards partners to a household's profile.

Recyclebank

https://recyclebank.com/

Recyclebank has partnerships with retailers and waste haulers which vary by community. Residents served by partnered haulers can receive rewards and discounts by physically placing recyclables out for collection or by completing games/quizzes and reading materials on the Recyclebank website. Recyclebank boasts nearly 4 million members in over 300 communities, the majority of whom report an increase in recycling rates after implementing the program. Community-based programs are charged a fee for participating.

Payment for Goods and Services using Recyclables

Finally, there are several examples emerging of rewards programs that interact more directly with consumers by allowing cash payments to be made in recyclables such as plastic bottles and cans. For example:

1. Public transportation: In Rome, Italy commuters can get 5 cents off the price of their next journey for recycling a plastic bottle. The scheme is being tested at three stations where special machines compact the bottles and add credit to the user's metro travel application. A similar scheme was launched in Beijing, China in 2014. In Istanbul, Turkey plastic bottles can help pay for both tram and subway trips. In Surabaya, Indonesia buses accept plastic cups and bottles as payment for journeys. A two-hour bus ride costs 10 plastic cups or five plastic bottles.
2. Vouchers or cash: In the U.K. and Germany, supermarkets have installed reverse vending machines that issue vouchers for every plastic bottle deposited. In Australia's "Cash for Containers" program, empty bottles and cans can be fed into reverse vending

machines in return for vouchers or cash. People can choose bus ticket vouchers, movie tickets, candy bars, or various other awards.

3. Car parking: In 2018, the City of Leeds in the U.K. launched a scheme in which drivers could pay car park charges with plastic bottles. Each bottle is worth about 25 cents in parking fees.

In Baltimore, reverse vending machines could be used to reward recycling by offering credit for parking meters, mobile phone top-ups, vouchers for public transportation, or credit against residential water bills. Systems that offer cash for recyclables may be overly burdensome to administer and protect.

8.5 Sharing and Reuse Opportunities

Libraries and Lending Organizations

Opportunities for sharing items that are used infrequently are becoming more prevalent in many communities. The City could support organizations (e.g., non-profit organizations or public libraries) or develop partnerships with existing organizations to provide opportunities for the public to borrow items such as bikes, appliances, or tools. Items can be donated to the libraries or organizations can purchase and cover expenses through user fees.

Depending on the City's level of engagement in these initiatives, some staff time and effort would be expected for promotion and support. Overall, however, sharing programs and libraries provide a low-cost mechanism for reducing generation and waste (by eliminating duplicate purchases of infrequently used items) and raising awareness about unnecessary purchases and opportunities to reuse and share materials. These types of initiatives provide good opportunities for community development and engagement as well as social equity by offering useful materials and objects regardless of family income.

It is almost impossible to formally track the impact of these initiatives on waste diversion, although tracking how frequently items are borrowed may assist with calculation of waste reduction or diversion. City support could also be contingent on providing regular data updates on usage/activities. Regardless, the waste reduction/diversion rate achieved would be modest at tens of tons per year at best; however, supporting library-style initiatives sends a strong message encouraging behavioral changes.

Library-style initiatives could be particularly successful in areas with a high number of smaller multi-family units with limited storage space and/or with a high student population who may not be able to afford or want to outright purchase larger or more expensive items with limited usage. Specific examples of existing materials/resource sharing operations include:

1. Tool lending libraries for hand and power tools, such as the Baltimore Community Tool Bank (only for community-based organization use) and Station North Tool Library (paid membership only).
2. Kitchen appliance libraries, examples being the Kitchen Share locations in Portland OR.
3. Musical instrument library, an example being the public library in Halifax NS.
4. Media lending library for audio, visual, creative, and event production tools, an example being iTooLL in Indianapolis IN.

5. Community farming and food processing tools, an example being Mother Hubbard's Cupboard in Bloomington IN.

Other examples of libraries could include bikes, cars and trucks, camping and sports equipment, party/event supplies, board games, and toys. Existing hardware stores that rent out tools could be promoted as well.

Fix-It/Repair Clinics

As previously discussed in Section 6.1 with reference to reducing bulk trash generation, the City could help fund or make space available for fix-it or repair clinics. These are facilities where residents can learn how to repair or upcycle clothes, jewelry, homewares, etc. or to fix broken furniture, electronics, appliances or bikes so they can continue to be used or donated rather than thrown away. Many people lack the knowledge to make simple repairs to these items; fix-it clinics offer the opportunity for residents to learn. These clinics are usually staffed by volunteers with skills to share, gained either professionally or through hobbies, and so are free of charge for attendees although donations may be encouraged. Clinics could be hosted by the City, local nonprofits (e.g., Baltimore Community Tool Bank), local businesses, or some combination thereof. Clinics are relatively low-cost efforts: in Section 6.1, it was estimated that the City would need to spend no more than $20,000 per year to support clinics at a basic level, including rent and information campaigns.

Fix-it clinics can be held at permanent locations on scheduled dates, or can be held one or two times a year at other venues such as farmers markets, festivals, or other community events. A good local example is GreenFest, an annual environmental festival in Montgomery County that includes an event called "The Repair Café" for individuals to learn how to fix their broken items for free. The event is sponsored by the Silver Spring Timebank, which allows residents to donate their time through a broad range of services in exchange for credits which can be used to receive other services.

If managed directly by DPW, fix-it clinics could be offered in coordination with, or in a similar manner to, their existing GROW centers, which offer tips and materials for greening and landscaping. The City could also fund advertising or PSA campaigns to raise public awareness about the value of certain items and to encourage people to take worn/broken items to a fix-it clinic to learn how to repair them, as well as providing tips on how to care for items to make them last longer.

Closely related to the fix-it/repair concept, mobile sharpening services can be utilized for knives, scissors, axes, shovels, hedge trimmers, chain saws, lawn mower blades, etc. Typically operated out of a van or truck, these services can be offered on an advertised schedule at grocery stores and farmers markets (some already operate at the Baltimore Farmers' Market and Bazaar). The City could work with vendors to support and advertise these services so that people know where and when to access them.

Reuse and Swap Events

Some survey responders encouraged the City to promote freecycling, reuse events, and swaps for clothing and other materials between neighborhoods. Reuse events allow residents to get rid of or obtain gently used materials (e.g., furniture, clothes, and toys) in a convenient and structured way in a formal or semi-formal setting. These managed events avoid contributing to uncleanliness or litter in the way that informal garage or yard sales may do, and also reduce the incentive for residents to simply dump used items on the street. Reuse events could

include curbside giveaway events in common areas of multi-residential buildings, block parties for single-family neighborhoods, and swap events such as jewelry or clothing exchanges. Many counties and municipalities promote once or twice yearly curbside events, generally held in the spring or fall as people adjust and update their homes and closets.

The benefits of these events are that they create reuse opportunities and therefore reduce the amount of waste sent for recycling or disposal. They also give residents the opportunity to access used goods instead of buying new. Events can be staged so that used goods are available either at reduced rates or for free. Drawbacks and challenges are the potential for prohibited or unacceptable materials to be set out, which may pose health and safety concerns (e.g., mattresses containing bed bugs, non-compliant or internally damaged child car seats or bike helmets, etc.), and the risk of residents not removing materials after the event which can create litter and an uncleanly neighborhood. However, these challenges can be managed through providing good stewardship and oversight during the planning and execution of events. Reuse events are low-cost efforts that would likely require some City staff time and outreach/educational materials on the order of $10,000 annually to promote events and educate residents on the benefits of material reuse.

A good example of a reuse event is GrowNYC in New York City, which holds "Stop 'N' Swap" community reuse events throughout the year at various locations throughout the city. Their goal is to hold one event in each community annually. These events are often held in partnership with other organizations such as parenting groups and sometimes feature repair cafes. Materials brought to these events are weighed in order to estimate the tons diverted. In 2018, GrowNYC held 51 Stop 'N' Swap events which attracted over 12,000 people and diverted 61.5 tons of materials from disposal. Leftovers are sorted and recycled or donated for reuse to the extent possible. These events also provide an opportunity to educate residents about recycling.

8.6 Legislative Initiatives

This section describes some of the legislative initiatives that could be enacted by the City Council, or that the City could support at the State Legislature, as a means of helping to meet the goals of the BSP. However, it is important to note that this LWBB Plan does not necessarily encourage direct advocacy for any particular legislation. Several external challenges exist with regard to successfully implementing mandates for increased recycling: for example, the ability of regional recycling infrastructure such as the Waste Management Recycle America (WMRA) MRF to handle new materials or small items such as straws and utensils, the persistently weak global markets for traditional recyclables (see Section 4.1), and the lack of markets for some low value plastics that are technically recyclable but not currently recycled widely (see Section 6.3). Therefore, this section focuses primarily on potential legislative efforts to reduce waste generation and ban/restrict use of low value, hard-to-recycle materials.

The discussion in this section is qualitative and makes no attempt to quantify the waste diversion tonnage that could be achieved through full or partial implementation of any initiative. In the overall context of the LWBB Plan, however, no single action is expected to have a significant effect on the quantity of recycling and waste diversion achieved in the city, although they would likely increase the quality (i.e., reduce contamination) of residential curbside and other recycling streams.

Bans or Restrictions on Specific Materials

Results from the survey of stakeholders indicated clear support for policies aimed at eliminating specific "bad actor" materials from the waste and recycling streams. For example, 86% of responders supported a ban on single-use plastics such as food containers, plastic bags, and straws. As an alternative to outright bans, however, some responders suggested taxing the use of single-use materials or introducing laws to incentivize reuse. For example, customers bringing reusable bags to grocery stores and other retail outlets could be offered a credit on their bill (many grocery stores already offer this in Baltimore) or restaurants could be required to accept clean, reusable containers to package customers' leftover food.

Single-Use Plastics

A ban on single-use plastic bags has already been passed by the City Council on 19 November 2019 and signed into law on 13 January 2020. Beginning one year after the ordinance is enacted, retailers will be banned from giving shoppers plastic bags in most cases and required to charge a nickel for any other type of bag provided, including paper.

Reducing single-use plastic water bottle use can be achieved by enacting a container deposit law (CDL) or "bottle bill" (as discussed later) or by banning the sale of bottles. Examples of communities that have enacted full or partial bans on single-use plastic bottles include Concord, MA (2012), San Francisco, CA (2014), and Barrington, MA (2018). To offset impacts of the ban, San Francisco has implemented a "Drink Tap Program" with proactive installation of outdoor water bottle refilling stations. It is noted that Baltimore already has a five-cent bottle tax on soft drinks, iced teas, water, and juices, although this is hidden from consumers at the point of sale. This tax could be made visible so that consumers see the extra amount they are charged for single-use bottled drinks. Because it may be difficult for Baltimore to pass a wholesale ban on single-use bottles, an option could be to start with a law banning the use of single-use water bottles in all City Government offices and providing each staff person with a reusable bottle and convenient refill stations. The ban could then be extended to public schools, universities, and other institutions before being rolled out citywide.

