



OFFICE OF THE COUNTY EXECUTIVE

Marc Elrich  
*County Executive*

March 2, 2026

The Honorable Natali Fani-González, President  
Montgomery County Council  
100 Maryland Ave  
Rockville, MD 20850

Dear Council President Fani-González,

Thank you for your January 23, 2026 letter regarding the County's solid waste management. I appreciate your acknowledgment of our shared responsibility and commitment to determine the best path forward for managing the County's municipal solid waste.

I agree when you say, "the future of trash disposal is a once-in-a-generation decision, and a robust, countywide, deliberative, and equitable community outreach process must inform this enormous decision." This is why my team has been consulting with stakeholders throughout the spring and summer of 2025. We continue to have regular conversations with these stakeholders, which include the County's Solid Waste Advisory Committee (SWAC), Dickerson Area Facilities Implementation Group (DAFIG), and the County Council since that time, such as the briefing before the full Council last July.

In addition to this, my administration will be hosting a series of open house sessions beginning this week to provide residents with information about our current solid waste management system, explain the current need to select a future direction, review the options under consideration, and gather public feedback. I would welcome your participation, as well as that of any Council colleagues, at any of the sessions. A public survey has also been distributed to solicit broader community input, which we are working to ensure is amplified to reach residents and community groups across the County.

At the July 2025 Council session, DEP staff had proposed another briefing in January after we had more information about cost comparisons. On December 17, 2025, members of my administration met with you to again request the opportunity for a full public County Council briefing on these findings and proposed next steps. As that request was not approved, we are currently conducting individual briefings to Councilmembers. **It is in our shared commitment to public engagement and transparency that I respectfully ask that you reconsider the request for my staff to provide the full Council with a comprehensive public briefing on the options before us.** Given the scale and significance of this decision, I believe we owe it to the public to discuss these options openly with the Council rather than exclusively through individual meetings.

Reconsidering how the County manages its waste is not a decision that is undertaken regularly, and there is no mandated process by which Council concurrence must be provided before moving forward. My team has explored amending the Solid Waste Management Plan (SWMP) as one possible procedural approach but has concluded that such a process is neither required nor preferred at this stage. Updating the SWMP to reflect our agreed-upon direction would likely take close to a year and is most appropriately initiated once a path forward has already been agreed upon. The most effective mechanism for the Council to convey its support would be through adoption of a resolution expressing agreement with the chosen approach and/or approval of funding for the transition to long-haul which will be included in my FY27 proposed budget.

Many of the points in your letter were also discussed at the briefing last summer, and I have attached the reports from the consultants addressing a number of these issues. And as you note, the County's current SWMP does not prescribe a transition to long-hauling our waste; rather, it directs the County to compare the costs and impacts of continued use of the incinerator with alternative options. We believe we have completed these analyses.

Any path forward—whether repairing and upgrading the existing waste-to-energy facility or transitioning to long-haul transport of waste to landfills combined with countywide composting and advanced waste processing—will require major capital investments. Both approaches would continue to rely on landfilling; currently, about 23 percent by weight of the material processed at the incinerator is transported by rail to a landfill located in a predominantly minority, low-income community. However, repairing and improving the incinerator would create a large fixed cost that limits financial incentives to reduce waste as well as limits the availability of funds to support additional waste diversion opportunities. To continue with the current system will require an additional \$17 million in FY27 and \$14 million in FY28, simply to keep it operating. Switching to long-haul this year would avoid making these additional investments in an aging system and allow those funds to be reallocated to support a more sustainable solution.

By contrast, shifting to long-haul landfilling would provide both the financial incentives and the operational capacity to pursue waste-reduction strategies. These include countywide collection and composting of food-scrap and enhanced recycling before materials reach the transfer station, as well as advanced waste processing that recovers additional recyclables and organic material from the waste stream.

As you know, due to the longstanding consent agreement, adding food-scrap composting at the current Dickerson facility requires approval from the Sugarloaf Citizens Association, which has conditioned its approval on the County issuing notice of termination for the current incinerator contract. In other words, food-scrap cannot be accepted at the facility until there is a confirmed closure date for the incinerator. Other sites have been considered for composting but would add significant costs.

Studies confirm that reducing waste disposal is the best way to reduce environmental impacts from waste management. This conclusion is also supported by a report commissioned by the County's Department of Environmental Protection (DEP) and published in 2025 that found advanced waste processing (AWP) technologies were the preferred alternative for managing the County's waste.

DEP has also engaged a consultant with expertise in municipal service rate modeling to develop preliminary annual cost estimates for each option and found that over the long-term the impacts to rates are relatively similar. It is important to note that entering into a new 20-year contract to upgrade the incinerator would bring the facility up to current operational standards to maintain reliability and safety, but it would not fund state-of-the-art improvements.

Although the projected FY28–FY31 costs for AWP, universal food-scrap composting, and long-hauling residual waste are slightly higher than continuing to operate the incinerator, costs for the incinerator option are largely fixed, regardless of reductions in waste generation. By contrast, closing the incinerator would allow the County to redirect funds into a range of strategies designed to significantly reduce the volume of residual waste sent to landfills. Because long-haul disposal is charged on a per-ton basis rather than a fixed-cost model, reductions in the county's waste stream would directly translate into lower long-term disposal costs.

Further, the County's analysis of the environmental, equity, and waste diversion impacts demonstrates that a transition to AWP, composting, and long-hauling residual waste is the most beneficial option. A summary of those analysis results, as well as the projected rate impacts, is attached for your reference.

Lastly, as raised in your letter, any of these options could potentially utilize an in-county landfill ("site 2") for final disposal at a future date. However, a sole source aquifer was identified at the site after it was previously permitted as a landfill, which would complicate development due to contamination concerns.

It is critical for the County to make a decision on the path forward for managing our solid waste, as the current contract to operate the Resource Recovery Facility (RRF) expires in 2031 and requires on-going investment to maintain. As demonstrated by the recent emissions exceedances, many components of the facility are nearing the end of life and will need refurbishment to continue operating safely and reliably in the coming years. Delays in approving a transition to long-haul trucking as a short-term bridge to zero waste programs will lead to expenditures for the RRF that could be avoided.

I look forward to continuing our partnership with the Council as we work toward the best outcome for our residents and communities.

Sincerely,

A handwritten signature in black ink, appearing to read "Marc Elrich", with a stylized, cursive script.

Marc Elrich  
County Executive

Enclosures: Council President Letter Response Attachments  
Organics Management Plan  
MSW Management System Alternative Analysis



# **Aiming for Zero Waste**

A Vision for Sustainable Materials  
Management in Montgomery County

February 2026



# Goals for our Waste Management System



**Reliable Operations**



**Affordability**



**Environmental  
Justice**

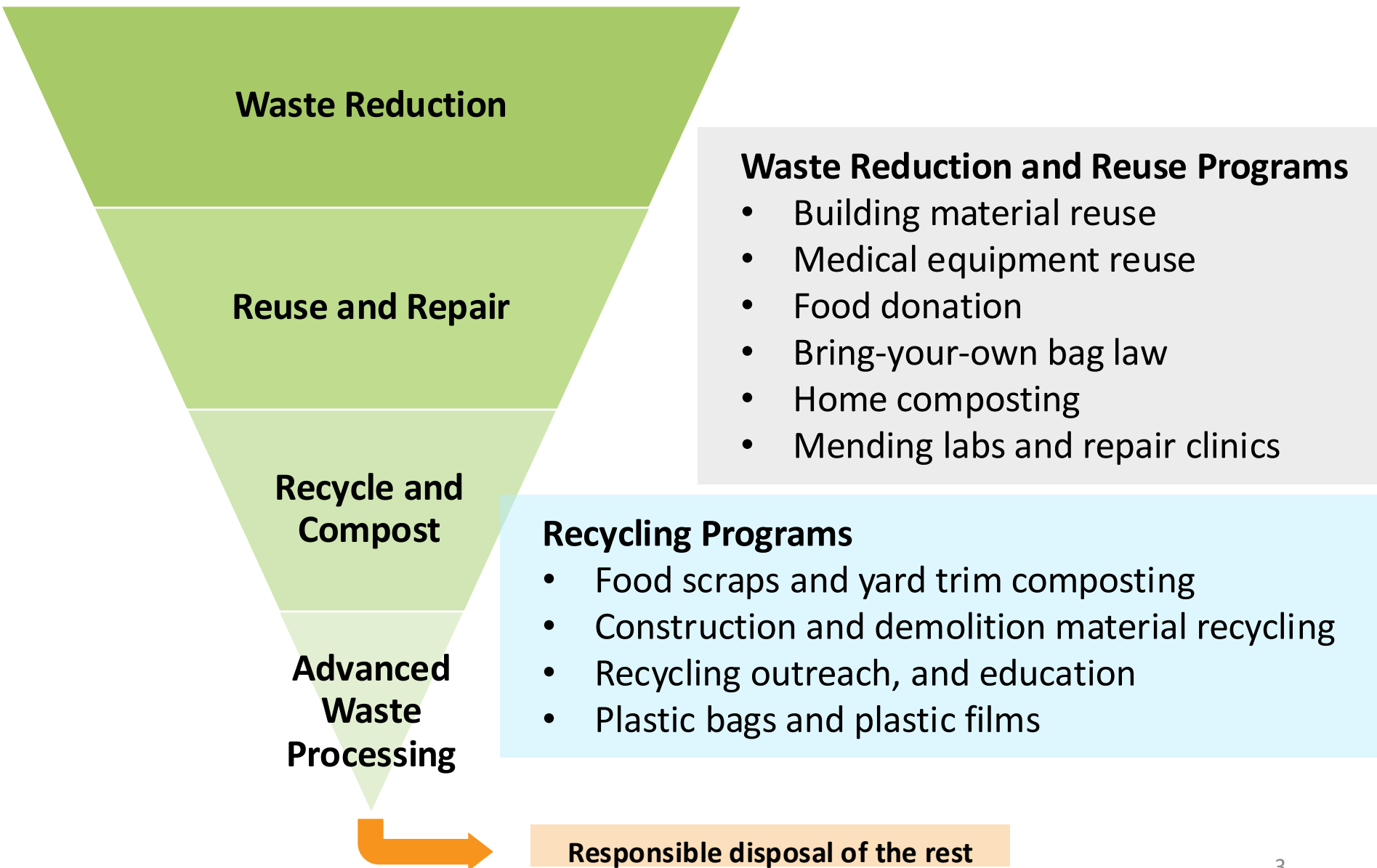


**Environmental  
Protection**



**Maximum Waste  
Diversion**

# Our Vision: Aiming For Zero Waste



# Where We Are Now



**Waste Is  
Produced**



**Collected and  
Recycled**



**Waste-to-  
Energy  
Incineration**



**Ash Hauled to  
a Landfill**



# Why We Must Act



**Incinerator Reliability  
Is Declining**



**Incinerator Contract Is  
Expiring**



**The Trash Keeps Coming!**

# Available Options

## **Option 1 (current): Incinerator + long-haul ash to landfill**

*(also known as: Resource Recovery Facility (RRF); Municipal Waste Combustor; Waste-to-Energy Facility)*

- Poses near-term risks of reliability
- Locks in investment in long-term incineration at the expense of a transition toward less waste

## **Option 2: Food composting + long-haul waste to landfill**

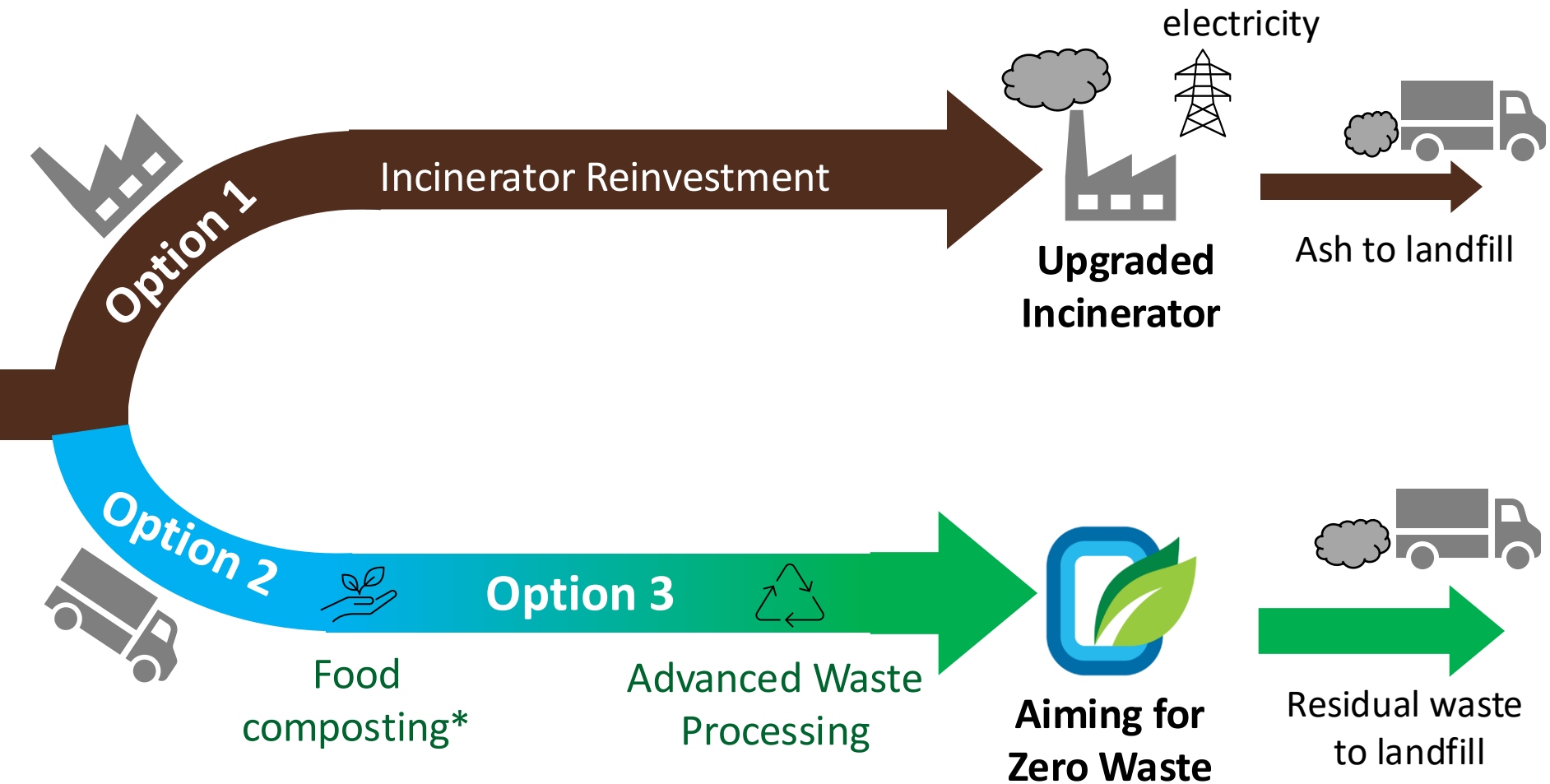
- Brings us closer to our zero waste goals

## **Option 3: Food composting + Advanced Waste Processing (AWP) + long-haul residual waste to landfill**

- Brings us closer to our zero waste goals
- Reduces environmental impacts, including Greenhouse gases
- Includes minimal additional costs

\*Any of these options could potentially utilize an in-county landfill ("site 2") for final disposal, at a future date; however, site 2's proximity to a sole source aquifer would complicate development

# Available Options



\*Due to County agreement with Sugarloaf Citizen Association, food composting at yard trim facility is only available if incinerator closes.

**Option 1:** Incinerator + long-haul ash to landfill

**Option 2:** Food composting + long-haul waste to landfill

**Option 3:** Food composting + AWP + long-haul residual to landfill

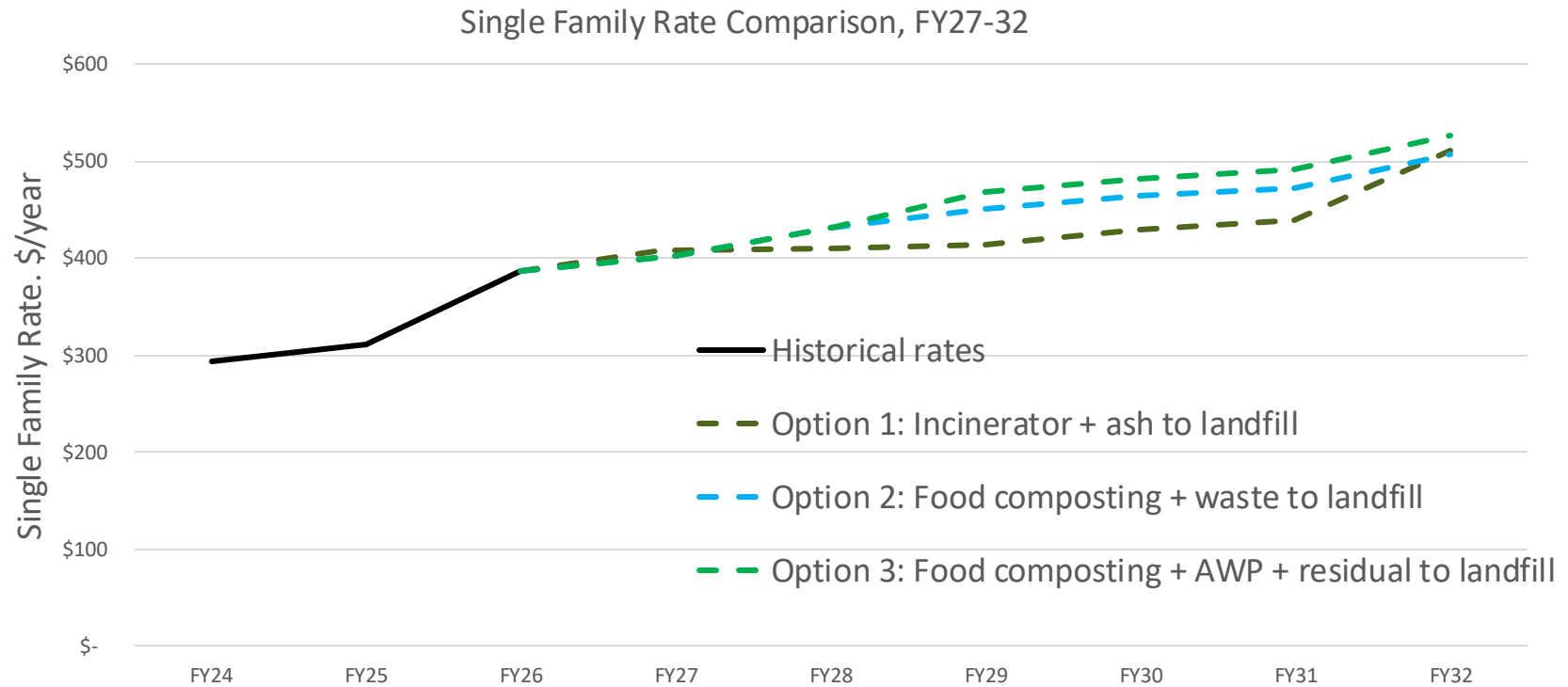
# Analysis

**DEP has conducted analysis to better understand the impacts of our current management system as well as to compare the alternative options.**

Analyses included potential impacts to costs, waste diversion, the environment, and environmental justice.

- HDR Evaluation of Site 2 and Other Alternatives (2018)
- EA Organics Management Plan and Citing Study (2024)
- MSW Management System Alternatives Analysis (2025)
- Long-Haul RFP Responses (2025)
- Raftelis Detailed Cost and Rate Modeling (2026)
- Updated Environmental Justice Analysis (2026)

# Rate Impacts – Single Family Homes



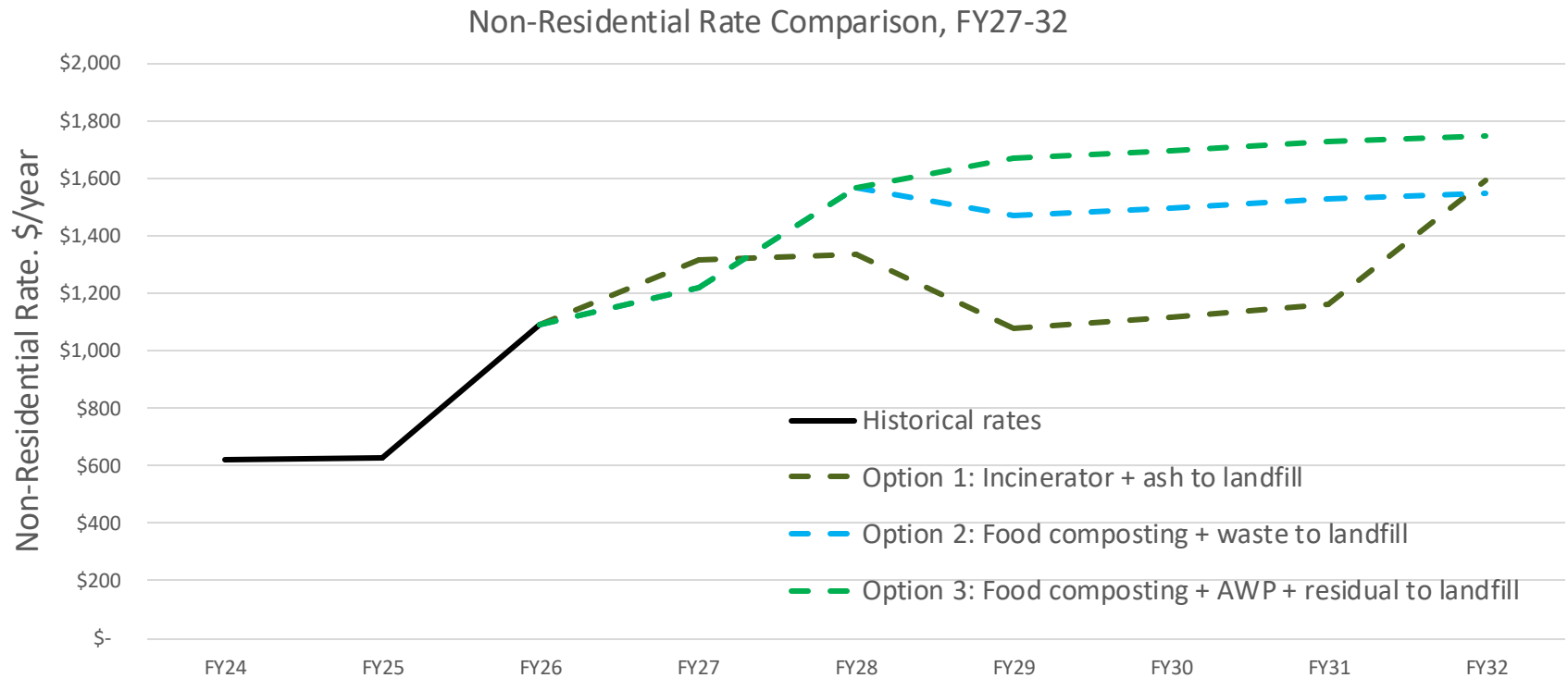
|                                                    | FY27  | FY28  | FY29  | FY30  | FY31  | FY32  |
|----------------------------------------------------|-------|-------|-------|-------|-------|-------|
| <b>Option 1:</b> Incinerator + ash to landfill     | \$410 | \$411 | \$415 | \$430 | \$440 | \$512 |
| <b>Option 2:</b> Food composting + Long-haul       | \$402 | \$432 | \$451 | \$464 | \$473 | \$508 |
| <b>Option 3:</b> Food composting + AWP + Long haul | \$402 | \$432 | \$469 | \$483 | \$492 | \$526 |

\* FY26 single family rate: \$388

\* Additional construction and demolition materials diversion is consistent with all options



# Rate Impacts – Non-Residential



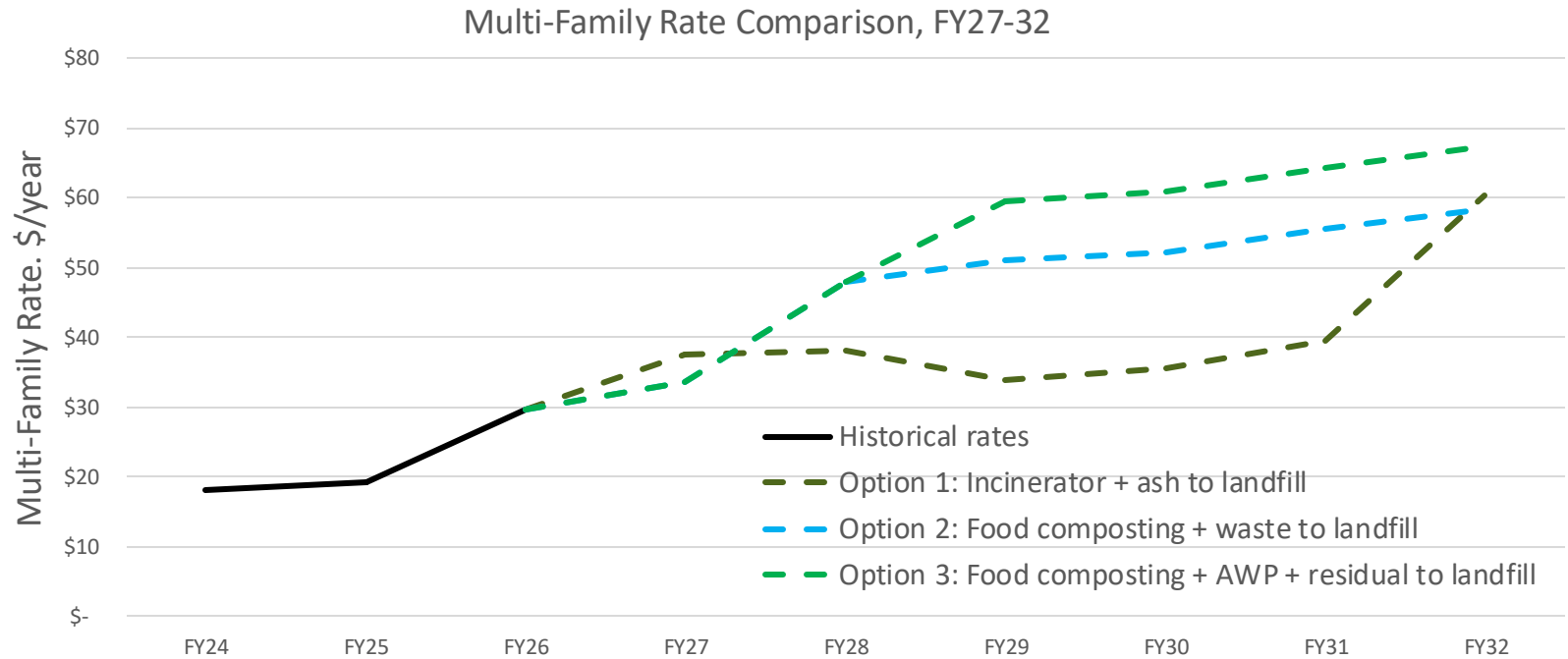
|                                                    | FY27    | FY28    | FY29    | FY30    | FY31    | FY32    |
|----------------------------------------------------|---------|---------|---------|---------|---------|---------|
| <b>Option 1:</b> Incinerator + ash to landfill     | \$1,315 | \$1,338 | \$1,079 | \$1,115 | \$1,163 | \$1,592 |
| <b>Option 2:</b> Food composting + Long-haul       | \$1,223 | \$1,567 | \$1,474 | \$1,497 | \$1,531 | \$1,550 |
| <b>Option 3:</b> Food composting + AWP + Long haul | \$1,223 | \$1,567 | \$1,672 | \$1,696 | \$1,731 | \$1,750 |

\* Non-residential rate shown is for the “medium” generator category and is charged per 2,000 sq ft of gross floor area

\* FY26 non-residential rate: \$1,090

\* Additional construction and demolition materials diversion is consistent with all options

# Rate Impacts – Multi-Family

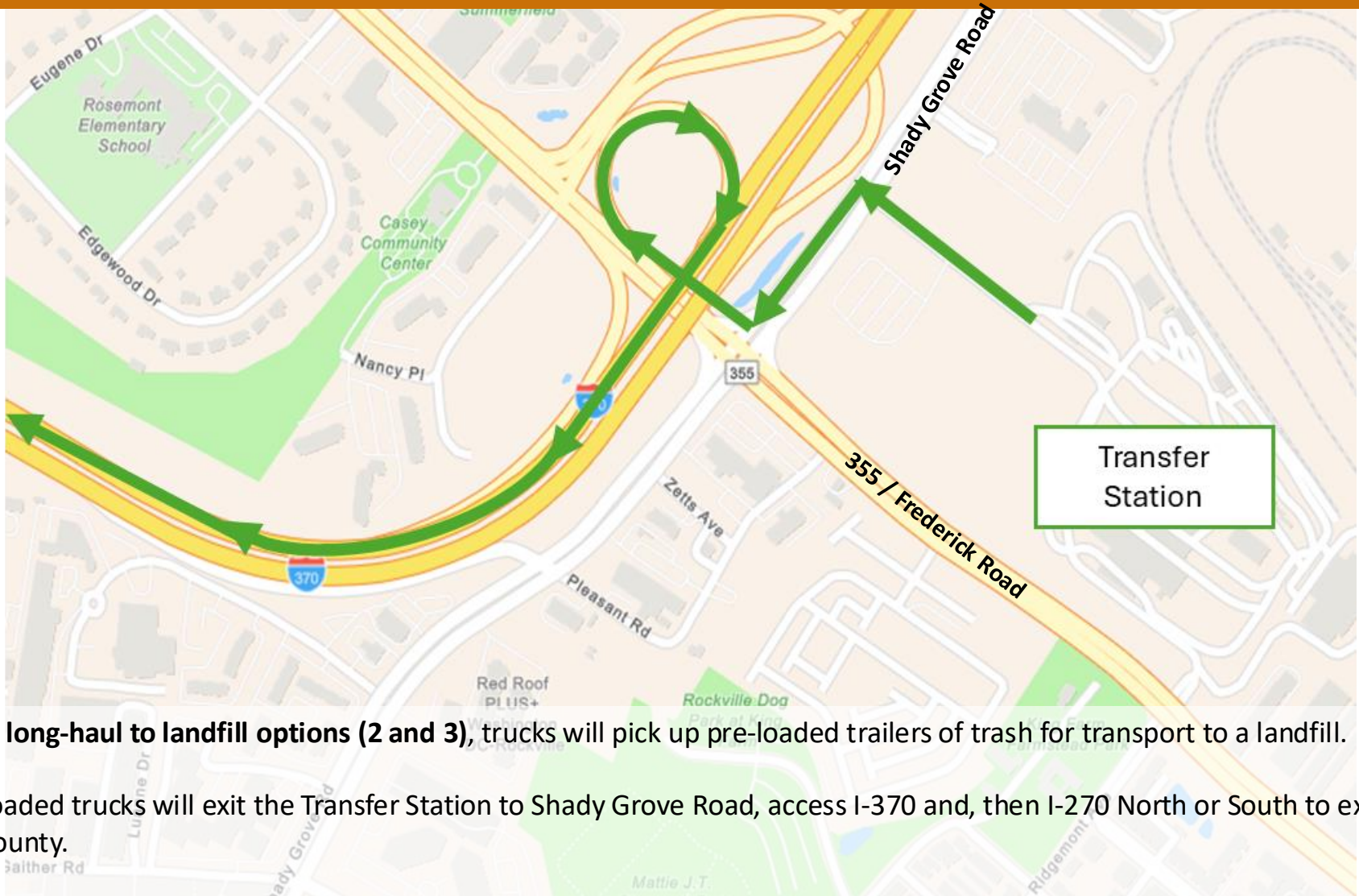


|                                                    | FY27 | FY28 | FY29 | FY30 | FY31 | FY32 |
|----------------------------------------------------|------|------|------|------|------|------|
| <b>Option 1:</b> Incinerator + ash to landfill     | \$38 | \$38 | \$34 | \$36 | \$40 | \$60 |
| <b>Option 2:</b> Food composting + Long-haul       | \$34 | \$48 | \$51 | \$52 | \$56 | \$59 |
| <b>Option 3:</b> Food composting + AWP + Long haul | \$34 | \$48 | \$61 | \$61 | \$64 | \$67 |

\* FY26 multi-family rate: \$30

\* Additional construction and demolition materials diversion is consistent with all options

# Traffic and Route Information



In the **long-haul to landfill options (2 and 3)**, trucks will pick up pre-loaded trailers of trash for transport to a landfill.

The loaded trucks will exit the Transfer Station to Shady Grove Road, access I-370 and, then I-270 North or South to exit the County.

Long-hauling trash to a landfill would require approximately 80 additional loads per day. Traffic would be roughly evenly distributed between 3:00 AM and 3:00 PM.

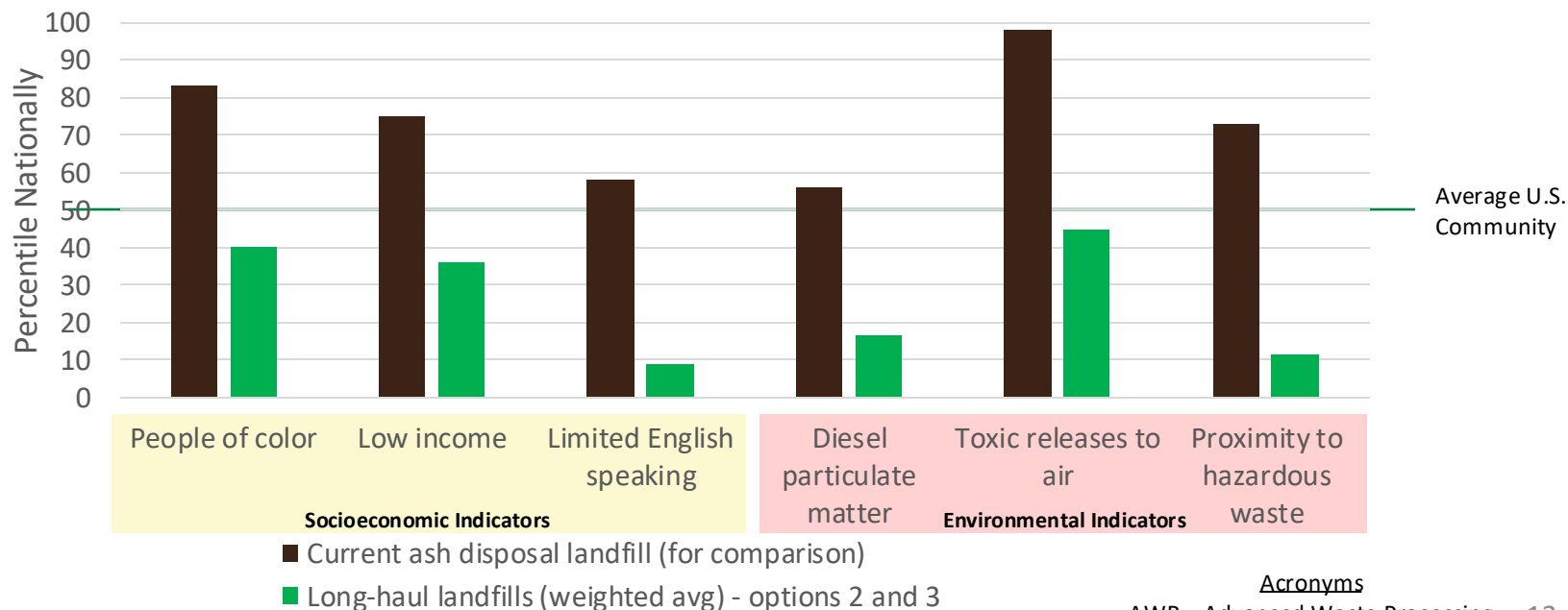
The County plans to phase out acceptance of large loads of construction materials at the Transfer Station, which will offset approximately half the additional loads from long-hauling trash.

# Environmental Justice

## Environmental Justice (EJ) Considerations

|                                                    | Transfer Station | Incinerator Location | Out-of-County Landfill Location |
|----------------------------------------------------|------------------|----------------------|---------------------------------|
| <b>Option 1:</b> Incinerator + ash to landfill     | Moderate         | Low                  | High (current landfill)         |
| <b>Option 2:</b> Food composting + Long-haul       | Moderate         | -                    | Low-moderate                    |
| <b>Option 3:</b> Food composting + AWP + Long-haul | Moderate         | -                    | Low-moderate                    |

Selected EJ Screening Results for Disposal Landfills  
1 mile radius



### Acronyms

AWP = Advanced Waste Processing  
EJ = Environmental Justice

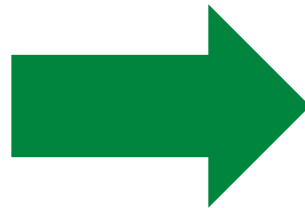
# Environmental Impacts

**Reducing food  
scraps and other  
organics  
in landfills**



**Reducing  
greenhouse gas  
emissions**

**Option 3** is estimated to reduce greenhouse gas emissions compared to the current process of **Option 1**.



Similar to taking nearly **100,000 passenger vehicles** off the road each year.

**Option 1:** Incinerator + long-haul ash to landfill

**Option 2:** Food composting + long-haul waste to landfill

**Option 3:** Food composting + AWP + long-haul residual to landfill

# Environmental Impacts

**Landfills and Waste-to-Energy Facilities potentially impact the environment and surrounding communities in different ways**



**Studies confirm that reducing waste disposal is the best way to reduce environmental impacts from waste management**

## Example Studies:

- Ouedraogo, A. S., Kumar, A., Frazier, R., & Sallam, K. A. (2024). Comparative Life Cycle Assessment of Landfilling with Sustainable Waste Management Methods for Municipal Solid Wastes. *Environments*, 11(11), 248. <https://doi.org/10.3390/environments11110248>
- Morris, J. Comparative LCAs for Curbside Recycling Versus Either Landfilling or Incineration with Energy Recovery (12 pp). *Int J Life Cycle Assessment* 10, 273–284 (2005). <https://doi.org/10.1065/lca2004.09.180.10>
- Hanna Merrild, Anna W. Larsen, Thomas H. Christensen, Assessing recycling versus incineration of key materials in municipal waste: The importance of efficient energy recovery and transport distances, *Waste Management*, Volume 32, Issue 5, 2012, Pages 1009-1018, ISSN 0956-053X, <https://doi.org/10.1016/j.wasman.2011.12.025>.



# Waste Diversion

Currently, more than 365,000 tons of waste are kept out of the landfill through recycling programs.