Use of plastic utensils could be reduced by banning food outlets from providing them to customers or only provided when requested, or by requiring that utensils are made from recyclable plastics (e.g., PET #1). However, recycling of utensils is difficult as recycling symbols are often hard to see. In addition, small items such as these often cause jamming problems at MRFs. A better option may be to encourage the use of reusable (washable) utensils.

Plastic straws are currently the subject of many legislative bans, with dozens of jurisdictions around the country having enacted or are considering enacting bans. The 2019 Maryland Legislative session read but did not pass a bill prohibiting restaurants from providing single-use plastic straws to customers unless requested. Although compostable straws and paper straws exist, they cannot easily be recycled and still contribute to GHG emissions when produced and managed downstream. A better option is to encourage consumers to simply go without straws, and restaurants to not provide them, unless requested.

Expanded Polystyrene (Styrofoam)

EPS bans on food serviceware are already in place at both the City and State level. Bans on the use of EPS could be extended to packing peanuts (such as in Montgomery County, MD) and other non-durable EPS

products such as coolers, trays used for raw meat, seafood, mushrooms, and other produce, and packing foam used in boxes for shipping. Alternative packaging materials to EPS include starch-based foam plank, layered corrugated pads, and recycled polyethylene foam.

Plastic Film Packaging

Plastic film is not accepted in most curbside recycling programs for many of the same reasons that plastic bags are not accepted, which is that these materials tend to jam processing equipment at MRFs. Film may be recycled in the same way as bags, but individuals are responsible for taking the material back to a collection center (typically a local grocery store) to be recycled. The optimal way to minimize plastic film waste may be to develop extended producer responsibility (EPR) policies that would require businesses to reduce the packaging of their products that they sell to outlets in Baltimore (as discussed later). For the plastic packaging that is used, the City could provide more direct education to the public about their ability to drop off clean/dry packaging film to collection centers. For this, legislation to require all stores to accept plastic film for recycling would be needed.

Extended Producer Responsibility (EPR)

EPR is a government mandate for product stewardship that requires a manufacturer's responsibility for its product to extend to post-consumer management of that product and its packaging and/or upstream redesign/reduction. EPR policies therefore shift financial and management responsibility for waste management upstream to the manufacturer and away from the public sector, while incentivizing manufacturers to incorporate environmental considerations into the design of their products and packaging. Applied effectively, EPR can be valuable in helping communities manage and fund the reduction/recycling/diversion of difficult materials. To maximize leverage and economies of scale, EPR legislation is generally more effective at state rather than local level except in cities/counties representing very large markets. Toronto, for example, has EPR programs in place for agricultural pesticides, fertilizers, and solvents (including for bags and containers) as well as for tires, alcoholic beverage containers, electronics, paint, household hazardous waste (HHW), fluorescent lamps, pharmaceuticals, and refrigerants.

Currently, there are no federal EPR mandates in place; however, the Product Stewardship Institute (PSI), a national, membership-based nonprofit organization, promotes and tracks product stewardship legislation and voluntary initiatives across the country. Its members currently include 47 state environmental agency members, as well as local governments (including non-U.S.), corporations, businesses, academic institutions, and non-profit organizations.

Strong examples of EPR legislation can be found at the state level, including California, Massachusetts, and Washington. California is a good case study, having passed the most EPR laws in the U.S. Examples include EPR laws covering recycling and disposal of mercury thermostats, pesticide containers, paint, carpet, and mattresses. California's EPR efforts are led by the California Product Stewardship Council, a network of local governments, non-government organizations, businesses, and individuals.

It is noted that Maryland has EPR-type laws in place governing recycling and disposal of electronics (although there are very limited funds, if any, going to municipalities), mercuric oxide batteries, and fluorescent and compact fluorescent light bulbs. In the 2014 Zero Waste Maryland Plan,

since repealed, MDE included initiatives to support EPR for packaging and other difficult-to-manage materials such as mattresses, carpets, and paint.

Product Take-Back Programs

Similar to EPR programs, product take-back programs are a form of product stewardship for hard-to-recycle items and packaging. These initiatives are typically organized by a manufacturer or retailer to collect used products or materials from consumers and reintroduce them to the original processing and manufacturing cycle. A company may implement this program in collaboration with end-of-life logistics and material processing firms. For manufacturers and retailers, there are multiple benefits for implementing a take-back program, including stronger customer relationships, lower cost of goods sold due to secondary material supply, providing an alternative supply of critical raw minerals, mitigating risks associated with hazardous materials handling, and reduced environmental impacts. These benefits often result in no cost or discounts to consumers when they participate. Companies can estimate the success of their take-back programs by measuring the total mass of products sold against those collected each year.

According to PSI, take-back programs in the U.S. are most robust for electronics, with dozens already in place. Retailer programs include Best Buy, Circuit City, Costco, Staples, and Verizon, while manufacturer take-back programs exist at Apple, Canon, Dell, Oracle, and Sony (although many of these manufacturers and retailers change consumers for take-back, and/or do not have a physical drop-off location which makes take-back difficult when having to mail the item in, especially if it is large). A number of take-back programs also exist for prescription drugs. However, there is plenty of scope to improve existing programs (i.e. mandate free manufacturer sponsored collection points for electronic drop-off by residents and/or provide funding for municipal programs), as well as extend take-back programs to other hard-to-recycle products such as mattresses, paint and carpets.

Mandated Recycled Content (MRC)

MRC laws require that a certain percentage of recycled material be included in certain new products and packaging. MRC laws offer an opportunity for governments to promote innovation and creativity in product design while ensuring the quality and performance of recycled content products measure up to those made from virgin materials. Perhaps more importantly in the current context of global recycling markets, introducing minimum recycled content requirements for selected products and packaging in the U.S. can help ensure the continued movement of recyclables and provide an economic incentive to increase collection, irrespective of global markets conditions in China or elsewhere. This would make domestic producers more resilient to market fluctuations and would also help secure against job losses and the closure of MRFs.

MRC laws are most effectively passed at the national or state level rather than by cities or counties. It is not known whether Maryland is considering any MRC laws at this time. If so, however, setting minimum requirements that escalate over time is generally recommended, so as to gradually increase the use of recycled content in plastic products and packaging. This helps creates a level playing field for corporations while offering some flexibility. Examples of such a MRC law includes California's recently proposed Assembly Bill 792, which although not

passed in 2019 would have required 100% post-consumer recycled plastic to be used in beverage containers by 2035. By 2021, beverage containers would have to be made with at least 25% post-consumer recycled plastic, increasing to 50% in 2025, 75% in 2030, and 100% by 2035. Similar mandates are already in place in California for plastic film used for trash bags and rigid non-food containers.

Independent of government mandates, corporate commitments to minimum recycled content should also be encouraged. The Association of Plastic Recyclers' "Recycling Demand Champions" initiative is a good move in that direction. Some corporations have implemented their own initiatives: for example, Unilever has committed to using 50% post-consumer recycled content in its North American packaging by the end of 2019.

Container Deposit Law (CDL) or Bottle Bill

CDLs or bottle bills seek to increase rates of beverage container recovery by implementing a refund program. These are a proven, sustainable method of capturing beverage bottles and cans for recycling. The refund value of the container (usually 5 or 10 cents) provides a monetary incentive to return the container for recycling. This could help low income people with an additional source of revenue.

There is good experience in the U.S. with bottle bills, with 10 states having enacted some form of container deposit legislation. It is reported that recycling rates for beverage containers are higher compared to those states without such legislation and that roadside littering is generally lower. While bottle bills can be somewhat contentious, the City could consider developing a position on such a bill and advocating with the State Legislature to encourage its adoption. In that regard, however, it is noted that Maryland Legislature made repeated attempts to pass CDL proposals between 2013 and 2016, all of which failed. This suggests that it may not be feasible or realistic to spend time and resources pursuing this option, since jurisdictions tend to rely on the bottle material captured in MRFs for revenue and sustaining their solid waste programs.

Right to Repair Bill

Right to repair bills, typically focused on electronic devices and small appliances, refer to government legislation that is intended to allow consumers the ability to repair and modify their own consumer products, rather than being obligated by the manufacturer of such devices to use their (often expensive) repair or replacement services. Right to repair legislation has been introduced in 17 states. California Assembly Bill 1163 (2019), for example, would require manufacturers to make available sufficient service literature, at no charge, and functional parts, on fair and reasonable terms, to owners of a wide range of equipment or products, as well as service and repair facilities.

A right to repair bill in Maryland would support efforts to develop fix-it/repair clinics and other resource/material sharing opportunities in the City as discussed in Section 8.5. Although no legislative proposals are currently underway in Maryland, the Baltimore-based Maryland Public Interest Research Group as well as other advocacy groups are currently petitioning citizens to write to their legislator to support a bill.

Disposal Bans or Surcharge Fees

Food Scraps and Organic Waste

Organic waste disposal bans are a category of policy that has emerged in recent years at the state and local level, mainly to address food waste.

Defined broadly, organic waste bans refer to policies that restrict the amount of food waste and other organics that certain entities can dispose of to landfills or WTE incinerators, as well as those that require diversion or subscription to an organics collection/processing service. As evaluated in Section 3.3, placing restrictions on disposal of organic waste or adding surcharge fees to organics disposal are expected to be effective at driving food waste generators to explore more sustainable practices such as source reduction, donation, composting, and anaerobic digestion (AD). Surcharge fees earned for organics disposal can be used to accumulate capital for investment in composting/AD infrastructure.

To date, five states and six municipalities have implemented organic waste bans or mandatory recycling laws. Most of these policies took effect within the last five years. The states are California, Connecticut, Massachusetts, Rhode Island, and Vermont. The municipalities are Austin, TX, Boulder, CO, New York, NY, San Francisco, CA, and Seattle, WA. Additionally, Oregon Metro, the regional government for the Portland area, passed a policy in July 2018 that will require some businesses to divert food scraps. Austin's and Portland's food waste reduction and recycling policies were studied as part of the Task 4 benchmarking analysis for the LWBB Plan.

During the 2013 Maryland Legislative session, SB799 proposed to phase in restrictions on the disposal of "unprocessed" waste (mainly organics) to landfill and require recycling diversion rates of up to 50% of total waste generated in a landfill catchment zone. While this bill did not become law, it is an indication that Maryland could consider implementing mandatory waste diversion goals in the future.