We can increase the amount by almost 180,000 tons with Option 3.

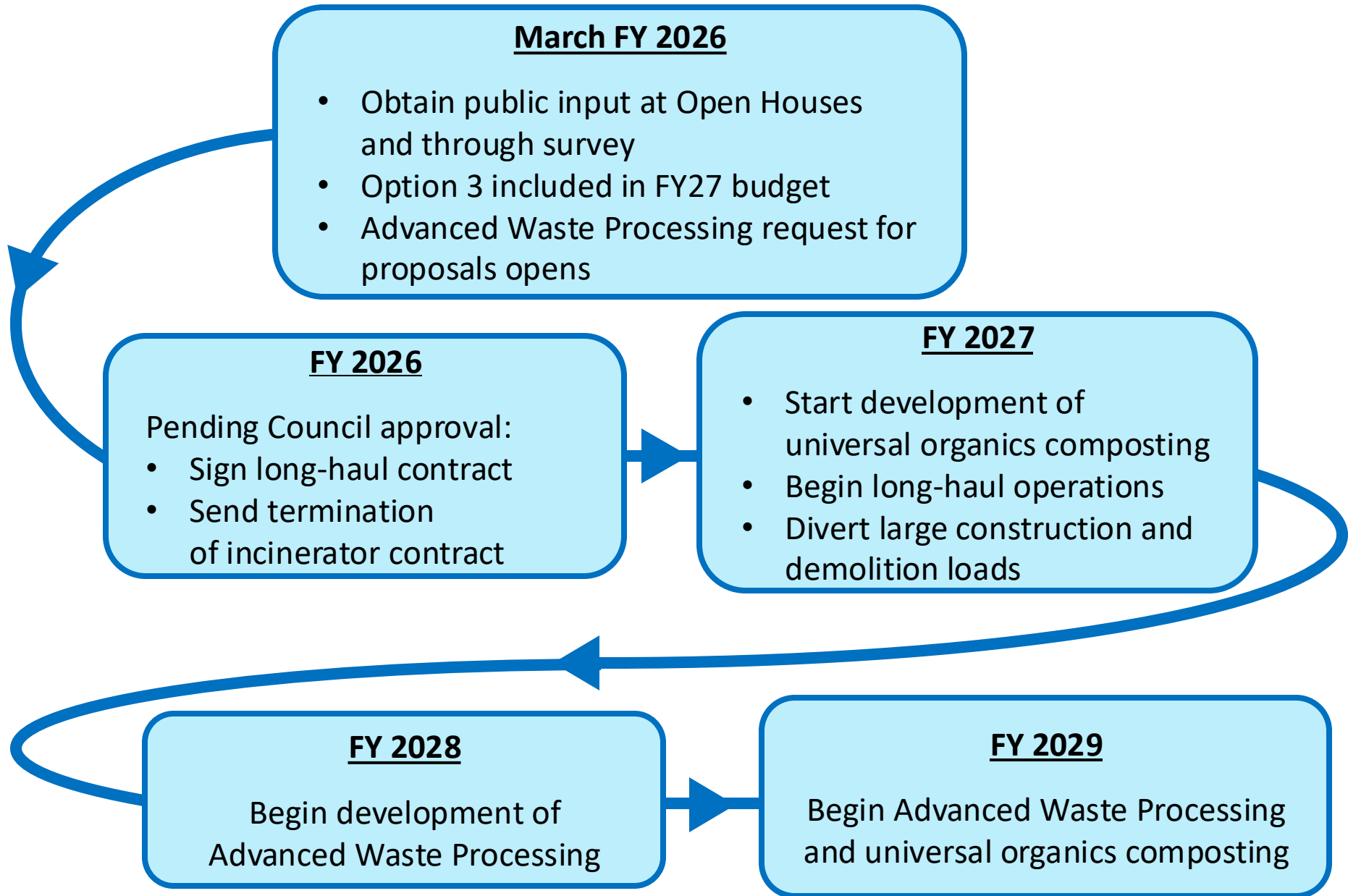
## Projected Waste Recycling in FY32

|                                                                               |              |
|-------------------------------------------------------------------------------|--------------|
| <b>Option 1:</b> Incinerator + Long-haul ash to landfill                      | 365,000 tons |
| <b>Option 2:</b> Food composting + Long-haul waste to landfill                | 405,600 tons |
| <b>Option 3:</b> Food composting + AWP + Long-haul leftover waste to landfill | 543,571 tons |



\* Assumes a 30% diversion rate for waste processed through Advanced Waste Processing.

# Option 3 - Next Steps



# Appendix

# Rate Impacts - All

| OPTION 1: RRF                               |                |                   |                   |                   |                   |                   |                   |
|---------------------------------------------|----------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|
| FISCAL PROJECTIONS                          | ACTUAL<br>FY26 | PROJECTED<br>FY27 | PROJECTED<br>FY28 | PROJECTED<br>FY29 | PROJECTED<br>FY30 | PROJECTED<br>FY31 | PROJECTED<br>FY32 |
| Single-Family Charges (\$/Household)        | 387.72         | 410.10            | 410.76            | 414.97            | 429.60            | 439.85            | 512.07            |
| % change in rate from previous year         | 24.7%          | 5.8%              | 0.2%              | 1.0%              | 3.5%              | 2.4%              | 16.4%             |
| Multi-Family Charges (\$/Dwelling Unit)     | 29.76          | 37.65             | 38.19             | 33.85             | 35.56             | 39.54             | 60.39             |
| % change in rate from previous year         | 55.6%          | 26.5%             | 1.4%              | -11.3%            | 5.0%              | 11.2%             | 52.7%             |
| Nonresidential Charges (medium "category" d | 1,090.30       | 1,314.69          | 1,337.82          | 1,079.01          | 1,115.06          | 1,162.67          | 1,592.32          |
| % change in rate from previous year         | 72.7%          | 20.6%             | 1.8%              | -19.3%            | 3.3%              | 4.3%              | 37.0%             |

| OPTION 2: LONG-HAUL + ORGANICS              |                |                   |                   |                   |                   |                   |                   |
|---------------------------------------------|----------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|
| FISCAL PROJECTIONS                          | ACTUAL<br>FY26 | PROJECTED<br>FY27 | PROJECTED<br>FY28 | PROJECTED<br>FY29 | PROJECTED<br>FY30 | PROJECTED<br>FY31 | PROJECTED<br>FY32 |
| Single-Family Charges (\$/Household)        | 387.72         | 401.76            | 431.66            | 450.97            | 464.44            | 473.40            | 508.20            |
| % change in rate from previous year         | 24.7%          | 3.6%              | 7.4%              | 4.5%              | 3.0%              | 1.9%              | 7.4%              |
| Multi-Family Charges (\$/Dwelling Unit)     | 29.76          | 33.72             | 48.08             | 50.97             | 52.21             | 55.66             | 58.52             |
| % change in rate from previous year         | 55.6%          | 13.3%             | 42.6%             | 6.0%              | 2.4%              | 6.6%              | 5.1%              |
| Nonresidential Charges (medium "category" d | 1,090.30       | 1,223.15          | 1,567.15          | 1,474.11          | 1,497.47          | 1,531.05          | 1,549.84          |
| % change in rate from previous year         | 72.7%          | 12.2%             | 28.1%             | -5.9%             | 1.6%              | 2.2%              | 1.2%              |

| OPTION 3: LONG-HAUL + ORGANICS + ADVANCED WASTE PROCESSING (30% DIVERSION) |                   |                   |                   |                   |                   |                   |                   |
|----------------------------------------------------------------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|
| FISCAL PROJECTIONS                                                         | PROJECTED<br>FY26 | PROJECTED<br>FY27 | PROJECTED<br>FY28 | PROJECTED<br>FY29 | PROJECTED<br>FY30 | PROJECTED<br>FY31 | PROJECTED<br>FY32 |
| Single-Family Charges (\$/Household)                                       | 387.72            | 401.76            | 431.66            | 469.00            | 482.55            | 491.60            | 526.47            |
| % change in rate from previous year                                        | 24.7%             | 3.6%              | 7.4%              | 8.7%              | 2.9%              | 1.9%              | 7.1%              |
| Multi-Family Charges (\$/Dwelling Unit)                                    | 29.76             | 33.72             | 48.08             | 59.55             | 60.86             | 64.40             | 67.35             |
| % change in rate from previous year                                        | 55.6%             | 13.3%             | 42.6%             | 23.9%             | 2.2%              | 5.8%              | 4.6%              |
| Nonresidential Charges (medium "category" d                                | 1,090.30          | 1,223.15          | 1,567.15          | 1,671.98          | 1,696.33          | 1,730.80          | 1,750.41          |
| % change in rate from previous year                                        | 72.7%             | 12.2%             | 28.1%             | 6.7%              | 1.5%              | 2.0%              | 1.1%              |

# Milestones in Transition to Zero Waste

## Waste Reduction and Recycling Milestones

- ★ = Council Briefing
- ★ = Public Committee Meetings

|                                    |                            |  |                               |  |                                                 |                                  |
|------------------------------------|----------------------------|--|-------------------------------|--|-------------------------------------------------|----------------------------------|
| Food scraps collection pilot began | Food scraps pilot expanded |  | Save-as-you-throw pilot began |  | Construction and demolition sorting pilot began | Bring your own bag law in effect |
| Nov. 2021                          | Mar. 2023                  |  | Jun. 2025                     |  | Nov. 2025                                       | Jan. 2026                        |



## MSW Management Milestones

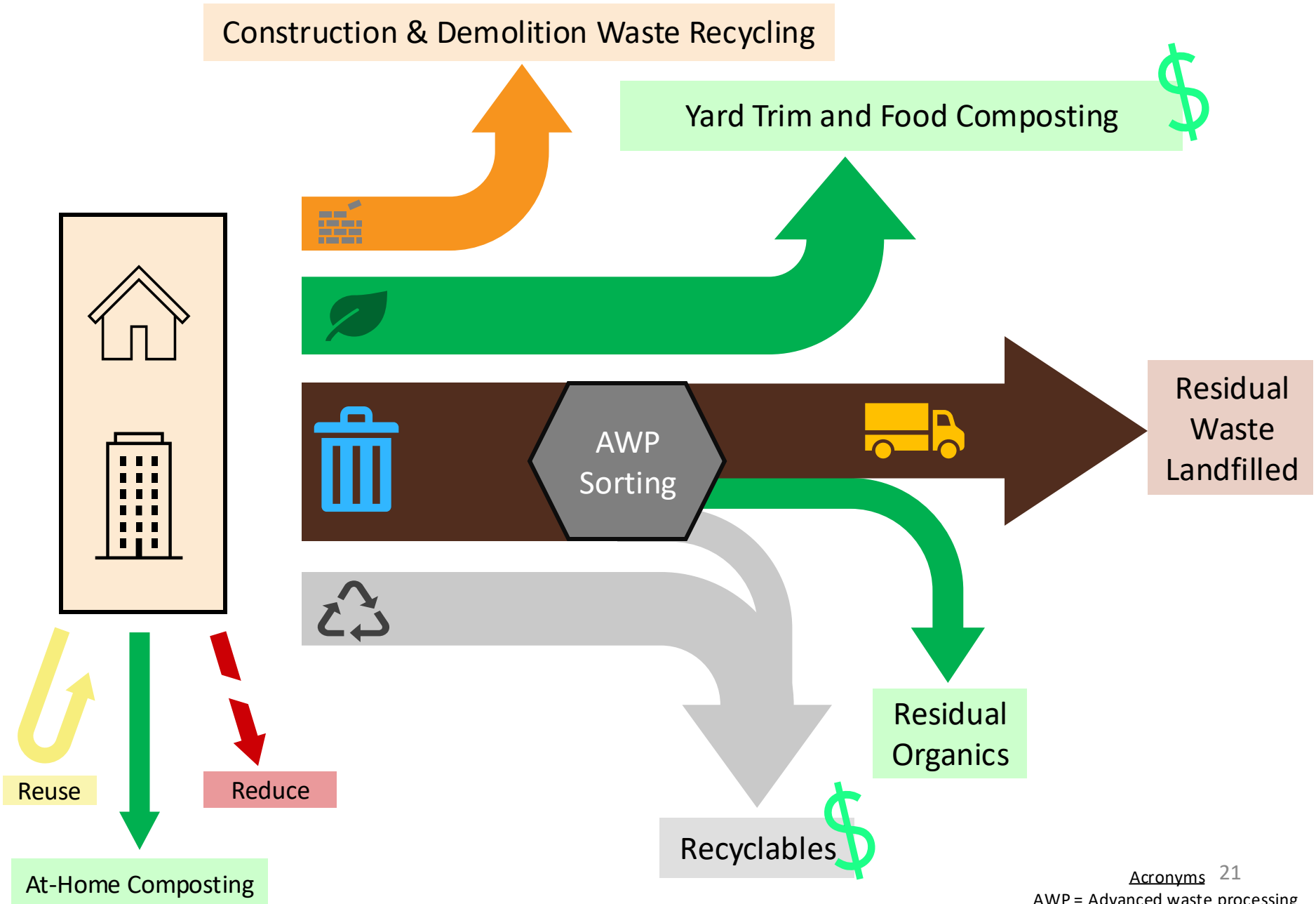
|                                                                          |                                                         |                                                                             |                                                                                                       |                          |                                                              |                                                            |
|--------------------------------------------------------------------------|---------------------------------------------------------|-----------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------|--------------------------|--------------------------------------------------------------|------------------------------------------------------------|
| Dec. 2021                                                                | Jan. 2024                                               | Mar. 2025                                                                   | May 2025                                                                                              | Sept. 2025               | Dec. 2025                                                    | Mar. 2026                                                  |
| County Executive commitment to MSW transition as part of zero waste goal | Issued REOI for long-haul and advanced waste processing | County Executive's proposed FY26 budget including advanced waste processing | MSW alternatives analysis identified transition to advanced waste processing as preferred alternative | Issued RFP for long-haul | DEP updates councilmembers and requests Council work session | Public engagement; County Executive's proposed FY27 budget |

← MSW Alternatives Analysis →

### Acronyms

MSW = Municipal Solid Waste  
 FY = Fiscal Year  
 RFP = Request for Proposals  
 REOI = Request for Expressions of Interest

# Option 3: Organics + AWP + Residual to Landfill







# **Organics Management Plan, including Siting, Technology and Capacity Planning, for Montgomery County, Maryland**

*Prepared for*

Montgomery County Department of Environmental Protection  
Under Contract to Maryland Environmental Service  
259 Najoles Road  
Millersville, Maryland 21108

*Prepared by*



EA Engineering, Science, and Technology, Inc., PBC  
225 Schilling Circle, Suite 400  
Hunt Valley, Maryland 21031  
410-584-7000

*in conjunction with*



Coker Composting and Consulting  
Troutville, Virginia

*And*



Amplify for Change  
Arlington, Virginia

March 2024  
Version: DRAFT FINAL  
EA Project No. 1630705

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|         |                                                            |      |
|---------|------------------------------------------------------------|------|
| 2.3.1   | Private Collections .....                                  | 2-16 |
| 2.3.2   | Decentralized Processing .....                             | 2-17 |
| 2.3.2.1 | Backyard Composting.....                                   | 2-17 |
| 2.3.2.2 | Community Composting.....                                  | 2-18 |
| 2.3.2.3 | On-Farm Composting .....                                   | 2-19 |
| 2.4     | ORGANIC WASTE CAPTURE SCENARIOS .....                      | 2-20 |
| 2.4.1   | Food Scraps.....                                           | 2-20 |
| 2.5     | ORGANIC WASTE PROCESSING .....                             | 2-21 |
| 2.5.1   | Yard Trim Processing Capacity Limitations.....             | 2-21 |
| 2.5.2   | Food Scrap and Yard Trim Collection.....                   | 2-22 |
| 2.5.3   | Compost Recipe .....                                       | 2-23 |
| 2.5.4   | Processing Capacity Basis for Facility Planning .....      | 2-24 |
| 3.      | SOURCE SEPARATED ORGANICS PROCESSING OPTIONS (TASK 2)..... | 3-1  |
| 3.1     | AEROBIC PROCESSING TECHNOLOGIES .....                      | 3-1  |
| 3.1.1   | Aerated Static Pile (ASP).....                             | 3-1  |
| 3.1.2   | Enclosed (In-Vessel) Composting .....                      | 3-3  |
| 3.1.2.1 | Tunnel Reactor.....                                        | 3-3  |
| 3.1.2.2 | Rotating Drum .....                                        | 3-3  |
| 3.1.3   | Agitated Bed .....                                         | 3-4  |
| 3.1.4   | Aerobic Processing Technologies Summary Table .....        | 3-5  |
| 3.2     | ANAEROBIC PROCESSING TECHNOLOGIES .....                    | 3-9  |
| 3.2.1   | Wet (Low-Solids) CSTR Anaerobic Digestion .....            | 3-9  |
| 3.2.2   | High-Solids Dry Fermentation Anaerobic Digestion .....     | 3-10 |
| 3.2.3   | High-Solids Plug Flow Anaerobic Digestion .....            | 3-10 |
| 3.2.4   | Anaerobic Processing Technologies Summary Table .....      | 3-11 |
| 3.3     | SUPPORTING PROCESSING INFRASTRUCTURE .....                 | 3-15 |
| 3.3.1   | Pre-Treatment .....                                        | 3-15 |
| 3.3.2   | Post-Treatment.....                                        | 3-16 |
| 3.4     | POLLUTANTS OF CONCERN.....                                 | 3-17 |
| 3.4.1   | PFAS .....                                                 | 3-17 |
| 3.4.2   | Microplastics.....                                         | 3-18 |
| 3.4.3   | Persistent Herbicides.....                                 | 3-19 |

|         |                                                                        |      |
|---------|------------------------------------------------------------------------|------|
| 3.4.4   | Summary Table.....                                                     | 3-20 |
| 3.5     | GREENHOUSE GAS (GHG) IMPACTS .....                                     | 3-22 |
| 3.6     | ANALYSIS.....                                                          | 3-22 |
| 3.6.1   | Technology Evaluation Criteria.....                                    | 3-23 |
| 3.6.2   | Technology Scoring.....                                                | 3-24 |
| 3.6.3   | Technology Ranking.....                                                | 3-27 |
| 4.      | RECYCLED ORGANICS PRODUCT USAGE OPTIONS (TASK 3).....                  | 4-1  |
| 4.1     | RECYCLED ORGANICS PRODUCTS .....                                       | 4-1  |
| 4.1.1   | Product Types .....                                                    | 4-1  |
| 4.1.2   | Product Requirements – Compost End Products .....                      | 4-1  |
| 4.1.2.1 | Maryland Department of Agriculture .....                               | 4-1  |
| 4.1.2.2 | Maryland State Highway Administration .....                            | 4-2  |
| 4.1.2.3 | Maryland Department of the Environment.....                            | 4-3  |
| 4.1.2.4 | County Agency Requirements and Incentives.....                         | 4-4  |
| 4.1.3   | Product Requirements – Anaerobic Digestion End Products .....          | 4-4  |
| 4.1.3.1 | Maryland Department of Agriculture .....                               | 4-4  |
| 4.1.3.2 | Biogas .....                                                           | 4-4  |
| 4.1.4   | Product Competition .....                                              | 4-6  |
| 4.2     | RECYCLED ORGANICS PRODUCT MARKETS .....                                | 4-8  |
| 4.2.1   | Market Capacity By Sector.....                                         | 4-9  |
| 4.2.1.1 | Landscape Market.....                                                  | 4-9  |
| 4.2.1.2 | Agriculture Market.....                                                | 4-11 |
| 4.2.1.3 | Stormwater Management for New Construction/Re-development Market ..... | 4-12 |
| 4.2.1.4 | Market Capacity Summary .....                                          | 4-13 |
| 4.2.1.5 | Emerging Markets.....                                                  | 4-14 |
| 4.3     | INFLUENCE OF COUNTY POLICY .....                                       | 4-16 |
| 5.      | SITING EVALUATION (TASK 4) .....                                       | 5-1  |
| 5.1     | SHADY GROVE PROCESSING FACILITY AND TRANSFER STATION ...               | 5-1  |
| 5.1.1   | Current Site Operations.....                                           | 5-2  |
| 5.1.2   | Considerations for Future Site Use .....                               | 5-3  |

|         |                                                                                                                                           |      |
|---------|-------------------------------------------------------------------------------------------------------------------------------------------|------|
| 5.2     | YARD TRIM COMPOSTING FACILITY AT DICKERSON (MCYTCF).....                                                                                  | 5-5  |
| 5.2.1   | Current Site Operations.....                                                                                                              | 5-7  |
| 5.2.2   | Considerations for Future Site Use .....                                                                                                  | 5-8  |
| 5.3     | SITE 2 (DICKERSON).....                                                                                                                   | 5-9  |
| 5.3.1   | Current Site Operations.....                                                                                                              | 5-10 |
| 5.3.2   | Considerations for Future Site Use .....                                                                                                  | 5-10 |
| 5.4     | GIS REVIEW .....                                                                                                                          | 5-12 |
| 5.4.1   | Non-County Owned Parcels .....                                                                                                            | 5-15 |
| 5.4.2   | Transportation Analysis .....                                                                                                             | 5-16 |
| 5.5     | SITE DEVELOPMENT REQUIREMENTS.....                                                                                                        | 5-16 |
| 5.5.1   | Federal Requirements – Composting Facilities .....                                                                                        | 5-17 |
| 5.5.2   | State Requirements – Composting Facilities .....                                                                                          | 5-17 |
| 5.5.2.1 | Facility Siting.....                                                                                                                      | 5-18 |
| 5.5.2.2 | Facility Design and Construction.....                                                                                                     | 5-18 |
| 5.5.3   | Local Requirements – Composting Facilities .....                                                                                          | 5-18 |
| 5.5.4   | State Requirements – Anaerobic Digestion Facilities .....                                                                                 | 5-19 |
| 5.6     | ANALYSIS.....                                                                                                                             | 5-20 |
| 5.6.1   | Siting Evaluation Criteria .....                                                                                                          | 5-20 |
| 5.6.2   | Site Scoring.....                                                                                                                         | 5-22 |
| 5.6.3   | Site Ranking.....                                                                                                                         | 5-25 |
| 6.      | DEVELOPMENT AND EVALUATION OF ALTERNATIVES (TASK 5) .....                                                                                 | 6-1  |
| 6.1     | ALTERNATIVES.....                                                                                                                         | 6-2  |
| 6.1.1   | Option 1 – ASP Composting at Montgomery County Yard Trim<br>Composting Facility (MCYTCF).....                                             | 6-2  |
| 6.1.1.1 | Option 1.1 – Pilot Scale ASP at Montgomery County Yard<br>Trim Composting Facility.....                                                   | 6-3  |
| 6.1.2   | Option 2 – In-Vessel Tunnel Reactor Composting at Shady Grove TS<br>and Product Finishing at MCYTCF.....                                  | 6-3  |
| 6.1.3   | Option 3 – Agitated Bed Composting at Site 2.....                                                                                         | 6-4  |
| 6.1.4   | Option 4 – Dry Fermentation Anaerobic Digestion at Shady Grove TS<br>with Product Finishing at MCYTCF via Tunnel Reactor Composting ..... | 6-5  |

|       |                                                                                                                                              |      |
|-------|----------------------------------------------------------------------------------------------------------------------------------------------|------|
| 6.1.5 | Option 5 – Dry Fermentation Anaerobic Digestion at Shady Grove Transfer Station with Product Finishing at MCYTCF via Windrow Composting..... | 6-7  |
| 6.2   | ADDITIONAL PROGRAM DEVELOPMENT MODEL .....                                                                                                   | 6-8  |
| 6.3   | LIFE-CYCLE COST ANALYSIS.....                                                                                                                | 6-10 |
| 6.3.1 | Conceptual Cost Estimates .....                                                                                                              | 6-10 |
| 6.4   | ANALYSIS.....                                                                                                                                | 6-11 |
| 6.4.1 | Alternatives Evaluation Criteria .....                                                                                                       | 6-11 |
| 6.4.2 | Alternatives Scoring.....                                                                                                                    | 6-12 |
| 6.4.3 | Alternatives Ranking .....                                                                                                                   | 6-12 |
| 7.    | SUMMARY AND CONCLUSIONS .....                                                                                                                | 7-1  |
| 7.1   | SUMMARY .....                                                                                                                                | 7-1  |
| 7.1.1 | Source Separated Organics Processing Options Materials Feedstock Projections .....                                                           | 7-1  |
| 7.1.2 | Source Separated Organics Processing Options .....                                                                                           | 7-1  |
| 7.1.3 | Recycled Organics Product Usage Options .....                                                                                                | 7-2  |
| 7.1.4 | Siting Evaluation.....                                                                                                                       | 7-2  |
| 7.1.5 | Evaluation of Alternatives .....                                                                                                             | 7-3  |
| 7.1.6 | Next Steps .....                                                                                                                             | 7-3  |
| 7.1.7 | Conclusions.....                                                                                                                             | 7-4  |
| 8.    | REFERENCES .....                                                                                                                             | 8-1  |
|       | Chapter 2 – Source Separated Organic Material Feedstock Projections .....                                                                    | 8-1  |
|       | Chapter 3 – Organics Processing Technologies.....                                                                                            | 8-4  |
|       | Chapter 4 – Organics Product Markets.....                                                                                                    | 8-5  |
|       | Chapter 5 – Siting Evaluation.....                                                                                                           | 8-7  |



## LIST OF TABLES

|             |                                                                              |      |
|-------------|------------------------------------------------------------------------------|------|
| Table ES-1. | Projected Food Scraps Capture (Tons) by Year .....                           | ES-1 |
| Table ES-2. | Technology Ranking Summary Table .....                                       | ES-2 |
| Table ES-3. | Site Ranking Summary Table .....                                             | ES-3 |
| Table ES-4. | Alternatives Ranking Summary Table.....                                      | ES-3 |
| Table 2-1.  | Population and Housecount Projections, 2025–2045 .....                       | 2-2  |
| Table 2-2.  | Organic Waste Generation Projections, 2025-2045 (tons) .....                 | 2-4  |
| Table 2-3.  | Calendar Year 2021 Organic Waste Capture by Sector and Material (tons) ..... | 2-5  |
| Table 2-4.  | Single-Family Food Scrap Tons Captured Scenarios .....                       | 2-9  |
| Table 2-5.  | Multi-Family Food Scrap Tons Captured Scenarios .....                        | 2-10 |
| Table 2-6.  | Non-Residential Food Scrap Tons Captured Scenarios.....                      | 2-11 |
| Table 2-7.  | Large Food Waste Generators by Sector .....                                  | 2-12 |
| Table 2-8.  | Yard Trim Tons Captured .....                                                | 2-13 |
| Table 2-9.  | Non-Recyclable Paper Tons Captured Scenarios .....                           | 2-14 |
| Table 2-10. | Private Collections Capture Scenarios Basis .....                            | 2-17 |
| Table 2-11. | Private Collections Tons Captured Scenarios.....                             | 2-17 |
| Table 2-12. | County Backyard Composting Outreach .....                                    | 2-17 |
| Table 2-13. | Backyard Composting Capture Scenarios Basis.....                             | 2-18 |
| Table 2-14. | Backyard Composting Tons Captured Scenarios .....                            | 2-18 |
| Table 2-15. | Community Composting Capture Scenarios Basis .....                           | 2-19 |
| Table 2-16. | Community Composting Organics Diversion Scenarios (Tons) .....               | 2-19 |
| Table 2-17. | On-Farm Composting Capture Scenarios Basis .....                             | 2-20 |
| Table 2-18. | On-Farm Composting Tons Captured Scenarios .....                             | 2-20 |
| Table 2-19. | Food Scrap Capture Scenarios .....                                           | 2-21 |
| Table 2-20. | Food Scraps Capture (Tons) by Year.....                                      | 2-21 |

|             |                                                                                                                      |      |
|-------------|----------------------------------------------------------------------------------------------------------------------|------|
| Table 2-21. | Yard Trim Processed and Transported to Montgomery County Yard Trim Composting Facility (MCYTCF) (Tons), FY19-23..... | 2-22 |
| Table 2-22. | Estimated Food Scrap and Yard Trim Collection Costs.....                                                             | 2-23 |
| Table 2-23. | Bulk Density Summary Table.....                                                                                      | 2-24 |
| Table 2-24. | Organics Processing Capacity Basis.....                                                                              | 2-24 |
| Table 3-1.  | Compost Technology Alternatives – Centralized Aerobic Processing.....                                                | 3-7  |
| Table 3-2.  | Anaerobic Digestion Technology Alternatives – Centralized Anaerobic Processing .....                                 | 3-13 |
| Table 3-3.  | Persistent Herbicides Commonly Found in Organics Feedstocks .....                                                    | 3-20 |
| Table 3-4.  | Pollutants of Concern in Organics Processing.....                                                                    | 3-21 |
| Table 3-5.  | GHG Emissions Mitigation Per Ton of Diverted Organic Material .....                                                  | 3-22 |
| Table 3-6.  | Organics Processing Technologies – Evaluation Criteria.....                                                          | 3-23 |
| Table 3-7.  | Technology Scoring.....                                                                                              | 3-25 |
| Table 3-8.  | Technology Ranking Summary Table .....                                                                               | 3-27 |
| Table 3-9.  | Technology Weighted Matrix .....                                                                                     | 3-29 |
| Table 4-1.  | MDA Parameter Limits for General Use Compost.....                                                                    | 4-2  |
| Table 4-2.  | MDOT SHA Compost Types – Physical Properties.....                                                                    | 4-3  |
| Table 4-3.  | Illustrative Gas Quality Considerations for RNG Injection.....                                                       | 4-5  |
| Table 4-4.  | Food Scrap Compost Products Produced and Sold in Maryland.....                                                       | 4-8  |
| Table 4-5.  | Recycled Organics Product Market Types .....                                                                         | 4-9  |
| Table 4-6.  | County Landscape Market Capacity .....                                                                               | 4-11 |
| Table 4-7.  | County Agriculture Market Capacity.....                                                                              | 4-12 |
| Table 4-8.  | Stormwater Management (SWM) for New Construction/Re-Development Market Sector Analysis .....                         | 4-13 |
| Table 4-9.  | Market Capacity Summary .....                                                                                        | 4-14 |
| Table 5-1.  | Site Adequacy Assessment – Shady Grove TS.....                                                                       | 5-4  |

|             |                                                                       |      |
|-------------|-----------------------------------------------------------------------|------|
| Table 5-2.  | Shady Grove Transfer Station Pros and Cons for Site Development ..... | 5-5  |
| Table 5-3.  | Yard Trim (Tons) Received at MCYTCTF by Mode .....                    | 5-7  |
| Table 5-4.  | Site Adequacy Assessment – MCYTCTF .....                              | 5-8  |
| Table 5-5.  | MCYTCTF at Dickerson Pros and Cons for Site Development .....         | 5-9  |
| Table 5-6.  | Site Adequacy Assessment – Site 2 .....                               | 5-11 |
| Table 5-7.  | MCYTCTF at Dickerson Pros and Cons for Site 2 Development .....       | 5-12 |
| Table 5-8.  | Anaerobic Digestion Permitting Summary Table.....                     | 5-20 |
| Table 5-9.  | Facility Siting – Evaluation Criteria .....                           | 5-21 |
| Table 5-10. | Siting Scoring.....                                                   | 5-23 |
| Table 5-11. | Site Ranking Summary Table .....                                      | 5-25 |
| Table 5-12. | Site Ranking Summary Table .....                                      | 5-27 |
| Table 6-1.  | Conceptual Facility Capital Costs.....                                | 6-10 |
| Table 6-2.  | Conceptual Facility Annual O&M Costs.....                             | 6-11 |
| Table 6-3.  | Alternatives – Evaluation Criteria .....                              | 6-11 |
| Table 6-4.  | Alternatives Scoring.....                                             | 6-12 |
| Table 6-5.  | Alternatives Ranking Summary Table.....                               | 6-15 |
| Table 6-6.  | Alternatives Weighted Matrix.....                                     | 6-15 |
| Table 7-1.  | Projected Food Scraps Capture (Tons) by Year .....                    | 7-1  |
| Table 7-2.  | Technology Ranking Summary Table .....                                | 7-2  |
| Table 7-3.  | Site Ranking Summary Table .....                                      | 7-3  |
| Table 7-4.  | Alternatives Ranking Summary Table.....                               | 7-3  |

## LIST OF FIGURES

|              |                                                                                                     |      |
|--------------|-----------------------------------------------------------------------------------------------------|------|
| Figure 2-1.  | Housecount by Subgroup.....                                                                         | 2-2  |
| Figure 2-2.  | Organic Waste Fraction of County-Managed MSW, Calendar Year 2021 .....                              | 2-3  |
| Figure 2-3.  | Organic Waste Generation by Material Type .....                                                     | 2-3  |
| Figure 2-4.  | Organic Waste Capture by Material Type .....                                                        | 2-5  |
| Figure 2-5.  | Historical Food Scrap Capture Trends.....                                                           | 2-6  |
| Figure 2-6.  | Public Interest in Participating in County Food Scrap Diversion Programs .....                      | 2-8  |
| Figure 2-7.  | Large Food Waste Generators .....                                                                   | 2-13 |
| Figure 3-1.  | ASP alternatives in windrow, bunker, and extended ASP configurations.....                           | 3-2  |
| Figure 3-2.  | Fabric-covered ASPs .....                                                                           | 3-2  |
| Figure 3-3.  | Rotating Drum Composting.....                                                                       | 3-4  |
| Figure 3-4.  | Agitated Bed Composting NRAES-54 .....                                                              | 3-5  |
| Figure 3-5.  | Cross Section through Dry Fermenter .....                                                           | 3-10 |
| Figure 3-6.  | Horizontal Plug Flow Digester .....                                                                 | 3-11 |
| Figure 3-7.  | Tub Grinder.....                                                                                    | 3-15 |
| Figure 3-8.  | Mechanical Depackager.....                                                                          | 3-16 |
| Figure 3-9.  | Mechanical Mixers.....                                                                              | 3-16 |
| Figure 3-10. | Optimum composting environment .....                                                                | 3-16 |
| Figure 3-11. | Post-treatment separators including drum-style ballistics separator and densimetric separators..... | 3-17 |
| Figure 4-1.  | Typical Radii for Bulk (50-mile) and Bagged (200-mile) product sales.....                           | 4-7  |
| Figure 5-1.  | Shady Grove Processing Facility and Transfer Station. ....                                          | 5-2  |
| Figure 5-2.  | MCYTFC at Dickerson.....                                                                            | 5-7  |
| Figure 5-3.  | Montgomery County Site 2 at Dickerson. ....                                                         | 5-10 |
| Figure 5-4.  | GIS Desktop Findings from Initial (Tier 1) Screening .....                                          | 5-13 |

Figure 5-5. GIS Desktop Findings from Secondary (Tier 2) Screening..... 5-14

Figure 5-6. GIS Desktop Findings of Non-County-Owned Parcels ..... 5-15

Figure 5-7. Transportation Analysis of Remaining Sites ..... 5-16

Figure 6-1. Organics Processing Flow Diagram..... 6-1

Figure 6-2. GIS Screening of County-Owned Sites for Distributed Composting ..... 6-9

## **LIST OF APPENDIXES**

Appendix A: Organic Waste Projections

Appendix B: Current County Food Scrap Diversion Efforts

Appendix C: Single-Family Survey

Appendix D: Biogas and Hydrogen Yield Analysis from Food Waste

Appendix E: Outreach and Education – Minimizing Contamination

Appendix F: Capital and O&M Cost Estimates

Appendix G: Vendor Product Information

## LIST OF ACRONYMS AND ABBREVIATIONS

|                    |                                                                    |
|--------------------|--------------------------------------------------------------------|
| °F                 | Degrees Fahrenheit                                                 |
| μm                 | Micrometer(s)                                                      |
| AASHTO             | American Association of State Highway and Transportation Officials |
| AD                 | Anaerobic digestion                                                |
| AR                 | Agricultural Reserve                                               |
| ASP                | Aerated static pile                                                |
| BMP                | Best Management Practice                                           |
| BSM                | Bioretention soil mix                                              |
| C:N                | Carbon to nitrogen                                                 |
| CH <sub>4</sub>    | Methane                                                            |
| CO <sub>2</sub>    | Carbon dioxide                                                     |
| CO <sub>2</sub> eq | Carbon dioxide equivalent                                          |
| Coker              | Coker Composting and Consulting                                    |
| COMAR              | Code of Maryland Regulations                                       |
| County             | Montgomery County                                                  |
| CSTR               | Continuous-stirred tank reactor                                    |
| CY                 | Cubic yard(s)                                                      |
| DEP                | Department of Environmental Protection                             |
| EA                 | EA Engineering, Science, and Technology, Inc., PBC                 |
| EPA                | U.S. Environmental Protection Agency                               |
| ESD                | Environmental Site Design                                          |
| ft                 | Foot (feet)                                                        |
| FY                 | Fiscal year                                                        |
| GHG                | Greenhouse gas                                                     |
| GIS                | Geographic information system                                      |
| IH                 | Heavy industrial                                                   |
| ILSR               | Institute for Local Self-Reliance                                  |
| in.                | Inch(es)                                                           |
| kg                 | Kilogram(s)                                                        |
| M-NCPPC            | Maryland-National Capital Parks and Planning Commission            |
| MCYTFC             | Montgomery County Yard Trim Composting Facility                    |
| MDA                | Maryland Department of Agriculture                                 |
| MDE                | Maryland Department of the Environment                             |
| mg/kg              | Milligram(s) per kilogram                                          |

|                     |                                                        |
|---------------------|--------------------------------------------------------|
| MTCO <sub>2</sub> e | Metric tons of carbon dioxide equivalents              |
| MDOT                | Maryland Department of Transportation                  |
| MEP                 | Maximum Extent Practicable                             |
| MES                 | Maryland Environmental Service                         |
| mm                  | Millimeter(s)                                          |
| mmhos/cm            | Millimhos per centimeter                               |
| MP                  | Microplastic                                           |
| MS4                 | Municipal separate storm sewer system                  |
| MSF                 | 1,000 square feet                                      |
| MSW                 | Municipal solid waste                                  |
| nm                  | Nanometer(s)                                           |
| NRAES               | Natural Resource, Agriculture, and Engineering Service |
| O&M                 | Operation and maintenance                              |
| P                   | Phosphorus                                             |
| PFAS                | Per- and polyfluoroalkyl substances                    |
| PFOA                | Perfluorooctanoic acid                                 |
| PFOS                | Perfluorooctanesulfonic acid                           |
| PH                  | Persistent herbicide                                   |
| ppb                 | Part(s) per billion                                    |
| ppt                 | Part(s) per thousand                                   |
| psi                 | Pound(s) per square inch                               |
| RNG                 | Renewable natural gas                                  |
| RRF                 | Resource Recovery Facility                             |
| RRMD                | Recycling and Resource Management Division             |
| RRS                 | Resource Recycling Systems                             |
| SCA                 | Sugarloaf Citizens Association                         |
| SF                  | Square foot (feet)                                     |
| SHA                 | State Highway Administration                           |
| Shady Grove TS      | Shady Grove Processing Facility and Transfer Station   |
| SSO                 | Source-separated organics                              |
| SWM                 | Stormwater Management                                  |
| TPY                 | Ton(s) per year                                        |
| USDA                | U.S. Department of Agriculture                         |
| v/v                 | Volume per volume                                      |
| VOC                 | Volatile organic compound                              |
| WARM                | EPA Waste Reduction Model                              |



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## EXECUTIVE SUMMARY

EA Engineering, Science, and Technology, Inc., PBC (EA) and its team, including Coker Composting and Consulting and Amplify for Change, were contracted by the Maryland Environmental Service for Montgomery County to prepare this organics siting study plan to evaluate the siting, technology, and capacity planning for a County-owned organics processing facility in Montgomery County to meet the food scrap, non-recyclable paper, and yard trim diversion needs of the County for the next 20 years. The EA Team completed the evaluation as outlined below.