Clothing and Textiles

The City of Markham in Ontario, Canada has banned textiles from disposal and is the first municipality in North America to do so. Residents must take clothing and textiles to one of over 110 bins located at fire stations, recycling depots, and large multi-family buildings. Bins contain sensors to detect fullness and signal when they need emptying. Two non-profit agencies collect and recycle all donated textiles.

Role of the Baltimore Zero Waste Plan

Geosyntec understands that advocacy for legislative initiatives will be a key focus of the BZWP, developed independent of the LWBB Plan. According to information shared to date, the BZWP intends to explore the City's role to lead the following statewide legislative efforts:

1. Extended producer responsibility and product stewardship to recycle items such as mattresses, paint, electronics, carpets, etc.
2. Addressing the mounting problems with plastics, including:
    a. Replacing #3, #6, and #7 plastics with more recyclable, less toxic resins;
    b. Phasing out avoidable, single-use plastics most likely to cause marine litter;
    c. Product take-back programs;
    d. Supporting commitments to use more recycled content, build more U.S. remanufacturing facilities and support programs that collect materials;
    e. Investing in bottle-to-bottle recycling, not chemical recycling of low-value plastics; and

f. Scaling up polypropylene (PP, #5 plastic) market development and collection programs.

3. Investing substantially in reusable packaging as a business model, focusing on innovative solutions that reject disposable as the default condition.

As noted in the introduction to this section, the LWBB Plan does not encourage direct advocacy for any particular legislation. However, the LWBB Plan broadly supports the BZWP's goals of advocating for these legislative initiatives, many of which overlap with initiatives outlined in Chapter 8. The BZWP should provide addition details and specifications as to how it envisions the City could successfully engage in such advocacy.

8.7 Other Options

Inter-Jurisdictional Partnerships

The City should consider developing or joining inter-jurisdictional partnerships with neighboring counties and cities to facilitate knowledge sharing and exchange of ideas. Such partnerships could serve to:

1. Explore joint procurement opportunities and sharing of critical infrastructure for new waste diversion programs (e.g., waste transfer, sorting, and/or composting or AD facilities); and
2. Work towards harmonizing programs so that residents who work and live in the region all have access to similar levels of service.

Partnerships could also explore opportunities for joint market development, including under zero waste or circular economy initiatives.

Green Procurement

Green procurement is defined as purchasing products and services that cause minimal adverse environmental impacts while incorporating human health and environmental concerns into the search for high quality products and services at competitive prices. Common examples for local government agencies include requiring the purchase of Energy Star computers, printers, and copiers as well as energy saving vending machines; paper products with minimum 30% post-consumer recycled content; green cleaning supplies; and remanufactured toner cartridges.

Specific details regarding green procurement policies that are currently mandated or voluntarily practiced by the City are not clear. However, the City should consider leading by example in achieving the waste diversion recycling goals of the BSP. Options to consider if not already practiced include:

1. Eliminating EPS/Styrofoam and other single-use plastics from all City food service contracts;
2. Requiring contractors and vendors bidding to perform City contracts to be prequalified as having green credentials (e.g., construction related contractors bidding on large projects could be required to show a certain number of Leadership in Energy and Environmental Design (LEED) Accredited Professionals on staff);
3. Requiring the use of recycled materials in public construction and renovation projects, including to meet LEED certification standards;
4. Requiring the use of food waste or yard waste derived compost for City landscaping contracts;

5. Requiring that purchasing requests for food or other supplies include language to increase the percentage that is locally sourced; or
6. Giving preference to vendors offering refurbished or remanufactured products.

Successful implementation of green procurement policies will require investment in training of staff in the specific goals and procedures related to proposed programs.

Supporting Innovation and Research

Spurring innovation in new ways to reduce and reuse waste could actively contribute to meeting the waste diversion and recycling goals of the LWBB Plan. Examples suggested by survey responders include hosting a "Shark Tank" style event for innovative ideas to reuse plastic, studying other countries and cultures to find creative ways of reusing materials, or sponsoring high school students and university research teams to find new ways to use waste products or develop markets for secondary materials. Other options include providing grants to social enterprises, entrepreneurs, mission-based recyclers/composters/digesters, reuse organizations, or decentralized worker-owned cooperatives to assist City residents and businesses in implementing innovative reduction, reuse, recycling and composting programs. To ensure transparency, grants should be awarded following review of proposals received in response to open requests for proposals (RFPs). RFPs may be broad in seeking any innovative idea or may be tailored to a specific need. Offering open RFPs in this way can help support small businesses and non-profits, which are often highly accountable to neighborhoods, and can serve as engines for youth engagement and training.

Business incubators serve as catalysts for local or regional economic development and could be an effective mechanism for spurring innovation and research into advanced waste diversion and recycling technologies and programs. Incubators are private or public facilities that help new and startup companies grow by providing seed capital and/or services such as management training and office or laboratory space. Two good examples of recycling related incubators are:

1. The Innovation Barn (Charlotte, NC): Developed as part of the Circular Charlotte initiative (studied as part of the Task 4 benchmarking exercise), which outlines a commitment to adopting the circular economy as a public sector strategy for waste diversion and recycling, the Barn is Charlotte's first experimental hub. The Barn is intended to become the physical seat of circular activities around Charlotte, encouraging participation and providing ways of engagement for all residents. A key feature planned for the Barn is the Materials Innovation Lab, a concept for a university-affiliated student-startup incubator program focused on reducing the total amount of organic waste by generating and supporting innovative local initiatives for high-value upcycling of specific organic waste fractions. The vision for the Lab is that Charlotte can tap into the rising trend in the number of local startups using organic waste streams to produce new products or resources, thereby stimulating entrepreneurial spirit. Charlotte estimates the Lab would require an initial investment of around $60,000, and an annual budget of around $220,000 to cover salaries, marketing, and overheads, with an optional $600,000 in annual seed investments for the approximately 60 startups.

2. Pennsylvania Recycling Markets Center (Harrisburg, with satellites in Pittsburgh and Philadelphia): The mission of the Center, which commenced operations in 2005, is to expand and develop more secure and robust markets for recovered materials by helping to overcome market barriers and inefficiencies. The Center aims to be the state's clearinghouse of environmental, economic development, and manufacturing resources for end use support of recycled commodities and products. Activities are centered around feedstock conversion, research and commercialization, technology acceleration, and outreach and information. The Center reports having helped 680 Pennsylvania organizations and businesses since 2005 with a return on investment to the state of $6.70 for every $1.00 spent.

9. OTHER SERVICE IMPROVEMENTS

Although the LWBB Plan is focused on medium- to long-term changes that the City and the broader community of stakeholders in Baltimore could implement to effect meaningful improvements in waste diversion and recycling, many comments/suggestions received from residents and other stakeholders at outreach meetings and via the online survey related to dissatisfaction with current services. This suggests that getting waste materials into the existing waste collection system is a more urgent focus in some neighborhoods than efforts to separate materials into different streams to improve recycling. Specifically, comments expressed dissatisfaction around the themes of:

- Infrequency of street cleaning and litter removal services in many neighborhoods;
- The inadequate number of trash cans and recycling bins provided on streets and in parks, public areas, or for special events;
- Illegal dumping, and DPW's (perceived) slow response to cleanup illegal dumping once reported;
- Overflowing cans or waste placed out in plastic bags adding to the city's rat problem;
- Litter accumulation in storm drains contributing to pollution in the Inner Harbor and Chesapeake Bay;
- Unreliability of collection services (e.g., scheduled trash/recycling pickup dates aren't always honored and there seems to be no back-up plan in place when this happens);
- Lack of enforcement of penalties for littering, dumping, bulk trash setouts, and not moving cars for street sweeping; and
- Lack of engagement and ownership amongst residents in keeping their own neighborhoods clean.

An editorial in the Baltimore Sun from 11 April 2019, "Baltimore's perpetual trash problem," effectively summed up many residents' frustrations and provided historical context to some current issues.

While these are major issues that need to be addressed, it is understood that DPW in conjunction with the Major's Office and other City departments has been actively investigating new approaches to clean up the city, in particular, managing the issue of illegal dumping and clean up, which puts a major strain of DPW's budget for solid waste management. Following many outreach meetings and conversations with community leaders, DPW is planning several pilot programs in high priority neighborhoods. In each case, DPW is hoping to go beyond addressing illegal dumping and littering by looking at ways to increase overall recycling rates or, in some cases, restart recycling programs that have effectively ceased functioning.

Given DPW's active stance, the discussion in this chapter does not elaborate in much detail on addressing immediate deficiencies, perceived or otherwise, or on making short-term improvements to existing services. The brief discussion is rather focused on new products and other innovations that could be bring about operational and administrative efficiencies. An important driver for the discussion is widespread sentiment that DPW's services – in particular street sweeping, number of public trash and recycling receptacles, litter control, and removal of illegally dumped bulky trash – are disproportionately provided to affluent neighborhoods. Therefore, a key goal must be that DPW is seen to be providing services equitably across all neighborhoods consistently and reliably. This will require analyzing allocation of resources in

neighborhoods and communities to ensure all areas are served properly. Better community outreach on these issues will be critical. In this regard, it is understood that community outreach and equity will be key components of the BZWP. As noted previously, this LWBB Plan supports the BZWP in these outreach efforts, details of which should be elaborated therein.

9.1 Operational

Street Sweeping and Litter Control

This subsection summarizes stakeholder feedback and provides some suggestions on investments and changes that could be made to improve existing services.

1. Education: Baltimore needs to build ownership to keep neighborhoods clean, which requires educating residents and schoolchildren on littering and what is recyclable (e.g., through anti-littering campaigns and PSAs).
2. Lids for Recycling Bins: Currently, trash cans are required to have well-fitting lids but recycling bins – including the 25-gal. and 18-gal. bins available from DPW – are not required to have lids. This results in recycling being blown around and adding to litter on windy days. Open bins set out the evening before collection also invite passersby to drop trash into them. To address this, the City could consider an ordinance requiring recycling bins to have lids.
3. Street Sweeping: The current street sweeping schedule is seen as intermittent and hard to understand. This could be improved by ensuring sweepers come as scheduled and by making the schedule simpler to understand. The efficacy of street sweeping could be improved by offering sweeping services in more places (e.g., alleys) and by enforcing parking rules for sweeping days.
4. Litter Crews: DPW could provide more litter cleanup crews, separate from curbside collection crews, or alternatively contract private organizations for street litter collection. One example is to have "on calls" for rapid cleanup of litter or illegal dumping by small hauling contractors.
5. Litter Collection Drives: The City could organize litter collection initiatives with local schools or communities, providing certificates for community service hours and/or offering awards for groups that clean up and recycle the most litter. This could be conducted as an extension of the biannual Mayor's Spring and Fall Cleanups in which participants earn credits towards their stormwater fee.
6. Responsible Businesses: The City could conduct educational campaigns to encourage businesses such as restaurants, cafes, and stores to collect litter from in front of their premises.
7. Residents' Litter Squads: The City could create jobs for those who need them by hiring squads to collect litter and bulk trash from the streets. Squads could be staffed by vulnerable and at-risk members of the community (e.g., youth and homeless people), connecting and organizing them with additional support services. Communities are less likely to tolerate littering and dumping in areas they have cleaned. Examples of U.S. cities that have programs to give homeless people and panhandlers jobs picking up trash, pulling weeds, and street cleaning include Albuquerque, NM, which started their program in 2015, as well as Los Angeles, CA, Chicago, IL, Denver, CO, and Portland, ME.

A good case study of a successful, citywide initiative to reduce litter and clean up neighborhoods is San Fernando, Philippines, a city of 300,000 people that increased the percentage of trash diverted from landfills (or that ended up as litter clogging storm drains and waterways) from 12% in 2012 to 80% in 2018. Municipal and community leaders attribute the initiative's success to a combination of local government commitment, strict, zero-tolerance implementation of policies, and a robust educational campaign for households. Neighborhoods take direct responsibility and ownership over recycling and composting at a community scale.

Trash and Recycling Collection Services

Curbside Collection

Overall, most survey responders indicated they were satisfied with their curbside collection services. However, some residents complained that roads and alleys are littered due to messy waste collection practices and suggested providing collection crews with brooms and shovels to clean up waste dropped during collection. DPW may consider reviewing the efficiency and effectiveness of their existing collection system (including collection practices, routing efficiencies, and staffing efficiencies) to optimize their collection system.

With regard to household bins/carts, some stakeholders complained that DPW's yellow recycling bins are too small and not accessible to everyone as they are sold (albeit for a modest fee) rather than provided for free. It was suggested that free recycling bins should be provided to all households. It was also suggested that DPW's existing green trash carts should be converted to recycling carts and a new smaller trash cart provided (this is assessed as an option to improve curbside recycling in Section 4.2). It was also suggested that DPW should create a way for residents to donate money towards others' recycling bins (similar to BGE utility donations).

Collection in Public Spaces

Some stakeholders requested that more public cans be provided on streets and in parks, public areas, or for special events. In this regard, rather than simply providing a larger number of cans in more places, all of which would require additional emptying by collection crews, DPW could look for ways to embrace the smart transformation of waste operations in public spaces that many other U.S. cities have implemented. Details on some smart collection systems were provided in Section 4.3.

Illegal Dumping

It is noted that DPW is actively investigating new approaches to clean up the city, in particular managing the issue of illegally dumping; therefore, the LWBB Plan does not specifically look at this. However, many residents complained about widespread illegal dumping and provided suggestions for how to address this issue. These include:

1. Provide stronger enforcement of fines for illegal dumping violations equally throughout the city;
2. Offer more bulk trash pickup;
3. Use surveillance cameras in highly impacted areas to identify people illegally dumping their trash;
4. Remove fees for small haulers and residents using commercial vehicles (e.g., U-Haul vans) at QRL, NWTS, and the other residents' drop-off centers;

5. Contract residents and/or small haulers to pick up and transport illegally dumped waste in their private vehicles;
6. Increase DPW staff capacity to improve reliability of waste collection services and information and to provide better response to illegal dumping, including following up more promptly on complaints from 311 calls/website;
7. Identify common illegal dumping sites (e.g., in Carrollton Ridge, Shipley Hill, and Edmondson Village), place a dumpster there, and schedule regular collections;
8. Get input from local haulers who could help identify the culprits of illegal dumping;
9. Require small haulers of junk to report where they take the materials they collect;
10. Maintain a list of registered contractors to help track and identify where illegally dumped material is coming from;
11. Use social media to reward those reporting illegal dumping, and to publicize contractors and small haulers determined to be illegally dumping so others don't use them;
12. Establish a smartphone app that would provide credits or coupons to people who take verifiable pictures of illegal dumping in the act;
13. Work more closely with community development organizations, neighborhood business districts, conservation land trusts, BMORE Beautiful, small haulers, and other interested parties to explore and provide opportunities for the purchase and transfer of derelict land and buildings to residents and nonprofits to create public safe clean green spaces, reduce blight, and implement a vision of community led stewardship for the land;
14. Require absentee landowners to perform cleanups and make the site improvements required by the City, or forfeit their property under eminent domain for transfer to a Conservation Land Trust that is willing to make those site improvements; and
15. Transfer lands in public ownership (e.g. plots where public housing was torn down but not replaced) to Conservation Land Trusts to begin pilot programs.

To engender trust in moving forward to address community concerns, it was recommended that DPW expand its existing Clean City Committee to address concerns from communities that feel they are currently under-served by waste collection and cleanup programs.

9.2 Administrative

DPW's current administration of solid waste and recycling services was described in detail in the Task 3 Report for the LWBB Plan. This master planning effort does not look in any detail at modifying existing administrative structures or responsibilities for providing existing services, but only summarizes administrative changes/additions that may be required to implement options proposed in previous chapters.

Investigation and Enforcement

Along with education, investigation and enforcement are critical to the successful implementation of any of the option presented in this Report. Several options discussed the need for an investigation and enforcement component to ensure compliance, which would require additional City staffing efforts. These efforts and costs were estimated for each option and are stated where relevant.

It will be important for the City to be fully committed to investigating non-compliance, issuing citations and fines, and following up where penalties are unpaid, including for existing ordinances. Higher rates of participation in and compliance with new programs can only be successfully where businesses and residents see consequences for non-compliance. This means that the City also needs to enforce existing statutes, such as littering and the use of nets/tarps on haulage trucks to prevent debris from falling off. Other statutes to consider include increasing the number of zones where moving cars for street-sweeping is mandatory rather than voluntary. As widely expressed at community meetings and in the online survey, the City's apparent non-enforcement of existing statues reduces residents' confidence in their willingness and ability to enforce future laws.

Some other stakeholder suggestions include:

1. Increase surveillance (e.g., set up cameras at areas with a lot of illegal dumping);
2. Ensure fines are charged to the responsible party (e.g., landlords should be fined if they fail to provide sufficient trash and recycling cans to apartment residents; residents should not be fined); and
3. Empower community surveillance of waste laws (e.g., post warning signs about laws including littering and landlord trash can requirements, launch a "see something, say something" campaign, or organize monthly walks with residents to identify and report dumping areas).

To track progress (i.e., expenditure on enforcement vs. results), the City could document the number of enforcement activities needed each year (e.g. fines for illegal dumping, "oops" stickers for contamination in recycling bins) as a measure of the effectiveness of education, outreach, and enforcement activities. An alternative measure is to use waste audits, although this would be costlier.

Coordination and Communication

Finally, stakeholders provided some suggestions on changes that could be made to improve administration of DPW's trash and recycling services. Implementing these changes would require hiring more full-time employees.

1. 311 Service: Several suggestions for improving the 311 service were provided, most of which involved improving the service request rate and providing better and more prompt feedback about the status of a request.
2. Online and Social Media: Increase social media presence to help inform residents of service changes or updates in near-real time. This could include direct linkage to DPW's existing website and Recycle Coach app. The website and app could also promote upcoming special events (e.g., swap events, fix-it clinics) for residents to repair, reuse, or recycle materials.
3. Coordination: Cleanup efforts should be coordinated with other departments/offices (e.g., Police Department, Health Department, and DHCD).

Other suggestions to improve alignment and coordination between City departments/offices and plans have been addressed extensively throughout this Report.

10. SUMMARY OF MAJOR FINDINGS

This final chapter contains a summary of the main options considered in this Report. Section 10.1 contains detailed summary tables for each of the major options considered, followed by a comparative summary of each option. Thereafter, Section 10.2 summarizes the combination of options that achieves the **maximum diversion potential (MDP)**. Section 10.3 discusses expected timing and phasing issues for achieving the MDP, enabling illustration of the range of available options between the "status quo," which would maintain overall waste diversion in Baltimore at about 50%, and the MDP, which would boost the overall diversion rate to its maximum achievable level. Based on this, Section 10.3 also summarizes the estimated quantity and composition of waste that would still require disposal between 2020 and 2040 under various levels of performance between the "status quo" option (i.e., 0% of MDP) and the MDP. It is reiterated that many options are susceptible to underperforming and are sensitive to cost overages. As such, wholesale rollout of programs at full capacity is not envisioned. Instead, the City would be better advised to explore incremental rollout on a pilot scale with expansion only after success can be demonstrated. This is reflected in discussions on phasing.

10.1 Quantitative Summary of Options

This section contains summary tables for the major categories of options considered in this Report, followed by an objective comparative summary of each option within a material or facility class. **With the exception of CAPEX, numerical values in the tables are annual**. Where appropriate, expected costs to the City are identified. Other potential cost allocations between the public and private sectors were discussed previously.