## SOURCE SEPARATED ORGANIC MATERIAL FEEDSTOCK PROJECTIONS

The County has a long-standing yard trim diversion program, capturing around 90% of the yard trim generated, and processing up to the processing limit of 77,000 tons of yard trim per year at the Montgomery County Yard Trim Composting Facility (MCYTFC). In contrast, food waste and non-recyclable paper present organic waste streams with significant opportunity to improve upon historically low capture rates.

Projections for capture of food waste and non-recyclable paper were developed based on eight scenarios considering the potential of low, medium, high, and mandatory participation by single-family, multi-family, and non-residential sectors in the county. Survey response data were used to inform the projections for single-family households, by creating an understanding for the potential for future public engagement. In four of the scenarios, decentralized processing strategies, including backyard, community, and on-farm composting, were considered to understand the extent to which these pathways may process food scraps and offset the processing capacity required by the County. Projected food scrap capture quantities varied from 8,800 to 65,800 tons per year in low to mandatory scenarios, and up to 58,300 tons per year captured where diversionary measures through decentralized processing were in place. The food scrap capture projections are shown in Table ES-1.

**Table ES-1. Projected Food Scraps Capture (Tons) by Year**

| Scenario | 2025  | 2030   | 2035   | 2040   | 2045   |
|----------|-------|--------|--------|--------|--------|
| 1        | 4,600 | 5,700  | 6,700  | 7,700  | 8,800  |
| 2        | 6,400 | 10,700 | 15,100 | 19,600 | 24,100 |
| 3        | 7,300 | 18,500 | 30,000 | 41,900 | 54,000 |
| 4        | 7,300 | 35,500 | 45,300 | 55,400 | 65,800 |
| 5        | 4,600 | 5,700  | 6,700  | 7,700  | 8,800  |
| 6        | 4,800 | 7,600  | 11,900 | 16,500 | 21,100 |
| 7        | 5,700 | 15,400 | 26,900 | 38,800 | 51,000 |
| 8        | 3,500 | 28,100 | 37,700 | 47,900 | 58,300 |

## SOURCE SEPARATED ORGANICS PROCESSING OPTIONS

Organics processing technologies were reviewed, focusing on the current state-of-practice technologies and their potential to support municipal-scale processing of food scrap and yard trim. Several aerobic processing technologies were evaluated in this study, including aerated static pile (ASP); enclosed in-vessel tunnel reactors; rotating drums; and agitated bed composting

systems. In addition, anaerobic processing technologies were evaluated, including wet (low-solids) continuous-stirred tank reactor (CSTR) anaerobic digestion (AD), high-solids dry fermentation AD, and high-solids plug flow AD. Technology review included discussion of pre- and post-treatment processing; pollutants of concern, including per- and polyfluoroalkyl substances, microplastics, and persistent herbicides; and greenhouse gas emissions assessment. To discern the most suitable organics processing technology, the EA Team used a weighted matrix approach to rank each technology with County input on 20 evaluation criteria considering systems factors, operations, end products, and environmental concerns. The technologies were ranked as shown in Table ES-2.

**Table ES-2. Technology Ranking Summary Table**

| <b>Technology</b>     | <b>Weighted Score</b> |
|-----------------------|-----------------------|
| ASP                   | 269.8                 |
| Tunnel Reactor        | 253.5                 |
| Agitated Bed          | 227.5                 |
| Dry Fermentation      | 225.9                 |
| Rotating Drum         | 212.9                 |
| High Solids Plug Flow | 201.5                 |
| Wet (low-solids) CSTR | 185.3                 |

## **RECYCLED ORGANICS PRODUCT USAGE OPTIONS**

As all organics processing end products must have viable end markets to be successful, a review of the end products and potential capacities of end markets in the county to absorb recycled organics products from aerobic and anaerobic organics processing technologies was conducted. End products reviewed included compost, biogas, and digestate. Market capacity by sector was considered for landscaping, agriculture, and stormwater management for new construction/redevelopment, with an estimated market capacity of 276,600 cubic yards (CY) per year, or 69,800 CY per year for the County's market share. Although not quantified, additional emerging discussion included erosion and sediment control applications, development of soil organic matter content, and climate sequestration and climate action plans.

## **SITING EVALUATION**

To support an organics processing facility, a site must meet the needs to receive, process, and distribute organic feedstocks and finished products. The siting evaluation examined the feasibility of using County-owned property for the development of an organics management facility, including review of the Shady Grove Processing Facility and Transfer Station (TS), the MCYTFC at Dickerson, and the tract of land known as Site 2 in Dickerson. To discern the most suitable site, the EA Team used a weighted matrix to rank each technology with County input, using 17 evaluation criteria for evaluating each site, including site characteristics that may affect site development, conditions local to each site, and community considerations. The sites were ranked as shown in Table ES-3.

**Table ES-3. Site Ranking Summary Table**

| <b>Technology</b> | <b>Weighted Score</b> |
|-------------------|-----------------------|
| MCYTCF            | 267.0                 |
| Shady Grove TS    | 236.0                 |
| Site 2            | 219.8                 |

In addition, the EA Team performed a desktop analysis based on publicly available geographic information system data to determine whether any additional County-owned parcels merit further review as potential locations for facility siting. From the initial desktop analysis, EA identified 101 parcels meeting evaluation criteria for County ownership over 25 acres and outside of the presence of wetlands and floodplains. However, with further County review and refined selection criteria, all sites were removed from consideration due to current use or accessibility. A preliminary desktop evaluation was done with non-County-owned sites over 25 acres, but further consideration and discussion would be needed to identify if the sites were viable and merit the additional costs of land acquisition.

## **EVALUATION OF ALTERNATIVES**

The projections, the technology evaluation, and the siting study were combined into five alternatives for consideration. While other combinations of technology and siting may be viable, these five alternatives were prioritized based on rankings previously developed in this report. Additional combinations of technology and siting beyond those represented as Options 1 through 5 are discussed in Chapter 6 with additional cost considerations.

The five alternatives presented considered a phased processing facility development, with adequate capacity to process up to 97,400 tons (273,500 CY) of yard trim and food scrap in Phase I, and to meet the future processing capacity needs identified in the mandatory program and some high capture scenarios in Phase II. Conceptual capital and operation and maintenance costs were developed for the purposes of comparing alternatives. To discern the preferred alternative, the EA Team used a weighted matrix to rank each alternative, with County input, using eight evaluation criteria important for facility development. The alternatives were ranked, with pros and cons for each alternative summarized, as shown in Table ES-4.

**Table ES-4. Alternatives Ranking Summary Table**

| <b>Alternative</b>                  | <b>Weighted Score</b> | <b>Pros</b>                                                                                                                                                       | <b>Cons</b>                                                                                                                                                                                         |
|-------------------------------------|-----------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Option 1 – ASP Composting at MCYTCF | 103.8                 | <ul style="list-style-type: none"> <li>Technology process controls optimize material processing</li> <li>Established technology familiar to regulators</li> </ul> | <ul style="list-style-type: none"> <li>Material receiving requires transport from Shady Grove TS</li> <li>Site upgrades to MCYTCF required</li> <li>Management of contact water required</li> </ul> |

| Alternative                                                                                                     | Weighted Score | Pros                                                                                                                                                                                                     | Cons                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|-----------------------------------------------------------------------------------------------------------------|----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Option 3 – Agitated Bed Composting at Site 2                                                                    | 92.0           | <ul style="list-style-type: none"> <li>• Effective system for large-scale operations</li> <li>• Indoor processing yields little to no contact water</li> <li>• High degree of process control</li> </ul> | <ul style="list-style-type: none"> <li>• Significant capital costs for equipment and building</li> <li>• Material receiving requires transport from Shady Grove TS and would require additional road access from RRF to Site 2</li> </ul>                                                                                                                                                                                                                                  |
| Option 2 – In-Vessel Tunnel Reactor Composting at Shady Grove TS and Product Finishing at MCYTFC                | 75.3           | <ul style="list-style-type: none"> <li>• Minimal contact water generation</li> <li>• High degree of process control to minimize odors and optimize material processing</li> </ul>                        | <ul style="list-style-type: none"> <li>• Significant capital costs for equipment and concrete construction</li> <li>• Shady Grove TS at capacity with existing operations, requiring relocation of current activities or acquisition of adjacent parcels</li> <li>• Material receiving and processing at Shady Grove TS with curing off-site with significant transportation cost</li> </ul>                                                                               |
| Option 5 – Dry Fermentation AD at Shady Grove TS with Product Finishing at MCYTFC                               | 71.5           | <ul style="list-style-type: none"> <li>• Enclosed system yields little to no contact water</li> <li>• No MCYTFC upgrades required</li> </ul>                                                             | <ul style="list-style-type: none"> <li>• Material receiving and processing at Shady Grove TS with curing off-site</li> <li>• Shady Grove TS at capacity with existing operations, requiring relocation of current activities or acquisition of adjacent parcels</li> <li>• Unclear permitting pathway and unfamiliar to regulators</li> <li>• End products include digestate and biogas which require additional management</li> </ul>                                     |
| Option 4 – Dry Fermentation AD at Shady Grove TS with Product Finishing at MCYTFC via Tunnel Reactor Composting | 64.0           | <ul style="list-style-type: none"> <li>• Enclosed system yields little to no contact water</li> </ul>                                                                                                    | <ul style="list-style-type: none"> <li>• Material receiving and processing at Shady Grove TS with curing off-site</li> <li>• Shady Grove TS at capacity with existing operations, requiring relocation of current activities or acquisition of adjacent parcels</li> <li>• Unclear permitting pathway and unfamiliar to regulators</li> <li>• End products include digestate and biogas which require additional management</li> <li>• MCYTFC upgrades required</li> </ul> |

## CONCLUSION

The County has a demonstrated need for organics processing capacity to meet the yard trim and food scrap generation and capture projected over the planning period. Final alternatives provide the outline of facility site development alternatives that utilize proven organics processing technologies at County-owned sites. Achieving food scrap diversion at low, medium, or high capture levels will continue to require rigorous program development and public engagement.

While all alternatives presented rely on a centralized processing approach concentrating processing capacity at a single site, it is noted that a distributed processing approach merits further evaluation by the County, including identification of suitable land area for development. While pursuing a distributed processing approach would require further study, it may provide the County with an avenue to address its already burdened solid waste management facilities. Moreover, implementation of decentralized processing approaches may be effective for geographic regions of the County, while a centralized processing option located at an existing County facility may also be an effective systems approach. Further, where diversionary measures such as expanded backyard, community, and on-farm composting are utilized, the viable capacity life of proposed organics processing alternatives developed in this study may be extended beyond the planning period.

## 1. INTRODUCTION

The EA Engineering, Science, and Technology, Inc., PBC (EA) Team, including Coker Composting and Consulting (Coker) and Amplify for Change, was contracted by the Maryland Environmental Service (MES) to conduct a study for the development of a Montgomery County (County)-owned organics processing facility to meet the food scrap, non-recyclable paper, and yard trim diversion needs of the County for the next 20 years.

Currently, the County manages the collection by contractor of recyclables, yard trim, and scrap metal for approximately 222,000 households, and the collection by contractor of refuse for approximately 92,000 households. The remaining 130,000 households arrange for private collection individually or through their homeowner's association. This study considers the organics captured from single-family residences located in Subdistricts A and B, municipalities; multi-family and commercial sectors (e.g., businesses, non-profits, institutions, and federal, state, and local government offices) within Montgomery County.

### 1.1 METHODOLOGY

The intent of this study is to evaluate the potential for organic waste processing separately from the municipal solid waste (MSW) stream currently managed through waste to energy. The feasibility of diverting organic waste and processing by other methods was evaluated as follows:

- **Source Separated Organic Materials Feedstock Projections (Chapter 2)** – Projections for organic waste generated and captured from residential, commercial, industrial, and agricultural sectors were estimated over the planning period, to assess the organic waste processing capacity that may be required over the planning period.
- **Source Separated Organics Processing Options (Chapter 3)** – A review of the state-of-practice of organics processing technologies in the country was evaluated and the capabilities and costs of organics processing options were outlined, including compost and anaerobic digestion technologies.
- **Recycled Organics Product Usage Options (Chapter 4)** – Potential uses of recycled material produced during organics processing were assessed, including end products from compost and anaerobic digestion, including compost, biogas, and digestate.
- **Siting Evaluation (Chapter 5)** – Three County-owned sites and a geographic information system (GIS)-based review of additional County-owned sites were evaluated for their characteristics to support an organics processing facility and ranked according to feasibility of development.
- **Development and Evaluation of Alternatives (Chapter 6)** – Five final alternatives were evaluated, based on the highest-ranking organics processing technologies and sites, and are reviewed in detail for capital and operation and maintenance costs.

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## **2. SOURCE SEPARATED ORGANIC MATERIAL FEEDSTOCK PROJECTIONS**

Based on organic waste projected to be generated over the planning period 2025 to 2045 and levels of capture considered, this chapter is developed to understand the processing capacity necessary for a County organics processing facility. Projections considered herein are based on what may enter a County processing system and independent of existing processing capacity.

### **2.1 ORGANIC WASTE GENERATION**

#### **2.1.1 Overview of Data Sources**

The EA Team examined publicly available and County-provided data sources providing critical context for County organic waste generation. A summary of select sources is presented below.

##### **2.1.1.1 Montgomery County's Comprehensive Solid Waste Management Plan 2020–2029**

Developed and updated at least every 3 years in accordance with Title 9, Subtitle 5 of the Environment Article of the Annotated Code of Maryland Regulation (COMAR) and COMAR 26.03.03.03, the plan provides a thorough review of current generation and collection systems, identifies needs of current systems, and highlights a plan of action for moving waste diversion forward, including outlining potential future efforts to improve organics diversion. In calendar year 2021, over 1.57 million tons of waste was generated within the county, including approximately 910,900 tons of County-managed MSW (Montgomery County Department of Environmental Protection [DEP] 2021a, 2023c). The organic fraction of County-managed MSW is the focus of this report.

##### **2.1.1.2 Montgomery County's Solid Waste Capture Model**

The County's Capture Model provides a spreadsheet-based analysis of waste within the County, including waste tracking by material type, and tonnages generated and captured in single-family, multi-family, and non-residential sectors. For consistency with County tracking and available data, organics material types including yard trim, food scrap, non-recyclable paper, manure, and animal protein are considered in this report. For the organics material types noted, the Capture Model identifies that County-managed MSW included over 339,800 tons of organic waste in calendar year 2021 (Montgomery County DEP 2023c).

##### **2.1.1.3 County's Waste Composition Studies**

The County regularly performs waste characterization studies to identify the composition of their disposed waste and to understand where material diversion from disposal can be improved. The most recent study examined waste data collected from 300 samples of the as-disposed waste stream across all four seasons. This study, which the County uses to inform its Capture Model for waste disposed, estimates that compostable organics accounted for approximately 23.4% of the solid waste disposed, comprised of 16.6% food waste and 6.9% non-recyclable paper (SCS Engineers 2023). The County's Capture Model shows that this represented 130,400 tons of

food waste and non-recyclable paper disposed in calendar year 2021 (Montgomery County DEP 2023c).

### 2.1.2 Projected Household and Population Growth

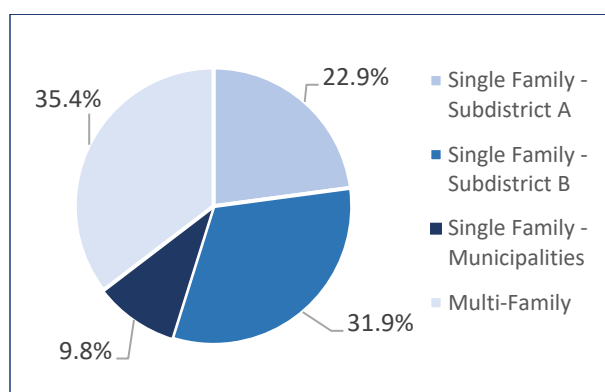
The Montgomery County Planning Department, the Maryland-National Capital Park and Planning Commission (M-NCPPC), maintains growth forecasts for the County developed in the Round 9.2 Cooperative Forecasts (Metropolitan Washington Council of Governments 2022). Population projections utilize 2020 census data and econometric model projections for employment, population, and households, to develop population projections in 5-year increments. Montgomery County DEP utilizes these data to develop projections for the total number of households in the County, including single-family households in the County's Subdistricts A, B and municipalities, and multi-family households. The resulting housecount projections are utilized for County solid waste and recycling collections planning.

Over the planning period, population projections show an increase of 14.7% and a total housecount increase of 15.8% (Montgomery County DEP 2023b), as shown in Table 2-1. Figure 2-1 shows a percentage breakdown of housecount by subgroup. The EA Team utilized housecount projections to estimate organic waste generation within the single-family and multi-family sectors, and to consider participation in future organics diversion efforts tailored to the waste generation characteristics of the County's Subdistrict A, B, and municipalities.

**Table 2-1. Population and Housecount Projections, 2025–2045**

| Parameter                                | 2025      | 2030      | 2035      | 2040      | 2045      | Percent Change Over period |
|------------------------------------------|-----------|-----------|-----------|-----------|-----------|----------------------------|
| Population                               | 1,090,000 | 1,130,000 | 1,170,000 | 1,210,000 | 1,250,000 | 14.7%                      |
| Employment (no. of jobs)                 | 573,000   | 605,000   | 627,000   | 650,000   | 673,000   | 17.5%                      |
| Housecount – Single Family Subdistrict A | 93,200    | 95,500    | 97,900    | 100,300   | 102,700   | 10.2%                      |
| Housecount – Single Family Subdistrict B | 129,800   | 133,000   | 136,300   | 139,700   | 143,100   | 10.2%                      |
| Housecount – Municipalities              | 39,900    | 40,900    | 41,900    | 43,000    | 44,000    | 10.3%                      |
| Housecount – Multi-Family                | 147,400   | 158,000   | 167,100   | 176,300   | 185,400   | 25.8%                      |
| Housecount Total                         | 410,300   | 427,300   | 443,300   | 459,200   | 475,200   | 15.8%                      |

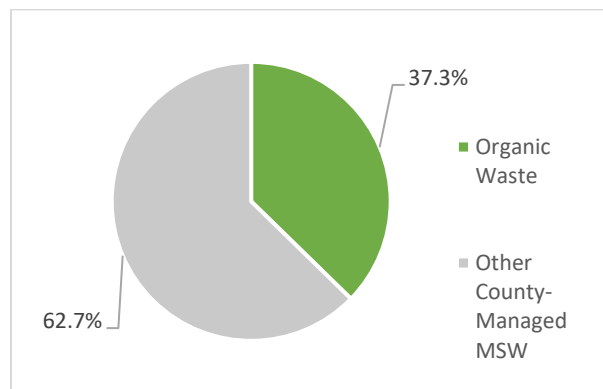
Source: Montgomery County DEP 2023b.



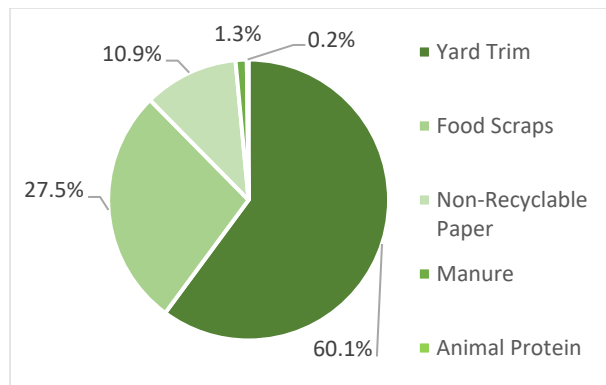
**Figure 2-1. Housecount by Subgroup**

### 2.1.3 Organic Waste Generation Projections (Baseline)

To develop organic waste generation projections over the planning period, the EA Team utilized County data for organic waste generation coupled with housecount and employment projections previously discussed. This approach was utilized in lieu of population-based projections, as it provides a more accurate representation of residential food scrap generation between County Subdistricts A, B, and municipalities. For non-residential waste generation, the County's employment data are utilized to account for commercial waste generated in-County, including that generated by those working in the County that are not County residents. Of the total 910,900 tons of County-managed MSW generated in calendar year 2021, organic waste represented 37.3%, or 339,800 tons, as shown in Figure 2-2. Of the organic waste considered for diversion in this report, the breakdown of generated material by type is shown in Figure 2-3.



**Figure 2-2. Organic Waste Fraction of County-Managed MSW, Calendar Year 2021**



**Figure 2-3. Organic Waste Generation by Material Type**

A summary of organic waste generation projections by material type is included in Table 2-2, with complete projections included in Appendix A. Projections consider that organic waste generation increases proportionally with the number of households and employment, respectively, for the target organic waste material types considered in this report.

**Table 2-2. Organic Waste Generation Projections, 2025-2045 (tons)**

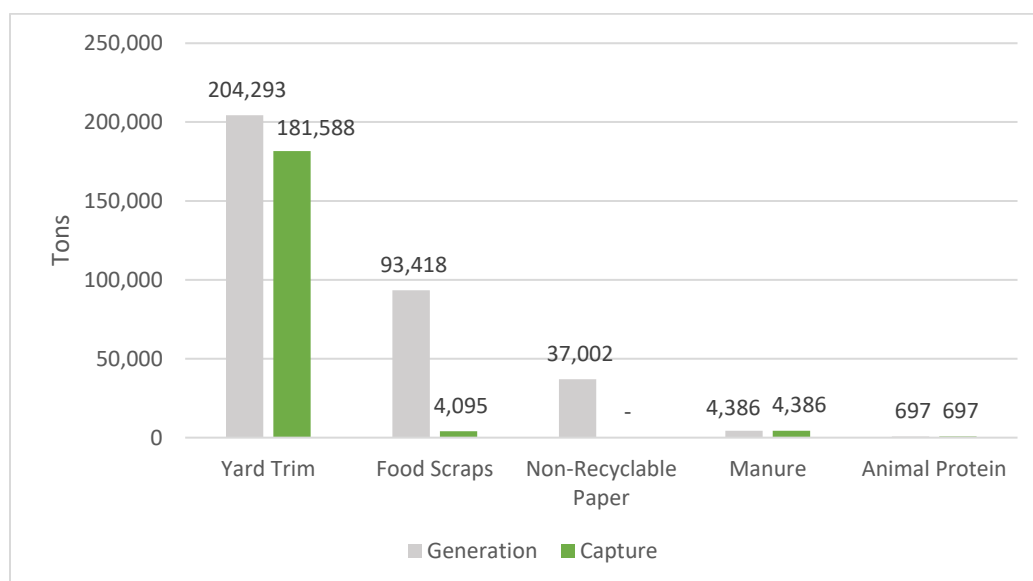
| <b>Group</b>         | <b>Calendar<br/>Year<br/>2021<br/>(Actual)</b> | <b>2025</b>    | <b>2030</b>    | <b>2035</b>    | <b>2040</b>    | <b>2045</b>    |
|----------------------|------------------------------------------------|----------------|----------------|----------------|----------------|----------------|
| Yard Trim            | 204,293                                        | 223,700        | 226,900        | 230,100        | 233,300        | 236,500        |
| Food Scraps          | 93,418                                         | 102,300        | 103,700        | 105,200        | 106,700        | 108,200        |
| Non-Recyclable Paper | 37,002                                         | 40,500         | 41,100         | 41,700         | 42,300         | 42,800         |
| Manure               | 4,386                                          | 4,800          | 4,900          | 4,900          | 5,000          | 5,100          |
| Animal Byproducts    | 697                                            | 760            | 770            | 780            | 800            | 810            |
| <b>Total</b>         | <b>339,795</b>                                 | <b>372,100</b> | <b>377,400</b> | <b>382,700</b> | <b>388,100</b> | <b>393,400</b> |

Projections present the baseline of organics generation and serve as a reference point for the organics capture projections presented later in this chapter. These baseline projections are based on historical data through calendar year 2021, with actual calendar year 2021 data shown for reference, and do not reflect reductions in organics generation resulting from more recent County initiatives for waste reduction and diversion in the residential and commercial sectors; emerging trends affecting organics diversion are considered later in this chapter.

## **2.2 ORGANIC WASTE CAPTURE IN COUNTY SYSTEMS**

### **2.2.1 Calendar Year 2021 Organic Waste Capture**

In calendar year 2021, the organic waste captured by material type is shown in Figure 2-4. Generation and capture of yard trim was very high, demonstrating the already successful efforts by the County to meet the State mandate of diverting these materials from disposal. Capture of manure and animal protein was near 100%; however, only *de minimis* amounts were generated. In contrast, capture of food scraps and non-recyclable paper generated was low. Capture varied by single-family, multi-family, and non-residential sectors, as demonstrated in Table 2-3. Given the tons of food scrap and non-recyclable paper generated with relatively little capture across all sectors, these organic materials present a significant opportunity for capture going forward.



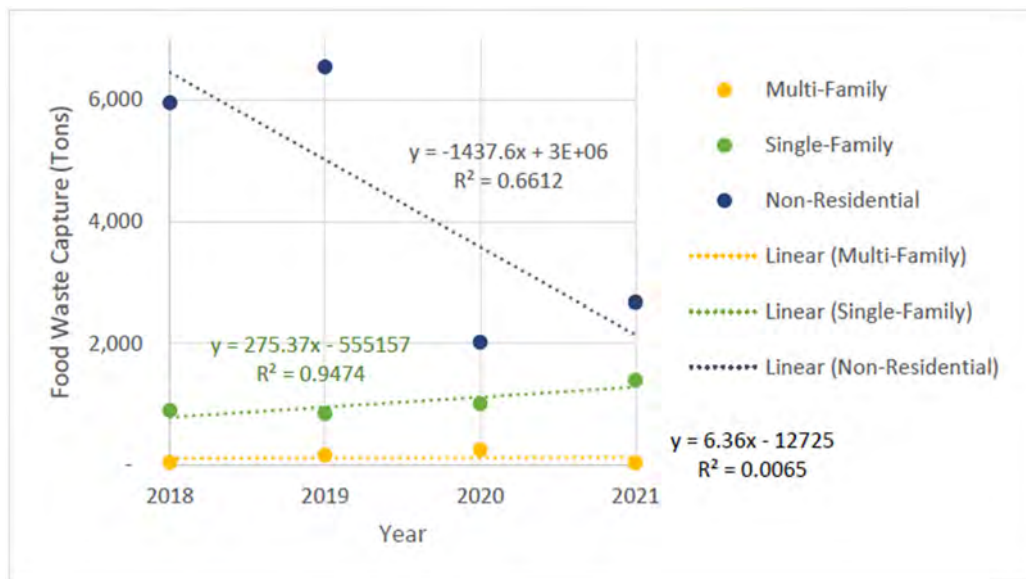
**Figure 2-4. Organic Waste Capture by Material Type**

**Table 2-3. Calendar Year 2021 Organic Waste Capture by Sector and Material (tons)**

| Parameter            | Single-Family | Multi-Family | Non-Residential | Total          |
|----------------------|---------------|--------------|-----------------|----------------|
| Yard Trim            | 63,900        | 2,000        | 115,700         | 181,600        |
| Food Waste           | 1,400         | 30           | 2,700           | 4,100          |
| Non-Recyclable Paper | -             | -            | -               | -              |
| Manure               | -             | -            | 4,400           | 4,400          |
| Animal Byproducts    | -             | -            | 700             | 700            |
| <b>Total</b>         | <b>65,300</b> | <b>2,030</b> | <b>123,500</b>  | <b>190,800</b> |

### 2.2.2 Historical Trends in Organic Waste Capture

Based on review of the County's available Capture Model data from 2018 through 2021, food scrap capture in single-family and multi-family sectors increased steadily, albeit modestly, while food scrap capture in the non-residential sectors decreased, as shown in Figure 2-5. The positive trend in residential (single-family and multi-family sectors) food scrap capture may suggest public awareness of food scrap diversion in the general population has increased in step with both local and national environmental awareness. Capture trends observed within the County seem to mirror solid waste generation trends observed during the COVID-19 pandemic, whereby residential food and packaging waste generation increased relative to pre-pandemic levels, while industrial, commercial, and institutional waste generation decreased.



**Figure 2-5. Historical Food Scrap Capture Trends**

### 2.2.3 Organic Waste Capture Scenarios

To estimate the food scrap capture potential, the EA Team developed projections over the planning period for food scrap capture with voluntary participation in diversion programs considering low, medium, and high capture scenarios. In addition, projections considered capture in a mandatory diversion requirement scenario. The assumptions of each capture scenario are summarized below, and associated projections detailed in this section.

- **Low Capture** – Assumes historical trends in the County’s capture of food scrap continue as is through the planning period. No additional processing capacity is required.
- **Medium Capture** – Assumes historical capture trends are improved by the implementation of new County diversion programs. Existing processing capacity may not be adequate to process material captured in this scenario, and securing additional processing capacity in the future may be required.
- **High Capture** – Assumes historical capture improved by new program implementation and increased public participation. Existing processing capacity is not adequate to process material captured in this scenario, and securing additional processing capacity in the future will be required.
- **Mandatory Diversion** – Assumes implementation of a mandatory County program, requiring food scrap diversion in all sectors. Existing processing capacity is not adequate to process material captured in this scenario, and securing additional processing capacity in the future will be required.

## 2.2.4 County Diversion Programs

In accordance with the Montgomery County Council Bill 28-16 “Strategic Plan to Advance Composting, Compost Use, and Food Waste Diversion” passed in 2016 as an amendment to Chapter 48 of the County Code, DEP was required to develop a strategic plan to achieve the objectives of the bill. In response, the DEP Recycling and Resource Management Division (RRMD) developed the Strategic Plan to Advance Composting, Compost Use, and Food Scraps Diversion in Montgomery County, Maryland (Montgomery County DEP 2018a), organizing over 215 stakeholders to provide recommendations for food scrap diversion over six focus areas:

- Reducing Wasted Food/Channeling Food to Others
- In-Home, Backyard, and Community-Scale Composting
- On-Site Institutional and On-Site Business Composting
- On-Farm Composting
- Composting in Montgomery County
- Strategies to Maximize Food Scrap Collection at the Curb

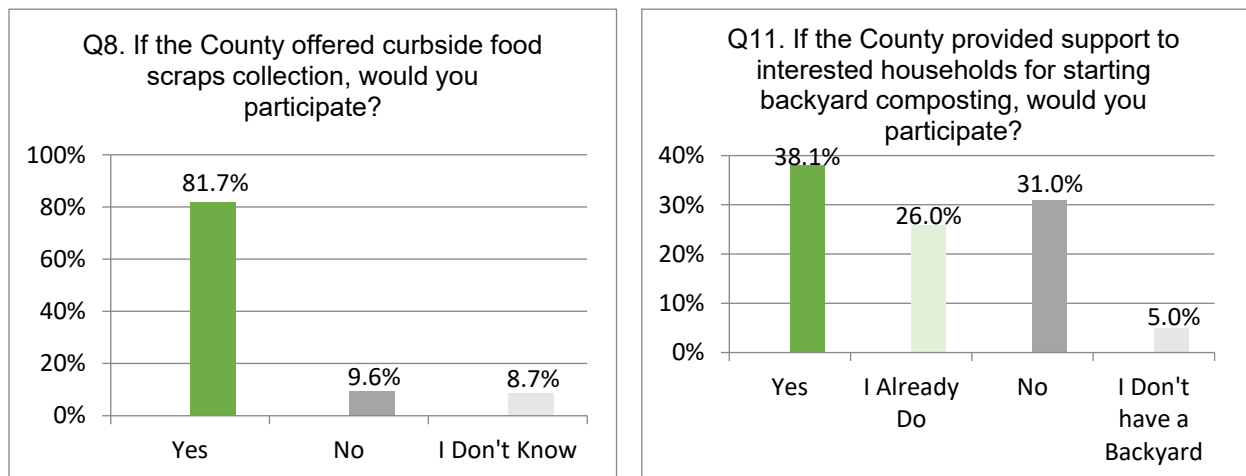
Based on the plan of action outlined within each focus area, the DEP RRMD proceeded with developing, implementing, and managing programs, education and outreach initiatives, and other efforts to improve single-family residential, multi-family residential and commercial food scrap diversion. As of April 2023, DEP RRMD food scrap programs and initiatives are noted below and highlighted in Appendix B. Program data, where available, are utilized to inform the medium capture scenarios developed for single-family, multi-family, and non-residential sectors, as discussed by sector in the following section.

- Backyard Composting – *Total backyard composting bins distributed, total backyard composting events hosted, and total event attendees from calendar year 2018 to 2022.*
- Single-Family Residential Food Scraps Curbside Recycling Collection Pilot Program – *Total tons collected from Potomac and Silver Spring (Phase I) from December 2021 through April 2023.*
- Multi-Family Residential Food Scraps Recycling Program – *Total tons collected from participating properties provided from calendar year 2014 to 2021.*
- Commercial Food Scraps Recycling Partnership Program – *Total tons collected from June 2020 through April 2023.*
- Edible Food Recovery Program
- “Food Is Too Good To Waste” Wasted Food Reduction Program

In addition, the County is currently conducting a Pay as You Throw program study and pilot implementation. This may affect future organic waste generation and capture efforts.

## 2.2.5 Public Participation

For food scrap capture projections, it is critical to understand public interest in food scrap reduction and diversion initiatives. To gain this insight, the EA Team developed a survey distributed by SurveyMonkey link and QR code to single-family households in the County, accessible in English and Spanish. Disseminated through existing County communications channels, including by email, social media, community newsletters, and in-person events attended by DEP, the survey invited a wide base of respondents representing a diversity of viewpoints on the County's solid waste management. From over 900 responses received from County residents in Subdistrict A, Subdistrict B and municipalities with a 95% confidence level and 5% margin of error, over 80% of respondents indicated they had an interest in participating in a curbside food scrap collection program, and over 35% of respondents indicated they would be interested in participating in backyard composting programs, as shown in Figure 2-6.



**Figure 2-6. Public Interest in Participating in County Food Scrap Diversion Programs**

Survey responses obtained were considered, along with additional comments providing anecdotal and situational insights from County residents, to qualitatively inform high capture projections for single-family households. Considering this information in developing projections for future planning creates a more realistic basis for estimating the rate of future program adoption based on the expression for which organic waste diversion approaches constituents already engage in or may have interest in engaging in. The complete report of survey results is included in Appendix C, including survey questions and response data, and distribution channel details.

## 2.2.6 Food Scrap Capture by Sector

### 2.2.6.1 Single-Family Households

Based on the historical trend of food scrap capture from single-family households, the low capture scenario projects that capture of food scraps from single-family households will increase by about 0.3% annually, from approximately 3.6% of food scrap generated in 2025 to 9.3% by 2045 or capture of approximately 5,200 tons in 2045. The medium capture scenario builds on



this by considering participation trends in pilot programs for curbside collection of food scraps active into 2023. As of 31 July 2023, the pilot in Silver Spring (Subdistrict A) demonstrated participation (enrollment) by 35% of the 2,053 eligible households, generating an average of 8.5 pounds of food scraps (including non-recyclable paper) collected per participating household per week with a weekly setout rate of 90%; the pilot in Potomac (Subdistrict B) demonstrated participation by 19% of the 1,909 eligible households, generating an average of 10.1 pounds of food scraps per household per week with a 74% weekly setout rate; and the pilot in Bethesda (Subdistrict B) demonstrated participation by 18% of the 2,053 eligible households, generating an average of 11.6 pounds per household per week with a 72% weekly setout rate (Montgomery County DEP 2023e). Given these factors, the medium capture scenario projects that capture of food scrap from single-family households will increase by about 1.4% annually, from approximately 6.0% of food scrap generated in 2025 to 33.3% by 2045 or capture of approximately 18,900 tons in 2045.

The high capture scenario was estimated based on low and medium capture factors, as well as survey respondents' interest in participating in curbside collection food scrap programs. While over 80% of respondents noted they would participate in a County program, there are examples of curbside collections programs nationwide struggling to achieve higher than 50–60% participation, and some recent studies suggesting upper limits at 20–30% participation. Factoring in high interest with actual program participation across the country, the high capture scenario projects an initial spike of food scrap capture from single-family households reaching 28.7% by 2035, and thereafter increasing by approximately 2.1% annually to reach a voluntary program maximum of 50% by 2045, or approximately 28,300 tons.

The final capture scenario considers implementation of a mandatory diversion program implemented in 2025. Like the high capture scenario, the mandatory capture scenario projects an initial spike of food scrap capture from single-family households reaching 41.7% by 2035, and thereafter increasing by approximately 1.8% to reach 60% program participation by 2045 or capture of approximately 34,000 tons. In practice, the participation and capture from mandatory programs is strongly linked with program design and enforcement measures.

**Table 2-4. Single-Family Food Scrap Tons Captured Scenarios**

| Scenario                 | 2025   | 2030   | 2035   | 2040   | 2045   |
|--------------------------|--------|--------|--------|--------|--------|
| <i>Generation (tons)</i> | 54,000 | 54,400 | 55,000 | 56,000 | 57,000 |
| Low Capture (%)          | 3.6%   | 5.1%   | 6.5%   | 7.9%   | 9.3%   |
| Medium Capture (%)       | 6.0%   | 12.9%  | 19.7%  | 26.5%  | 33.3%  |
| High Capture (%)         | 7.5%   | 18.1%  | 28.7%  | 39.4%  | 50.0%  |
| Mandatory Program (%)    | 7.5%   | 32.6%  | 41.7%  | 50.9%  | 60.0%  |
| Low Capture (tons)       | 1,900  | 2,800  | 3,600  | 4,400  | 5,200  |
| Medium Capture (tons)    | 3,200  | 7,000  | 10,900 | 14,800 | 18,900 |
| High Capture (tons)      | 4,000  | 9,800  | 15,800 | 22,000 | 28,300 |
| Mandatory Program (tons) | 4,000  | 17,700 | 23,000 | 28,400 | 34,000 |

### 2.2.6.2 Multi-Family Households

The multi-family sector in the County, defined as residential buildings with 7 or more dwelling units (Montgomery County 2016), includes over 730 multi-family properties with over 145,000

dwelling units (Montgomery County DEP 2018b), with the greatest growth potential in this sector over the planning period as shown in Table 2-1. However, barriers to growth in multi-family food scrap collection include property manager concerns around vectors, contamination, and the space and personnel to manage on-site food scrap collections (Montgomery County DEP 2017). As previously noted, historical and projected organics tonnages and program participation presented in this section refers to the Multi-Family Residential Food Scraps Recycling Program and available program data from calendar year 2014 to 2021.

Based on the historical trend of food scrap capture from multi-family households, the low capture scenario projects that capture of food scraps from multi-family households will increase by about 0.04% annually, from approximately 0.8% of food scraps generated in 2025 to 1.5% by 2045 or capture of approximately 280 tons in 2045. This capture scenario reflects that historically, capture from multi-family households has been very limited. The medium capture scenario builds on the low capture scenario by examining emerging participation trends in multi-family food scrap diversion. Multi-family buildings enrolled in the program and reporting data as of 2022 represented approximately 2,000 dwelling units, contributing 30 tons of food scraps (Montgomery County DEP 2023d). Based on program participation trends, the medium capture scenario projects that capture of food scraps from multi-family households will increase by about 0.8% annually, from approximately 1.4% of food scraps generated in 2025 to 3.1% by 2045 or capture of approximately 590 tons in 2045.

The high capture scenario was estimated based on these factors and the results of a survey distributed to property managers of over 700 multi-family properties in 2017 (Montgomery County DEP 2017), with over 14% of respondents noting food scrap recycling as viable in the future for their property. Factoring this potential for future participation with current program participation rates, the high capture scenario projects that capture of food scraps from multi-family households will increase by approximately 0.7% annually, reaching a voluntary diversion program maximum of 17.1% by 2045 or capture of approximately 3,260 tons in 2045.

The final capture scenario considers implementation of a mandatory diversion program implemented in 2025. Like the high capture scenario, steady 1.7% increases will reach 35% multi-family property participation by 2045 or capture of approximately 6,690 tons. The participation and capture from mandatory programs is strongly linked with program design and enforcement measures. To support improvements to multi-family food scrap diversion, resources and support for program development at individual residential buildings will be critical.

**Table 2-5. Multi-Family Food Scrap Tons Captured Scenarios**

| Scenario                 | 2025          | 2030          | 2035          | 2040          | 2045          |
|--------------------------|---------------|---------------|---------------|---------------|---------------|
| <i>Generation (tons)</i> | <i>18,100</i> | <i>18,300</i> | <i>18,600</i> | <i>18,900</i> | <i>19,100</i> |
| Low Capture (%)          | 0.8%          | 1.0%          | 1.2%          | 1.3%          | 1.5%          |
| Medium Capture (%)       | 1.4%          | 1.9%          | 2.3%          | 2.7%          | 3.1%          |
| High Capture (%)         | 2.7%          | 6.3%          | 9.9%          | 13.5%         | 17.1%         |
| Mandatory Program (%)    | 1.4%          | 12.7%         | 20.1%         | 27.6%         | 35.0%         |
| Low Capture (tons)       | 150           | 180           | 220           | 250           | 280           |
| Medium Capture (tons)    | 260           | 340           | 420           | 510           | 590           |
| High Capture (tons)      | 490           | 1,150         | 1,840         | 2,550         | 3,260         |
| Mandatory Program (tons) | 260           | 2,320         | 3,740         | 5,210         | 6,690         |

### 2.2.6.3 Commercial Sector

The non-residential sector in the County is estimated to include over 2,800 industrial, commercial and institutional food scrap generators in the County, including over 1,400 restaurants and food service businesses (U.S. Environmental Protection Agency [EPA] 2023a,b). While the County is not required by Code to provide waste disposal capacity for the non-residential sector, organic capture from this sector represents a significant waste tonnage for organics diversion.

Based on the historical trend of food scrap capture from the non-residential sector, the low capture scenario projects that capture of food scraps will increase by about 0.09% annually, from approximately 8.3% of food scraps generated in 2025 to 10.0% by 2045 or capture of approximately 3,200 tons in 2045. In addition to these factors, the medium capture scenario considers participation trends in commercial food scrap diversion programs; as of 2022, 32 businesses participating in the program contributed 352 tons of food scraps (Montgomery County DEP 2023f). Based on program participation trends since 2018, the medium capture scenario projects that capture of food scraps from the non-residential sector will increase by about 0.3% annually, from approximately 9.8% of food scraps generated in 2025 to 15.5% by 2045 or capture of approximately 5,000 tons in 2045.

For the non-residential sector, both the high capture and mandatory program scenarios were estimated to capture food waste tonnages based on the current State diversion mandate for large food waste generators in effect as of 1 January 2023 codified in HB264/SB483. Based on review of the Excess Food Opportunities Map database (EPA 2023a), 29 large generators (excluding exempted restaurants and food service businesses) were estimated to meet the generation threshold of 2 tons per week, generating over 8,000 tons per year of food waste. As of 1 January 2024, the diversion threshold of 1 ton per week is estimated to require 27 total businesses to divert (excluding exempted restaurants and food service business), generating an additional 3,000 tons per year of food waste. Both the high capture and mandatory program scenarios assume the addition of a 0.5 ton per week threshold requiring diversion in 2029 with no generators exempted, that could be implemented as part of a County mandate or further State-wide legislation. This would require a total of 139 businesses to divert, generating an additional 5,000 tons per year of food waste. Table 2-7 summarizes the breakdown by sector of businesses generating food waste in excess of the threshold requiring diversion. Figure 2-7 presents the distribution of food waste generators within the County.

**Table 2-6. Non-Residential Food Scrap Tons Captured Scenarios**

| Scenario              | 2025   | 2030   | 2035   | 2040   | 2045   |
|-----------------------|--------|--------|--------|--------|--------|
| Generation (tons)     | 31,000 | 31,000 | 31,000 | 32,000 | 32,000 |
| Low Capture (%)       | 8.3%   | 8.7%   | 9.1%   | 9.6%   | 10.0%  |
| Medium Capture (%)    | 9.8%   | 11.3%  | 12.7%  | 14.1%  | 15.5%  |
| High Capture (%)      | 9.8%   | 26.7%  | 43.7%  | 60.6%  | 77.6%  |
| Mandatory Program (%) | 9.8%   | 49.7%  | 59.0%  | 68.3%  | 77.6%  |
| Low Capture (tons)    | 2,600  | 2,700  | 2,800  | 3,100  | 3,200  |
| Medium Capture (tons) | 3,000  | 3,500  | 3,900  | 4,500  | 5,000  |
| High Capture (tons)   | 3,000  | 8,300  | 13,500 | 19,400 | 24,800 |

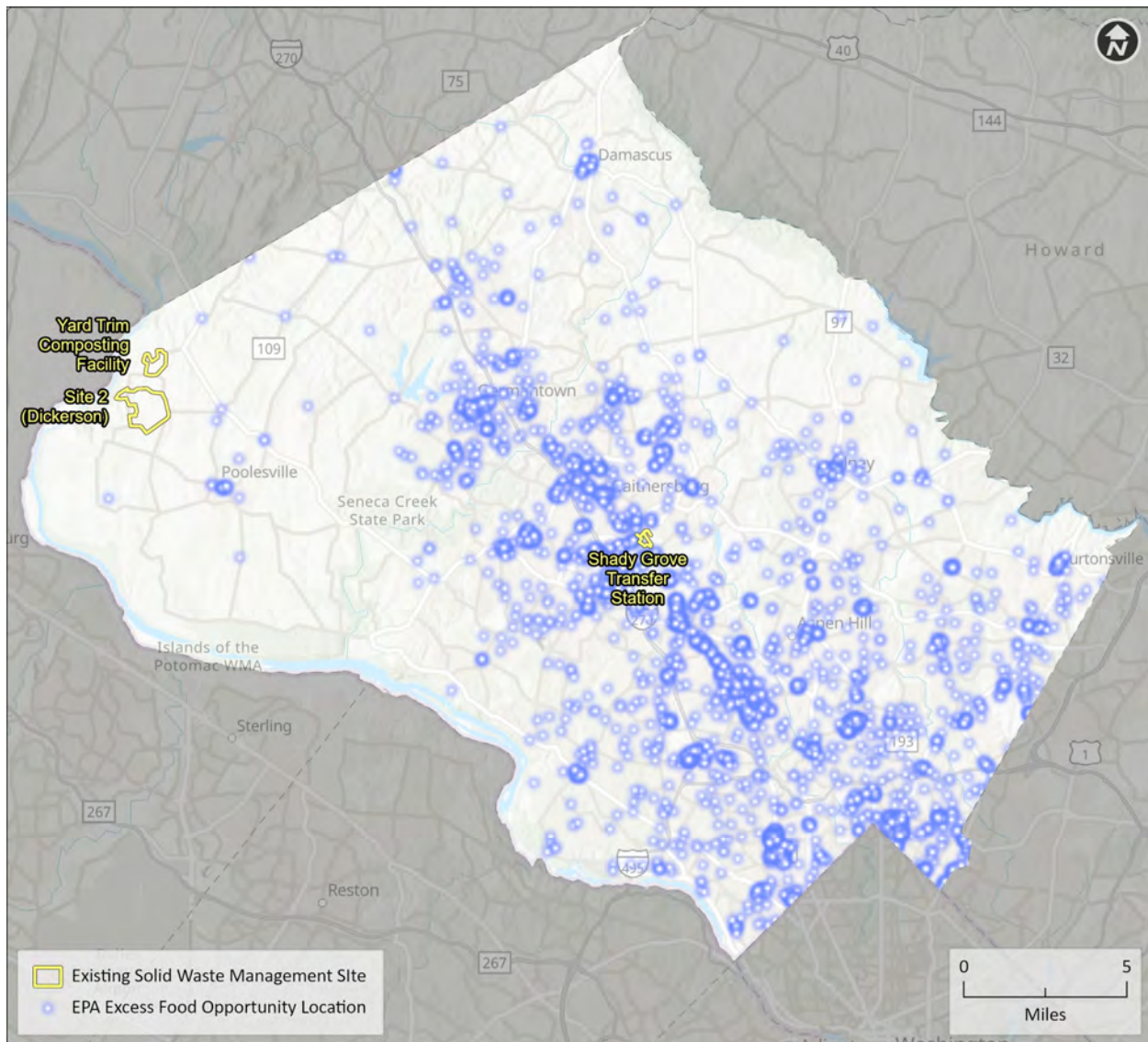
| Scenario                 | 2025  | 2030   | 2035   | 2040   | 2045   |
|--------------------------|-------|--------|--------|--------|--------|
| Mandatory Program (tons) | 3,000 | 15,400 | 18,300 | 21,900 | 24,800 |

**Table 2-7. Large Food Waste Generators by Sector**

| Sector                       | No. of Large Generators as of 1 January 2023 (>2 tons/week) | No. of Large Generators as of 1 January 2024 (>1 tons/week) | No. of Large Generators in future (>1 tons/week) |
|------------------------------|-------------------------------------------------------------|-------------------------------------------------------------|--------------------------------------------------|
| Correctional Facilities      | 1                                                           | 0                                                           | 2                                                |
| Educational Institutions     | 2                                                           | 5                                                           | 21                                               |
| Food Manufacturers           | 6                                                           | 5                                                           | 17                                               |
| Food Wholesale               | 16                                                          | 14                                                          | 9                                                |
| Restaurants and Food Service | 17*                                                         | 29*                                                         | 84                                               |
| Hospitality                  | 1                                                           | 1                                                           | 4                                                |
| Healthcare Facilities        | 3                                                           | 2                                                           | 2                                                |
| Total                        | 29                                                          | 27                                                          | 139                                              |

Notes:

1. Restaurants and food service businesses are exempt from diversion requirements of HB264. In 2023 and 2024, the estimated number of large food waste generators in this category is not included in totals as denoted with “\*”. However, these have been included in estimates for future regulations.



**Figure 2-7. Large Food Waste Generators**

### 2.2.7 Yard Trim and Non-Recyclable Paper Capture

Captured tons of food scraps will be processed in combination with yard trim and non-recyclable paper. As noted previously, generation and capture of yard trim has historically been near 90% and was projected to continue at this level throughout the planning period, with growth in tons attributable to population growth, as shown in Table 2-8.

**Table 2-8. Yard Trim Tons Captured**

| Material          | 2025    | 2030    | 2035    | 2040    | 2045    |
|-------------------|---------|---------|---------|---------|---------|
| Generation (tons) | 223,700 | 226,900 | 230,100 | 233,300 | 236,500 |
| Capture (%)       | 90%     | 90%     | 90%     | 90%     | 90%     |
| Capture (tons)    | 201,300 | 204,200 | 207,100 | 210,000 | 212,900 |

Capture of non-recyclable paper, including tissues, paper towels, napkins, cardboard paper, food-soiled paper that cannot be recycled, and other non-recyclable paper, was projected in low, medium, and high scenarios, as shown in Table 2-9. Since historical capture of this waste stream was at or near zero, the projected scenarios mimic the food waste capture projections, as non-recyclable paper can be handled similarly. In practice, it will require outreach and education to ensure residents are aware of which types of materials constitute non-recyclable paper, and that they are acceptable for disposal along with food waste in organics collection bins.

**Table 2-9. Non-Recyclable Paper Tons Captured Scenarios**

| Scenario              | 2025   | 2030   | 2035   | 2040   | 2045   |
|-----------------------|--------|--------|--------|--------|--------|
| Generation (tons)     | 40,500 | 41,100 | 41,700 | 42,300 | 42,800 |
| Low Capture (%)       | 4.4%   | 5.4%   | 6.2%   | 7.3%   | 8.2%   |
| Medium Capture (%)    | 6.4%   | 10.5%  | 14.6%  | 18.7%  | 22.7%  |
| High Capture (%)      | 7.2%   | 17.8%  | 28.5%  | 39.2%  | 50.0%  |
| Low Capture (tons)    | 1,800  | 2,200  | 2,600  | 3,100  | 3,500  |
| Medium Capture (tons) | 2,600  | 4,300  | 6,100  | 7,900  | 9,700  |
| High Capture (tons)   | 2,900  | 7,300  | 11,900 | 16,600 | 21,400 |

## 2.2.8 Other Capture Considerations

### 2.2.8.1 Local and Regional Diversion Programs

While mandatory diversion programs have been considered in the development of food scrap projections, there are many local and regional examples of voluntary and mandatory programs presented for the County's consideration. The following recent and relevant examples are provided giving both regulatory framework and program design considerations. Moreover, these programs are continuing to drive public awareness and understanding of the importance of food scrap diversion across the region.

Many jurisdictions have targeted large commercial food waste generators in their initial diversion program efforts. To date, state-wide commercial food waste diversion mandates have been developed in many states, including California, Connecticut, Maryland, Massachusetts, New Jersey, New York, and Rhode Island. Many of these mandates have set food waste generation thresholds, above which a business or facility is required to divert food waste from landfill when alternative organics reduction or recycling options are available within a 25- to 35-mile radius. In addition to state-wide mandates, jurisdictions are also pursuing similar legislation at the local level:

- Washington, District of Columbia – The District of Columbia passed the Zero Waste Omnibus Amendment Act of 2020 requiring some of the largest industrial, commercial, and institutional food scrap generators to begin source separating food scraps for diversion (D.C. Law 23-211 2021). D.C. estimates that of 5,600 commercial entities generating food scraps in the district, including hundreds of large generators, these entities contribute more than 85,000 tons of food scraps to the district's waste stream annually, 42,000 tons of which are produced by large generators (Zero Waste DC Plan 2023). The implementation plan is currently being developed to identify which commercial entities will be required to divert and when. An early draft of the Plan called

for required non-residential diversion of food scraps if an organics processing facility were located within 35 miles of the Capitol Dome, demonstrating the need for additional regional organics processing capacity.

To improve food waste diversion in the residential sector, curbside collection programs have been developed with voluntary sign-up, standard offering (all residents receive a collection bin but can opt out of participating), and, more recently, mandatory program models:

- Boston, Massachusetts – In addition to a drop-off program known as Project Oscar, where citizens can drop off food waste for processing at one of 15 sites in the city, a new voluntary sign-up curbside collection program serving 10,000 participating households (with another 8,000 households on the waiting list) launched in August 2022. Boston’s program covers buildings with six units or less and prioritizes enrollment from residents in environmental justice communities. The curbside diversion program collected 510 tons of food waste between August and December 2022, in addition to 226 tons collected at Project Oscar sites (Coker 2023).
- Arlington County, Virginia – In 2017 the County began planning for a food scrap diversion program, as neighboring Prince William County was developing a facility upgrade to its yard trim composting facility in Manassas to process food scraps. That expanded and upgraded the Prince William County facility operated by Free State Farms which came online in September 2020, and Arlington County began its food scrap diversion program on 1 July 2021. Single-family dwelling units in Arlington County currently utilize a three-cart system—trash, conventional recyclables, and yard trim. Food scraps have been integrated into the current collections of 33,000 households by allowing co-mingled yard trim and food waste. The County is focusing on food scraps first and may add non-recyclable paper to the program in the future (Coker 2020).
- City of Laurel, Prince George’s County, Maryland – Based on the ordinance recently passed by the City Council, the separation of organics at all single-family and multi-family residences is required as of 1 July 2025. A pilot program is currently underway for volunteers, giving residents a 2-gallon countertop bin with carbon filter, a locking 35-gallon large curbside bin, and biodegradable composting bags, with weekly curbside compost collection (City of Laurel, Maryland 2023). As of the 2020 census, there were over 11,000 households in the City of Laurel.
- New York City, New York – The Zero Waste Act is a set of five bills passed in June 2023 that codifies mandatory residential organics curbside collection and food scrap drop-off sites, among other efforts to achieve the City’s zero waste goals. Residential curbside collection of separate yard trim and food scraps is expected to be phased in by borough across the city, with service available citywide by October 2024 and participation mandatory by April 2025. Curbside collection will be provided weekly by the Department of Sanitation. For organic waste drop-off sites, the Department of Sanitation is required to establish a minimum number of sites per borough, making access

to food scrap diversion equitable and accessible across the city (New York City Council 2023).

Developing diversion programs and mandates that encompass both the commercial and residential sectors has been tackled in Vermont, Oregon, and Washington. These established programs have grown over time and provide examples of successful long-term programs for consideration. The Vermont program is highlighted here, considered most relevant to the development of other East Coast diversion programs.

- Vermont – As a regional hallmark, the State of Vermont passed the Universal Recycling Law in 2012 to divert recyclables and organics, including yard trim and food scraps, from landfill. The law phased diversion in over time, requiring first commercial diversion from large institutions with successively restrictive tiers of entities required to divert, and in 2020, phased in mandatory residential food scrap diversion. The law requires facilities that offer trash collection to also offer recycling and food scrap collection. Food scrap drop-off is also available at many transfer stations. Prior to the enactment of residential organics diversion, it was estimated that organic waste made up 30% of a typical Vermont family's waste (Vermont Agency of Natural Resources 2023).

## **2.3 ORGANIC WASTE CAPTURE IN NON-COUNTY SYSTEMS**

### **2.3.1 Private Collections**

The private sector has played a role in collecting food scraps from commercial and institutional sources for about 25 years, with a rapid rise seen more recently in subscription services for residential food scraps collection and/or drop-off (Goldstein 2021b). Collection services vary in type and scale, from micro-haulers collecting by bicycle and niche collectors utilizing customized trailers, both including non-profit and worker-owned operations; to commercial haulers with dedicated organics collection routes. According to DEP's website, private organics collection in Montgomery County is currently provided by several companies, including Compost Cab, Compost Crew, EnviRelation, Key Compost, Organic Agriculture Recycling, LLC, Organic Waste Haulers, and Veteran Compost (Montgomery County DEP 2023a). Based on a review of all company websites, published prices for weekly subscription services for curbside collection of food scraps were generally found to range from \$30 to \$40 per month (Compost Cab n.d., Compost Crew n.d., Key Compost n.d.).

Based on available data for tonnage collected by private organics haulers from Hauler Reports and other sources, private collection is estimated at 2,500 tons of food scraps in calendar year 2022, collected from residential and commercial sources. Of the companies noted, only Veteran Compost had a currently permitted operating facility; it is assumed the other collection companies noted currently process collected organics at a municipal or commercial processing facility. As a note, Compost Crew did have a planned and permitted facility in the County at the time of this report, but it is not yet operational. Although companies may continue to enter and exit the market, private collections may continue to provide an avenue for collection and processing of commercial and institutional food scrap sources, particularly if additional processing capacity is developed by the private sector.



For the purposes of the capture projections, private collections are projected to increase at 4% year on year in the low capture scenario, 6% year on year in the medium capture scenario, and 8% year on year in the high capture scenario, as summarized in Table 2-10 with projections over the planning period presented in Table 2-11.

**Table 2-10. Private Collections Capture Scenarios Basis**

| Scenario       | Annual Tonnage<br>Captured Growth Rate<br>(%) |
|----------------|-----------------------------------------------|
| Low Capture    | 4.0                                           |
| Medium Capture | 6.0                                           |
| High Capture   | 8.0                                           |

**Table 2-11. Private Collections Tons Captured Scenarios**

| Scenario              | 2025  | 2030  | 2035  | 2040  | 2045   |
|-----------------------|-------|-------|-------|-------|--------|
| Low Capture (tons)    | 2,780 | 3,380 | 4,110 | 5,000 | 6,090  |
| Medium Capture (tons) | 2,940 | 3,940 | 5,270 | 7,050 | 9,440  |
| High Capture (tons)   | 3,110 | 4,570 | 6,720 | 9,870 | 14,510 |

## 2.3.2 Decentralized Processing

### 2.3.2.1 Backyard Composting

Backyard composting has a critical role for developing homeowner understanding and know-how around food scrap diversion. The County began providing outreach, education and training on grasscycling and backyard composting of yard trim in 1991, initially including recommendations for homeowners on purchase of compost bins, and later distributing compost bins for yard trim. The most recent five years of backyard composting program data in Table 2-12 shows that backyard composting bins have been distributed to nearly 14,000 households, and events attended by over 2,300 County residents, with a slowdown to these efforts during the COVID-19 pandemic (Montgomery County DEP 2023g). In addition, the County has guidance on its website for materials appropriate for backyard composting with the grass and leaves bin (e.g., dry leaves, straw, wood chips [browns], flowers, pruning materials, grass clippings [greens], no food scraps, etc.) (Montgomery County DEP 2023h).

**Table 2-12. County Backyard Composting Outreach**

| Year  | Backyard<br>Composting Bins<br>Distributed | Education Events<br>Hosted | Total Event<br>Attendees |
|-------|--------------------------------------------|----------------------------|--------------------------|
| 2018  | 2,460                                      | 9                          | 620                      |
| 2019  | 3,030                                      | 9                          | 690                      |
| 2020  | 1,860                                      | 6                          | 250                      |
| 2021  | 2,420                                      | 4                          | 190                      |
| 2022  | 4,070                                      | 11                         | 550                      |
| Total | 13,840                                     | 39                         | 2,300                    |

In 2022, the County began testing of two models of enclosed backyard compost bins for rodentproof attributes and effectiveness in backyard composting of food scraps.

Low, medium, and high capture scenarios for backyard composting of food scraps by single-family households over the planning period were developed by applying estimations for weekly diversion rate (pounds per household) and percentage of households participating, as summarized in Table 2-13. Based on a review of recent program data and backyard composting studies looking at both local cities, such as Baltimore and Cheverly, Maryland (Resource Recycling Systems [RRS] and Institute for Local Self-Reliance [ILSR] 2019; Platt and Fagundes 2018), and national examples (Hoover 2017), weekly generation varied from 8.7 to 12.0 pounds of food scraps per household per week. Given average generation in the County's curbside collection program for food scraps of 8.5 pounds per household per week, the diversion rates for low, medium, and high scenarios were assumed to range from 5.0 to 8.5 pounds per household per week. Participation for a low capture scenario was developed assuming 5% participation of single-family households, medium capture assuming 10% participation, and high capture assuming 15% participation. Survey results from over 900 respondents to the single-family survey noted that 25% are already participating in backyard composting, suggesting program uptake may reach higher levels in interested groups within the County. Based on the assumptions noted, tonnages captured through backyard composting over the planning period are summarized in Table 2-14.

**Table 2-13. Backyard Composting Capture Scenarios Basis**

| <b>Scenario</b> | <b>Diversion Rate<br/>(pounds/household/week)</b> | <b>Percentage of Single-Family Households<br/>Participating</b> |
|-----------------|---------------------------------------------------|-----------------------------------------------------------------|
| Low Capture     | 5.0                                               | 5%                                                              |
| Medium Capture  | 6.75                                              | 10%                                                             |
| High Capture    | 8.5                                               | 15%                                                             |

**Table 2-14. Backyard Composting Tons Captured Scenarios**

| <b>Scenario</b>       | <b>2025</b> | <b>2030</b> | <b>2035</b> | <b>2040</b> | <b>2045</b> |
|-----------------------|-------------|-------------|-------------|-------------|-------------|
| Low Capture (tons)    | 1,710       | 1,750       | 1,790       | 1,840       | 1,870       |
| Medium Capture (tons) | 4,610       | 4,730       | 4,850       | 4,970       | 5,060       |
| High Capture (tons)   | 8,720       | 8,930       | 9,150       | 9,380       | 9,560       |

### 2.3.2.2 Community Composting

The definition of community composting can be broadly interpreted as various small-scale, local, and diverse composting practices led by communities to engage, empower, and educate people in recycling organic materials and recovering resources (ILSR 2023). Community composting can be located in and supported by neighborhoods, housing associations, schools, or in community gardens, with site areas of tens to hundreds of square feet, up to an acre. A nationwide census of community composters conducted in 2022 revealed there are operations in 33 states in the U.S., with the annual average growth of new community composting programs at 21.6% between 2010 and 2021 (Libertelli et al. 2023). Locally, a site-based community composting network in Washington, D.C. called the Community Compost Cooperative Network, hosts 50 cooperative compost sites. The D.C. Parks and Recreation Department has one full-time program staff

member to manage the program, who supports identifying a local champion at each site and ensures necessary three-bin systems are available. Each site diverts around 12 tons of material a year and is supported by around 100 active composters (Department of Parks and Recreation n.d.). With a more mature community composting network, New York City has built a successful community program from the founding of the NYC Compost Project in 1993 to a program now boasting over 200 community sites processing up to a ton of feedstock monthly; 250 smart composting bins across the city; and 7 larger hub sites processing up to 1,000 tons per year (Biocycle 2013; Department of Sanitation New York 2023).

To develop capture scenarios for community composting over the planning period, estimations for the number of active sites consider model programs in Washington, D.C., New York City, and other cities; areas of population density and land use that may support a community composting model; and the 14-site community garden network managed by the M-NCPPC Community Gardens Program in Montgomery County providing residents park land for food production (Montgomery Parks 2023). Based on a review of self-reported processing capacities at various community composting sites, the average processing capacity at each site was assumed to be 8 tons per site per year (RRS and ILSR 2019). The basis for the capture scenario projections is summarized in Table 2-15. Based on the assumptions noted, tonnages captured through community composting over the planning period are summarized in Table 2-16.

**Table 2-15. Community Composting Capture Scenarios Basis**

| Scenario       | Number of Active Composting Sites | Site Processing Capacity (tons per year) |
|----------------|-----------------------------------|------------------------------------------|
| Low Capture    | 5                                 | 8.0                                      |
| Medium Capture | 15                                | 8.0                                      |
| High Capture   | 30                                | 8.0                                      |

**Table 2-16. Community Composting Organics Diversion Scenarios (Tons)**

| Scenario              | 2025 | 2030 | 2035 | 2040 | 2045 |
|-----------------------|------|------|------|------|------|
| Low Capture (tons)    | 41   | 42   | 44   | 45   | 46   |
| Medium Capture (tons) | 122  | 126  | 131  | 134  | 137  |
| High Capture (tons)   | 243  | 252  | 261  | 268  | 274  |

### 2.3.2.3 On-Farm Composting

Maryland Department of the Environment laws surrounding composting on-farm are complex, allowing various exemptions for production of compost on-farm in the state. The exemptions depend on the feedstock and the size of the compost processing area. If a farm utilizes feedstock material from the farm and does not intend to sell or use the compost in any location besides the farm, there are no restrictions. If the farm intends on selling the compost, and the non-food feedstock is from the farm and off-site sources, the compost processing area is limited to 40,000 square feet (SF). In 2023, for feedstocks including food scraps, the passage of SB262/HB253 in the Maryland state legislature increased the compost processing area from 5,000 SF to 10,000 SF for farms intending on selling the compost. At the County level, the Agricultural Reserve Zoning Amendment of 2021 increased the percentage of off-site materials farmers are allowed to include in their compost or mulch. Now, 50% of the feedstock can come

from off-site sources and be incorporated into on-farm compost. These complexities make it important to define how composting on farms is measured.

After review of publicly available data for on-farm composting at two farms in Montgomery County, Butler's Orchard (Compost Crew 2022) and Koiner Farm (Charles Koiner Conservancy for Urban Farming 2023), and accounting for average farm size, tons of organic waste diverted to composting per acre per month was estimated for the low, medium, and high capture scenarios, at 0.01, 0.05, and 0.07 tons per acre per month (Israel 2022, Brolis 2023, Biocycle 2022, DEP Division of Solid Waste Services 2018). Of 48,500 acres of cropland in Montgomery County (U.S. Department of Agriculture [USDA] 2017), the County Office of Agriculture provided additional information that 3,540 acres of farmland is operated by farmers who are likely to be currently participating in on-farm composting, estimated from around 30 vegetable farms with an average size of 118 acres. The basis for the capture scenario projections is summarized in Table 2-17. Based on the assumptions noted, tonnages captured through on-farm composting over the planning period are summarized in Table 2-18, with no year on year increases to composting rate nor participating acreage assumed.

**Table 2-17. On-Farm Composting Capture Scenarios Basis**

| Scenario       | Composting Rate<br>(tons / acre / month) | Acreage of Farms<br>Participating |
|----------------|------------------------------------------|-----------------------------------|
| Low Capture    | 0.01                                     | 3,540                             |
| Medium Capture | 0.05                                     | 3,540                             |
| High Capture   | 0.07                                     | 3,540                             |

**Table 2-18. On-Farm Composting Tons Captured Scenarios**

| Scenario              | 2025  | 2030  | 2035  | 2040  | 2045  |
|-----------------------|-------|-------|-------|-------|-------|
| Low Capture (tons)    | 430   | 430   | 430   | 430   | 430   |
| Medium Capture (tons) | 2,120 | 2,120 | 2,120 | 2,120 | 2,120 |
| High Capture (tons)   | 2,970 | 2,970 | 2,970 | 2,970 | 2,970 |

## 2.4 ORGANIC WASTE CAPTURE SCENARIOS

### 2.4.1 Food Scraps

Based on the capture projections presented, Scenarios 1 through 4 in Table 2-19 consider the potential food scrap capture of the low, medium, high, and mandatory capture conditions as shown. In these scenarios, private collection occurs at the low condition and is recognized to offset County-managed waste tonnages above the low condition only. Decentralized waste processing, through backyard, community, and on-farm composting, are not considered in these scenarios. In contrast, Scenarios 5 through 8 consider the offset to County-managed waste that can be provided through decentralized channels.

Captured tons of food scraps over the planning period are summarized in Table 2-20. Given the scenarios developed, this summary shows that capture of food scraps in 2045 could range from 9,000 tons per year in the low condition (Scenario 1) to 51,000 to 54,000 tons per year in the high condition (Scenarios 3 and 7), with a mandatory diversion program potentially reaching capture of 58,300 to 65,800 tons per year (Scenarios 4 and 8).

Estimated food scrap capture varies widely across the scenarios, suggesting that the County's investment in developing food scrap diversion programs will ultimately drive the food scrap diversion achieved. Decentralized processing provides a noteworthy offset to County-managed waste; developing these channels will support the overall success of the County's organics diversion efforts and are critical to developing a more resilient waste management system in the County. In addition, these approaches contribute to increased awareness and education of residents around composting and could begin to influence household disposal habits.

**Table 2-19. Food Scrap Capture Scenarios**

| Scenario | County Processed |           |           | Outside Processing and Decentralized |          |           |         |
|----------|------------------|-----------|-----------|--------------------------------------|----------|-----------|---------|
|          | SF               | MF        | NR        | Private                              | Backyard | Community | On-Farm |
| 1        | Low              | Low       | Low       | Low                                  | None     | None      | None    |
| 2        | Med              | Low       | Med       | Med                                  | None     | None      | None    |
| 3        | High             | Med       | High      | High                                 | None     | None      | None    |
| 4        | Mandatory        | Mandatory | Mandatory | Mandatory                            | None     | None      | None    |
| 5        | Low              | Low       | Low       | Low                                  | Low      | Low       | Low     |
| 6        | Med              | Low       | Med       | Med                                  | Med      | Med       | Med     |
| 7        | High             | Med       | High      | High                                 | Med      | Med       | Med     |
| 8        | Mandatory        | Mandatory | Mandatory | Mandatory                            | High     | High      | High    |

**Table 2-20. Food Scraps Capture (Tons) by Year**

| Scenario | 2025  | 2030   | 2035   | 2040   | 2045   |
|----------|-------|--------|--------|--------|--------|
| 1        | 4,600 | 5,700  | 6,700  | 7,700  | 8,800  |
| 2        | 6,400 | 10,700 | 15,100 | 19,600 | 24,100 |
| 3        | 7,300 | 18,500 | 30,000 | 41,900 | 54,000 |
| 4        | 7,300 | 35,500 | 45,300 | 55,400 | 65,800 |
| 5        | 4,600 | 5,700  | 6,700  | 7,700  | 8,800  |
| 6        | 4,800 | 7,600  | 11,900 | 16,500 | 21,100 |
| 7        | 5,700 | 15,400 | 26,900 | 38,800 | 51,000 |
| 8        | 3,500 | 28,100 | 37,700 | 47,900 | 58,300 |

## 2.5 ORGANIC WASTE PROCESSING

### 2.5.1 Yard Trim Processing Capacity Limitations

While captured yard trim is projected at up to 212,900 tons (Table 2-8), captured non-recyclable paper projected at up to 21,400 tons (Table 2-9) and captured food waste is projected at up to 65,800 tons (Table 2-20), not all material will be processed by the County.

Yard trim received and processed at the Shady Grove Processing Facility and Transfer Station (TS) has historically been only a fraction of the yard trim captured. This is due in part to the yard trim receiving and processing operation at the Shady Grove TS being constrained by site operations and available area on-site for material processing. Since yard trim is an important carbon-rich feedstock providing the bulk of volume in a compostable mix, organics processing will be limited by the availability of yard trim feedstock. Table 2-21 summarizes the yard trim processed at Shady Grove TS from fiscal year (FY) 2019 to FY23.

**Table 2-21. Yard Trim Processed and Transported to Montgomery County Yard Trim Composting Facility (MCYTCF) (Tons), FY19-23**

| <b>Scenario</b>          | <b>FY19</b> | <b>FY20</b> | <b>FY21</b> | <b>FY22</b> | <b>FY23</b> |
|--------------------------|-------------|-------------|-------------|-------------|-------------|
| <i>Generation (tons)</i> | 223,700     | 226,900     | 230,100     | 233,300     | 236,500     |
| Capture (tons)           | 201,300     | 204,200     | 207,100     | 210,000     | 212,900     |
| Capture (%)              | 90%         | 90%         | 90%         | 90%         | 90%         |
| Processed (tons)         | 67,900      | 63,400      | 60,900      | 55,800      | 59,700      |
| Processed (%)            | 34%         | 31%         | 29%         | 27%         | 28%         |

Given this, facility sizing developed later in this report will consider that a County-owned organics processing facility will be limited by processing of yard trim at approximately 70,000 tons per year, consistent with the material historically received and processed at the Shady Grove TS. While yard trim capture exceeds this limit, processing additional yard trim by the County will require significant changes in centralizing the receiving and processing operation currently housed at the Shady Grove TS, and is beyond the scope of this report.

## **2.5.2 Food Scrap and Yard Trim Collection**

Collection of food scrap and yard trim feedstocks is another variable that will impact processing of diverted organic waste by the County. Currently, yard trim is collected separately from refuse, and placed in brown paper yard trim/lawn bags or other non-plastic reusable containers or bundled by residents for curbside collection.

Co-collection of yard trim and food scrap would require making collection carts adequate for the waste stream available to single-family households throughout the County, such as a 65-gallon cart with latching lid. While the cost of supplying carts would be a significant capital cost, this would allow existing yard trim collection routes to be maintained. However, processing of co-collected yard trim and food scrap material may yield an organic waste stream with higher contamination, requiring additional pre-processing.

As an alternative, separate collection of food scrap and yard trim could be achieved by maintaining current yard trim collection at curbside and adding a food-scrap-only collection route. The costs of an additional collection route are based on average monthly per household costs for the County's current yard trim collection (Montgomery County DEP 2023i). Thirty-five-gallon food scrap bins similar to those used currently in the County's pilot program could be provided to single family households for curbside food scrap collection. Separately collected food scraps would likely have less contamination, and could be pre-processed as separate streams, then combined in mix ratios for optimal processing. However, separate collection would increase hauling traffic and associated greenhouse gas (GHG) emissions, along with greater safety considerations for both truck drivers and pedestrians.

Estimated costs for each collection approach are summarized in Table 2-22, with costs developed for a standard offering (e.g., provided standard to all single-family households) or voluntary sign-up (e.g., households opt-in). Estimated costs do not include any fleet upgrades, and assumed bagged yard trim can be collected by the same trucks as co-collected food and yard trim.