Section 3.1 – Reducing Food Wastage: Summary of Major Findings

Metric		Description
	**Max. Diversion Potential**	Universities: 3,250 tons Commercial: 20,400 tons Residential: 48,750 tons **TOTAL: 72,400 tons**
	**Costs**	**Programs:** Not calculated (see Section 3.1) **Administration:** $4.7M OPEX **Indirect Costs:** • Reduced tip fees at QRL • Job losses at disposal facilities • Reduced demand for local food (farmers) • Increased need for donations
	**Benefits**	**Environmental:** -304,600 MTCO2E **Airspace:** $4.9M **Indirect Benefits:** • Reduced trash collection frequency • Savings on food purchase/waste collection (residents and businesses) • Downstream employment opportunities
	**Challenges**	• Changing buying/disposal habits • Resistance from affected businesses • Hygiene standards for food rescue
	**Experience**	• Current recycling/source reduction programs
	**Timeline**	• BFWRS target: 50-100% reduction by 2040 (depending on sector) • Begin with City government/public schools

Section 3.2 – Residential Organics Diversion: Summary of Major Findings

Metric		Description			
		Scenario RO1[1]		Scenario RO2[1]	
	Max. Diversion Potential	Public Schools: 2,150 tons food waste (FW); no yard waste (YW) Government Offices: 1,900 tons FW; no YW Residential: 48,750 tons FW; 29,000 tons YW **TOTAL: 52,800 tons FW; 29,000 tons YW**		Government Offices: 1,900 tons FW; no YW Public Schools: 2,150 tons FW; no YW Residential: 9,750 tons FW; 29,000 tons YW **TOTAL: 13,800 tons FW; 29,000 tons YW**	
	Costs	**Scenario RO1-A[1]** **Collection:** • CAPEX: $7.4M • OPEX: $13.1M **Processing:** • No. Facilities: 6 • CAPEX: $16.0M • OPEX: $6.2M	**Scenario RO1-B[1]** **Collection:** • CAPEX: $14.4M • OPEX: $13.1M **Processing:** • No. Facilities: 6 • CAPEX: $16.0M • OPEX: $6.2M	**Scenario RO2-A[1]** **Collection:** • CAPEX: $7.4M • OPEX: $13.1M **Processing:** • No. Facilities: 4 • CAPEX: $10.7M • OPEX: $4.1M	**Scenario RO2-B[1]** **Collection:** • CAPEX: $14.4M • OPEX: $13.1M **Composting:** • No. Facilities: 4 • CAPEX: $10.7M • OPEX: $4.1M
	Benefits	**Revenue:** $3.0M **Jobs:** 54 **GHG:** -19,100 MTCO2E **Airspace:** $5.5M	**Revenue:** $3.0M **Jobs:** 194 **GHG:** -19,100 MTCO2E **Airspace:** $5.5M	**Revenue:** $2.0M **Jobs:** 36 **GHG:** -4,500 MTCO2E **Airspace:** $2.9M	**Revenue:** $2.0M **Jobs:** 176 **GHG:** -4,500 MTCO2E /year **Airspace:** $2.9M
	Challenges	• Promoting participation: Difficult to persuade residents to separate organics; stigma of odor, bugs, vermin, etc. • Enforcement: Voluntary program may not meet diversion goals; mandatory program is hard/expensive to enforce • Siting: Large, inexpensive lots may be hard to come by			
	Experience	• City has minimal experience managing composting/AD facilities; may considering hiring private company (incl. under PPP) • DPW has experience collecting trash and/or recycling from SFH, government buildings, small businesses, and public schools • DPW has most of the collection equipment and staff required to implement a SSO collection program • DPW has experience leading education and outreach campaigns to promote recycling and to reduce littering			
	Timeline	• Phase 1: Public schools and government office; 2 year implementation; first compost facility at City-owned property; • Phase 2: Staged rollout to city neighborhoods; 10-year implementation; construct compost/AD facilities as needed • Full diversion potential may take up to 20 years to realize			

Notes: 1. Scenario RO1 = City does not meet BFWRS reduction goals; RO2 = City meets BFWRS reduction goals; A = Optimistic assumptions for collection; B = pessimistic assumptions for collection

Section 3.3 – Commercial Organics Diversion: Summary of Major Findings

Metric		Scenario CO1[4]					Scenario CO2[4]				
		Option 1[5]	*Option 2*[5]	*Option 3*[5]	*Option 4*[5]	*Option 5*[5]	*Option 1*[5]	*Option 2*[5]	*Option 3*[5]	*Option 4*[5]	*Option 5*[5]
	Max. Diversion Potential[1]	**F**: 44,050 **Y**: 15,150 **T**: 59,200	**F**: 13,950 **Y**: 4,800 **T**: 18,750	**F**: 9,450 **Y**: 3,250 **T**: 12,700	**F**: 3,200 **Y**: 1,100 **T**: 4,300	**F**: 6,350 **Y**: 2,200 **T**: 8,500	**F**: 20,400 **Y**: 15,150 **T**: 35,550	**F**: 5,250 **Y**: 3,900 **T**: 9,150	**F**: 3,550 **Y**: 2,650 **T**: 6,200	**F**: 1,250 **Y**: 900 **T**: 2,150	**F**: 2,450 **Y**: 1,800 **T**: 4,250
	Costs[2]	**Coll+Com:** **C:** $19.6M **O:** $9.6M **No.:** 5 **Admin:** **O:** $280K	**Coll+Com:** **C:** $7.4M **O:** $3.5M **No.:** 2 **Admin:** **O:** $280K	**Coll+Com:** **C:** $4.0M **O:** $2.0M **No.:** 1 **Admin:** **O:** $280K	**Coll+Com:** **C:** $3.2M **O:** $1.4M **No.:** 1 **Admin:** **O:** $160K	**Coll+Com:** **C:** $3.6M **O:** $1.7M **No.:** 1 **Admin:** **O:** $530K	**Coll+Com:** **C:** $11.8M **O:** $5.8M **No.:** 3 **Admin:** **O:** $280K	**Coll+Com:** **C:** $3.7M **O:** $1.7M **No.:** 1 **Admin:** **O:** $280K	**Coll+Com:** **C:** $3.3M **O:** $1.5M **No.:** 1 **Admin:** **O:** $280K	**Coll+Com:** **C:** $3.0M **O:** $1.2M **No.:** 1 **Admin:** **O:** $160K	**Coll+Com:** **C:** $3.2M **O:** $1.4M **No.:** 1 **Admin:** **O:** $460K
	Benefits[3]	**Revenue:** **P:** $2.5M **G:** $390K **Jobs:** **P:**119 **G:** 3 **GHG:** -1.9K	**Revenue:** **P:** $1.0M **G:** $200K **Jobs:** **P:** 42 **G:** 3 **GHG:** -600	**Revenue:** **P:** $500K **G:** $80K **Jobs:** **P:** 25 **G:** 3 **GHG:** -400	**Revenue:** **P:** $500K **G:** $2.8M **Jobs:** **P:** 15 **G:** 1 **GHG:** -140	**Revenue:** **P:** $500K **G:** $0 **Jobs:** **P:** 21 **G:** 1 **GHG:** -270	**Revenue:** **P:** $1.5M **G:** $390K **Jobs:** **P:** 71 **G:** 3 **GHG:** -760	**Revenue:** **P:** $500K **G:** $200K **Jobs:** **P:** 21 **G:** 3 **GHG:** -200	**Revenue:** **P:** $500K **G:** $80K **Jobs:** **P:** 17 **G:** 3 **GHG:** -130	**Revenue:** **P:** $500K **G:** $2.5M **Jobs:** **P:** 13 **G:** 1 **GHG:** -50	**Revenue:** **P:** $500K **G:** $0 **Jobs:** **P:** 15 **G:** 1 **GHG:** -100
	Challenges	• Encouraging participation: Organics disposal bans (Options 1-3) are likely to be unpopular and costly for businesses • Enforcement: City would have to hire and train inspectors to enforce organics disposal bans • Processing Capacity: Currently there is little available processing capacity for organics in/around Baltimore									
	Experience	• Recycling Administration: DPW currently administers a successful commercial recycling program • Inspections: DPW currently performs thousands of annual inspections as part of rat abatement • Polystyrene Ban: City has implemented a commercial ban on polystyrene									
	Timeline	• Four phases: Phase 1 would be Options 4 and 5; Phase 2 would be Option 3; Phase 3 would be Option 2; Phase 4 would be Option 1 implemented as a permanent policy • Full diversion potential may take up to 20 years to realize									

Notes:
1. "F" refers to food waste, "Y" refers to yard waste, and "T" refers to total organic waste.
2. "C" refers to CAPEX, "O" refers to OPEX, and "No." refers to the number of composting/AD facilities required; M = million, K = thousand
3. "P" refers to process operator (assumed private sector), "G" refers to City government; M = million, K = thousand
4. Scenarios: CO1 = City does not meet BFWRS reduction goals, CO2 = City meets BFWRS reduction goals
5. Options: 1 = blanket ban; 2 = ban on large generators; 3 = ban on very large generators; 4 = disposal surcharge; 5 = credit for organics collection

Section 4.2 – Improved Curbside Recycling: Summary of Major Findings

Metric		Description				
	Max. Diversion Potential	84,200 tons				
	Costs[1,2]	**Cost**	**Op. 1**	**Op. 2**	**Op. 3**	**Op. 4**
		CAPEX	$7.0M	$0	$0	$7.0M
		OPEX	$0	- $6.2M	$12.3M	$0
	Benefits	• Cost offsets (Option 2) • GHG: -194,300 MTCO2E • Airspace: $5.7M				
	Challenges	• Public resistance: small trash bins, monthly cost (SAYT), less frequent trash collection • Contamination: Options 1, 2, 4 reduce trash volume and encourage residents to put more in recycling bin • Vermin: Option 1 and 2 may encourage residents to place uncontained trash bags on curbside for pickup				
	Experience	• Expansion of existing collection programs • Inspections: rat abatement program				
	Timeline	• Options 1, 2, and 4 could be implemented relatively quickly (within 5 years) • Option 3 may require additional planning and educational outreach prior to implementation, which may take 10 years				

Notes: 1. Options: 1 = change bin size/allocation; 2 = reduce trash collection frequency; 3 = multi-stream recycling; 4 = SAYT
2. Costs are assumed to be borne by the City

Section 4.3 – Expanded Access to Recycling: Summary of Major Findings

Metric		Description		
	Max. Diversion Potential	69,300 tons		
	Costs[1]	**Option**	**CAPEX**	**OPEX (annual)**
		1	$1.1M	$740,000
		2	$150,000	$150,000
		3	$8.2M	--
		4	--	$30,000
		5	$7.3M	$5.2M
	Benefits	• 50% collection cost offset for Option 3 • GHG: -155,500 MTCO2E • Jobs: 14 for Option 1, 3 for Option 2, 0 for Option 3, 0.5 for Option 4, 86 for Option 5 • Airspace: $ 4.7M		
	Challenges	• Promoting participation in the program • Enforcing participation • Contamination of recycling stream		
	Experience	• Existing collection programs • Smart cans already used • DPW already supports recycling services at special events		
	Timeline	• Options 2, 3, and 4 are short-term and can be implemented within five years • Options 1 and 5 may be more intermediate to long-term (10-15 years)		

Notes: 1. Options: 1 = collect from MFDs; 2 = provide mobile collection units; 3 = improved collection from public spaces; 4 = improved collection from special events; 5 = collect from commercial generators