**Table 2-22. Estimated Food Scrap and Yard Trim Collection Costs**

| Scenario                              | FW + YT Co-Collection |                   | Separate FW + YT Collection |                   |
|---------------------------------------|-----------------------|-------------------|-----------------------------|-------------------|
|                                       | Standard Offering     | Voluntary Sign-Up | Standard Offering           | Voluntary Sign-Up |
| Existing Yard Trim Collection         | \$9,458,000           | \$9,458,000       | \$9,458,000                 | \$9,458,000       |
| Additional Collection Cost            | \$-                   | \$-               | \$14,186,000                | \$5,151,000       |
| 65-gallon cart for Co-mingled FW + YT | \$4,500,000           | \$1,090,000       | \$-                         | \$-               |
| 35-gallon cart for FW only            | \$-                   | \$-               | \$3,335,000                 | \$808,000         |
| 1.8-gallon countertop bin             | \$1,334,000           | \$323,000         | \$1,334,000                 | \$323,000         |
| Total                                 | \$15,292,000          | \$10,871,000      | \$28,313,000                | \$15,740,000      |

Notes:

FW = Food waste

YT = Yard trim

Both models are used in food scrap programs nationwide.

### 2.5.3 Compost Recipe

Composting of source-separated organics (SSO) is a volumetric materials handling and processing endeavor, but it starts with a mass (weight)-based recipe. Composting recipes are used in facility design and are based on tonnages of anticipated feedstocks and laboratory analyses of the compostability parameters of those feedstocks. Composting recipes balance, at a minimum, carbon-to-nitrogen ratios (C:N) which should be between 25:1 and 30:1 on a weight basis, and moisture content, which should be between 50% and 55% for turned windrow operations (like the MCYTFC) or 55% to 60% for ASP systems. Recipes can also be used to balance volatile solids and predicted free air space. These mass-based recipes are converted to volumetric recipes using the bulk density measurements of the feedstocks.

For the purposes of this analysis, the compost recipe to be used in sizing alternatives is assumed to be four parts carbon-rich feedstock to one part nitrogen-rich feedstock on a volumetric basis. This 4:1 volumetric ratio is higher than the traditional 3:1 ratio commonly found in backyard composting instruction manuals, as it takes into consideration the fact that the lignin content of carbon-rich wood chips, brush, etc. is not available to the bacteria responsible for organics conversion to compost in active composting (lignaceous carbon is more easily degraded by the fungi found in compost curing and storage piles).

In addition, bulk densities can vary widely based on feedstock materials, contamination, moisture, etc. For the purposes of recipe planning, we have utilized the EPA Guide (EPA 2016) to represent general industry-accepted material bulk densities. It is important to acknowledge that these values may differ considerably across various materials, prompting the annotation of a range of observed bulk densities obtained from diverse sources, including vendor information and research studies like the one conducted for Hennepin County, which found the bulk density of SSO food scraps to be 1,163 pounds/calendar year (Coker 2019). In future facility development, analysis can be tailored to the unique characteristics of the County's organic waste stream. Bulk densities utilized and observed ranges are summarized in Table 2-23.

**Table 2-23. Bulk Density Summary Table**

| <b>Feedstock</b>                  | <b>EPA<br/>(pounds/cubic yard)</b> | <b>Range<br/>(pounds/cubic yard)</b> |
|-----------------------------------|------------------------------------|--------------------------------------|
| Food Scraps <sup>1</sup>          | 1,000                              | 1,000-1,400                          |
| Yard Trim (Ground) <sup>2</sup>   | 640                                | 640-1,500                            |
| Non-Recyclable Paper <sup>3</sup> | 323                                | ---                                  |

Source: EPA 2016

Notes:

1. Category “source separated organics – commercial.”
2. Category “Mixed Loose Paper.”
3. Category “source separated organics – commercial.”
4. Mixed Loose Paper, source separated organics – commercial, compacted mixed yard trim.

For an organics program developed based on co-collection of food waste and trim, processing based on a mass-based recipe may be more difficult to implement. While carbon sources (e.g., yard trim) may be sufficient, it is typical that co-collected material may not have sufficient nitrogen (e.g., food waste). To optimize the co-collected material for processing, addition of a nitrogen-rich amendment may be required, such as grass clippings, commercial food processing residuals, or other high-nitrogen inoculant. Processing co-collected material without the use of high-nitrogen amendment may extend the processing time.

#### 2.5.4 Processing Capacity Basis for Facility Planning

Based on the County’s current yard trim processing capacity, recommended compost recipe processing feedstocks in a volumetric ratio of four parts carbon-rich feedstock to one part nitrogen-rich feedstock, and bulk densities utilized, the following recipe is developed to establish the processing capacity that will be the basis for Phase I facility planning later in this report, as summarized in Table 2-24.

**Table 2-24. Organics Processing Capacity Basis**

| <b>Feedstock</b> | <b>Tons</b> | <b>Cubic Yards</b> |
|------------------|-------------|--------------------|
| Yard Trim        | 70,000      | 218,800            |
| Food Scrap       | 27,400      | 54,700             |
| Total            | 97,400      | 273,500            |

Based on food scrap capture scenarios outlined in Table 2-20, the County will have adequate processing capacity for food scraps captured in all scenarios except mandatory scenarios 4 and 8, and some high scenarios. These scenarios were utilized as the basis for Phase II facility planning. However, alternatives to centralized material receiving and processing at the Shady Grove TS will be required to meet processing capacity for these scenarios, in addition to the facility planning proposed herein.



### **3. SOURCE SEPARATED ORGANICS PROCESSING OPTIONS (TASK 2)**

Organics processing technologies vary widely from traditional windrows to sophisticated anaerobic digesters, all involving biological, chemical, and physical transformation of organic material into end-products such as finished compost, digestate, and biogas.

This review of organics processing technologies focuses on the current state-of-practice technologies, including evaluation of their potential to support centralized municipal-scale processing. Organics processing technologies evaluated in this section include aerobic and anaerobic processing approaches that are capable of processing up to or greater than 100,000 tons per year (TPY) of organic waste. Additional technologies with smaller processing capacities (under 30,000 TPY), such as modular static and agitated containers, although well proven for organics processing, are less appropriate for processing organic wastes anticipated to be generated at the County-wide scale, and therefore are excluded from evaluation herein.

Due to concerns around GHG emissions, lack of proven commercial-scale operations, and opposition to existing, local incineration efforts, technologies relying on thermal processing of organic matter, such as waste gasification and pyrolysis, are not evaluated in this study. In addition, passive processing methods poorly suited for putrescible wastes that will generate odors, such as unturned open or covered windrows, are not included in this study.

#### **3.1 AEROBIC PROCESSING TECHNOLOGIES**

Aerobic processing technologies evaluated include aerated static pile (ASP) and extended aeration composting, enclosed (in-vessel) composting (such as tunnel reactors and rotating drums), and agitated bed reactors. Each processing technology is discussed in detail in this section, and considerations including land area requirements, processing and feedstock considerations, public benefits and concerns, and equipment costs are summarized in Table 3-1.

##### **3.1.1 Aerated Static Pile (ASP)**

ASP composting is the second-most popular method of aerobic composting of source-separated organics (behind turned windrows) but is gaining in popularity due to the growth in food scrap composting in the United States. Developed in the early 1970s, ASP composting utilizes forced aeration to accelerate decomposition of organic matter placed in large piles, thereby improving compost process control and increasing facility throughput over a fixed area.

Forced air is typically delivered beneath piles, with installations varying in sophistication from at-grade perforated piping to in-ground trenches or ductwork with integrated process controls. Aeration can be delivered in positive (pushing), negative (pulling) or reversing regimes. ASP configurations include material placement in stand-alone piles (like windrows), within walls or bunkers, or in extended bed configurations where each new pile is constructed immediately adjacent to the previously built pile. Each of these configurations (see Figure 3-1) yields increasing material processing density (i.e., increased processing tons per square foot (SF) of composting area), thereby decreasing the land required for each layout.



**Figure 3-1. ASP alternatives in windrow (left), bunker (center), and extended ASP (right) configurations. Photos courtesy of Coker Composting and Consulting.**

ASP composting is well suited for processing food scraps, yard trim, and manure; however, attentive management is required to maintain optimal material biodegradation. Recipe development is recommended and should consider specific feedstocks and any seasonable variability in materials. ASP composting does require achieving balanced C:N ratios (>25:1) and maintaining optimum moisture (50–55%), volatile solids (>80%) and free air space (40–60%) to optimize air flow throughout the pile (Platt et al. 2014). Moisture demand can be considerable in warm/arid climates. ASP composting is not well suited for processing large quantities of animal byproducts or grease from food processing industries (EPA 2023). To minimize odor concerns, piles can be covered with compost (known as biolayers) or fabric covers, and/or aeration air can be directed through a biofilter. Use of fabric covers (Figure 3-2) provides additional means of controlling temperature, oxygen, and moisture within compost piles, and allows the collection and treatment of the process air prior to venting. Use of fabric covers has the additional benefit of minimizing contact water production, as the Maryland Composting regulations codified in COMAR 26.04.11 dictate that water coming into contact with the fabric cover can be handled as stormwater. ASP systems utilizing biocovered material must collect and manage any stormwater coming into contact with the pile as contact water, potentially requiring tanks for contact water collection and holding, or recirculation systems to collect and reuse contact water for material wetting prior to material placement within bunkers. However, the labor effort required to remove and reinstall fabric covers is considerable.



**Figure 3-2. Fabric-covered ASPs. Photos courtesy of Coker Composting and Consulting.**

ASP composting performs optimally when material is well ground, reducing particle size and thereby increasing surface area for material degradation, and well mixed, to achieve the proper process design properties noted above, prior to placement in piles. The active composting phase can vary in material handling requirements, from installations requiring no pile turning (low handling); remixing halfway through active composting to re-establish free air space and ensure even temperature distribution throughout the pile (medium handling); or the placement of fabric

covers either via specialized mechanical winders or use of other on-site equipment for cover placement (high handling). Secondary curing is typically necessary after the active composting phase to improve compost maturity. ASPs typically produce compost within 3–6 months including active composting and secondary curing (EPA 2023).

### **3.1.2 Enclosed (In-Vessel) Composting**

Like ASP composting, enclosed or in-vessel composting utilizes forced aeration; however, it differs from the ASP in-bunker configuration by fully enclosing the compost pile. In-vessel systems are available in multiple configurations, including storage-style tunnel reactors and rotating drums discussed further in this section.

#### **3.1.2.1 Tunnel Reactor**

Tunnel reactors, which are better-suited to the larger processing volumes of centralized composting, utilize a long, narrow, cast-in-place concrete enclosure resembling a self-storage garage. Enclosures are typically designed for entry by front-end loaders for material placement, with gasketed doors to ensure an airtight seal when doors are closed. Tunnel composting can utilize positive aeration via in-ground aeration systems or exhaust process air in the headspace of the tunnel, or both. The fully enclosed active composting area coupled with complex aeration and process controls provides even greater control over material degradation. Land area requirements for enclosed composting are like ASP bunkers and can be installed in indoor and outdoor settings. Tunnel systems may require management as confined spaces with appropriate personal protective equipment to ensure adequate worker health and safety.

While enclosed or in-vessel composting facilities can process smaller volumes, the higher capital cost for cast-in-place concrete tunnel construction lends itself to facilities processing higher volumes of organics. The process is well suited for composting of separated municipal organic waste, commercial food scraps, yard trim, digestate from anaerobic digestion, and biosolids from wastewater treatment and manure. For optimal composting, material is ground prior to placement in reactors, reducing particle size and thereby increasing surface area for material degradation. The high degree of process air containment minimizes odor concerns, and the enclosed system lends itself to improved moisture management and leachate production.

#### **3.1.2.2 Rotating Drum**

Rotating drum composting systems utilize mechanical agitation to achieve material aeration, although some systems do also utilize auxiliary air injection systems to meet process air requirements. Vessels can vary in size and capacity; however, they generally require significantly less land area than windrow composting. Large-scale drums typically consist of a steel drum with diameter up to 16 feet (ft) and length between 100 and 250 ft, positioned on an incline less than 5% (Figure 3-3). Drum rotation at 0.5–5 revolutions per minute moves material down the drum in a corkscrew pattern. Process air containment within the drum does minimize odor concerns.



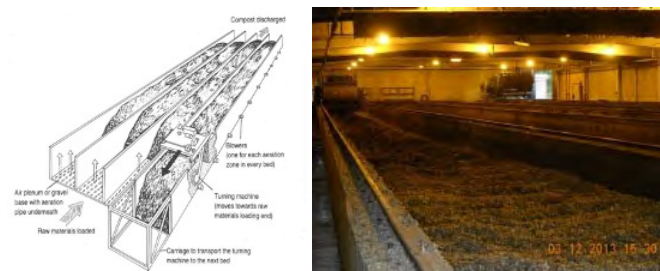
**Figure 3-3. Rotating Drum Composting. Photo of XACT Systems, Trenton, Ontario, Canada.**

This technology can accommodate virtually any type of organic waste (e.g., meat, animal manure, biosolids, food scraps); however, skilled operators are required to ensure attentive process management throughout the short active composting window. Drum loading/unloading does introduce mechanical complexity in comparison to other enclosed or in-vessel composting. In addition, drive train components may need regular calibration and servicing, requiring a skilled operator and/or mechanic be available to minimize system downtime.

Since drums provide effective mixing and agitation of feedstocks and amendments, material pretreatment is limited to material grinding only. Rotating drum composting typically produces compost within 1–3 months including active composting and secondary curing. Due to the high mechanical agitation, the active composting phase typically lasts 7–10 days. Once the compost comes out of the drum, however, several more weeks or months are required in secondary composting and in curing for the microbial activity to stabilize the organics and mature the compost.

### **3.1.3 Agitated Bed**

Equipped with forced aeration like ASP and enclosed (in-vessel) systems, agitated beds utilize large beds of material placed at depths up to 10 ft, enclosed within perimeter walls in long narrow bays. Material is mechanically turned in individual bays every 1–3 days, with mechanical agitation achieved via an auger riding on perimeter wall rails or suspended from a bridge crane that can reach all areas of the bed (Figure 3-4). As the auger mixes and moves the compost along the axis of the bed, a certain amount of stable (but immature) compost is exhausted for further processing and an empty space is created at the upstream end of the bed to allow new mixed feedstocks to be emplaced. Agitated bed systems are an effective use of land area, as space requirements per ton of capacity are lower than other configurations. In addition, agitated beds are typically installed within buildings, allowing a higher degree of odor control. The high use of automation in agitated bed systems does require high capital cost but reduces the labor effort necessary.



**Figure 3-4. Agitated Bed Composting NRAES-54. Photo courtesy of Coker Composting and Consulting.**

Processing by agitated bed system is appropriate for food scraps and yard trim and is well suited for handling large volumes of material. While material grinding is required prior to processing and additional agitation is provided during active composting, the preparation of feedstocks and amendments prior to active composting is critical. Due to the high degree of automation, material handling requirements during the active composting phase are low. Front-end loaders or conveyors are typically used to place material at the receiving end of an agitated bed, with material moved along beds by the turning auger throughout active composting. Augured compost is discharged onto the bed floor or a conveyor belt for further processing at the completion of the active composting phase. Agitated bed composting typically produces compost within 2–4 months including active composting and secondary curing. Due to mechanical agitation, the active composting phase typically lasts 3–4 weeks. Additional secondary curing is typically required.

### **3.1.4 Aerobic Processing Technologies Summary Table**

A summary of aerobic processing technologies discussed in this section is included in Table 3-1.

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Table 3-1. Compost Technology Alternatives – Centralized Aerobic Processing

| Compost Technology                  | General Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Land Area Requirements                                                                                                                                                                                                                                                                                                                                                                                                                  | Feedstock Considerations                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Processing Considerations and Timeline                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Public Benefits and Concerns                                                                                                                                                                                                                                                                                                                                                                                  | Cost                                                                                                                                                                                                                                 |
|-------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Aerobic Processing Technologies     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                      |
| Aerated Static Pile (ASP)           | Forced aeration system which utilizes at-grade (low tech) or in-ground (high tech) piping to provide positive, negative, or reversing aeration to mixed organic waste piles. Piles can be managed with biocovers or fabric covers. Contact water can be minimized through use of fabric covers, or captured for reuse with biocovers. Systems may utilize temperature and moisture probes for continuous pile management and optimization.                                                                                             | <p>Low to Moderate</p> <p>Controlled aeration supply allows construction of large piles (e.g., 30 ft wide × 100 ft long × 10 ft high), with ASP requiring less land than windrow composting. Configurations for ASP can be standalone piles, in-bunker, or extended aeration, with processing density increasing for each and decreasing land area. Low difficulty to add piles but requires cost of additional aeration equipment.</p> | <p>1,000 to &gt;100,000 TPY</p> <p>Appropriate for large volumes of food scraps, yard trim, and manure. “Recipe” development considering specific and seasonal availability of feedstocks. Recommended for achieving balanced C:N ratio (&gt;25:1), optimum moisture (50–55%), volatile solids (&gt;80%) and free air space (40–60%) (Coker 2014). Moisture demand can be considerable in warm/arid climates. Not well suited for processing animal byproducts or grease from food processing industries (EPA 2023).</p> | <p>2–6 months</p> <p><u>Pre-Treatment</u> Material grinding/mixing prior to placement in piles.</p> <p><u>Active Composting</u> Fan aeration. No mechanical agitation required. Depending on facility configuration and level of technology, material handling can be <b>Low</b> (no pile turning during active composting), <b>Medium</b> (one pile rebuild), or <b>High</b> (use of fabric pile covers). Typically, 2–8 weeks.</p> <p><u>Post-Processing</u> Secondary curing/maturation.</p>                          | <p><u>Public Benefits</u><br/>Reduced processing facility footprint and size. Reduced volatile organic compound (VOC) emissions compared to turned windrows.</p> <p><u>Public Concerns</u><br/><b>Odor</b> – Requires process design and attentive management of moisture and temperature throughout process. Can also be optimized through use of aeration regime, pile covers, and biofilters.</p>          | <p>Moderate</p> <p>Significant cost and technical assistance to purchase, install, and maintain aeration equipment (e.g., blowers, piping and ductwork, process controls).</p>                                                       |
| Enclosed (In-Vessel) Tunnel Reactor | Forced aeration system with compost processed in a fully enclosed structure, typically a long, narrow, cast-in-place concrete enclosure resembling a tunnel. Positive aeration via an in-ground aeration system and/or process air can be exhausted from the headspace of the tunnel. Complex aeration and control systems provide increased control over optimizing material degradation. Tunnel can be entered by front-end loader for material placement, and gasketed door sealed during composting creates an airtight enclosure. | <p>Low to moderate</p> <p>Land area requirement like ASP bunker facility configurations. Can be installed in indoor and outdoor settings.</p>                                                                                                                                                                                                                                                                                           | <p>25,000 to &gt;100,000 TPY</p> <p>Composting of separated municipal organic waste, commercial food scraps, yard trim, digestate from anaerobic digestion, biosolids from wastewater treatment and manure. While facilities can process smaller volumes, the higher capital costs for tunnel construction lend use of this technology to facilities processing higher volumes of organics.</p>                                                                                                                          | <p>2–4 months</p> <p><u>Pre-Treatment</u> Material grinding/mixing prior to placement in enclosed system.</p> <p><u>Active Composting</u> Fan aeration. No mechanical agitation required. Depending on the facility processing approach, material handling can be <b>Low</b> (no pile turning during active composting) or <b>Medium</b> (one pile rebuild). Typically, 2–4 weeks.</p> <p><u>Post-Processing</u> Secondary curing.</p>                                                                                   | <p><u>Public Benefits</u><br/>Reduced processing footprint and reduced processing size. Reduced VOC emissions compared to turned windrows.</p> <p><u>Public Concerns</u><br/><b>Odor</b> – High degree of process air containment minimizes odor concerns.<br/><b>Worker Health and Safety</b> – Tunnel systems may require management as confined spaces with appropriate personal protective equipment.</p> | <p>Moderate to High</p> <p>Cast-in-place concrete for tunnel systems increases construction costs. Significant cost and technical assistance to purchase, install, and maintain complex aeration equipment and process controls.</p> |
| Enclosed (In-Vessel) Rotating Drum  | Rotating drum systems utilize mechanical agitation to achieve material aeration, rotating organic material in large-scale drums at 0.5–5 revolutions per minute, moving material down the drum in a corkscrew pattern. Air is typically injected into drums to meet process air requirements.                                                                                                                                                                                                                                          | <p>Low to Moderate</p> <p>Vessels can vary in size and capacity; however, they generally require significantly less land area than windrow composting. Large-scale systems typically consist of a steel drum with diameter up to 16 ft and length between 100 and 250 ft, positioned on an incline less than 5%.</p>                                                                                                                    | <p>1,000 to 100,000 TPY</p> <p>Can accommodate virtually any type of organic waste (e.g., meat, animal manure, biosolids, food scraps).</p>                                                                                                                                                                                                                                                                                                                                                                              | <p>1–3 months</p> <p><u>Pre-Treatment</u> Material grinding only. Drums provide effective mixing and agitation of feedstocks and amendments, minimized pre-treatment needs.</p> <p><u>Active Composting</u> <b>Low</b> material handling. Drum loading/unloading introduces mechanical complexity in comparison to other enclosed or in-vessel composting. Typically, 7–10 days. Additional active composting may be required.</p> <p><u>Post-Processing</u> Secondary curing.</p>                                       | <p><u>Public Benefits</u><br/>Reduced processing footprint.</p> <p><u>Public Concerns</u><br/><b>Odor</b> – Process air containment minimizes odor concerns.</p>                                                                                                                                                                                                                                              | <p>Moderate to High</p> <p>High cost of equipment and technical expertise may be required to support operations.</p>                                                                                                                 |
| Agitated Bed                        | Equipped with forced aeration like ASP and enclosed (in-vessel) systems, agitated beds utilize large beds of material placed at depths up to 10 ft, enclosed within perimeter walls. Material mechanically turned in individual bays every 1–3 days. Mechanical agitation can be achieved with an auger suspended from a bridge crane spanning across the bed floor, which can reach all areas of the bed.                                                                                                                             | <p>Low</p> <p>Effective use of land area; space requirements per ton of capacity are low.</p>                                                                                                                                                                                                                                                                                                                                           | <p>50,000 to &gt;100,000 TPY</p> <p>Appropriate for food scraps and yard trim. While facilities can process smaller volumes, the technology is well suited for handling large volumes of material.</p>                                                                                                                                                                                                                                                                                                                   | <p>2–4 months</p> <p><u>Pre-Treatment</u> Material grinding. Preparation of feedstocks and amendments critical. Additional mechanical mixing during active composting.</p> <p><u>Active Composting</u> High degree of automation requires <b>Low</b> material handling. Front-end loaders or conveyors are used to place material at bed receiving ends. Material moved across bays and discharged on floor or conveyor belt after processing. Typically, 3–4 weeks.</p> <p><u>Post-Processing</u> Secondary curing.</p> | <p><u>Public Benefits</u><br/>Reduced processing facility footprint and size. Reduced VOC emissions compared to turned windrows.</p> <p><u>Public Concerns</u><br/><b>Odor</b> – Agitated beds are typically installed within buildings, allowing a higher degree of odor control.</p>                                                                                                                        | <p>High</p> <p>High use of automation requires high capital cost.</p>                                                                                                                                                                |

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## 3.2 ANAEROBIC PROCESSING TECHNOLOGIES

Anaerobic processing technologies rely on the decomposition of organic materials in the absence of oxygen in either wet (low-solids) or dry (high-solids) digesters. The anaerobic digestion (AD) technology evaluated herein includes traditional wet continuous-stirred tank reactor (CSTR) and high-solids configurations including dry fermentation and plug flow. Each processing technology is discussed in detail in this section, and considerations including land area requirements, processing and feedstock considerations, public benefits and concerns, and equipment costs are summarized in Table 3-2. An analysis of biogas yield potential from a high-solids AD technology is included in Appendix D.

### 3.2.1 Wet (Low-Solids) CSTR Anaerobic Digestion

As AD was developed in the U.S. for handling sewage sludges at wastewater treatment plants, most AD systems are wet (low-solids) digesters, and were some of the first digester designs used for processing residential food scraps. Wet (low-solids) systems have moisture content greater than 80% and conversely, dry matter content of 20% or less. Typically requiring water addition, feedstocks are dissolved or suspended in a liquid form and are handled as a liquid. Based on this processing approach, a high level of pretreatment is required, including removal of floatables and settleables; removal of large, fibrous materials that could interfere with the stirring and mixing mechanisms; and size reduction, such as shredding, to achieve higher surface area for effective degradation and render the slurry pumpable. This processing approach is best-suited for low-solids feedstocks. Some examples of low-solids feedstocks include dairy manure and food processing residuals such as from juice, cheese whey, and spoiled milk.

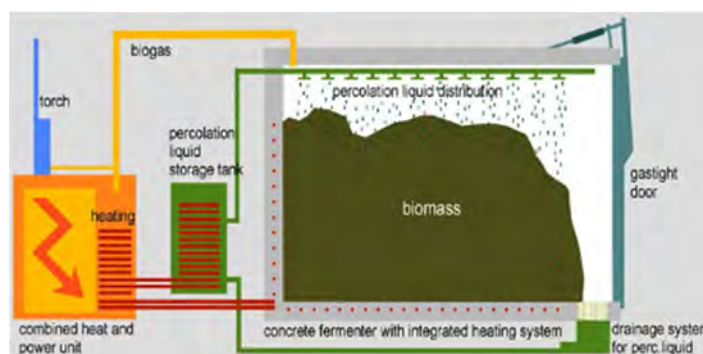
Wet (low-solids) can be operated under mesophilic (86 to 100 degrees Fahrenheit [°F]) or thermophilic (122 to 144°F) temperature regimes, in single-, dual-, or multi-stage digesters. A typical single-stage CSTR digester can process up to 250,000 TPY with a typical material retention time of 14–40 days. Anaerobic digestion also produces biogas, primarily methane and carbon dioxide, that can be used on-site or sold to provide energy, although it has the lowest net energy output per ton of input feedstocks relative to other AD systems presented in this section (Environment Canada 2013). Due to the high (70–90%) moisture content of digestate, the low-solids, nutrient-rich liquid digestate requires significant dewatering, typically done with filter/screw presses, centrifuges, or other techniques. Digestate typically requires additional processing, such as composting, although processing time is reduced due to the decomposition partially achieved during digestion. Up to 45% of the moisture fed into the digester for processing may be discharged as effluent during digestate dewatering.

With the enclosed digester vessels, there is a high degree of odor control with AD processing. AD processing facilities require high capital and site development costs to establish the pre-processing, dewatering, and composting areas in support of the digester vessels and process equipment required and would not be suitable for organics diversion programs developed around co-collection of food waste and yard trim. AD can be expensive compared to traditional aerobic composting systems.

### 3.2.2 High-Solids Dry Fermentation Anaerobic Digestion

Dry fermentation AD is a batch process well suited for high-solids material, including commercial and residential food scraps. In the batch process, the digester is filled with a mix of fresh organic matter—screened of materials too large for digestion and mixed with a bulking agent to facilitate the free air space necessary for percolation—then closed with a gas- and liquid-tight seal. The digester remains closed until the end of the desired retention time, up to 30 days. It is then emptied and filled with new material, often a mixture of partially digested material that was just removed and fresh, undigested material to seed the digestion process. Digesters can be operated under mesophilic or thermophilic conditions, in single- or dual-stage systems to optimize digestion.

Anaerobic microorganisms require a moist environment in which to thrive. A dry system is not moist enough to foster this, so a liquid “percolate” is typically sprayed into the fermenter over the digesting feedstocks, filling the biomass pore spaces with liquid, and shifting the bacterial activity to anaerobic decomposition, producing biogas (see Figure 3-5). An organic waste mix with free air space for effective percolation typically requires roughly equal volumes of food scraps and bulking agent. The percolate has already been through an active digester; therefore, it contains anaerobic microorganisms. As percolate is recycled in the process, little water addition is necessary throughout the process, and minimal process effluent is produced. Once a fermenter has been re-seeded, and percolate has been sprayed in, gas production begins almost immediately. Over the retention time of the digester, the percolate is repeatedly drained and re-sprayed onto the fermenting mass.



**Figure 3-5. Cross Section through Dry Fermenter. Illustration courtesy of P. Lutz, BEKON Technologies.**

### 3.2.3 High-Solids Plug Flow Anaerobic Digestion

Plug flow reactors are, like the wet (low-solids) CSTR reactors, continuous systems. The digester contents are not completely mixed but move as a plug through the reactor from the feed port to the exit. This process requires heavy process equipment that can handle dry, viscous material that does not flow freely. High solids plug flow digesters are typically operated at a moisture content of 60–80% by weight, maintaining at least 20% solids in the tank. This digester type can accommodate a wider variety of materials than dry fermentation AD, including large volumes of wet materials, and residential and commercial food scraps. In addition, these digesters are more

robust regarding acceptance of non-biodegradable material, such as glass, metals, or plastic contamination, that may be present in feedstocks. Feedstock quality could necessitate complex pre-treatment, including size reduction, mixing, and slurry pumping. Digesters are typically managed at mesophilic temperature regimes, in vertical silo or horizontal tank configurations, through one or more processing stages.

One vertical plug-flow configuration uses vertical steel tanks with a central baffle that extends two-thirds of the way through the center of the tank. The material is forced to flow around the baffle from the inlet to reach the outlet port on the opposite side, creating a plug flow in the reactor. These tanks can operate between 25% and 35% total solids. A biogas mixing system is used to create local mixing in the tank. The biogas mixing provides adequate interaction between fresh product and mature digestate. As a result, fresh feedstock does not necessarily require inoculation with finished product or leachate outside the tank prior to feeding.

A horizontal plug flow reactor is a horizontal steel tank with slowly rotating axial mixers that assist in conveying the material from the inlet to the outlet, keep heavy solids in suspension, and degas the thick digestate (Figure 3-6). The total solids in the reactor are held in the range of 23–28% to facilitate flow. Recycled digestate is mixed with the feed stream to inoculate the material and process water may be added to reduce the solids content.



**Figure 3-6. Horizontal Plug Flow Digester. Photo courtesy of BioCycle CONNECT LLC.**

### **3.2.4 Anaerobic Processing Technologies Summary Table**

A summary of anaerobic processing technologies is included in Table 3-2.

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Table 3-2. Anaerobic Digestion Technology Alternatives – Centralized Anaerobic Processing

| AD Technology                                    | General Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Land Area Requirements                                                                                                                                                                                   | Feedstock Considerations                                                                                                                                                                                                                                                                                                                                                       | Processing Considerations and Timeline                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Public Benefits and Concerns                                                                                                                                                                                                                                                                                                                                                                    | Cost                                                                                                                                                                                                                                                                                                                                                                                                                         |
|--------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Anaerobic Processing Technologies                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                              |
| Wet (low-solids) CSTR Anaerobic Digestion        | Closed vessel system that utilizes wet (low-solids) organic material and maintains a high moisture content (more than 80%) slurry for processing. Microorganisms digest the slurry within the anaerobic system to create a digestate. Up to 45% of the moisture fed into the digester for processing may be discharged as effluent during digestate dewatering.                                                                                                                                                                                                                                                                                                                       | Moderate to High<br><br>Digesters can be single-, dual-, or multi-stage to optimize digestion. Processing equipment required for pre-processing, dewatering, and composting.                             | 3,000 to 250,000 TPY<br><br>Best suited for high-liquids/low-solids organic waste (e.g., dairy manure, and food processing residuals such as from juice, cheese whey, and spoiled milk). Yard trim can be resistant to digestion at typical processing temperatures and is not well suited for processing via AD.                                                              | 14–40 days digester retention time, additional digestate processing time<br><br><u>Pre-Treatment</u> <b>High</b> Material grinding for particle size reduction and to render pumpable slurry. Floatables and settleables removal. Addition of moisture as necessary to achieve 80% water content. No addition of bulking material necessary.<br><br><u>Digestate Management</u> <b>High</b> Due to the high (70–90%) moisture content of digestate, the low-solids, nutrient-rich liquid digestate requires significant dewatering, typically done with filter/screw presses. Additional processing typically required, such as composting. | <u>Public Benefits</u><br><b>Energy Production</b> – Biogas produced can be used for on-site power and heating or sold for off-site use with appropriate gas transmission infrastructure. Lowest net energy output per ton of input feedstocks.<br><br><u>Public Concerns</u><br><b>Odor</b> – Enclosed digester minimizes odor concerns during processing. Odor may be present from digestate. | High<br><br>High capital cost for digester vessel and related pre-processing, digestate dewatering and composting equipment. Technical expertise required to support operation of digester and maintenance of flare and biogas monitoring. Significant site development costs for processing and administrative facilities and access roadways. Biogas sold for energy can provide system revenue to offset operating costs. |
| High-Solids Dry Fermentation Anaerobic Digestion | Dry fermentation AD is a batch process in which the digester is filled with a mix of fresh organic matter and partially digested material from a previous batch to seed digestion, then closed with a gas- and liquid-tight seal for a retention time, up to 30 days. Digestate recycle rates vary between manufacturer’s systems, varying from 20% to 50% for dry fermentation batch systems. Liquid percolate is sprayed over the digesting feedstocks, shifting the bacterial activity to anaerobic decomposition, producing biogas. As percolate is recycled in the process, little water addition is necessary throughout the process, and minimal process effluent is produced. | Moderate to High<br><br>Digesters can be single- or dual-stage systems to optimize digestion. Processing equipment required for pre-processing, dewatering, and composting.                              | 3,000 to 250,000 TPY<br><br>Well suited for high-solids material, including commercial and residential food scraps.                                                                                                                                                                                                                                                            | 14–30 days digester retention time, additional digestate processing time<br><br><u>Pre-Treatment</u> <b>Medium</b> Material screening for removal of materials too large for digestion. Material mixing with bulking agent in equal quantity as organic waste to facilitate the free air space necessary for percolation. Material shredding is limited, to prevent rendering the organic matter into slurry.<br><br><u>Digestate Management</u> <b>Medium</b> Additional active composting typically required for digestate.                                                                                                               | <u>Public Benefits</u><br><b>Energy Production</b> – Biogas produced can be used for on-site power and heating or sold for off-site use with appropriate gas transmission infrastructure. Medium net energy output per ton of input feedstocks.<br><br><u>Public Concerns</u><br><b>Odor</b> – Enclosed digester minimizes odor concerns during processing. Odor may be present from digestate. | High<br><br>High capital cost for digester vessel and related pre-processing. Technical expertise required to support operation of digester and maintenance of flare and biogas monitoring. Significant site development costs for processing and administrative facilities and access roadways. Biogas sold for energy can provide system revenue to offset operating costs.                                                |
| High-Solids Plug Flow Anaerobic Digestion        | Plug flow reactors are not mechanically mixed, but process digester contents as a plug through the reactor from the feed port to the exit. This process requires heavy process equipment that can handle dry, viscous material that does not flow freely. High solids plug flow digesters are typically operated at a moisture content of 60–80% by weight, maintaining at least 20% solids in the tank. Digesters are typically managed at mesophilic temperature regimes.                                                                                                                                                                                                           | Moderate to High<br><br>Reactors in vertical silo or horizontal tank configurations, through one or more processing stages. Processing equipment required for pre-processing, dewatering and composting. | 10,000 to 100,000 TPY<br><br>Can accommodate a wider variety of materials than dry fermentation AD, including large volumes of wet materials, and residential and commercial food scraps. In addition, these digesters are more robust regarding acceptance of non-biodegradable material, such as glass, metals, or plastic contamination, that may be present in feedstocks. | 14–30 days digester retention time, additional digestate processing time<br><br><u>Pre-Treatment</u> <b>Medium</b> Feedstock quality could necessitate complex pre-treatment, including size reduction, mixing, and slurry pumping.<br><br><u>Digestate Management</u> <b>Medium</b> Additional active composting typically required for digestate.                                                                                                                                                                                                                                                                                         | <u>Public Benefits</u><br><b>Energy Production</b> – Biogas produced can be used for on-site power and heating or sold for off-site use with appropriate gas transmission infrastructure. High net energy output per ton of input feedstocks.<br><br><u>Public Concerns</u><br><b>Odor</b> – Enclosed digester minimizes odor concerns during processing. Odor may be present from digestate.   | High<br><br>High capital cost for digester vessel and related pre-processing, dewatering, and composting equipment. Technical expertise required to support operation of digester and maintenance of flare and biogas monitoring. Significant site development costs for processing and administrative facilities and access roadways. Biogas sold for energy can provide system revenue to offset operating costs.          |

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### 3.3 SUPPORTING PROCESSING INFRASTRUCTURE

#### 3.3.1 Pre-Treatment

Pretreatment, or pre-processing, is usually needed to optimize feedstocks for processing by either aerobic or anaerobic means. The most common pretreatment steps are particle size reduction, contaminant removal, and mixing. Particle size reduction is usually done by mechanical shredding or grinding of woody materials like yard trim. Contaminant removal can be done manually with a sorting line or mechanically with a depackager. Mixing feedstocks is needed to optimize proportions for the composting or digestion “recipe” and to homogenize the feedstocks.

Grinding is normally done with either horizontal or tub grinders (high-speed rotary hammermills), although slow-speed, high-torque shredders are increasing in popularity as they can process large-diameter tree trunks and root balls. Figure 3-7 shows a tub grinder at work. Currently the County utilizes a grinder at the Shady Grove TS to reduce yard trim and land-clearing debris particle size.



**Figure 3-7. Tub Grinder. Photo courtesy of BioCycle CONNECT LLC.**

Contaminant removal is necessary for wet (low-solids) digestion and is increasingly of concern for composting and high-solids anaerobic digestion facilities. Contaminant removal conducted manually or robotically via a sorting line may be required for food waste material co-collected with yard trim or with high contamination rates, however staffing manual removal operations and maintaining removal rates over time can be key obstacles. Facilities such as the Prince William County/Freestate Farms yard trim and food scrap composting facility in Manassas, Virginia that previously staffed a sorting line for manual contaminant removal, and the Atlas Organics facility in San Antonio which previously utilized robotic equipment to mechanize contaminant removal in sorting lines have both abandoned the practices due to the challenges noted.

Depackaging is used for both contaminant removal and for opening packaged food products, although is not typically designed to work with co-collected food scraps and yard trim. Mechanical depackagers are available from multiple sources in the U.S. and abroad (Coker 2021a,b). Most depackaging systems operate by pressing the organics against a rigid screen (Figure 3-8) with the extract being the recovered food materials and the rejects consisting of more rigid materials like plastics and metals. However, the depackaging pressures often lead to

plastics fracturing and creating microplastics and nanoplastics (see Section 3.4 for additional discussion on pollutants of concern). Depackagers used in contaminant removal for wet (low-solids) digestion often use added water to create a pumpable slurry of 5–15% total solids. One depackaging machine in the U.S. market uses 70 gallons per minute of water to make a digestible slurry.

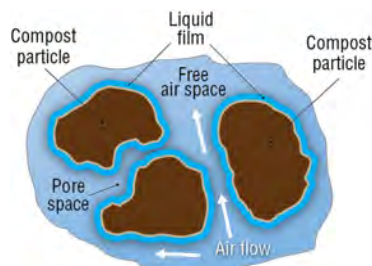


**Figure 3-8. Mechanical Depackager. Photo courtesy of Dupps Mavitec.**

Mechanical mixers (Figure 3-9) are often used in ASP composting to ensure good particle size homogeneity (turned windrow operations like the MCYTFC mix by turning the windrows). Most mixers are horizontal counter-rotating shaft configurations that can blend pre-processed materials together efficiently to create an optimum composting environment (Figure 3-10).



**Figure 3-9. Mechanical Mixers. Photo courtesy of Coker Composting and Consulting.**



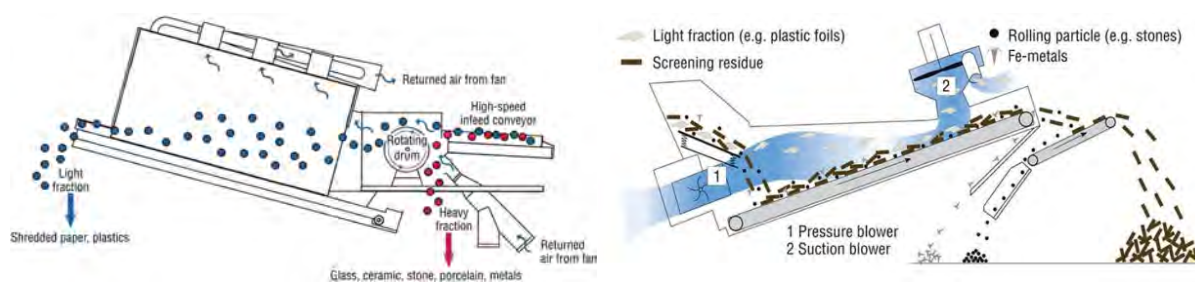
**Figure 3-10. Optimum composting environment. Graphic courtesy of BioCycle CONNECT LLC.**

### 3.3.2 Post-Treatment

Even with thorough pre-treatment steps there is often a need for further refinement of the compost or high-solids digestate product following processing (liquid digestates from wet [low-solids] digesters have all contaminants removed prior to processing). The simplest form of post-treatment is simple mechanical screening, which most yard trim and food scrap composting



facilities utilize to make the product more “market-ready,” including removal of oversized woody particles and some larger-scale contaminants like plastics. Mechanical screens can be equipped with magnets on the discharge conveyor to remove ferrous metal contaminants such as nails, and/or can be equipped with vacuum-extraction systems to remove film plastics. Harder, denser contaminants like stones, metal, and broken glass can be removed by taking advantage of the differences in densities between the compost or high-solids digestate and the contaminants. These removal systems include ballistic separators and densimetric tables (Figure 3-11).



**Figure 3-11. Post-treatment separators including drum-style ballistics separator (left) and densimetric separators (right). Graphics courtesy of BioCycle CONNECT LLC.**

### 3.4 POLLUTANTS OF CONCERN

Even with pre- and post-processing controls, contamination is increasingly a concern for organics processing facilities. Contaminants can include glass, metal, hard plastic, and film plastics. In particular, the County has noted a particular issue with scrap metal in yard trim feedstocks received for processing. Contamination in source-separated organics feedstocks destined for composting or digestion can be reduced significantly with public education and outreach, using educational missives like “Compost It Right!” which educate the public about what is, and what is not, suitable for organics recycling. Additional discussion on education and outreach is included later in this report.

This section provides additional discussion on emerging contaminants in composting and digestion procession, per- and poly-fluoroalkyl substances (PFAS), and microplastics, as well as persistent herbicides, which have been long-present in organics processing.

#### 3.4.1 PFAS

PFAS are a large group of synthetic chemicals that are ubiquitous in the environment due to their widespread production and use since the 1940s. Many PFAS do not easily break down and therefore persist in the environment for a long time, earning them the nickname “forever chemicals.” Because of their persistence, many PFAS also accumulate in the human body. There is a growing body of evidence that, at certain levels, some have carcinogenic effects and adverse effects on the immune system, endocrine system, reproductive system, and liver. The two most studied PFAS are perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS).

PFAS have been used in a large number of commercial products and industrial processes due to their ability to repel water and oils, chemical and thermal stability, and other properties.

Commercial products that may contain PFAS include stain-resistant carpets, furniture, food packaging materials, personal care products, non-stick cookware, waterproof clothing, electronics, building materials, fire-fighting foams, and many more.

The likely source of PFAS in any compost or digestates made from residential and commercial food scraps is the food packaging that is erroneously included in a source-separated organics (SSO) collection bin. As SSO diversion in Montgomery County increases, the County should develop educational outreach materials about the need to keep food packaging out of the diverted SSO stream.

Although this study is not considering a County-wide organics processing facility to accept biosolids, there have been some recent findings and actions around biosolids with detectable PFAS levels. In December 2022, the town of Poolesville reported that PFAS were detected in the town's drinking water wells and disconnected the two wells with the highest levels. Believing a possible cause to be the application of biosolids on land overlying the local aquifer, in January 2023 two non-profit groups petitioned the County government to ban the application of biosolids on county agricultural fields, golf courses, and public land. Biosolids are produced by the Blue Plains Wastewater Treatment Plant in Washington, D.C., and dewatered biosolids are marketed under the brand name "Bloom." Bloom has been tested for PFAS and found to contain 42 parts per billion (ppb).

Although the Montgomery County Office of Agriculture does not currently have regulatory authority over the land-application of fertilizers, biosolids, and other nutrient sources on private properties (the Maryland Department of Agriculture does), the Office of Agriculture has recommended that County farmers voluntarily suspend the application of all biosolids on their fields until additional information is available. If PFAS are found to be present in compost or digestate from a County organics processing facility, this could have an impact on potential end markets of finished compost or digestate for agricultural uses. This concern may inform any limits to feedstocks that are accepted for County processing and provide a focus for public education and outreach efforts.

### **3.4.2 Microplastics**

Microplastics (MPs) are small plastic fragments that are less than 5 millimeters (mm) in size — slightly larger than one-eighth inch. A subcategory of microplastics is nanoplastics, synthetic polymers with dimensions ranging from 1 nanometer (nm) to 1 micrometer (µm). For perspective, a compost bacterium is about 1,000 nm in size and the width of a single human hair is 20 to 200 µm.

MPs can be introduced to agricultural soils through products engineered to be small, such as plastic-coated controlled release fertilizers, treated seeds, and capsule suspension plant protection products. They can be introduced via plastic mulching, contaminated soil amendments, irrigation water, atmospheric deposition, roads, and litter. MPs can also be formed during and because of food scrap depackaging, a pre-treatment approach previously discussed.

The research on the health effects of MP has focused, to date, on direct exposure, with inhalation and ingestion being the two primary exposure pathways. Inhalation causes physical damage to the lungs and ingestion is thought to have potential impacts on the immune system, liver, energy metabolism, and reproduction. There are no comprehensive studies of MPs in the diet, although MPs have been found in seafood/fish, salt, beer, honey, milk, rice, sugar, and seaweed. MPs in composts and digestates used as soil amendments are a secondary pathway of exposure, which has not yet been studied to any extent.

MPs are categorized as emerging persistent pollutants that occur widely in various ecosystems. A recent U.K. study (Brown 2023) evaluated MPs in wastewater, finding that raw plastics recycling wash waters were estimated to contain microplastic counts between  $5.97 \times 10^6$  and  $1.12 \times 10^8$  MPs per cubic meter, which they suggested was due to the grinding and washing of waste plastics for recycling. MP measurements reported in the literature are tens to thousands of particles per dry kilogram (kg) of agricultural soils, similar to levels found in composts and digestates. MPs' impacts on terrestrial plants (particularly crops) are poorly understood. Given the persistence and widespread distribution of MPs in the soil, they have potential impacts on terrestrial plants. Due to their small size and high adsorption capacity, MPs can adhere to the surfaces of seeds and roots, and thus inhibit seed germination, root elongation, absorption of water and nutrients, and ultimately inhibit plant growth.

Maryland has taken steps to ban single-use plastics and does regulate the inert and film plastics content of composts (and, by extrapolation, digestates); however, there are currently no known plans to regulate MPs. The transition from regulating inert content in finished composts and digestates to regulating the MP content of those products is mind-boggling in its complexity. Good policy and regulation should always be based on good science, and with MPs, good science is currently lacking in conformity of testing and reporting procedures, analysis procedures, and even in certification of laboratories in analyzing MPs. These scientific shortfalls will be addressed over time. As with PFAS and food packaging, microplastic concerns may inform public outreach and education efforts to reduce plastics erroneously included in SSO diversion streams, and thereby reduce sources of MPs in compost and digestates.

### **3.4.3 Persistent Herbicides**

Approximately 15 years ago, composters became aware that a certain class of weed killers was showing up in finished compost in a way that affected some plants. These weed killers are known as persistent herbicides (PHs). Chemically, these weed killers are picolinic acids designed to target many broadleaf plants. The picolinic acid family includes aminocyclopyrachlor, aminopyralid, clopyralid, and picloram as active ingredients included in numerous retail herbicide products—PHs and products familiar to the composting industry. Composters have come to understand that concentrations as low as 1 ppb may negatively affect some plants. For perspective, 1 ppb is equal to ½ teaspoon of product in an Olympic-sized swimming pool. The persistence, decay rate, and safe concentrations of commonly used herbicides that may be found in compost feedstocks and compost are shown in Table 3-3.

**Table 3-3. Persistent Herbicides Commonly Found in Organics Feedstocks**

| <b>Herbicide</b>         | <b>Trade Name</b>                                                                                            | <b>Reported Half-Life in Soils (days)</b> | <b>Estimated Composting Half-Life (days)</b> | <b>Plant Safe Concentration in Soils (ppb)</b> |
|--------------------------|--------------------------------------------------------------------------------------------------------------|-------------------------------------------|----------------------------------------------|------------------------------------------------|
| 2,4-D                    | Weed-B-Gon, Hi-Dep®, Weedar® 64, Weed RHAP A-4D®, Weed RHAP A                                                | 7                                         | 7–14                                         | 500                                            |
| Aminocyclopyrachlor (PH) | Imprelis®, Streamline®                                                                                       | 3–112                                     | No data                                      | No data                                        |
| Aminopyralid (PH)        | Capstone™, Chaparral™, CleanWave®, Forefront®, GrazonNext®, Milestone®, Opensight®, PasturAll®, and Sendero™ | 32–533                                    | No data                                      | No data                                        |
| Atrazine                 | Aatrex®, Atratul®, Atrazine                                                                                  | 100–300                                   | 21–50                                        | No data                                        |
| Clopyralid (PH)          | Stinger®, Reclaim®, Transline®, Confront, Curtail, Millenium Ultra                                           | 15–287                                    | 1–2 years                                    | 3                                              |
| Diazinon                 | Basudin, Dazzel, Gardentox, Kayazol, Knox Out, Nucidol, Spectracide, Diazinon                                | 14–28                                     | 1–2                                          | Not applicable                                 |
| Dicamba                  | Banvel®, Banex®, Trooper®                                                                                    | 7–42                                      | No data                                      | 50                                             |
| Glyphosphate             | Roundup®, Rodeo®, Accord®                                                                                    | 3–130                                     | No data                                      | No data                                        |
| Mecoprop (MCP)           | Kilprop, Mecopar, Triester-II, Mecomin-D, Triamine-II, Triplet TriPower, Trimec-Encore, U46 KV Fluid         | < 60                                      | No data                                      | 600                                            |
| Pendimethalin            | Prowl, AC 92553, Accotab, Go-Go-San, Herbadox, Penoxalin, Sipaxol, Stomp and Way-Up.                         | 90                                        | 7-14                                         | 100                                            |
| Picloram (PH)            | Tordon®, Grazon®, Access®, Pathway                                                                           | 20–300                                    | No data                                      | 10                                             |

As the majority of the PH problems in composts have been documented in composting facilities handling manures from herbivorous animals, and, as none of the known PHs are on the list of allowable pesticides in Montgomery County, the risk of PH contamination in Montgomery County organics feedstocks for may be minimal.

### 3.4.4 Summary Table

A summary of pollutants of concern in organics processing is included in Table 3-4.

**Table 3-4. Pollutants of Concern in Organics Processing**

| <b>Pollutant of Concern</b>                                                                   | <b>Sources in Source Separated Organics</b>                                          | <b>Measured Levels in Recovered Organic Products</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | <b>Related Regulatory Standards in Maryland</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|-----------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <u>Per- and Polyfluoroalkyl Substances</u><br>PFAS<br>PFOA<br>PFOS                            | Non-stick cooking tools<br>Food packaging<br>Paper products                          | <u>PFOA</u> <ul style="list-style-type: none"> <li>Food scrap/yard trim compost – 2.73–10.31 ppt<sup>1</sup></li> <li>Yard trim compost – 0.48 ppt<sup>1</sup></li> <li>Backyard compost – 1.05 ppt<sup>1</sup></li> </ul> <u>PFOS</u> <ul style="list-style-type: none"> <li>Food scrap/yard trim compost – 0.35–1.53 ppt<sup>1</sup></li> <li>Yard trim compost – 1.2 ppt<sup>1</sup></li> <li>Backyard compost – 1.69 ppt<sup>1</sup></li> </ul> <u>PFAS</u> <ul style="list-style-type: none"> <li>Food scrap digestates – 3.9–4.1 ppt<sup>2</sup></li> </ul> | <u>EPA National Primary Drinking Water Regulations</u> <ul style="list-style-type: none"> <li>PFOA – Maximum Contaminant Level (MCL) = 4.0 ppt</li> <li>PFOS – MCL = 4.0 ppt</li> </ul> <u>EPA Health Based Water Concentration</u> <ul style="list-style-type: none"> <li>PFHxS – 9.0 ppt</li> <li>PFNA – 10 ppt</li> <li>PFBS – 2,000 ppt</li> <li>HFPO-DA – 10 ppt</li> </ul> <u>Maryland Department of Health Advisory</u> <ul style="list-style-type: none"> <li>PFHxS – 140 ppt</li> </ul> |
| <u>Microplastics</u>                                                                          | Food packaging<br>Food service utensils<br>Compostable bags/servingware <sup>3</sup> | <ul style="list-style-type: none"> <li>Food scrap/yard trim compost – 0.001–0.1358% ww<sup>4</sup></li> <li>Yard trim compost – 0.00024–1.0% ww<sup>4</sup></li> <li>Food scrap digestate – 0.01–0.25% ww<sup>4</sup></li> </ul>                                                                                                                                                                                                                                                                                                                                  | <u>COMAR 15.18.4</u> <ul style="list-style-type: none"> <li>Film plastic &gt; 4 mm (0.16 in.) – 2% dwb</li> <li>Man-made inerts &gt; 4 mm, &lt; 13 mm (0.5 in.) – 2% dwb</li> </ul>                                                                                                                                                                                                                                                                                                              |
| <u>Persistent Herbicides</u><br>Aminocyclopyrachlor<br>Aminopyralid<br>Clopyralid<br>Picloram | Landscaping debris/residuals<br>Herbivorous animal feed                              | Numerous examples of phytotoxicity at < 1 ppb                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | None are included on the Montgomery County List of Approved Pesticides <sup>5</sup>                                                                                                                                                                                                                                                                                                                                                                                                              |

Notes:

1. Choi, Y.J., et.al. 2019. Perfluoroalkyl acid characterization in U.S. municipal organic solid waste composts. *Environ. Sci. Technol. Lett.* 6:372–377.

2. O'Connor, J., et.al. 2022. Physical, chemical and microbial contaminants in food waste management for soil application: A review. *Environ. Pollut.* 300.

3. Compostable packaging/servingware complies with ASTM 6800 if 90% of the compostable plastic disintegrates within 180 days in an industrial composting facility.

4. Porterfield, K., et.al. 2023. Microplastics in composts, digestates, and food wastes: A review. *J. Environ. Qual.* 1–16.

5. Montgomery County DEP. 2023. *What Pesticides Are Allowed*.

<https://www.montgomerycountymd.gov/lawns/law/allowed-pesticides.html>. Accessed on 16 May 12023.

dwb = dry weight basis

HFPO-DA = Hexafluoropropylene oxide – dimer acid

in. = inch(es)

mm = Millimeter(s)

PFBS = Perfluorobutanesulfonic acid

PFHxS = Perfluorohexane sulfonic acid

PFNA = Perfluorononanoic acid

PFOA = Perfluorooctanoic acid

PFOS = Perfluorooctanesulfonic acid

ppb = Part(s) per billion

ppt = Part(s) per trillion

wwb = wet weight basis

### 3.5 GREENHOUSE GAS (GHG) IMPACTS

The EA Team utilized the EPA Waste Reduction Model (WARM) to assess the mitigation potential of GHG emissions from organics processing technologies presented in this chapter. While assessment by specific technology is beyond the capability of the WARM model, it was utilized to provide a high-level assessment of the reduction in GHG emissions between processing via composting and anaerobic digestion (wet and dry).

The scenarios evaluated estimate the mitigation in metric tons of carbon dioxide equivalents (MTCO<sub>2</sub>e) from diversion of one ton of mixed organics from combustion, in the County's current disposal practice, to processing via composting or anaerobic digestion. Model assumptions were utilized to reflect current combustion practices and controls, and transportation distances of feedstocks to their respective processing locations. The models' 'mixed organics' categorization was deemed appropriate to consider the County-reported disposal of yard trim, food scrap, nonrecyclable paper, manure, and animal products appropriate for processing in an organics recycling facility.

**Table 3-5. GHG Emissions Mitigation Per Ton of Diverted Organic Material**

| Scenario Evaluated                                                                                                                                    | Avoided Metric Tons of Carbon Dioxide Equivalents |
|-------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------|
| Currently combusted mixed organics diverted to composting                                                                                             | 0.08 MTCO <sub>2</sub> e avoided                  |
| Currently combusted mixed organics diverted to wet (low-solids) anaerobic digestion (excluding yard trim), assuming process digestate is land applied | 0.14 MTCO <sub>2</sub> e avoided                  |
| Currently combusted mixed organics diverted to dry anaerobic digestion, assuming process digestate is land applied                                    | 0.08 MTCO <sub>2</sub> e avoided                  |

The model results estimate that utilizing composting or dry anaerobic digestion for diverted organics processing provides comparable GHG emissions reductions, while processing via wet anaerobic digestion provides marginally improved emissions reductions. Note that the scenario modeling anaerobic digestion assumes that the digestate is land applied. If instead, that digestate was composted or disposed of in another way, this would decrease emissions reduction; however, this reduction was not possible to quantify using the WARM model. Also of note is that any emissions reductions are only applicable to tonnages diverted from combustion, but not to organics tonnages that are already diverted, such as yard trim currently processed at the MCYTFC, or food scraps processed at the Prince George's Organics Composting Facility.

### 3.6 ANALYSIS

Aerobic and anaerobic organics processing technologies are assessed and ranked in this section using the weighted criteria decision matrix approach evaluating alternatives based on specific evaluation criteria, weighted by the importance of each criterion. This decision-making tool treats each criterion independently, which helps avoid bias or emphasis on a specific criterion. Additional discussion of methodology and analysis outcomes are discussed in the subsequent sections.

### 3.6.1 Technology Evaluation Criteria

To discern the most suitable organics processing technology for a County facility, the EA Team and the County developed 20 criteria against which to evaluate each technology, organized into categories including systems factors, operations, end products, and environmental concerns. After determining on the criteria most salient to the County, personnel across the DEP in management, planning, and operational roles assigned weighting factors on a scale of 1 to 5 to indicate the relative importance of each criterion. The weighting factors presented below represent an average of all responses received from County personnel and are applied in the weighted matrix discussed later in this section.

Among respondents, considerations regarding end-product usage, potential to produce odor, and solid wastes produced from processing were the most heavily weighted evaluation criteria.

**Table 3-6. Organics Processing Technologies – Evaluation Criteria**

| Criteria                 | Definitions                                                                                                                                                                                                                                                         | Weighting Factor<br>(Scale of 1-5) |
|--------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------|
| <b>System Factors</b>    |                                                                                                                                                                                                                                                                     |                                    |
| 1 – Relative Costs       | A technology with lower capital and operating costs will score higher.                                                                                                                                                                                              | 3.25                               |
| 2 – Ease of Construction | A technology that is easily constructed will score higher. This includes consideration of the County management of site development and processing technology installation.                                                                                         | 3.25                               |
| 3 – Proven Experience    | A technology with more current North American installations will score higher.                                                                                                                                                                                      | 4                                  |
| 4 – Reliability          | A technology that minimizes process downtime of mechanical components will score higher.                                                                                                                                                                            | 4.75                               |
| 5 – Adaptability         | A technology that is easily adaptable in layout to fit the site area, and expandable to process additional feedstock intake, will score higher.                                                                                                                     | 4.25                               |
| 6 – Permitting           | A permitting pathway that has greater definition and clarity of requirements will score higher. This considers permitting at the state and local level for site development around a given technology.                                                              | 3.5                                |
| <b>Operations</b>        |                                                                                                                                                                                                                                                                     |                                    |
| 7 – Ease of Operation    | A technology that is easy to operate will score higher. This includes consideration of material handling for loading/unloading and during material processing.                                                                                                      | 3.75                               |
| 8 – Energy Utilization   | A technology with lower net energy consumption will score higher.                                                                                                                                                                                                   | 3.5                                |
| 9 – Process Stability    | A technology that has reliable microbial processing will score higher. A technology that is more susceptible to microbial upset will score lower.                                                                                                                   | 4.5                                |
| 10 – Ease of Maintenance | A technology that is easier to maintain and repair will score higher. This includes consideration of repairs that can be conducted on-site, whether specialized subcontractors will be needed to conduct repairs, or if equipment must be sent off-site for repair. | 4.5                                |

| <b>Criteria</b>                                             | <b>Definitions</b>                                                                                                                                                                                                                                                          | <b>Weighting Factor<br/>(Scale of 1-5)</b> |
|-------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------|
| 11 – Feedstocks Processing Capability                       | A technology that accepts more feedstocks (e.g., food scraps, yard trim, manure, etc.) or that has more tolerance to seasonal changes in materials will score higher. A technology that accepts only one type or other limitation in feedstock acceptance will score lower. | 4.25                                       |
| 12 – Co-collection of food and yard trim collection         | A technology that allows co-collection of multiple feedstocks (e.g., food scraps and yard trim) will score higher. A technology that requires separate collections of feedstocks will score lower.                                                                          | 4.25                                       |
| 13 – Bulking Agents                                         | A technology with greater need for external bulking agent will score lower. This includes consideration of amount of bulking agent required and County's ease in securing the appropriate supply.                                                                           | 2.5                                        |
| <b>End Products</b>                                         |                                                                                                                                                                                                                                                                             |                                            |
| 14 – End product usage                                      | A technology that produces end products (e.g., compost, biogas) with proven usage in Montgomery County will score higher.                                                                                                                                                   | 5.0                                        |
| 15 – Ability of the end product to produce renewable energy | A technology whose byproducts can be used to generate renewable energy will score higher.                                                                                                                                                                                   | 4.0                                        |
| 16 – Byproducts                                             | A technology that produces byproducts (e.g., digestate, effluent) requiring additional management will score lower.                                                                                                                                                         | 4.75                                       |
| <b>Environmental Concerns</b>                               |                                                                                                                                                                                                                                                                             |                                            |
| 17 – Air Quality – Odor                                     | A technology with greater potential to produce odors will score lower. This includes consideration of odor generation during material processing and in end products. A technology with controls to prevent odors will score higher.                                        | 5.0                                        |
| 18 – Air Quality – GHG Emissions                            | A technology with less potential for GHG emissions will score higher.                                                                                                                                                                                                       | 3.75                                       |
| 19 – Contact Water Produced                                 | A technology that produces less contact water requiring treatment will score higher.                                                                                                                                                                                        | 4.5                                        |
| 20 – Solid waste produced                                   | A technology with a higher reject rate for non-processable contaminants would score lower.                                                                                                                                                                                  | 5.0                                        |

### 3.6.2 Technology Scoring

To provide an independent assessment of each organics processing technology, the EA Team scored each technology against the evaluation criteria, independent of facility size, siting, or other detailed County considerations. Based on the EA Team's organics industry experience and familiarity with organics processing facilities utilizing installations of all technologies presented, a score was assigned to each technology reflecting the merits and challenges of each technology. Annotations for each score are provided in Table 3-7 to provide additional information underlining each assigned score.



Table 3-7. Technology Scoring

| Criteria                                            | Aerobic Processing Technologies                                                                    |                                                                                                   |                                                                                                             |                                                                                                       | Anaerobic Processing Technologies                                           |                                                                                                   |                                                                                     |
|-----------------------------------------------------|----------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
|                                                     | ASP                                                                                                | Tunnel Reactor                                                                                    | Rotating Drum                                                                                               | Agitated Bed                                                                                          | Wet (low-solids) CSTR                                                       | Dry Fermentation                                                                                  | High-Solids Plug Flow                                                               |
| System Factors                                      |                                                                                                    |                                                                                                   |                                                                                                             |                                                                                                       |                                                                             |                                                                                                   |                                                                                     |
| 1 – Relative Costs                                  | 4 – Some electrical and concrete capital costs                                                     | 3 – Higher electrical and concrete capital costs                                                  | 3 – Higher electrical and concrete capital costs                                                            | 2 – Building, electrical, concrete capital costs                                                      | 2 – Building, electrical, concrete and process equipment capital costs      | 3 – Higher electrical and concrete capital costs                                                  | 2 – Building, electrical, concrete and process equipment capital costs              |
| 2 – Ease of Construction                            | 4 – County/MES experience with ASP construction                                                    | 3 – More complicated construction                                                                 | 3 – More complicated construction                                                                           | 3 – More complicated construction                                                                     | 2 – Very complicated construction                                           | 3 – More complicated construction                                                                 | 2 – Very complicated construction                                                   |
| 3 – Proven Experience                               | 5 – Established technology with many installations                                                 | 4 – Fewer than 10 U.S. Installations                                                              | 2 – Limited U.S. installations                                                                              | 3 – Fewer than 5 U.S. Installations                                                                   | 5 – Most U.S. AD installations are Wet (low-solids) CSTR                    | 2 – Limited U.S. installations                                                                    | 2 – Limited U.S. installations                                                      |
| 4 – Reliability                                     | 5 – Stable process with fewer mechanical components / equipment                                    | 4 – Stable process with somewhat more mechanical components / equipment                           | 3 – Stable process with more mechanical components / equipment                                              | 3 – Stable process with more mechanical components / equipment                                        | 2 – Easily upset process with more mechanical components / equipment        | 4 – Stable process with somewhat more mechanical components / equipment                           | 3 – Stable process with more mechanical components / equipment                      |
| 5 – Adaptability                                    | 3.5 – Flexible system layout potential, expandable with additional piles / bunkers                 | 3.5 – Flexible system layout potential, expandable with additional tunnels                        | 2 – Limited layout flexibility and expandability                                                            | 3 – Less flexible system layout, expandable with additional bays                                      | 3 – Somewhat flexible on layout and not expandable                          | 3.5 – Somewhat less flexible on layout but expandable                                             | 3 – Somewhat flexible on layout and not expandable                                  |
| 6 – Permitting                                      | 5 – Clear permitting pathway and Maryland Department of the Environment (MDE) experience with ASPs | 4 – Clear permitting pathway, limited MDE technology experience                                   | 4 – Clear permitting pathway, limited MDE technology experience                                             | 4 – Clear permitting pathway, limited MDE technology experience                                       | 3 – Unclear permitting pathway but MDE experienced with technology          | 2 – Unclear permitting pathway and no MDE experience with technology                              | 2 – Unclear permitting pathway and no MDE experience with technology                |
| Operations                                          |                                                                                                    |                                                                                                   |                                                                                                             |                                                                                                       |                                                                             |                                                                                                   |                                                                                     |
| 7 – Ease of Operation                               | 5 – Requires handling during material loading/unloading, limited labor during material processing  | 5 – Requires handling during material loading/unloading, limited labor during material processing | 2 – More effort required during loading/unloading and some material management needed throughout processing | 3 – More complex operations due to longitudinal agitator and moving agitator from one bed to the next | 3 – Complex process management with strong need for highly skilled operator | 5 – Requires handling during material loading/unloading, limited labor during material processing | 3 – More complex operations due to horizontal agitator                              |
| 8 – Energy Utilization                              | 4 – Electrical consumption needed, could be met with solar                                         | 3 – Electrical consumption needed                                                                 | 3 – Electrical consumption needed, including need for drum insulation                                       | 2 – Electrical consumption for blowers and agitator                                                   | 4 – Electrical consumption needed, can be met with parasitic energy usage   | 4 – Electrical consumption needed, can be met with parasitic energy usage                         | 4 – Electrical consumption needed, can be met with parasitic energy usage           |
| 9 – Process Stability                               | 5 – Aerobic composting very process-stable                                                         | 5 – Aerobic composting very process-stable                                                        | 5 – Aerobic composting very process-stable                                                                  | 5 – Aerobic composting very process-stable                                                            | 2 – Process can be easily upset by ammonia and volatile fatty acids         | 4 – High-solids AD less susceptible to process upsets                                             | 4 – High-solids AD less susceptible to process upsets                               |
| 10 – Ease of Maintenance                            | 4 – On-site repairs and maintenance generally feasible                                             | 3 – On-site repairs and maintenance generally feasible                                            | 2 – More mechanically complex systems, may need specialized subcontractors                                  | 2 – More mechanically complex systems, may need specialized subcontractors                            | 2 – More mechanically complex systems, may need specialized subcontractors  | 3 – Somewhat less mechanically complex systems, although may need specialized subcontractors      | 2 – More mechanically complex systems, may need specialized subcontractors          |
| 11 – Feedstocks Processing Capability               | 4.5 – ASP very flexible regarding feedstocks and contamination                                     | 4.5 – Very flexible regarding feedstocks and contamination                                        | 4 – Flexible regarding feedstocks and contamination; less flexible to volume surges                         | 4.5 – Very flexible regarding feedstocks and contamination                                            | 1 – Can’t handle yard trim, volume surges could upset process               | 4 – Flexible regarding feedstocks and contamination; less flexible to volume surges               | 4 – Flexible regarding feedstocks and contamination; less flexible to volume surges |
| 12 – Co-collection of food and yard trim collection | 5 – Can process co-collected food scraps and yard trim                                             | 5 – Can process co-collected food scraps and yard trim                                            | 4.5 – Can process co-collected food scraps and yard trim (mostly smaller materials)                         | 5 – Can process co-collected food scraps and yard trim                                                | 1 – Cannot process yard trim                                                | 5 – Can process co-collected food scraps and yard trim                                            | 5 – Can process co-collected food scraps and yard trim                              |
| 13 – Bulking Agents                                 | 3 – Food scrap composting optimal with 3:1 volume per volume (v/v) bulking agent ratio             | 3 – Food scrap composting optimal with 3:1 v/v bulking agent ratio                                | 3 – Food scrap composting optimal with 3:1 v/v bulking agent ratio                                          | 3 – Food scrap composting optimal with 3:1 v/v bulking agent ratio                                    | 5 – No bulking agent needed                                                 | 4 – Some bulking agent necessary for adequate material porosity for percolate                     | 3 – Food scrap processing via has similar C:N requirements to aerobic composting    |

| Criteria                                                    | Aerobic Processing Technologies                                            |                                                                                        |                                                                                          |                                                                                        | Anaerobic Processing Technologies                                                                       |                                                                                 |                                                                                 |
|-------------------------------------------------------------|----------------------------------------------------------------------------|----------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------|---------------------------------------------------------------------------------|
|                                                             | ASP                                                                        | Tunnel Reactor                                                                         | Rotating Drum                                                                            | Agitated Bed                                                                           | Wet (low-solids) CSTR                                                                                   | Dry Fermentation                                                                | High-Solids Plug Flow                                                           |
| End Products                                                |                                                                            |                                                                                        |                                                                                          |                                                                                        |                                                                                                         |                                                                                 |                                                                                 |
| 14 – End product usage                                      | 5 – Compost use well-established in County                                 | 5 – Compost use well-established in County                                             | 5 – Compost use well-established in County                                               | 5 – Compost use well-established in County                                             | 3 – Some County experience with biogas                                                                  | 3 – Some County experience with biogas                                          | 3 – Some County experience with biogas                                          |
| 15 – Ability of the end product to produce renewable energy | 1 – Renewable energy production not possible, some heat recovery potential | 1 – Renewable energy production not possible, some heat recovery potential             | 1 – Renewable energy production not possible, some heat recovery potential               | 1 – Renewable energy production not possible, some heat recovery potential             | 5 – Biogas can be used for electricity generation or renewable natural gas (RNG) or hydrogen production | 5 – Biogas can be used for electricity generation or RNG or hydrogen production | 5 – Biogas can be used for electricity generation or RNG or hydrogen production |
| 16 – Byproducts                                             | 5 – No byproducts produced                                                 | 5 – No byproducts produced                                                             | 5 – No byproducts produced                                                               | 5 – No byproducts produced                                                             | 2 – Digestate post-processing for non-thermophilic AD                                                   | 2 – Digestate post-processing for non-thermophilic AD                           | 2 – Digestate post-processing for non-thermophilic AD                           |
| Environmental Concerns                                      |                                                                            |                                                                                        |                                                                                          |                                                                                        |                                                                                                         |                                                                                 |                                                                                 |
| 17 – Air Quality – Odor                                     | 4 – Odor minimization with biolayers, fabric covers, and/or biofilters     | 4.5 – Enclosed processing, typically equipped with biofilters to minimize odors        | 3 – Odor potential from material requiring additional curing post-processing             | 4.5 – Processing within building, typically equipped with biofilters to minimize odors | 4 – Enclosed air-tight process, however digestate has odor potential                                    | 4 – Enclosed air-tight process, however digestate has odor potential            | 4 – Enclosed air-tight process, however digestate has odor potential            |
| 18 – Air Quality – GHG Emissions                            | 4 – Less GHG emissions than AD                                             | 3.5 – Less GHG emissions than AD, although more mechanized system utilizes more energy | 3.5 – Less GHG emissions than AD, although more mechanized system utilizes more energy   | 3 – Less GHG emissions than AD, although more mechanized system utilizes more energy   | 2 – Potential for methane leakage                                                                       | 2 – Potential for methane leakage                                               | 2 – Potential for methane leakage                                               |
| 19 – Contact Water Produced                                 | 3 – Contact water may be generated, requiring on-site management           | 5 – Enclosed system yields little to no contact water                                  | 3.5 – Drum enclosed, however some risk of contact water generation during compost curing | 5 – Enclosed system yields little to no contact water                                  | 5 – Enclosed system yields little to no contact water                                                   | 5 – Enclosed system yields little to no contact water                           | 5 – Enclosed system yields little to no contact water                           |
| 20 – Solid waste produced                                   | 4 – Aerobic composting can handle contaminants without rejects             | 4 – Aerobic composting can handle contaminants without rejects                         | 4 – Aerobic composting can handle contaminants without rejects                           | 4 – Aerobic composting can handle contaminants without rejects                         | 1 – Poor tolerance for contaminants and therefore a high reject rate                                    | 2 – Can handle somewhat less contaminants without rejects                       | 2 – Can handle somewhat less contaminants without rejects                       |

### 3.6.3 Technology Ranking

Organics processing technologies ranked using a weighted criteria decision matrix technique are detailed in Table 3-9 and summarized in Table 3-8. To develop the weighted score, the score of each technology was multiplied by the evaluation criteria weighting factor. The weighted score was totaled across all evaluation criteria for each technology. The scores for each technology are then compared to create a ranking among alternatives.

**Table 3-8. Technology Ranking Summary Table**

| <b>Technology</b>     | <b>Weighted Score</b> |
|-----------------------|-----------------------|
| ASP                   | 269.8                 |
| Tunnel Reactor        | 253.5                 |
| Agitated Bed          | 227.5                 |
| Dry Fermentation      | 225.9                 |
| Rotating Drum         | 212.9                 |
| High Solids Plug Flow | 201.5                 |
| Wet (low-solids) CSTR | 185.3                 |

Based on the technologies presented and ranked applying the County's evaluation factors with the EA Team's technology scoring, the weighted matrix approach identifies multiple aerobic processing technologies and one anaerobic processing technology as meriting additional consideration. The EA Team will proceed with consideration of ASP, Tunnel Reactors, Agitated Beds, and Dry Fermentation AD in future tasks evaluating program alternatives for a County-wide organics processing technology. Consideration of technology in conjunction with other County-specific factors will be detailed later in this report.