Section 4.4 – Increased Recycling Processing Capacity: Summary of Major Findings

Metric		Description			
	Max. Reduction Potential	**No additional:** Diversion is captured in Section 4.2 and 4.3			
	Costs[1]	**Cost**	**Op. S1**	**Op. ML1**	**Op. ML2**
		CAPEX	$0	$40.0M	$17.6M
		OPEX	$10.6M	$10.6M	$10.4M
	Benefits	**Benefit**	**Op. S1**	**Op. ML1**	**Op. ML2**
		Revenue[2]	$0	$3.8M	$3.8M
		Jobs	0	21	160
		GHG	-	-	-
		Airspace	-	-	-
	Challenges	• Depressed/volatile recycling market • Option ML1 has large space requirements • Option ML2 may require purchase of new specialized truck fleet			
	Experience	• City has minimal experience operating MRFs			
	Timeline	• Timeline for all option driven by collection options outlined in Section 4.2 and 4.3 • Options ML1 and ML2 require MRF construction; roughly 10 years to meet full diversion potential			

Notes: 1. Options: S1 = Continued contract with WMRA; ML1 = develop large centralized MRF; ML2 = develop system of "mini MRFs"
2. Revenues are subject to change; recycling market volatility is very high

Section 5.1 – Reduction and Reuse of C&D Waste: Summary of Major Findings

Metric		Description
	Max. Reduction Potential	Commercial C&D - Clay bricks and lumber: **28,350 tons**
	Costs[1]	**Option 1: Mandatory Deconstruction** • OPEX: $130,000 **Option 2: Architectural Salvage Program** • OPEX: $60,000; negligible if Option 1 is also implemented.
	Benefits	**Revenue:** Citation revenue expected from Option1, but not quantified here. **Jobs:** 3 for Option 1, 1 for Option 2 **GHG:** -25,000 MTCO2E **Airspace:** $1.9M
	Challenges	• Pushback from demolition companies – mandatory deconstruction could negatively impact demolition business. • Lack of demand/marketing for repurposed C&D waste • Lack of experience with C&D programs – DPW does not currently take an active role in C&D disposal/diversion
	Experience	• Education/Outreach – recycling and source reduction programs • Inspections: rat abatement program
	Timeline	• Options 1 and 2 could be implemented within 5 years

Notes: 1. All costs are assumed to be borne by the City

Section 5.2 – Diversion of C&D Debris: Summary of Major Findings

Metric		Description	
		Scenario CD1[1]	**Scenario CD2[1]**
	Max. Diversion Potential	Lumber: 16,750 tons Concrete: 156,550 tons Asphalt Concrete: 31,550 tons Asphalt Shingles: 5,600 tons Drywall: 6,400 tons **TOTAL: 216,850 tons**	Lumber: 0 tons Concrete: 156,550 tons Asphalt Concrete: 31,550 tons Asphalt Shingles: 5,600 tons Drywall: 6,400 tons **TOTAL: 200,100 tons**
	Costs	**C&D MRF:** • CAPEX: $22.1M • OPEX: $20.1M **Administration:** • OPEX: $180,000	**C&D MRF:** • CAPEX: $20.5M • OPEX: $17.9M **Administration:** • OPEX: $180,000
	Benefits	**Revenue:** $24.5M **Job Creation:** 30 (MRF), 3 (Administration) **GHG:** -32,700 MTCO2E **Airspace:** $14.6M savings	**Revenue:** $22.1M **Job Creation:** 30 (MRF), 3 (Administration) **GHG:** -32,700 MTCO2E **Airspace:** $13.5M savings
	Challenges	• Promotion: Difficult to persuade contractors to participate if program is not mandatory • Performance: Voluntary program may not meet diversion goals; mandatory program is hard/expensive to enforce • Siting: Large, inexpensive lots are hard to come by	
	Experience	• City has minimal experience managing C&D facilities; may considering hiring private company (incl. under PPP) • DPW has experience leading education campaigns to promote recycling • City has experience with waste disposal bans (polystyrene ban) • City has experience conducting inspections (incl. rat abatement program)	
	Timeline	• MRF permitting and construction is likely to take 2-3 years following implementation of the chosen policy option • The full diversion potential for this option may take as much as 20 years to realize	

Notes: 1. Scenarios: CD1 = city does not meet reduction goals in Section 5.1; CD2 = City meets reduction goals in Section 5.1

Section 6.1 – Bulk Trash Reduction and Diversion: Summary of Major Findings

Metric		Description
	Max. Reduction Potential	Reduction: 2,550 tons Diversion: 1,500 tons
	Costs[1]	• Education/Outreach: $50,000 • Waste to art: $50,000 • Fix-It Clinics: < $20,000 • Donation: Negligible • Fines/Charge for Collection: Cost of inspections, savings from fines/charges • Reduce collection frequency: Cost savings • Recycling Center: See Section 7.1
	Benefits	• Environmental: -11,400 MTCO2E • Airspace: $277,000 savings • Indirect: Downstream employment
	Challenges	• Sourcing recycling facilities • Education/outreach: changing habits • Difficulties for residents without vehicles • Inspection program/hiring inspectors • Illegal dumping
	Experience	• Current recycling and littering education programs • Bulk waste collection services • Inspections for rat abatement
	Timeline	• Most policies outlined here can be implemented within the next 5 years

Notes: 1. All costs are assumed to be borne by the City

Section 7.1 – Expanded Residents' Drop-Off Facilities and Small Hauler Program: Summary of Major Findings

Metric		Description
	Max. Diversion Potential	**Option 1 – New DOCs**: 7,800 tons **Option 2 – Expand DOCs:** 16,100 tons
	Costs[1]	**Option 1:** • CAPEX: $9M - $15M, ave. $12M • OPEX: $1.1M **Option 2:** • CAPEX: $200,000 • OPEX: $360,000
	Benefits	**Benefit** / **Option 1** / **Option 2** Jobs / 18 / 6 GHG / -8,800 / -25,800 Airspace / $ 527,000 / $ 1.1M
	Challenges	• Land acquisition and permitting • Education/outreach to change habits • Space restrictions at existing facilities
	Experience	• DPW currently operates several DOCs and the small hauler program
	Timeline	• Option 1: within 5 years, depending on land acquisition and permitting • Option 2: within 5 years, depending on space restrictions at existing facilities

Notes: 1. All costs are assumed to be borne by the City

Section 7.2 – Constructing a Resource Recovery Park
Expected Challenges and Benefits

Metric		Description	
	Diversion Potential	391,500 tons	
	Costs	**CAPEX:** $72.7M **OPEX:** $32.7M	
	Benefits	**Benefit**	**Value**
		Revenues	$25.0M
		Net Jobs	42
		GHG	-388,500 MTCO2E
		Airspace	$26.4M
	Challenges	• Land acquisition would be expensive and time consuming • DPW lacks experience with organics processing and MRF operation	
	Experience	• DPW currently operates large facilities (QRL, NWTS) as well as several drop-off centers	
	Timeline	• Permitting would be complex and time consuming • 5-10 years estimated for full buildout • Development could be phased to meet demand for services (e.g., composting facility only built once enough organics are collected)	

TABLE 10.1 – Comparison of Organics Reduction/Diversion Options from Chapter 3

Report Section	Description	Option[1]			Diversion Potential		CAPEX	Annual Net OPEX[5]	Job Creation	Annual GHG Reduction	Annual Airspace Offset Savings
		Scenario	#	Description	Total[3,4] (tons)	% BSP[6]	($/ton)	($/ton)		(MTCO2E)	
3.1	Food Waste Reduction	-	-	Varies - see text	72,400	11.0%	$ 687	$ 3,411	not calculated	-304,600	$ 4.9M
3.2	Residential Organics Diversion	RO1[1]	A	SSO coll. + compost	81,800	12.5%	$ 286	$ 200	54	-19,100	$ 5.5M
			B	SSO coll. + compost			$ 372	$ 200	194		$ 5.5M
		RO2[1]	A	SSO coll. + compost	42,800	6.5%	$ 422	$ 357	36	-4,500	$ 2.9M
			B	SSO coll. + compost			$ 586	$ 357	176		$ 2.9M
3.3	Commercial Organics Diversion	CO1[2]	1	Blanket ban	59,200	9.0%	$ 332	$ 119	122	-1,900	$ 4.0M
			2	Ban large generators	18,750	2.9%	$ 392	$ 138	45	-600	$ 1.3M
			3	Ban very large generators	12,700	1.9%	$ 317	$ 134	28	-400	$ 858,000
			4	Surcharge	4,300	0.7%	$ 738	-$ 411	16	-100	$ 288,000
			5	Credit	8,500	1.3%	$ 428	$ 201	22	-300	$ 574,000
		CO2[2]	1	Blanket ban	35,550	5.4%	$ 331	$ 118	74	-800	$ 2.4M
			2	Ban large generators	9,150	1.4%	$ 401	$ 144	24	-200	$ 618,000
			3	Ban very large generators	6,150	0.9%	$ 541	$ 196	20	-100	$ 416,000
			4	Surcharge	2,150	0.3%	$ 1,385	-$ 761	14	-50	$ 144,000
			5	Credit	4,250	0.6%	$ 741	$ 310	16	-100	$ 287,000

Notes: **1**. Scenarios: RO1 = City does not meet BFWRS reduction goals, RO2 = City meets BFWRS reduction goals, A = Optimistic collection, B = pessimistic collection; **2**. Scenarios: CO1 = City does not meet BFWRS reduction goals, CO2 = City meets BFWRS reduction goals, Options: 1 = blanket ban, 2 = ban on large generators, 3 = ban on very large generators, 4 = disposal surcharge, 5 = credit for organics collection; **3**. Red text indicates maximum diversion potential for combination of options; **4**. Diversion potential represents maximum plausible diversion assuming near perfect capture and participation rates; **5**. Net OPEX includes revenue and cost offsets; **6**. % BSP indicates contribution to meeting the 90% diversion goal of the BSP.