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| Table 3-9. Technology Weighted Matrix                       |                  |                                 |                |                |                |               |                |              |                |                                   |                |                  |                |                       |                |
|-------------------------------------------------------------|------------------|---------------------------------|----------------|----------------|----------------|---------------|----------------|--------------|----------------|-----------------------------------|----------------|------------------|----------------|-----------------------|----------------|
| Criteria                                                    | Weighting Factor | Aerobic Processing Technologies |                |                |                |               |                |              |                | Anaerobic Processing Technologies |                |                  |                |                       |                |
|                                                             |                  | ASP                             |                | Tunnel Reactor |                | Rotating Drum |                | Agitated Bed |                | Wet (low-solids) CSTR             |                | Dry Fermentation |                | High-Solids Plug Flow |                |
|                                                             |                  | Raw Score                       | Weighted Score | Raw Score      | Weighted Score | Raw Score     | Weighted Score | Raw Score    | Weighted Score | Raw Score                         | Weighted Score | Raw Score        | Weighted Score | Raw Score             | Weighted Score |
| System Factors                                              |                  |                                 |                |                |                |               |                |              |                |                                   |                |                  |                |                       |                |
| 1 – Relative Costs                                          | 3.25             | 4                               | 13.0           | 3              | 9.8            | 3             | 9.8            | 2            | 6.5            | 2                                 | 6.5            | 3                | 9.8            | 2                     | 6.5            |
| 2 – Ease of Construction                                    | 3.25             | 4                               | 13.0           | 3              | 9.8            | 3             | 9.8            | 3            | 9.8            | 2                                 | 6.5            | 3                | 9.8            | 2                     | 6.5            |
| 3 – Proven Experience                                       | 4                | 5                               | 16.3           | 4              | 13.0           | 2             | 6.5            | 3            | 9.8            | 5                                 | 16.3           | 2                | 6.5            | 2                     | 6.5            |
| 4 – Reliability                                             | 4.75             | 5                               | 16.3           | 4              | 13.0           | 3             | 9.8            | 3            | 9.8            | 2                                 | 6.5            | 4                | 13.0           | 3                     | 9.8            |
| 5 – Adaptability                                            | 4.25             | 3.5                             | 11.4           | 3.5            | 11.4           | 2             | 6.5            | 3            | 9.8            | 3                                 | 9.8            | 3.5              | 11.4           | 3                     | 9.8            |
| 6 – Permitting                                              | 3.5              | 5                               | 16.3           | 4              | 13.0           | 4             | 13.0           | 4            | 13.0           | 3                                 | 9.8            | 2                | 6.5            | 2                     | 6.5            |
| Operations                                                  |                  |                                 |                |                |                |               |                |              |                |                                   |                |                  |                |                       |                |
| 7 – Ease of Operation                                       | 3.75             | 5                               | 16.3           | 5              | 16.3           | 2             | 6.5            | 3            | 9.8            | 3                                 | 9.8            | 5                | 16.3           | 3                     | 9.8            |
| 8 – Energy Utilization                                      | 3.5              | 4                               | 13.0           | 3              | 9.8            | 3             | 9.8            | 2            | 6.5            | 4                                 | 13.0           | 4                | 13.0           | 4                     | 13.0           |
| 9 – Process Stability                                       | 4.5              | 5                               | 16.3           | 5              | 16.3           | 5             | 16.3           | 5            | 16.3           | 2                                 | 6.5            | 4                | 13.0           | 4                     | 13.0           |
| 10 – Ease of Maintenance                                    | 4.5              | 4                               | 13.0           | 3              | 9.8            | 2             | 6.5            | 2            | 6.5            | 2                                 | 6.5            | 3                | 9.8            | 2                     | 6.5            |
| 11 – Feedstocks Processing Capability                       | 4.25             | 4.5                             | 14.6           | 4.5            | 14.6           | 4             | 13.0           | 4.5          | 14.6           | 1                                 | 3.3            | 4                | 13.0           | 4                     | 13.0           |
| 12 – Co-collection of Food and Yard Trim Collection         | 4.25             | 5                               | 16.3           | 5              | 16.3           | 4.5           | 14.6           | 5            | 16.3           | 1                                 | 3.3            | 5                | 16.3           | 5                     | 16.3           |
| 13 – Bulking Agents                                         | 2.5              | 3                               | 9.8            | 3              | 9.8            | 3             | 9.8            | 3            | 9.8            | 5                                 | 16.3           | 4                | 13.0           | 3                     | 9.8            |
| End Products                                                |                  |                                 |                |                |                |               |                |              |                |                                   |                |                  |                |                       |                |
| 14 – End Product Usage                                      | 5                | 5                               | 16.3           | 5              | 16.3           | 5             | 16.3           | 5            | 16.3           | 3                                 | 9.8            | 3                | 9.8            | 3                     | 9.8            |
| 15 – Ability of the End Product to Produce Renewable Energy | 4                | 1                               | 3.3            | 1              | 3.3            | 1             | 3.3            | 1            | 3.3            | 5                                 | 16.3           | 5                | 16.3           | 5                     | 16.3           |
| 16 – Byproducts                                             | 4.75             | 5                               | 16.3           | 5              | 16.3           | 5             | 16.3           | 5            | 16.3           | 2                                 | 6.5            | 2                | 6.5            | 2                     | 6.5            |
| Environmental Concerns                                      |                  |                                 |                |                |                |               |                |              |                |                                   |                |                  |                |                       |                |
| 17 – Air Quality – Odor                                     | 5                | 4                               | 13.0           | 4.5            | 14.6           | 3             | 9.8            | 4.5          | 14.6           | 4                                 | 13.0           | 4                | 13.0           | 4                     | 13.0           |
| 18 – Air Quality – GHG Emissions                            | 3.75             | 4                               | 13.0           | 3.5            | 11.4           | 3.5           | 11.4           | 3            | 9.8            | 2                                 | 6.5            | 2                | 6.5            | 2                     | 6.5            |
| 19 – Contact Water Produced                                 | 4.5              | 3                               | 9.8            | 5              | 16.3           | 3.5           | 11.4           | 5            | 16.3           | 5                                 | 16.3           | 5                | 16.3           | 5                     | 16.3           |
| 20 – Solid Waste Produced                                   | 5                | 4                               | 13.0           | 4              | 13.0           | 4             | 13.0           | 4            | 13.0           | 1                                 | 3.3            | 2                | 6.5            | 2                     | 6.5            |
| TOTAL WEIGHTED SCORE                                        |                  |                                 | 269.8          |                | 253.5          |               | 212.9          |              | 227.5          |                                   | 185.3          |                  | 225.9          |                       | 201.5          |

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## **4. RECYCLED ORGANICS PRODUCT USAGE OPTIONS (TASK 3)**

All organics processing technologies produce recycled organics that must have viable end markets to be successful. To avoid processing disruptions, outgoing product volumes should equal incoming feedstock volumes. This chapter examines the potential capacities of markets in Montgomery County to absorb recycled organics products from aerobic and anaerobic organics processing technologies.

### **4.1 RECYCLED ORGANICS PRODUCTS**

#### **4.1.1 Product Types**

Based on technologies investigated in the previous chapter, end products from aerobic and anaerobic processing are examined. Composting end products reviewed include compost, and compost-based soil blends. Review of these product end markets has been limited to compost produced with food scrap feedstocks. However, it is noted that the influence of recycled organics products produced from non-food scrap sources, such as biosolids compost and yard trim-based mulch products, should be considered for these product end markets in the future.

Anaerobic digestion produces methane, which can be utilized as biogas, and carbon dioxide, and trace gases; liquid and solid residuals from digestion, known as digestate; and the wastewater from percolate used in dry fermentation AD systems and from dewatering of liquid digestates, known as effluent. Based on these products, markets for anaerobic digestion end products examined in this chapter include digestate, biogas for pipeline injection, biogas for electricity generation, and biogas for production of fleet vehicle fuel. Although both compost and digestate can be utilized as soil conditioners, they are discussed separately for the purposes of this discussion. Additional discussion of byproducts is included as necessary.

#### **4.1.2 Product Requirements – Compost End Products**

##### **4.1.2.1 Maryland Department of Agriculture**

Federal authority under EPA for regulating compost end products is delegated to the states; in Maryland, this lies with the Maryland Department of Agriculture (MDA). MDA defines compost in COMAR 15.18.04.01 as “a stabilized organic product produced by the controlled aerobic decomposition process in such a manner that the product may be handled, stored, and applied to the land or used as a soil conditioner in an environmentally acceptable manner without adversely affecting plant growth.” MDA identifies testing limits for contaminants in compost depending on its use in general, limited, or restricted capacities, with the general use standards being most stringent. Any compost distributed for public use must meet the general use requirements in accordance with COMAR 15.18.04.05. In addition, when compost feedstocks include anything other than agricultural or yard trim, such as food scraps, a material testing plan describing monitoring, sampling, and analysis plans for quality assurance and quality control must be approved by MDA. A summary of parameters and their MDA limits for general use compost is included in Table 4-1.

**Table 4-1. MDA Parameter Limits for General Use Compost**

| Parameters <sup>1</sup>       | Parameter Limit | Units         |
|-------------------------------|-----------------|---------------|
| pH                            | 6.0–8.0         | scale         |
| Metals                        |                 |               |
| Arsenic (As)                  | 41              | mg/kg dry wt. |
| Cadmium (Cd)                  | 39              | mg/kg dry wt. |
| Chromium                      | 1,200           | mg/kg dry wt. |
| Copper (Cu)                   | 1,500           | mg/kg dry wt. |
| Lead (Pb)                     | 300             | mg/kg dry wt. |
| Mercury (Hg)                  | 17              | mg/kg dry wt. |
| Molybdenum (Mo)               | 18              | mg/kg dry wt. |
| Nickel (Ni)                   | 420             | mg/kg dry wt. |
| Selenium (Se)                 | 36              | mg/kg dry wt. |
| Zinc (Zn)                     | 2,800           | mg/kg         |
| Polychlorinated biphenyls     | 5               | ppm           |
| Man-made inerts >4 mm, <13 mm | 2               | % dry wt.     |
| Film plastic >4 mm            | 2               | % dry wt.     |

Notes:

1. Material requirement to pass Process to Further Reduce Pathogens is applicable only to compost from MSW or manure, and therefore not included herein.

mg/kg = milligram(s) per kilogram

mm = millimeter(s)

ppm = parts per million

#### 4.1.2.2 Maryland State Highway Administration

Where compost is applied for achieving water quality improvements, the Maryland Department of Transportation (MDOT) State Highway Administration (SHA) has materials specifications for bioretention soil mix (BSM) and soil amendments used on its projects. Where compost produced from food scraps has moderate to high levels of phosphorus, a known water quality inhibitor in the Chesapeake Bay Watershed, these products are not suitable for use as soil amendments. In its *Standard Specifications for Construction and Materials* (MDOT SHA 2023), the products with potential for integrating compost include and are summarized below. Compost types for use as a soil amendment are summarized in Table 4-2:

- Furnished Topsoil, Section 920.01.02 – Provides for the use of compost to raise the topsoil's organic matter content in accordance with an applicable Nutrient Management Plan.
- BSM, Section 920.01.05 – Specifies that BSM composed of sand, furnished topsoil, and hardwood mulch may include approved soil amendments, such as compost.
- Compost Use as a Soil Amendment, Section 920.02.05 – Specifies the moisture content, material bulk density, and other parameters per compost type. Compost Type A is composed primarily of biosolids, manure, and similar compost source materials with low carbon-to-nitrogen ratios. Type B is composed primarily of tree leaves, lawn clippings, and similar compost source materials with high carbon-to-nitrogen ratios. Type C is



composed primarily of chipped, ground or granulated wood, bark, and similar compost source materials with very high carbon-to-nitrogen ratios. All compost types shall be biologically mature and no longer able to reheat to thermophilic temperatures per DeWar Self Heating > 5 stable; a moisture content of 30 to 55%; and a weight of 1,400 pounds per cubic yard (CY) or less when delivered.

**Table 4-2. MDOT SHA Compost Types – Physical Properties**

| Type A and B Compost                                                                                                                                                                                |       |                   | Type C Compost                                                                                                                                                                          |                   |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|-------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|
| Type A and Type B Compost shall have pH of 6.0 to 7.5; shall have soluble salt concentration less than 10.0 mmhos/cm; shall have a moisture content of 30 to 55%; and shall be screened as follows. |       |                   | Type C Compost shall have pH of 5.0 to 8.0; shall have soluble salt concentration less than 4.0 mmhos/cm; shall have a moisture content of 30 to 55%; and shall be screened as follows. |                   |
| Sieve                                                                                                                                                                                               |       | Passing by Volume | Sieve Size                                                                                                                                                                              | Passing by Volume |
| Size                                                                                                                                                                                                | mm    | mg/kg             |                                                                                                                                                                                         |                   |
| 0.5 in.                                                                                                                                                                                             | 12.5  | 100 % minimum     | 6 in.                                                                                                                                                                                   | 100 % minimum     |
| No. 4                                                                                                                                                                                               | 4.75  | 90 % maximum      | ¾ in.                                                                                                                                                                                   | 75 % minimum      |
| No. 40                                                                                                                                                                                              | 0.425 | 25 % maximum      |                                                                                                                                                                                         |                   |
| No. 200                                                                                                                                                                                             | 0.075 | 2.2 % maximum     |                                                                                                                                                                                         |                   |

Notes:

in. = inch(es)

mg/kg = milligram(s) per kilogram

mm = millimeter(s)

mmhos/cm = millimhos per centimeter

#### 4.1.2.3 Maryland Department of the Environment

Where compost is utilized in stormwater management Best Management Practices (BMPs), the Maryland Department of the Environment (MDE) includes specifications for filtering media and planting soil in its Stormwater Design Manual (MDE 2000). For use in micro-bioretenion, rain gardens, landscape infiltration, and infiltration berms, the use of compost in facility media is intended to improve the stormwater filtering capacity. The filtering media and planting soil must meet the following criteria:

- Soil Component – Loamy Sand or Sandy Loam (USDA Soil Textural Classification).
- Organic Content – Minimum 10% by dry weight (ASTM D 2974). In general, this can be met with a mixture of loamy sand (60% to 65%) and compost (35% to 40%) or sandy loam (30%), coarse sand (30%), and compost (40%).
- Clay Content – Media shall have a clay content of less than 5%.
- pH Range – Should be between 5.5 and 7.0. Amendments (e.g., lime, iron sulfate plus sulfur) may be mixed into the soil to increase or decrease pH.

#### **4.1.2.4 County Agency Requirements and Incentives**

In addition to the MDE BMP specifications for compost use in stormwater management, the County Department of Permitting Services has modified some specifications for infiltration practices, including bioswales, biofiltration, and micro-bioretenion facilities, and landscape infiltration, to require that “high grade compost free of stones and partially composted woody material” make up one-third of the planting medium (Montgomery County Department of Permitting Services 2012). The DEP has a RainScapes Rewards Rebate Program that awards residential and commercial/multi-family/institutional participants. There are a variety of techniques, and all guidelines must be followed to qualify for the rebate. For rain gardens, soil must be amended with 2 inches (in.) of compost to qualify for a residential rebate up to \$7,500 per parcel or a commercial/multi-family/institutional rebate of up to \$20,000 per parcel.

#### **4.1.3 Product Requirements – Anaerobic Digestion End Products**

##### **4.1.3.1 Maryland Department of Agriculture**

Digestate retains most of the nutrients present in the feedstocks being digested in a more concentrated form; solid digestates are usually composted prior to beneficial reuse, and liquid digestates are often land-applied to cropland, to capitalize on that nutrient value.

For use as a fertilizer or soil conditioner, digestates are regulated in Maryland by MDA under COMAR 15.18.03, including requirements for product registration, distribution, testing, and reporting. To register digestate as a commercial fertilizer, the distributor must include a legal claim of the digestate’s minimum percentages of plant nutrient content; these percentages cannot change after registration. To register digestate as a soil conditioner, the distributor must only include a statement of digestate composition. MDA’s State Chemist Section regulates fertilizer and soil conditioner sale and distribution, requiring annual registration of each brand and grade of commercial fertilizer or each product name of soil conditioners, in accordance with COMAR 15.18.03.02. MDA regulations also include testing and classification, labeling, and recordkeeping requirements. Distributors must submit a semiannual report on the tons of digestate distributed in the state and pay a 25-cent fee per ton of digestate distributed.

Effluent from digestate dewatering, also subject to MDA requirements, can be either land-applied on cropland or discharged to a sanitary sewer. However, percolate generated in dry fermentation digestion is typically recycled internally to seed the continuance of anaerobic processing, so this processing option in particular yields little effluent.

##### **4.1.3.2 Biogas**

While biogas itself is not regulated by the State of Maryland, standards dictated by uses for pipeline injection as renewable natural gas (RNG), direct use for on-site electricity generation, and as hydrogen fuel for fleet vehicles, are presented in this section. In addition, the flammable nature of biogas requires all processing of end products to be completed in gas-tight systems.

#### 4.1.3.2.1 Biogas Standards for Pipeline Injection as RNG

Increasingly, AD systems are exploring converting biogas to RNG either for pipeline injection or for use as vehicle fuel in engines converted to run on natural gas. For biogas use as RNG, gas impurities, such as carbon dioxide (CO<sub>2</sub>), must be removed, and the methane content concentrated to 97–98%. The removed CO<sub>2</sub> is either released to the atmosphere, or, in some cases, can be reused in greenhouse crop production. Typical specifications for RNG require considerable cleanup of biogas to meet maximum concentrations for oxygen, hydrogen sulfide, sulfur, and moisture content.

While biogas itself is not regulated by the State of Maryland, standards of the natural gas utility accepting the biogas are relevant. In Montgomery County, illustrative gas quality considerations for the local utility Washington Gas are summarized in Table 4-3. Currently, Washington Gas' first RNG interconnection project is currently under construction at the WSSC Water Piscataway Wastewater Treatment Facility in Accokeek, Maryland, as part of a larger bioenergy project at the Piscataway facility. Product competition for biogas end markets is less salient for discussion in this chapter than access to RNG transmission pipelines for biogas injection, to be discussed in later chapters of this report.

**Table 4-3. Illustrative Gas Quality Considerations for RNG Injection**

| Gas Quality Term                                        | Generally Acceptable Limit                                  |
|---------------------------------------------------------|-------------------------------------------------------------|
| Heating Value                                           | ≥960 Btu/SCF                                                |
| Sulfur (including dimethyl sulfur and hydrogen sulfide) | Total S: ≤20 grains/CCF, H <sub>2</sub> S: ≤0.25 grains CCF |
| Carbon Dioxide, CO <sub>2</sub>                         | ≤ 3.0%, by volume                                           |
| Nitrogen, N <sub>2</sub>                                | ≤ 4.0%, by volume                                           |
| Oxygen, O <sub>2</sub>                                  | ≤ 0.4%, by volume                                           |
| Ammonia                                                 | ≤ 0.001%, by volume                                         |
| Siloxanes                                               | ≤ 1 mg/m <sup>3</sup>                                       |
| Temperature                                             | 32 to 140°F                                                 |
| Moisture                                                | < 7 lb/MMSCF                                                |

Notes:

Btu/SCF = British thermal units per standard cubic foot

CCF = one hundred cubic feet

H<sub>2</sub>S = hydrogen sulfide

lb/MMSCF = pounds per million standard cubic feet

mg/m<sup>3</sup> = milligram(s) per cubic meter

Source: ICF Resources, LLC 2020

#### 4.1.3.2.2 Biogas Standards for On-Site Electricity Generation

Many AD systems (including landfill gas extraction systems) use biogas (55–60% methane [CH<sub>4</sub>], 30–35% CO<sub>2</sub>) as fuel for combined heat and power engines to generate electricity. This use requires the gas be condensed to remove moisture and filtered through a charcoal filter to remove hydrogen sulfide. While not a biogas quality standard, MDE air emissions permits may be required for combined heat and power electrical generators burning biogas.

#### 4.1.3.2.3 Biogas Standards for Hydrogen Fuel for Fleet Vehicles

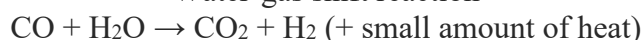
Another recycled organic product that could be produced from biogas is hydrogen fuel for fleet vehicles. While it is not yet clear which hydrogen-forming technologies will be most cost-effective in the future, the Department of Energy continues to support development of hydrogen technologies to identify a pathway for near-term hydrogen production. In addition, while some consider the carbon intensity of biogenic hydrogen fuel, such as that generated from biogas, to be carbon negative, there is uncertainty around how the carbon intensity will be recognized for pursuing federal incentives and whether waste and biomass may potentially be excluded by these rulemakings (Schill 2023).

Most hydrogen produced today in the United States is made via steam-methane reforming, a mature production process in which high-temperature steam (700–1,000 degrees Celsius) is used to produce hydrogen from a methane source, such as natural gas. In steam-methane reforming, methane reacts with steam under 3–25 bar pressure (1 bar = 14.5 pounds per square inch [psi]) in the presence of a catalyst to produce hydrogen, carbon monoxide, and a relatively small amount of carbon dioxide. Steam reforming is endothermic; heat must be supplied to the process for the reaction to proceed. Subsequently, in what is called the “water-gas shift reaction,” carbon monoxide and steam are reacted using a catalyst to produce carbon dioxide and more hydrogen. In a final process step called pressure-swing adsorption, carbon dioxide and other impurities are removed from the gas stream, leaving essentially pure hydrogen. Steam reforming can also be used to produce hydrogen from other fuels, such as ethanol, propane, or even gasoline (U.S. Department of Energy 2023).

Steam-methane reforming reaction



Water-gas shift reaction



Once the biogas has been upgraded to RNG by removing the carbon dioxide and water vapor, a steam/methane reformer is used to split the hydrogen molecules ( $\text{H}_2$ ) from the methane in the biogas to get the final product. The recovered hydrogen is compressed to 10,000 psi for vehicle fuel. With a carbon capture system to reuse or recycle the  $\text{CO}_2$  from the pressure-swing adsorption system, instead of releasing the  $\text{CO}_2$  to atmosphere, it may be possible to make a hydrogen fuel that is carbon negative. Another method of making hydrogen fuel for vehicles is by the electrolysis of water molecules, essentially splitting  $\text{H}_2$  from  $\text{H}_2\text{O}$ . Additional analysis of hydrogen yield from recycled organic sources in the County will be necessary to ensure the feedstocks available for processing will produce a beneficial volume of end product. An estimate of hydrogen gas yields are included in Appendix D.

#### 4.1.4 Product Competition

This section investigates compost product sales through bulk and bagged markets by competitor food scrap compost products. The geographic area of influence for sale of bulk compost and soil products is typically considered a 1-hour hauling travel time from production location for

manufacturing compost. While travel time is a function of road network capacity and quality, this analysis assumes a 50-mile radius for bulk sales. However, for parts of Montgomery County near interstate 95 or other high-speed corridors, this radius for bulk sales could reach 75 to 100 miles in practice. Bagged product sales have a considerably longer reach of +200 miles. However, the added cost of bagging is often a challenge for start-up and first-stage expansion facilities. Compost produced by small-scale entities that do not enter commercial markets, such as compost produced by community composters, is not currently considered in this analysis.



**Figure 4-1. Typical Radii for Bulk (50-mile) and Bagged (200-mile) product sales.**

In an aerated static pile compost facility co-located at the Alpha Ridge Landfill in Marriottsville, Maryland, Howard County, produces compost from food scrap, yard trim, and manure, marketed as HoCoGro. The facilities' finished product, available as compost or blended topsoil, is registered with MDA and is tested six times per year under the US Composting Council's Seal of Testing Assurance program. The HoCoGro products are sold primarily in a bulk market at the unit prices noted in Table 4-4. Wholesale sales to private entities make up over 80% of the products' sales, with some bulk sales to residents and some use on County projects at public schools and through the Department of Recreation and Parks.

The Prince George's Organics Composting Facility produces compost in an aerated static pile compost facility utilizing fabric covers, located in Upper Marlboro, Prince George's County. The finished product from residential food scraps and yard trim is marketed under the brand name Leafgro GOLD® by MES and is available as a finished compost product primarily in bulk markets at the unit prices noted in Table 4-4. The Leafgro GOLD® products are sold exclusively in Prince George's County under the same trade name (MES 2022), with the majority of product sales to private landscapers and lawn and garden shops, and sales to commercial landscapers increasing. Bulk compost sales do include sales of up to 5 CY to residents available at the County facility. Product sales to third parties that bag products and market in or out-of-county under other trade names are not included in this analysis. Note that the facility also produces

Leafgro® from grass clippings and leaves through windrowing; however, the market influence of the Leafgro® product is not considered in this analysis.

Veteran Compost, a privately and veteran-owned company, produces compost from residential and commercial food scrap, and wood chips; processed via vermicomposting or aerated static piles systems. Finished compost products are typically sold for bulk pickup, but bagged products are available for nationwide shipping. Pricing available from the producer website, along with estimated annual product sales, are included in Table 4-4.

**Table 4-4. Food Scrap Compost Products Produced and Sold in Maryland**

| <b>Product, Producer</b>                         | <b>Compost (Bulk) (\$/CY)</b> | <b>Compost (Bagged) (\$/CY)</b> | <b>Compost-Based Soil Blends (\$/CY)</b> | <b>Annual Product Sales (CY/year)</b> |
|--------------------------------------------------|-------------------------------|---------------------------------|------------------------------------------|---------------------------------------|
| HoCoGro, Howard County Compost Facility          | 24 <sup>1</sup>               | N/A                             | 28 <sup>1</sup>                          | 23,000 <sup>3</sup>                   |
| Leafgro GOLD®, PG Organics Composting Facility   | 16 <sup>2</sup>               | N/A                             | N/A                                      | 50,000                                |
| All-Natural Compost, Veteran Compost             | 39                            | 67.50                           | 175                                      | 25,000-30,000 <sup>4</sup>            |
| Estimated Total Food Scrap Compost Product Sales |                               |                                 |                                          | 98,000-103,000                        |

**Notes:**

1. Prices effective as of 1 January 2022. Price includes sales tax.
  2. Average sale price, given pricing tiers by volume for 0-1,000 CY, 1,000–5,000 CY and >5,000 CY. Price increase to \$16.30/CY anticipated fall 2023.
  3. Volume of compost removed from the facility in calendar year 2021.
  4. Production not available at time of reporting. Product sales estimated based on permitted facility capacity (MDE 2023).
- CY = Cubic yard

As composting expands, public and private entities within Maryland may pursue developing processing facilities yielding a competing product in compost end markets. Within Maryland, this includes growing municipal composting programs in the City of Baltimore and Frederick County. Outside of Maryland, Freestate Farms is a privately run compost operation processing food scraps and yard trim for the Prince William County, Virginia, government at a site in Manassas, Virginia. Currently the 88,000 ton/year facility is within the 50-mile radius considered viable for bulk compost markets; however, traffic and location west of the Potomac River make this finished product less competitive in the Maryland market. Lastly, private processors such as WeCare Denali, currently producing only yard trim-based products for Carroll County, have expressed interest in expanding operations to include food scrap feedstocks (WeCare Denali 2023). While these are not products that have yet entered the market, they are programs that have the potential to enter the production market in the short to medium term.

## 4.2 RECYCLED ORGANICS PRODUCT MARKETS

Markets for compost and compost-based soil blends can be classified as traditional and emerging. Traditional markets are those in which a product is considered well defined and has customers with well-developed buying patterns and established customer loyalty, while

emerging markets are those in which the benefits of a product are still being defined. Based on review of competing products currently on the market, traditional markets for compost and compost-based soil blends in Maryland include stormwater management for new construction/redevelopment, landscaping, and agriculture. Emerging markets for compost and compost-based soil blends with high potential for new product sales are commercial landscaping and erosion and sediment control.

Markets are also characterized in this section as “dollar” markets and “volume” markets. Dollar markets can be described as those with higher unit price potential, but lower volume sales expectations. Conversely, volume markets are those with the capacity to support large product volumes but exhibit a lower unit cost and willingness-to-pay. The distinctions between volume and dollar markets are not definitive, and potential compost markets can fluctuate between both dollar and volume markets depending on project size. For example, a small commercial landscaping job might be considered a dollar market but landscaping the grounds of a new shopping mall would be considered a volume market.

Traditional and emerging and dollar and volume recycled organics product markets are summarized in Table 4-5.

**Table 4-5. Recycled Organics Product Market Types**

| <b>Market Type</b> | <b>Dollar</b>                                                                                                      | <b>Volume</b>                                                                                                                                                |
|--------------------|--------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Traditional        | <b>Stormwater Management for New Construction/Redevelopment</b><br><b>Residential Landscaping (small projects)</b> | <b>Residential Landscaping (large projects)</b><br><b>Agriculture</b><br>Agriculture (specialty)<br>Containerized Horticulture<br>Engineered Soils           |
| Emerging           | Commercial Landscaping<br>Green Roofs<br>Sports Turf                                                               | Erosion and Sediment Control<br>Carbon sequestration/climate action plans<br>Development soil organic matter programs<br>Local gov’t sustainability programs |

## 4.2.1 Market Capacity By Sector

### 4.2.1.1 Landscape Market

Landscaping represents a traditional market for recycled organics products, appropriate for use of compost and compost-based soil blends. Based on their ability to fortify soil health and structure, improve nutrient and water retention, and encourage microbial activity, these products are advantageous for use in planting beds and for turfgrass growth. Potential methods of compost use are incorporation into the top 6 to 8 in. of soil, incorporation into plant backfill material, loosely spread on the surface of turf as a topdressing, and (more rarely) as a 2- to 3-in. mulch layer. This landscaping market has been the main outlet for the compost produced by MCYTCF to date.

The landscape market has several potential sectors including design professionals (landscape architects and consulting engineers), landscape contractors (installation/maintenance), wholesalers/retailers of landscape soil amendment products, and homeowners/gardeners.

Wholesale landscape material supply yards mainly serve contractors and large residential markets. As such, these businesses often stock bulk inventories of compost-based soils (i.e., manufactured topsoil), rootzone mixes, mulches, gravels, stones, and other similar bulk supplies.

Homeowners and gardeners represent a significant market share for bulk compost sales, with much of Montgomery County's current production of yard trim-based products oriented toward this market. While many residential customers appreciate the convenience of bagged products, there are still a significant number of "pick-up truckload" (up to 5 CY per purchase) buyers willing to travel some distance to capture cost efficiencies associated with bulk compost purchases. Given that, timely small-scale deliveries and local distribution through wholesale and retail outlets are important considerations to sales growth in this market sector. The retail landscape material supply distribution chain is heavily dominated by "big box" stores and generally serves smaller residential customers. These businesses are commonly more interested in bagged products. This is evidenced by the local lawn and garden centers increasingly converting the use of their limited space from bulk materials to bagged merchandise.

To estimate the landscape market capacity within the county, the EA Team considered the single-family home as the most significant user of recycled organics products. While multi-family, commercial, and other property types within the county have landscaping needs, the number of single-family households in the County was considered a reasonable proxy for the overall residential compost need. Future study efforts could refine these assumptions.

Based on review of average lot sizes across the county, and minimum lot sizes and maximum building coverage area in each residential zoning codes (Zoning Montgomery 2023), average planting bed and turf grass areas were assumed to be 3% and 50%, respectively, of the average lot size. For every 1,000 square feet (MSF) of planting bed or turfgrass area, an application rate of compost was assumed in cubic feet per year. The annual total compost usage was calculated by multiplying application rate, landscaping area, by the total number of housing units in the County, and by the percentage of households estimated to apply recycled organics products. Based on the comparable recycled organics products available on the market, as discussed previously in the product competition section of this report, a 25% market share was assumed. Achieving this market share will require the development of detailed business plans and marketing strategies in the future. The market sector analysis is summarized in Table 4-6.



**Table 4-6. County Landscape Market Capacity**

|                                  |                        |
|----------------------------------|------------------------|
| Single-Family Households         | 259,300                |
| Average Lot Size                 | 18,880 SF/household    |
| Average Planting Bed Area        | 800 SF/household       |
| Compost Application Rate         | 3 CY/MSF/year          |
| Households Applying Compost      | 8%                     |
| Compost Usage                    | 49,800 CY/year         |
| Average Turf Grass Area          | 10,000 SF/household    |
| Compost Application Rate         | 1.5 CY/MSF/year        |
| Households Applying Compost      | 4%                     |
| Compost Usage                    | 155,600 CY/year        |
| <b>Landscape Market Capacity</b> | <b>205,400 CY/year</b> |
| County Market Capture            | 25%                    |
| <b>County Market Share</b>       | <b>52,000 CY/year</b>  |

#### 4.2.1.2 Agriculture Market

While compost has been used in agricultural applications for centuries, the practice of using recycle-based composts made off-site for farm applications in lieu of that generated from on-farm sources (i.e., manures), such as row-crop agriculture, is a more recent trend. Compost use in organic agriculture is a well-established tendency and is becoming a larger phenomenon in conventional agriculture. The supporting research on compost addition to agricultural soils has been developed for the past 10 to 15 years, and results consistently point to improved crop yields, improved crop quality, reduced incidences of root-rot-type diseases, and reduced demand for fertilizers, herbicides, and fungicides.

Potential agricultural uses for compost include incorporation into soil as an amendment prior to planting, surface-applied mulch layers for weed control, and distilling compost into a water-based extract (compost “tea”) for use as a foliar spray or in root drench applications. The benefits of compost use in agriculture are improved soil organic matter, increased soil water-holding capacity (resulting in reduced irrigation demand), increased soil microbial activity (one of the reasons for improved disease suppression), long-term slow-release of plant nutrients, and improved soil pH buffering. The main drawbacks to its use in agriculture are the cost of transport to the fields and a historically low willingness-to-pay by farmers. Consequently, many compost professionals use agricultural markets as “relief valves” to clear space at their composting facility for other uses.

Product to be used as an agricultural soil amendment need not be as mature and stable as compost used in landscaping or in container mixes as it is often incorporated into soils after crop harvest and allowed to “winter over” until the following spring planting season. Application rates are dependent on local soil testing for organic matter but rates of approximately 20 tons per acre per year are typical (Natural Resource, Agriculture, and Engineering Service [NRAES] 1999). This application rate typically achieves a planted soil organic matter content of 3 to 5% over a 3- to 5-year period. Sandy soils, generally along and east of I-95 in Maryland, receive greater benefit from organic matter addition than loam or clay soils. Farmers in sandy soil regions have a higher willingness-to-pay for compost amendment. Compost is also used in agriculture as a weed-control mulch and has been shown to be more effective when immature due to its

phytotoxic effects on weeds (Ozores-Hampton 2001). It was shown to be effective as a weed control agent in 3-in.-thick layers (approximately 10 CY per 1,000 SF per year). One concern that has been voiced about compost use in agriculture is that some composts contribute to a build-up of phosphorus (P) in farm soils, which can constrain agricultural use in future years. In addition, as more regulations are developed surrounding PFAS and MP in soil application to crops, maintaining a high quality of organic feedstock will be important to keep organics products competitive in the market.

Agricultural applications represent a potentially major market for compost, where Montgomery County protects 93,000 acres of County land in Agricultural Reserve. The land use categories sourced from the 2017 Census of Agriculture (USDA 2019) show approximately 65,500 acres were used for agricultural purposes, including 74% in cropland and 12% in pastureland considered in this analysis. To estimate the compost market for agricultural use, compost application rates for each agricultural purpose were assumed to be applied to 2% of farming acreage in each use category. Based on other compost products currently available, the potential share of compost sale for agricultural use was estimated at 25%. The market sector analysis is summarized in Table 4-7.

**Table 4-7. County Agriculture Market Capacity**

|                                                        | <b>Cropland</b> | <b>Pastureland</b> | <b>Total</b>  |
|--------------------------------------------------------|-----------------|--------------------|---------------|
| Agricultural Reserve (acres)                           |                 |                    | 93,000        |
| Farming Area (acres)                                   | 48,400          | 7,800              | 56,200        |
| Farms Applying Compost                                 | 2%              | 2%                 |               |
| Farm Area Using Compost (acres)                        | 900             | 150                |               |
| Compost Application Rate (Tons/acre/year) <sup>1</sup> | 30              | 20                 |               |
| <b>Agricultural Market Capacity (CY/year)</b>          | 49,100          | 5,300              | 54,400        |
| County Market Capture                                  | 25%             | 25%                |               |
| <b>County Market Share (CY/year)</b>                   | 12,300          | 1,300              | <b>13,600</b> |

Note:

Application rates from the US Composting Council 2001.

#### **4.2.1.3 Stormwater Management for New Construction/Re-development Market**

In Maryland, the Stormwater Management Act of 2007 outlines the stormwater management strategy entitled Environmental Site Design (ESD) to the Maximum Extent Practicable (MEP), which prioritizes smaller-scale solutions that mimic local and natural hydrology, to control runoff and improve stormwater quality. New development or re-development activities that result in more than 20% of new impervious surface across a site require the implementation of ESD to the MEP to address stormwater management. Implementation of bioretention and micro-bioretention facilities, rain gardens, bioswales, landscape infiltration, and infiltration berms can utilize compost as facility media or in amended soils, to carry out the ESD to the MEP strategy. Design and sizing of facility ESD BMPs, including selection of practice media, reflect site drainage areas, rainfall, slope, soil type, and other factors. Implementation of designed stormwater BMPs removes non-point-source pollutants in stormwater runoff through filtration, absorption, adsorption, and in some cases microbial degradation (i.e., total petroleum hydrocarbons from road and parking lot runoff). The pollutant removal efficiencies of these

systems are dependent upon the physical, chemical, and biological quality of the substrate used to grow vegetation within each practice.

To estimate the capacity of the compost market for stormwater management in new construction and/or redevelopment projects in the county, the EA Team applied assumptions about the total developable land area in the county of 223,800 acres, or the total land area of 316,800 acres minus area in agricultural reserve of 93,000 acres. Based on the Residential Development Capacity Analysis performed by the County, the annual county acreage for new construction/redevelopment was estimated at 5% of the total area for development. If 50% of parcels under development require stormwater management, the total area for construction requiring stormwater management is expected to be 5,600 acres per year. Applying an annual compost usage of 3 CY per year for stormwater management, based on historical project experience, and a county market share of 25%, market capacity for compost sales in the county for stormwater management for new construction/redevelopment is estimated to be 4,200 CY per year. The market sector analysis is summarized in Table 4-8.

**Table 4-8. Stormwater Management (SWM) for New Construction/Re-Development Market Sector Analysis**

|                                                                   |                       |
|-------------------------------------------------------------------|-----------------------|
| Total Land Area in Montgomery County                              | 316,800 acres         |
| Total Land Area in Agricultural Reserve                           | 93,000 acres          |
| Total Land Area for New Development/Re-Development                | 223,800 acres         |
| Assume 5% Land Area for Annual New Construction/Re-development    | 11,190 acres          |
| Assume 50% of New Construction/Re-development Parcels Require SWM | 5,600 acres/year      |
| Average SWM Compost Application Rate                              | 3 CY/acre             |
| <b>SWM for New Construction/Re-Development Market Capacity</b>    | <b>16,800 CY/year</b> |
| County Market Capture                                             | 25%                   |
| <b>County Market Share</b>                                        | <b>4,200 CY/year</b>  |

#### 4.2.1.4 Market Capacity Summary

Based on review of the markets for compost use in landscape, agriculture, and stormwater management for new construction/redevelopment within the County, the market capacity is estimated to support use of 276,600 CY per year. This is a conservative estimate, given that only the traditional use markets are quantified, and application is considered only within the County.

The estimate of 69,800 CY per year represents a 25% market share for the County. Given that there are three similar and competing products produced from food scraps currently on the market, this estimate reflects current conditions; however, as noted, additional products or other conditions have the potential to shift market dynamics. In addition, non-food-scrap recycled organic products, such as biosolids compost or mulch products may influence the market and should be further considered in the future.