TABLE 10.2 – Comparison of Traditional Recyclables Diversion Options from Chapter 4

Report Section	Description	Option			Diversion Potential		CAPEX	Annual Net OPEX[3]	Job[5] Creation	Annual GHG Reduction	Annual Airspace Offset Savings
		Scenario	#	Description	Total[1,2] (tons/yr)	% BSP[4]	($/ton)	($/ton)		(MTCO2E)	
4.2	Improved Recycling Collection	-	1	Bin size/allocation	84,200	12.8%	$ 83	$ 73	not calculated	-194,300	$ 5.7M
			2	Reduce collection frequency							
			3	Dual/multi-stream							
			4	SAYT							
4.3	Expanded Recycling Collection	-	1	MFD collection	69,300	10.6%	$ 193	$ 89	104	-155,500	$ 4.7M
			2	Mobile collection							
			3	Public spaces							
			4	Special events							
			5	Commercial collection							
4.4	Increased Processing Capacity	-	S1	WMRA	-	-	$ 0	$ 61	0	-	-
			ML1	New centralized MRF	-	-	$ 230	$ 39*	21	-	-
			ML2	Mini-MRF system	-	-	$ 101	$ 38*	160	-	-

Notes: 1. Red text indicates maximum diversion potential for combination of options; 2. Diversion potential represents maximum plausible diversion assuming near perfect capture and participation rates; 3. Net OPEX includes revenue and cost offsets; 4. % BSP indicates contribution to meeting the 90% diversion goal of the BSP; 5. N.C. = not calculated.
* Revenues are highly variable due to volatility in markets, net OPEX indicated may not be reliable long-range forecast

TABLE 10.3 – Comparison of C&D Waste Diversion Options from Chapter 5

Chapter	Description	Option			Diversion Potential		CAPEX	Annual Net OPEX[4]	Job Creation	Annual GHG Reduction	Annual Airspace Offset Savings
		Scenario[1]	#	Description	Total[2,3] (tons)	% BSP[5]	($/ton)	($/ton)		(MTCO2E)	
5.1	C&D Reuse/ Reduction	-	1	Deconstruction	**28,350**	4.3%	$ 0	$ 7	3	-25,000	$ 1.9M
			2	Architectural salvage							
5.2	Develop C&D MRF Facility	CD1	-	C&D MRF	216,900	33.0%	$ 102	-$ 19	33	-32,700	$ 14.6M
		CD2	-	C&D MRF	**200,100**	30.5%	$ 103	-$ 20	33	-32,700	$ 13.5M

Notes: 1. Scenarios: CD1 = City does not meet reduction goals in Section 5.1; CD2 = City meets reduction goals in Section 5.1; 2. Red text indicates maximum diversion potential for combination of options; 3. Diversion potential represents maximum plausible diversion assuming near perfect capture and participation rates; 4. Net OPEX includes revenue and cost offsets; 5. % BSP indicates contribution to meeting the 90% diversion goal of the BSP.

TABLE 10.4 – Comparison of Non-Traditional Recyclables Diversion Options from Chapter 6

Chapter	Description	Option			Diversion Potential		CAPEX	Annual Net OPEX[3]	Job Creation	Annual GHG Reduction	Annual Airspace Offset Savings
		Scenario	#	Description	Total[1,2] (tons)	% BSP[4]	($/ton)	($/ton)		(MTCO2E)	
6.1	Bulk Waste	-	1	Education and outreach	4,100	0.6%	$ -	$ 120	not calculated	-11,400	$ 277,000
			2	Waste-to-art							
			3	Fix-it clinic							
			4	Collection for donation							
			5	Charges/fines							
			6	Collection frequency							
			7	Recycling center							

Notes: 1. Red text indicates maximum diversion potential for combination of options; 2. Diversion potential represents maximum plausible diversion assuming near perfect capture and participation rates; 3. Net OPEX includes revenue and cost offsets; 4. % BSP indicates contribution to meeting the 90% diversion goal of the BSP.

TABLE 10.5 – Comparison of Integrated Facility Options from Chapter 7

Chapter	Description	Option			Diversion Potential		CAPEX	Annual Net OPEX[3]	Job Creation	Annual GHG Reduction	Annual Airspace Offset Savings
		Scenario	#	Description	Total[1,2] (tons)	% BSP[4]	($/ton)	($/ton)		(MTCO2E)	
7.1	Residential Drop-Off Centers and Small Hauler Program	-	1	New facilities	7,800	1.2%	$ 1,538	$ 142	18	-8,800	$ 527,000
			2	Expand existing facilities	**16,100**	2.5%	$ 12	$ 22	6	-25,800	$ 1.1M
7.2	Resource Recovery Park	-	-	Develop new facility*	391,500	59.6%	$ 186	$ 20	42	-388,500	$ 26.4M

Notes: 1. Red text indicates maximum diversion potential for combination of options; 2. Diversion potential represents maximum plausible diversion assuming near perfect capture and participation rates; 3. Net OPEX includes revenue and cost offsets; 4. % BSP indicates contribution to meeting the 90% diversion goal of the BSP.

* Diversion potential and other performance indicators are combinations of various previous options from Tables 10.1 through 10.4, and thus are not additional.

10.2 Maximum Diversion Potential (MDP)

As indicated by the red text in Tables 10.1 through 10.5 with regard to navigating the path to maximum diversion potential (MDP) through the various groups of options, not all options are mutually exclusive (i.e., several cannot be implemented at the same time as others, and thus represent "either/or" choices). For example, if food waste reduction is maximized (MDP = 72,400 tons) in accordance with options outlined in Section 3.1, then less food waste is available for diversion in corresponding Scenario RO2 in Section 3.2 (MDP = 42,800 tons). This appears lower than the diversion achieved under Scenario RO1 (MDP = 81,800 tons), which assumes that no food waste reduction measures are implemented. However, since the first two options are synergistic, their combined MDP of 115,200 tons (i.e., 72,400 + 42,800 tons) would be superior.

Summary of MDP Options and Tonnages

For this analysis, it is assumed that the City will implement the combination of mutually exclusive options that achieves the MDP. This combination of options is summarized below (as shown in red in Tables 10.1 through 10.5):

1. Food waste reduction (Section 3.1): This option would focus on source reduction programs as well as donation and rescue programs for food waste. Education, outreach, tracking, enforcement, and health monitoring for the program would be implemented by the City (likely administered by BOS), while the private sector would provide food rescue infrastructure. It is expected that this program would take up to 20 years to reach its full potential.
2. Residential organics diversion (Section 3.2, Scenario RO2): This option would focus on curbside collection and composting of SSO from customers currently served by DPW. Collection of SSO would be performed by DPW, while the composting operation could be performed by either the City (likely DPW or BCRP) or by the private sector (including through a PPP). It is expected that this program would take up to 20 years to achieve its full potential and would be implemented in phases (collection from City government buildings, public schools, and a pilot residential program in Phase 1, full implementation in four to six phases).
3. Commercial organics diversion (Section 3.3, Scenario CO2): This option would focus on collection and composting of SSO from entities not currently served by DPW for trash collection (i.e., most businesses, industries, and institutions in Baltimore, as well as private multi-family dwellings). Organics collection and composting would likely be performed by the private sector while the City would bear administrative costs for the program. It is expected that this program would take up to 20 years to achieve its full potential and would be implemented in four phases (starting with a combined subsidy for participating businesses and a surcharge on waste disposal, then moving to a disposal ban on very large commercial generators of organic waste, then a disposal ban on large commercial organic waste generators, and finally a blanket ban on disposal of all commercial organic waste).
4. Improved curbside recycling (Section 4.2): This option would focus on improved collection of traditional recyclables from the residential sector by implementing policies that encourage participation in the current recycling program and improve the

quality of collected recyclables. This option would likely be implemented by DPW and is expected to take up to 10 years to achieve its full potential. This option is coupled with development of new mini-MRFs (Section 4.4).

5. Expanded access to recycling (Section 4.3): This option would focus on expanding access to the existing recycling program by collecting from MFDs and commercial generators as well as improving recycling in public spaces and at special events. This option would likely be implemented by DPW and is expected to take up to 10 years to achieve its full potential. This option is coupled with development of new mini-MRFs (Section 4.4).
6. C&D reuse/reduction (Section 5.1): This option would focus on source reduction and reuse of C&D waste through implementation of a deconstruction program, an architectural salvage program, and green construction policies. This option would be implemented entirely by the City and is expected to take up to 10 years to achieve its full potential.
7. C&D diversion (Section 5.2, Scenario CD2): This option would focus on diversion of recyclable waste from the C&D waste stream by constructing a new C&D MRF. For this option, the costs associated with construction and operation of the MRF would likely be borne by the private sector, while administrative costs associated with education and enforcement of C&D recycling policies would be borne by the City. It is expected that this option would take up to 20 years to achieve its full potential.
8. Bulk waste diversion (Section 6.1): This option would focus on improving reduction and diversion of bulk waste by offering donation and reuse programs for bulk waste, reducing bulk waste collection frequency, and constructing bulk waste recycling centers (likely at existing residential drop-off centers). All costs would likely be borne by the City. This option is expected to take ten years to achieve its full potential.
9. Expanded residential drop-off centers and small hauler program (Section 7.1): This option would seek to expand the residential drop-off and small hauler programs by constructing additional DOCs and small hauler drop-off areas or expanding existing DOCs. The costs associated with this option would likely be borne by the City and operated by DPW. It is expected that this option would achieve its full potential within 5 years.

The total estimated diversion/reduction potential for each of the options that make up the MDP is given in the table below.

Report Section	Reduction / Diversion Option	MDP (tons/year)
3.1	Food Waste Reduction	72,400
3.2	Residential Organics Diversion	42,800
3.3	Commercial Organics Diversion	35,550
4.2	Improved Recycling Collection	84,200
4.3	Expanded Recycling Collection	69,300
5.1	C&D Reuse and Reduction	28,350
5.2	C&D Diversion	200,100
6.1	Bulk Waste Diversion	4,100
7.1	Res. Dropoff and Small Hauler Prog.	16,100
TOTAL		**552,900**

Expected Reduction/Diversion Tonnage for MDP Options

As shown, the expected MDP is 552,900 tons per year. When considered in combination with the City's current diversion rate (738,500 tons currently recycled, 78,600 tons currently composted), achieving the MDP would increase the City's overall waste diversion rate from 50% to about 83%.

Although obtaining a true 83% waste diversion rate would be a world-beating achievement for a city the size and complexity of Baltimore, this rate nevertheless falls short of the 90% overall diversion goal established in the BSP. Given the analysis presented in this Report, it is Geosyntec's considered opinion that a 90% diversion rate is not realistically achievable using current technologies. However, it should be remembered that the BZWP, developed independent of the LWBB Plan, may be able to provide tangible examples of how to make up the missing 7%. The 83% waste diversion rate is also assuming all levels of funding required for the various programs would be approved and provided by City government. Lastly, the 83% waste diversion rate assumes near perfect participation across various sectors, which has not been demonstrated in other jurisdictions.

Summary of MDP Costs

The estimated total CAPEX and annual OPEX for each of the options that comprise the MDP (organized by Report Section) are given in the table opposite, with preliminary allocation between the public sector (essentially the City) and the private sector based on Geosyntec's preliminary assessment of the likely distribution of services. Note the following:

1. Costs in the table are in addition to current costs incurred for existing collection, recycling, and disposal programs.
2. It is assumed the private sector costs will run food waste recovery programs (Section 3.1); however, due to the high level of uncertainty associated with these programs (due to donations and volunteering), costs are not included. In any case, these costs are better tracked under the BOS's Food Matters program.
3. The local building industry will incur indirect costs as a result of C&D reuse programs (Section 5.1); however, these are hard to quantify and are not included.

Report Section	Public Sector		Private Sector	
	Total CAPEX	Annual OPEX	Total CAPEX	Annual OPEX
3.1	-	$ 4.7M	not included	not included
3.2	$ 14.4M	$ 13.1M	$ 10.7M	$ 4.1M
3.3	-	$ 280,000	$ 11.8M	$ 5.8M
4.2	$ 7.0M	$ 12.3M	-	-
4.3	$ 16.7M	$ 6.1M	-	-
4.4	-	-	$ 17.6M	$ 10.4M
5.1	-	$ 130,000	indirect	indirect
5.2	-	$ 180,000	$ 20.5M	$ 17.9M
6.1	-	$ 120,000	-	-
7.1	$ 200,000	$ 360,000	-	-
TOTAL	**$ 38.3M**	**$ 37.3M**	**$ 60.6M**	**$ 38.2M**

Expected Cost Allocations for MDP Options

As shown above, the City's total additional CAPEX and OPEX for implementing the MDP options in full would be approximately $38.3

million and $37.3 million/year, respectively. However, some of these costs may be reassigned to the private sector, particularly where this is feasible under a public-private partnership (PPP) or alternative contracting mechanism. Identifying potential PPP contracting opportunities, which often enable services to be provided more efficiently and/or at lower costs, will be a key area of focus in the Draft Master Plan in Task 8.

10.3 Timeline and Phasing: What's Left?

To further estimate the future disposed waste composition with time under the MDP options (i.e., to reflect recovery/diversion of materials over time), implementation schedules, performance timeframes, and waste growth projections were assumed as outlined in this section.

Implementation Schedule and Performance Timeframes

To estimate the changing composition of the waste stream in Baltimore over time as waste recovery and diversion increases, it is necessary to estimate the timeframe over which each of the nine options comprising the MDP can realistically be expected to achieve their full potential after having been implemented. The performance timeframe for each option is summarized in the table opposite. This timeframe represents the total time expected for diversion to achieve maximum performance levels in accordance with an s-curve participation rate (as previously described in Section 2.2).

Larger, more complex options have longer performance timeframes. In all cases, however, it is assumed that the City would implement the first phase of each option that contributes to the MDP beginning in 2020 (i.e., in Year 1 of the performance timeframe).

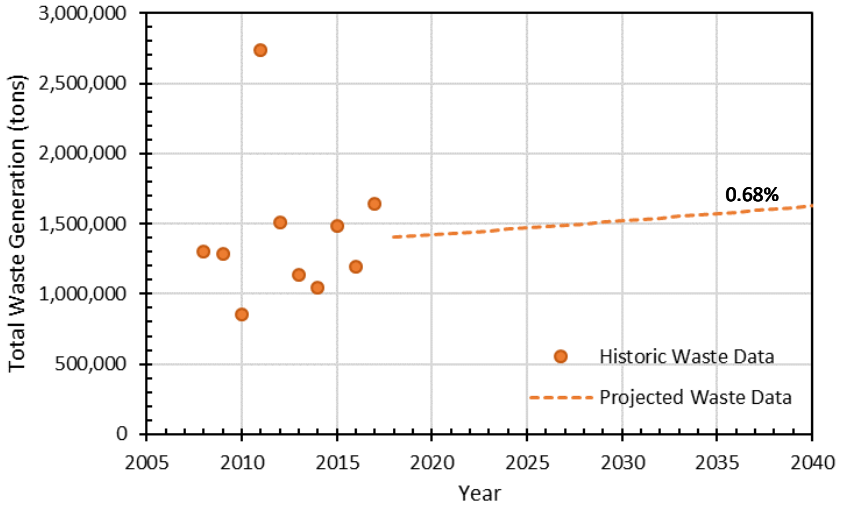
Report Section	Reduction / Diversion Option	Performance Timeframe (years)
3.1	Food Waste Reduction	20
3.2	Residential Organics Diversion	20
3.3	Commercial Organics Diversion	20
4.2	Improved Recycling Collection	10
4.3	Expanded Recycling Collection	10
5.1	C&D Reuse and Reduction	10
5.2	C&D Diversion	20
6.1	Bulk Waste Diversion	10
7.1	Residents' Drop-offs and Small Hauler Prog.	5

Expected Performance Timeframes for Diversion Options

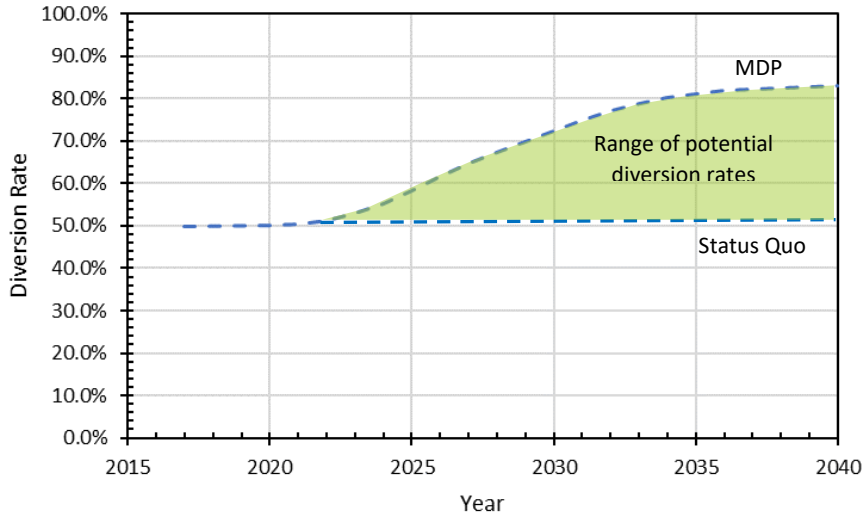
Waste Growth Projections

As described in the Task 3 Report, it is anticipated that the size of total waste stream will grow at an average annualized rate of 0.68% per year, based on historical waste generation data and projected population growth in the city. This assumption was used to estimate the total amount of waste generated in Baltimore between 2017 (the last year for which data are available based on MDE's Annual MRA Reports) and 2040 (when all of the options composing the MDP are assumed to have been fully implemented within their respective timeframes in order to meet the final targets for reduction/diversion under the BOS and BFWRS).

Estimated total waste generation in Baltimore through 2040 is indicated in the figure overleaf. Calculation details for this waste growth projection are provided in Appendix 3.



Historical and Projected Waste Generation in Baltimore

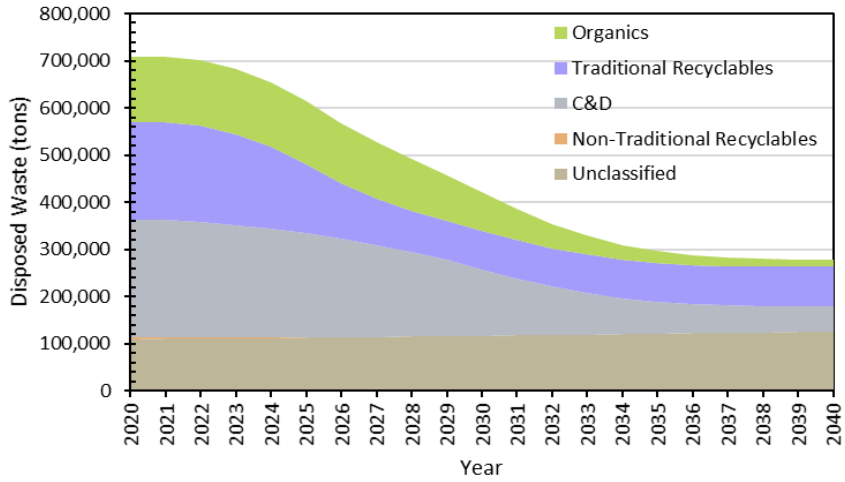


Range of Potential Diversion Rates with Time

What's Left for Disposal (Task 7)

A full analysis of the projected disposed and diverted waste mass and composition under the assumption that the City begins implementing all MDP options in 2020 can be found in Appendix 3. The figures opposite summarize what's left in the waste stream for disposal over time following implementation of the MDP options.

As shown in the top figure, the overall diversion rate is expected to increase from 50% under the status quo to about 83% by 2040 under the MDP. The range of potential diversion rates that could be achieved by implementing options somewhere between the status quo and the MDP is indicated by the green shaded area. The expected change in the relative composition of the disposed waste stream with time under the MDP is shown in the bottom figure.



Expected Change in Mass and Composition of Disposed Waste

Finally, to facilitate strategic planning under different "what if?" scenarios in Task 7, two tables representing the expected size of the residual waste stream for disposal between 2020 and 2040 are provided opposite, with different values representing disposal tonnages depending on whether the City achieves a diversion rate between 0% and 100% of the MDP (in 20% increments). The first table represents MSW (comprising organics, traditional recyclables, non-traditional recyclables, and unclassified waste) while the second table represents C&D waste only.

As shown in the tables, if the City achieves 100% of the MDP by 2040 the total tonnage of MSW and C&D waste for disposal is expected to decline from 461,000 tons and 247,700 tons, respectively, in 2020 to 224,400 tons and 53,700 tons, respectively, in 2040. This suggests that the minimum quantity of waste still requiring disposal in 2040 will be about 278,000 tons. Under the status quo (i.e., 0% MDP), the total quantity of waste for disposal would be expected to grow from about 713,500 tons in 2020 to about 815,000 tons in 2040.

Percent of MDP Achieved	2020	2025	2030	2035	2040
0%	463,700	479,700	496,200	513,200	530,800
20%	463,200	462,100	453,600	465,900	483,100
40%	462,600	444,600	410,700	413,900	428,600
60%	462,100	427,200	367,400	357,000	367,300
80%	461,600	409,900	323,700	295,200	299,200
100%	461,000	392,700	279,500	228,700	224,400

Expected MSW Disposal Tonnages under Various Diversion Rates as a Percentage of the MDP (0% represents Status Quo)

Percent of MDP Achieved	2020	2025	2030	2035	2040
0%	249,800	258,400	267,200	276,400	285,900
20%	249,400	251,000	241,200	225,000	226,000
40%	249,000	243,500	215,500	178,400	172,700
60%	248,500	236,000	190,300	136,600	126,300
80%	248,100	228,300	165,500	99,600	86,600
100%	247,700	220,500	141,000	67,500	53,700

Expected C&D Disposal Tonnages under Various Diversion Rates as a Percentage of the MDP (0% represents Status Quo)

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