The market capacity by sector is summarized in Table 4-9.

**Table 4-9. Market Capacity Summary**

| <b>Market</b>                           | <b>Market Capacity</b> | <b>County Market Share</b> |
|-----------------------------------------|------------------------|----------------------------|
| Landscape                               | 205,400 CY/year        | 52,000 CY/year             |
| Agriculture                             | 54,400 CY/year         | 13,600 CY/year             |
| SWM for New Construction/Re-Development | 16,800 CY/year         | 4,200 CY/year              |
| <b>Total</b>                            | <b>276,600 CY/year</b> | <b>69,800 CY/year</b>      |

#### **4.2.1.5 Emerging Markets**

While not quantified in this analysis, emerging markets for recycled organics products within the county include increased use of compost for erosion and sediment control, development of soil organic matter content, and enhanced carbon sequestration to support climate action plans. These markets are discussed below and can be considered in future market planning efforts.

##### **4.2.1.5.1 Erosion and Sediment Control**

MDE has regulatory authority over erosion and sediment control under COMAR 26.17.01 and requires erosion and sediment control plans for projects disturbing 5,000 SF or more of land or 100 CY or more of soil. Although MDE does not explicitly name compost as a soil amendment in its specifications for erosion and sediment control (MDE 2011), it is addressed in the 2023 update to the *Standard Specifications for Construction and Materials*, signaling a shift toward increasing use of compost in erosion and sediment controls. In practice, this may include future controls such as compost filter berms, compost filter socks, and compost blankets. Erosion and sediment control incentives and requirements may be initiated at the local and state levels to promote increased compost use in the future.

##### **4.2.1.5.2 Development Soil Organic Matter Content**

Several states and municipalities have adopted ordinances to require minimum soil organic matter content in new development. As compost-amended soils hold more water, less irrigation is needed, driving such ordinances in western states and other arid locations. As compost-amended soils reduce runoff by improving infiltration and water retention in soil pores, water quality improvements affecting the salmon industry in the Columbia River watershed in Washington state are the driver. To restore soil porosity and improve soil health, the Fairfax County Department of Public Works and Environmental Services published guidance for homeowners defining a soil compost amendment applying a minimum of 2 to 5 in. of compost incorporated 6 to 10 in. below the surface to deeply till compacted soils and backfill terraced slopes to slow down runoff and improve infiltration (Fairfax County 2014). Howard County notes that addition of compost into its blended topsoil product raises the organic matter content in the soil to 5–9% and adds billions of soil-enhancing microbes (Howard County, Maryland 2023) critical to improving soil health.

In Washington, the state’s stormwater manuals and local codes require 3 in. of compost to be tilled 8 in. into the soil for planting beds, and 1.75 in. of compost tilled in 8 in. deep for turf areas. Alternatively, a “calculated rate” can be used to meet the organic matter content

requirements, which are 8 in. of settled soil at 10% organic content for planting beds, and 5% organic content for turf. The soil must be scarified an additional 4 in. to achieve a total depth of 12 in. of uncompacted soil after the calculated amount of amendment is added. Scientific trials in Washington and elsewhere have shown that these simple soil BMPs can reduce stormwater runoff by 50% or more, and reduce the summertime need for landscape irrigation by 50%—which pays for the amendments in 3 to 5 years.

Fort Collins, Colorado, adopted a land use code in 1998 requiring use of compost at new building and development sites and expanded the rule to the municipal code in 2003. The ordinance requires building permit holders to incorporate soil amendments into at least 6 in. of soil in any turfed or landscaped area, at a minimum rate of 3 CY per 1,000 SF of area to be planted. Other cities in the state—including Greeley, Boulder, Castle Rock, Colorado Springs, and Westminster—have followed suit.

Voluntary programs encouraging homeowners to retrofit their landscaping—with an eye to increasing organic matter content in soil even where there is no development taking place—have also been on the rise in the Metropolitan D.C. region. This largely follows on the success of Montgomery County’s (Maryland) RainScapes program, which offers technical assistance and financial incentives to homeowners who install a RainScapes project on their property to reduce stormwater runoff volume and improve water quality. Projects include use of compost and rain barrels, and installation of rain gardens and conservation landscaping. Financial assistance is given in the form of RainScapes Rewards Rebates—a maximum of \$7,500 per parcel for residential properties and \$20,000 per parcel for commercial, multi-family, and institutional properties.

#### **4.2.1.5.3 Carbon Sequestration and Climate Action Plans**

Carbon dioxide, a potent GHG, is taken up by soil as a natural part of the carbon cycle, with increased organic content of soil improving carbon uptake. The Intergovernmental Panel on Climate Change has assessed soil carbon mitigation to be a stepping stone in the path to addressing climate change and has set forth the goal of 0.4% additional absorption of carbon per year. As carbon uptake, or sequestration, in soils is improved, atmospheric GHG mitigation is improved. Researchers at the University of California at Davis recently published a study examining the effect of compost amendment on carbon sequestration during 19 consecutive years of adding compost at the University’s Russell Ranch Sustainable Agriculture Facility. They found that repeated use of compost amendments increased the stockpile of soil organic carbon by 12.6% (or 0.7% annually) to a depth of 78.4 in. (Tautges et al. 2019).

In addition, local governments and regional institutions are engaged in developing climate action plans to address potential impacts from GHG. King County in Washington state has developed estimates of carbon dioxide equivalent (CO<sub>2</sub>eq) emissions reductions through the use of organic amendments in agriculture. The County land applied its biosolids compost product and calculated that application of the biosolids to farmland resulted in a projected decrease in CO<sub>2</sub>eq emissions of 1.55 metric tons per metric ton of biosolids applied (Brown and Beecher 2019b). Using that same methodology, researchers calculated that a new residential lawn using compost in lieu of fertilizer would reduce CO<sub>2</sub>eq emissions by 1.2 metric tons per metric ton of compost

used (Brown and Beecher 2019b). A compost product branded and marketed to promote CO<sub>2</sub>e reductions in residential landscaping could be successful.

### **4.3 INFLUENCE OF COUNTY POLICY**

The County should consider policy decisions that will stimulate demand and enhanced use of recycled organics products. Recommendations are included for development of specifications, enactment of ordinances, consideration of incentives, and support through technical assistance resources. Note some recommendations have been presented previously to the County through zero waste and waste diversion planning in other efforts.

#### Specifications

- Require US Composting Council Seal of Testing Assurance-registered compost for all County projects that include landscaping.
- Consider adopting a tree-planting media specification for urban trees that includes compost.

#### Ordinances

- Modify Chapter 59-3 of the Montgomery County Zoning Ordinance to allow “Agricultural Processing” (which includes composting) as a Permitted Use rather than as a Conditional Use.
- Adopt a New Construction Development Ordinance that specifies a minimum soil organic matter content of 5% to promote rainfall infiltration and reduce stormwater runoff (Coker 2021a)
- Consider a program similar to Arlington County, Virginia, for restoration of the soil profile for developed sites undergoing substantial reconstruction, to enhance rainfall infiltration and reduce stormwater runoff (Coker 2021b)
- Examine municipal separate storm sewer system (MS4) plans in other jurisdictions (e.g., Fairfax County) that have adopted compost use as a soil amendment to be part of their MS4 program.

#### Incentives

- Consider property tax credit for compost use on residential properties (ornamentals and turf grass).
- Expand the Office of Agriculture’s Soil Amendment Program to provide up to five 40-CY loads of County-produced food scrap compost to interested farms at no cost annually.

- Encourage compost-based alternatives for erosion control measures (e.g., compost filter socks instead of silt fence or compost blankets instead of erosion control blankets). MDOT SHA Type C Compost is specified for use in manufactured products for sediment and erosion control.
- Encourage Sustainable Building Practices in all County projects.

#### Technical Assistance

- Consider providing a certified nutrient management planner to support farmers.
- Support research into stormwater nutrient credits for compost use in soils, specifically how long the infiltration and stormwater benefits last.
- Work with the USDA Natural Resources Conservation Service to allow pilot-testing of Conservation Practice 336, Soil Carbon Amendment, on farms in Maryland and in Montgomery County.

#### Procurement

- Require County agencies and all municipalities in the County with land holdings, to purchase and use recycled organics products. An agency or jurisdiction can comply by directly procuring recovered organic waste products for use or giveaway, and/or requiring, through a written contract or agreement, that a direct service provider to the agency or jurisdiction procure recovered organic waste products.

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## 5. SITING EVALUATION (TASK 4)

To support an organics processing facility, a site must meet the needs to receive, process, and distribute organic feedstocks and finished products. This chapter examines the feasibility of utilizing County-owned property for the development of an organics management facility, including review of, at the direction of the County, the Shady Grove TS, the MCYTCTF at Dickerson, and the tract of land known as Site 2 in Dickerson. In addition, the EA Team performed a desktop analysis based on publicly available GIS data to determine whether any additional County-owned parcels merit further review as potential locations for facility siting. Site development and permitting requirements are reviewed later in the chapter.

### 5.1 SHADY GROVE PROCESSING FACILITY AND TRANSFER STATION

The Shady Grove TS is a 52.5-acre site zoned IM-2.5, located at 16101 Frederick Road in Derwood, Maryland. This site hosts material receipt, processing, homeowner drop-off, and Material Recovery Facility operations. The Shady Grove TS is the central point for solid waste collection in the County, accepting trash, recycling, scrap metal, yard trim, household hazardous waste, bulk trash, and construction and demolition waste from permitted solid waste collectors and haulers operating in the County, and from residents at public drop-off areas. The transfer station is currently served by public water and sewer services from WSSC Water and has three-phase power available on-site. The transfer station has been in operation since 1982, with rail haul of combustible waste to a Resource Recovery Facility (RRF) since 1995. The Processing Facility and Transfer Station Permit 2022-WPT-0617 granted by MDE allows the facility to process 821,500 tons of waste per year (MDE 2023a). Site improvements conducted in 2008 included the expansion of the transfer station building and tipping floor area, site road upgrades, installation of new scales, and the construction of a small vehicle drop-off center (Montgomery County DEP 2021). Site improvements currently underway include upgrades to the scale house (Montgomery County DEP 2023a). The site is shown in Figure 5-1.

Shady Grove TS is bordered to the northeast by the Washington Metropolitan Area Transit Authority and Shady Grove Rail Yard and Metro Station (both zoned IM-2.5); to the north by a CarMax dealership (zoned IM-0.5) and Maryland Route 370; to the northwest by two undeveloped parcels totaling 13.4 acres (zoned CR-1.5) privately owned by the Eugene Casey Foundation; to the southwest by a mix of retail and multi-family housing, including the King Farm residential development; and to the south by an institutional/community facility (zoned CR-2.25). Residents of the King Farm development across Frederick Road are the nearest residents to the transfer station, located within 400 ft. Across Maryland 370 is a residential area (zoned RP-T) of the City of Gaithersburg, and in the parcel adjacent to the rail yard east of the transfer station, new multi-family residential buildings are currently under construction. Given the mix of commercial and residential activity and proximity to the Shady Grove TS, odor and noise are prominent considerations for any organic waste receiving and/or processing considered for this location.



**Figure 5-1. Shady Grove Processing Facility and Transfer Station.**

### 5.1.1 Current Site Operations

On average, the facility receives 2,100 tons of waste daily, transported by collection trucks and personal vehicles (Montgomery County DEP 2023a). Based on visual observation of the site, there are significant logistical challenges from commercial trucks and personal vehicles accessing various loading and unloading areas of the site. Traffic queues from truck trailers entering the transfer station building to unload at the tipping floor and vehicles at the scale house exiting the facility regularly cause backups that impact the access and free movement of other site areas. This is further complicated by foot traffic from the public in material unloading areas and site operations personnel directing site activities. Given the daily volume of material handling and vehicular traffic from private haulers, public drop-off, and rail delivery, the transfer station is an active site with attentive traffic and operations management critical for safely conducting daily activities. Recommendations have been made from various County-commissioned planning studies for the relocation of operations currently sited at Shady Grove TS to other locations; however, in lieu of available alternate site locations, there are no active plans to relocate yard trim processing, Material Recovery Facility activities, or other on-site processing activities.

A significant source of organics currently processed on-site is yard trim, which is managed by the County in an approximately 2-acre lot adjacent to the transfer station building. Yard trim and recycling are collected separately from other residential waste by County and private haulers on a weekly basis across the County-designated areas Subdistrict A, Subdistrict B, and municipalities located within the County. Yard trim and leaves from residential curbside collection are sorted, processed, and loaded for transport from Shady Grove TS to the MCYTCTF for composting, while brush from residential curbside collection is ground and chipped into mulch and sold to commercial mulch companies. Existing site grinders process yard trim at up to 500–600 CY per hour; storage for ground material is limited within the processing area.

In calendar year 2021, approximately 578,000 tons of MSW were transported off-site for disposal at the RRF, and 60,900 tons of ground yard trim were transported off-site for windrow composting at the MCYTCTF (Montgomery County DEP 2023c, 2023j). Material is transported off-site from the Shady Grove TS by rail or truck. Rail haul is utilized Monday through Saturday, with enough containers available to facilitate daily roundtrips between the Shady Grove TS and the RRF. Rail containers hauling yard trim are transferred at the RRF from train cars to truck beds, then driven approximately 0.5 mile to MCYTCTF and over the scales before being discharged from the tipping chassis at a location near the active windrow building area.

### **5.1.2 Considerations for Future Site Use**

Given the daily volume of material handling and vehicular traffic currently at the Shady Grove TS site, changes to site operations that would increase the volume of material for daily processing and/or increase vehicle traffic at the site are not considered feasible without modifications to existing site operations. Any organic waste processing activities conducted on-site would require prioritizing these activities over current operations and relocating current processing activities elsewhere. An assessment of site adequacy for material processing is considered for various technologies as summarized in Table 5-1, where a darkened circle connotes that the processing area is sufficiently sized to accommodate the process noted and an open circle connotes that the area is insufficient. Technologies reviewed include the four highest-ranked technologies identified in the processing technologies analysis (Chapter 3) and site areas reviewed include the Upper Lot and adjacent Eugene Casey Foundation parcels (which would require acquisition by the County).

**Table 5-1. Site Adequacy Assessment – Shady Grove TS**

| Materials Handling Processes                          |           | Aerated Static Pile |                           | Tunnel Reactor |                           | Agitated Bed   |                           | Dry Fermentation |                           |
|-------------------------------------------------------|-----------|---------------------|---------------------------|----------------|---------------------------|----------------|---------------------------|------------------|---------------------------|
|                                                       |           | Upper Lot Only      | Upper Lot + Casey Parcels | Upper Lot Only | Upper Lot + Casey Parcels | Upper Lot Only | Upper Lot + Casey Parcels | Upper Lot Only   | Upper Lot + Casey Parcels |
| 1 – Feedstock Receipt by Truck                        |           | ●                   | ●                         | ●              | ●                         | ●              | ●                         | ●                | ●                         |
| 2 – Feedstock Receipt by Rail                         |           | ○                   | ○                         | ○              | ○                         | ○              | ○                         | ○                | ○                         |
| 3 – Feedstock Pre-Processing (e.g., grinding, mixing) |           | ●                   | ●                         | ●              | ●                         | ●              | ●                         | ●                | ●                         |
| 4 – Active Processing                                 |           | ●                   | ●                         | ●              | ●                         | ●              | ●                         | ●                | ●                         |
| 5 – Material Transport by Truck                       |           | ●                   | ●                         | ●              | ●                         | ●              | ●                         | ●                | ●                         |
| 6 – Material Transport by Rail                        |           | ●                   | ●                         | ●              | ●                         | ●              | ●                         | ●                | ●                         |
| 7 – Secondary Curing                                  |           | ○                   | ●                         | ○              | ●                         | ○              | ●                         | ○                | ●                         |
| 8 – Screening                                         |           | ○                   | ●                         | ○              | ●                         | ○              | ●                         | ○                | ●                         |
| 9 – Material Storage                                  | Compost   | ○                   | ○                         | ○              | ○                         | ○              | ○                         | N/A              | N/A                       |
|                                                       | Biogas    | N/A                 | N/A                       | N/A            | N/A                       | N/A            | N/A                       | ○                | ○                         |
|                                                       | Digestate | N/A                 | N/A                       | N/A            | N/A                       | N/A            | N/A                       | ○                | ○                         |
| 10 – Product Post-Processing                          | Compost   | ○                   | ○                         | ○              | ○                         | ○              | ○                         | N/A              | N/A                       |
|                                                       | Biogas    | N/A                 | N/A                       | N/A            | N/A                       | N/A            | N/A                       | ○                | ○                         |
|                                                       | Hydrogen  | N/A                 | N/A                       | N/A            | N/A                       | N/A            | N/A                       | ○                | ○                         |
|                                                       | Digestate | N/A                 | N/A                       | N/A            | N/A                       | N/A            | N/A                       | ○                | ○                         |
| 11 – Finished Product Transport/Distribution by Truck | Compost   | ○                   | ○                         | ○              | ○                         | ○              | ○                         | N/A              | N/A                       |
|                                                       | Biogas    | N/A                 | N/A                       | N/A            | N/A                       | N/A            | N/A                       | ○                | ○                         |
|                                                       | Hydrogen  | N/A                 | N/A                       | N/A            | N/A                       | N/A            | N/A                       | ○                | ○                         |
|                                                       | Digestate | N/A                 | N/A                       | N/A            | N/A                       | N/A            | N/A                       | ○                | ○                         |
| 12 – Finished Product Transport/Distribution by Rail  | Compost   | ○                   | ○                         | ○              | ○                         | ○              | ○                         | N/A              | N/A                       |
|                                                       | Biogas    | N/A                 | N/A                       | N/A            | N/A                       | N/A            | N/A                       | ○                | ○                         |
|                                                       | Hydrogen  | N/A                 | N/A                       | N/A            | N/A                       | N/A            | N/A                       | ○                | ○                         |
|                                                       | Digestate | N/A                 | N/A                       | N/A            | N/A                       | N/A            | N/A                       | ○                | ○                         |

As the centralized waste collection point within the County, the Shady Grove TS currently receives yard trim and MSW, among other waste streams. An expanded waste diversion program within the County would aim to reduce food scrap in MSW. Food scrap could be managed either co-collected with yard trim, or collected separately, as discussed in Section 2.5.2. For the purposes of this study, it is assumed that waste receiving of yard trim and food scraps remains centralized at the Shady Grove TS.

The approximately 7-acre Upper Lot of the Shady Grove TS could provide an area sufficient for feedstock pre-processing and active processing with various technologies, if this processing activity is prioritized for the site and current procession operations are relocated elsewhere. However, this area alone would be insufficient to also support secondary curing, material storage, or product post-processing. Any material handling conducted at the Upper Lot would require relocating the hazardous waste drop-off, scrap metal and other recycling activities that currently take place in this area. The two Eugene Casey Foundation parcels immediately adjacent to the transfer station site present an additional opportunity for supplementary organics processing area, with the potential for up to 8 acres of additional processing area. These parcels are currently assessed at \$6 million (Maryland Department of Assessments and Taxation 2023), and with market value anticipated to be \$10 million or greater, land acquisition of these parcels

would be costly. The presence of an existing stream channel through the parcels could trigger additional permitting and mitigation requirements prior to any site development in this area.

The highest levels of organic waste capture projected at high or mandatory program levels (Chapter 1) would require additional site area for materials handling processes beyond that which both the Upper Lot and Eugene Casey Foundation parcels could provide; however, low and medium organic waste volumes projected through the planning period could be accommodated as described.

Based on the EA Team review of the site, the pros and cons regarding the development of the site for supporting organics processing are summarized in Table 5-2.

**Table 5-2. Shady Grove Transfer Station Pros and Cons for Site Development**

| Pros                                                                                                                                                                                                                                                                                                      | Cons                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"> <li>Shady Grove TS is centrally located and connected via rail, reducing costs for haulers</li> <li>Existing water and sewer service exists on-site, although service upgrades may be required</li> <li>Limited groundwater concerns in Shady Grove TS area</li> </ul> | <ul style="list-style-type: none"> <li>Residents' proximity to the site necessitates attentive process control to minimize odor and vector issues</li> <li>Existing site infrastructure for internal access roads, traffic flow already constrained</li> <li>Limited site area to support all material handling on-site</li> <li>Shady Grove TS already receives food scrap on-site co-mingled with MSW; however, pending the food scrap collection pursued (e.g., separate or co-collected with yard trim), the processing burden will shift to the yard trim or other to-be-determined area.</li> <li>Use of Upper Lot and land acquisition of Eugene Casey Foundation parcels would allow more processing of organic waste on-site; however, organics capture at high and mandatory scenarios projected would require additional site area for processing</li> <li>Use of Upper Lot would require relocation of existing materials processing currently conducted in that area</li> <li>Electrical service exists on-site, although major service upgrades will be required</li> </ul> |

## 5.2 YARD TRIM COMPOSTING FACILITY AT DICKERSON (MCYTCF)

The MCYTCF is a 118-acre site zoned Agricultural Reserve (AR), located at 21210 Martinsburg Road, Dickerson, Maryland. This site hosts a yard trim windrow composting operation processing yard trim and leaves to manufacture a high-quality soil amendment marketed under the brand name Leafgro® sited on a 48-acre bituminous pavement pad, using open-air windrows with mobile windrow turners. In addition, the site includes an 80,000-square-foot pavilion for screening and bagging finished compost, an office/scale house, a maintenance building, a storage building, a pumphouse, and three stormwater management ponds. Public sewer and water service is not available at this site; however, on-site water supply and septic systems are present. The parcel was originally an interim sewage sludge composting facility (1981–1982) and was converted by the County in 1983 to be used for yard trim composting. The General Composting

Facility Permit issued by MDE on 2 June 2021 is based on the current site capability for processing up to 77,000 tons of waste per year (MDE 2023b). The MCYTCF is currently operated by MES (Figure 5-2) under an agreement with the County. The finished product, Leafgro<sup>®</sup>, is sold to landscapers and homeowners. The site is shown in Figure 5-2, including the RRF shown within the site boundary.

MCYTCF is surrounded almost entirely by land zoned AR, with the exception of adjacent RRF and power plant zoned IH-2.5 for use by utilities. Additional neighboring parcels are the Dickerson Conservation Park, deeded to M-NCPPC, to the west; and privately owned parcels to the east owned by the Evans James B Trust; to the southeast by the Sugarloaf Citizens Association, Inc. (SCA), a local citizens group; and to the south by GenOn, owner of the Westlands Ash Management Landfill.

The SCA is sensitive to the impacts of MCYTCF on nearby sensitive receptors and in 1996 entered into an agreement with the County to cap yard trim handled at the MCYTCF at 77,000 tons per year. The agreement restricts facility operations to the existing asphalt pads and buildings and prohibits the County from increasing the area of impervious surfaces of the facility beyond 48 acres of existing asphalt surfaces. The County is prohibited from adding additional buildings or expanding existing buildings; however, repair and replacement of existing buildings and impervious surfaces is allowed. Production of bagged compost at the site is limited to 650,000 bags per year. Any changes to the methods of operations, such as the use of new types of machinery, must be approved by the SCA. In 2018, SCA agreed to the County establishing a residential food scrap composting pilot program at MCYTCF. The pilot program must be conducted with the consent of SCA and in accordance with requirements of the agreement. However, to establish a permanent operation at the MCYTCF, SCA requires the County to close the RRF, operate a 1-year food scrap composting pilot outside of the Montgomery County Agricultural Reserve, and agree to abandon Site 2 as a landfill option while providing SCA control over the future use of the 815-acre property.





**Figure 5-2. MCYTCF at Dickerson.**

### 5.2.1 Current Site Operations

Yard trim is transported via rail and truck from the Shady Grove TS to the MCYTCF year-round, and leaves are trucked directly from the Department of Transportation's Silver Spring Depot during the County's vacuum leaf collection program where they capture the fall leaf surge. Transport of yard trim by rail is prioritized when possible, to reduce truck traffic on Maryland Route 28 and other roads near the MCYTCF. Table 5-3 shows the total tons of yard trim received at MCYTCF by mode (Montgomery County DEP 2023c).

**Table 5-3. Yard Trim (Tons) Received at MCYTCF by Mode**

| Tons by Mode | Fiscal Year |        |        |        |
|--------------|-------------|--------|--------|--------|
|              | 2020        | 2021   | 2022   | 2023   |
| Rail         | 21,600      | 26,700 | 16,700 | 13,900 |
| Truck        | 41,700      | 33,800 | 40,700 | 44,900 |
| Total        | 63,300      | 60,500 | 57,400 | 58,800 |

Upon receipt on-site, the material is windrowed, and using windrow turners, piles are turned as needed based on material moisture and temperature. Material is typically composted on-site over

a 9-month period, before being screened and prepared for bulk sale and bagged distribution. Eleven MES full-time staff manage daily site operations.

An ongoing structural maintenance program continues at MCYTCTF for the maintenance of existing site infrastructure, which includes scheduled replacement of portions of the paved pad, regular inspections, and preventative maintenance and as-needed repairs to its on-site stormwater management system. Additional recommendations have been made regarding additional improvements that could be undertaken to improve site operations.

### 5.2.2 Considerations for Future Site Use

The MCYTCTF is a natural site to consider for hosting additional organics processing capacity, as it currently hosts the County's yard trim processing in windrows. At 20-25 miles from the Shady Grove TS by truck, the site can receive material by both rail and truck. Given its location in an agricultural area, concerns regarding odor and vectors are less common. Assessment of site adequacy for material processing is considered for various technologies and site areas as summarized in Table 5-4, where a darkened circle connotes that the processing area is sufficiently sized to accommodate the process noted and an open circle connotes that the area is not sufficient. Technologies reviewed include the four highest ranked technologies identified in the processing infrastructure analysis (Chapter 3). As shown, the site is considered to provide adequate processing area for the technologies noted, including at the highest levels of organic material capture projected at high or mandatory program levels (Chapter 1).

**Table 5-4. Site Adequacy Assessment – MCYTCTF**

| Materials Handling Processes                          |           | Aerated Static Pile | Tunnel Reactor | Agitated Bed | Dry Fermentation |
|-------------------------------------------------------|-----------|---------------------|----------------|--------------|------------------|
| 1 – Feedstock Receipt by Truck                        |           | ●                   | ●              | ●            | ●                |
| 2 – Feedstock Receipt by Rail                         |           | ●                   | ●              | ●            | ●                |
| 3 – Feedstock Pre-Processing (e.g., grinding, mixing) |           | ●                   | ●              | ●            | ●                |
| 4 – Active Processing                                 |           | ●                   | ●              | ●            | ●                |
| 5 – Secondary Curing                                  |           | ●                   | ●              | ●            | ●                |
| 6 – Screening                                         |           | ●                   | ●              | ●            | ●                |
| 7 – Material Storage                                  | Compost   | ●                   | ●              | ●            | N/A              |
|                                                       | Biogas    | N/A                 | N/A            | N/A          | ●                |
|                                                       | Digestate | N/A                 | N/A            | N/A          | ●                |
| 8 – Product Post-Processing                           | Compost   | ●                   | ●              | ●            | N/A              |
|                                                       | Biogas    | N/A                 | N/A            | N/A          | ●                |
|                                                       | Hydrogen  | N/A                 | N/A            | N/A          | ●                |
|                                                       | Digestate | N/A                 | N/A            | N/A          | ●                |
| 9 – Product Transport/Distribution by Truck           | Compost   | ●                   | ●              | ●            | N/A              |
|                                                       | Biogas    | N/A                 | N/A            | N/A          | ●                |
|                                                       | Hydrogen  | N/A                 | N/A            | N/A          | ●                |
|                                                       | Digestate | N/A                 | N/A            | N/A          | ●                |
| 10 – Product Transport/Distribution by Rail           | Compost   | ●                   | ●              | ●            | N/A              |
|                                                       | Biogas    | N/A                 | N/A            | N/A          | ●                |
|                                                       | Hydrogen  | N/A                 | N/A            | N/A          | ●                |
|                                                       | Digestate | N/A                 | N/A            | N/A          | ●                |



The EA Team estimates that the existing infrastructure at MCYTCTF can accommodate up to 100,000 tons of organic waste utilizing windrow processing, with one option being to add food scraps to the open windrows. Under a new organics diversion program, food scraps could be co-collected with yard trim and ground/processed at the Shady Grove TS complex (although coarser screening would be needed to offset the free air space problem currently experienced), and then composted in the existing windrows. Adding food scraps would lower the C:N ratio and speed up the processing time. Higher quantities of food waste and yard trim could be handled by converting the composting operation to ASP, the methodology used when the facility was operated as an interim sewage sludge composting facility, or other technologies as noted.

The Montgomery County DEP would also need to pursue permit amendments to incorporate food scraps at the proposed capacity into their General Compost Facility Permit. Under COMAR, this would entail updates to the stormwater management system, specifically separation and containment of contact water and repair of the forebays on the ponds. Retrofitting MCYTCTF to accept food scraps would require renegotiation of the existing use agreement with the SCA.

Based on the EA Team review of the site, the pros and cons regarding the development of the site for supporting an organics processing facility are provided in Table 5-5.

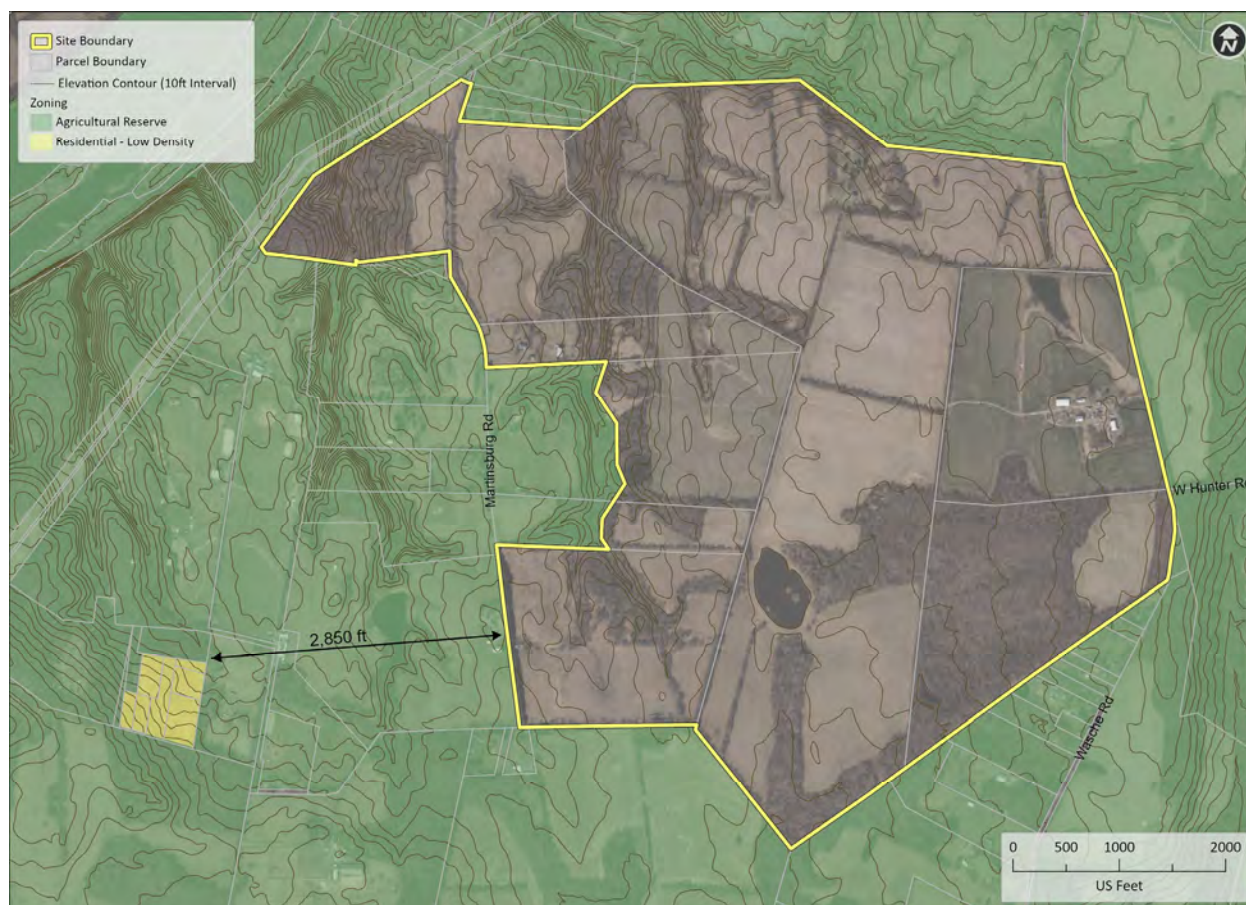
**Table 5-5. MCYTCTF at Dickerson Pros and Cons for Site Development**

| Pros                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Cons                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"> <li>• Large site area with few constraints/limited traffic for development of additional processing approach</li> <li>• MCYTCTF can be configured to accept food waste with less capital and operational expense for an expanded operation, given the current site infrastructure available</li> <li>• Existing compost equipment available on-site that may be reusable, including windrow turners, screens, and bagging equipment</li> <li>• Material can be transported to site by rail and truck from the Shady Grove TS</li> <li>• Equipment for material bagging and distribution operation already exists at the site</li> </ul> | <ul style="list-style-type: none"> <li>• MCYTCTF requires larger hauling distances than the Shady Grove TS</li> <li>• Requires renegotiation of the SCA agreement conditions around material type, processing capacity limits, bagging, infrastructure, and other terms that would impede optimal site operations</li> <li>• Upgrades to stormwater management infrastructure would be required</li> <li>• Electrical upgrades would likely be necessary if converting to aerated static pile or extended aerated static pile</li> <li>• Located in an area identified by EPA as a Sole Source Aquifer system, which may require additional review or permitting effort during site development.</li> </ul> |

### 5.3 SITE 2 (DICKERSON)

Montgomery County owns 810 acres of land zoned AR known as “Site 2” between Martinsburg Road and Wasche Road in Dickerson, Maryland. The site holds MSW landfill permit 2019-WMF-0237 expiring 23 July 2024, permitting landfilling on 125 acres of the site (MDE 2023a). While a landfill is not currently constructed at this site, the area is held in reserve in case out-of-County waste disposal becomes infeasible due to economic conditions, changes in the law, or other circumstances. To begin development of a landfill, the County would need to submit a notice to proceed 1 year in advance of starting construction at the site (Montgomery County DEP 2021). The site is shown in Figure 5-3.

Site 2 is surrounded almost entirely by other land zoned AR. The parcel to the east, the Woodstock Equestrian Park, is deeded to M-NCPPC; the parcel to the north by GenOn, owner of the Westlands Ash Management Landfill. Privately owned parcels surround the site to the west, south, and southeast. The nearest parcel zoned for residential (low density) is 0.5 mile to the west. As with the MCYTCF, the SCA is sensitive to the impacts on nearby sensitive receptors.



**Figure 5-3. Montgomery County Site 2 at Dickerson.**

### 5.3.1 Current Site Operations

Site 2 is currently leased to local farmers for crop production purposes. There is no solid waste infrastructure currently at Site 2. There are two test wells installed by adjacent parcel owner GenOn to monitor groundwater quality surrounding the Westlands Ash Management Facility. A plume from the Westlands Ash Landfill has impacted a key aquifer in this portion of the County; therefore, residents are concerned about any activities that could cause additional impact to groundwater quality.

### 5.3.2 Considerations for Future Site Use

Assessment of site adequacy for material processing is considered for various technologies and site areas as summarized in Table 5-6, where a darkened circle connotes that the processing area

is sufficiently sized to accommodate the process noted and an open circle connotes that the area is not sufficient. Technologies reviewed include the four highest ranked technologies identified in the processing infrastructure analysis (Chapter 3). As shown, the site is considered to provide adequate processing area for the technologies noted, including at the highest levels of organic waste capture projected at high or mandatory program levels (Chapter 1).

**Table 5-6. Site Adequacy Assessment – Site 2**

| Materials Handling Processes                          |           | Aerated Static Pile | Tunnel Reactor | Agitated Bed | Dry Fermentation |
|-------------------------------------------------------|-----------|---------------------|----------------|--------------|------------------|
| 1 – Feedstock Receipt by Truck                        |           | ●                   | ●              | ●            | ●                |
| 2 – Feedstock Receipt by Rail                         |           | ●                   | ●              | ●            | ●                |
| 3 – Feedstock Pre-Processing (e.g., grinding, mixing) |           | ●                   | ●              | ●            | ●                |
| 4 – Active Processing                                 |           | ●                   | ●              | ●            | ●                |
| 5 – Secondary Curing                                  |           | ●                   | ●              | ●            | ●                |
| 6 – Screening                                         |           | ●                   | ●              | ●            | ●                |
| 7 – Material Storage                                  | Compost   | ●                   | ●              | ●            | N/A              |
|                                                       | Biogas    | N/A                 | N/A            | N/A          | ●                |
|                                                       | Digestate | N/A                 | N/A            | N/A          | ●                |
| 8 – Product Post-Processing                           | Compost   | ●                   | ●              | ●            | N/A              |
|                                                       | Biogas    | N/A                 | N/A            | N/A          | ●                |
|                                                       | Hydrogen  | N/A                 | N/A            | N/A          | ●                |
|                                                       | Digestate | N/A                 | N/A            | N/A          | ●                |
| 9 – Finished Product Transport/Distribution by Truck  | Compost   | ●                   | ●              | ●            | N/A              |
|                                                       | Biogas    | N/A                 | N/A            | N/A          | ●                |
|                                                       | Hydrogen  | N/A                 | N/A            | N/A          | ●                |
|                                                       | Digestate | N/A                 | N/A            | N/A          | ●                |
| 10 – Finished Product Transport/Distribution by Rail  | Compost   | ●                   | ●              | ●            | N/A              |
|                                                       | Biogas    | N/A                 | N/A            | N/A          | ●                |
|                                                       | Hydrogen  | N/A                 | N/A            | N/A          | ●                |
|                                                       | Digestate | N/A                 | N/A            | N/A          | ●                |

As there is no existing solid waste infrastructure at the site, there is a need to construct water, electricity, and sewer lines on the property. In addition, due to concerns about potential impacts on the aquifer under Site 2, impermeable composting/processing areas, a lined stormwater pond and leachate collection and recycling system will likely need to be constructed.

The conditions of the county roads between Site 2 and the RRF rail yard are an additional infrastructure limitation. The portion of Martinsburg Road between the RRF and Whites Ferry Road is classified as an Exceptional Rustic Road due to its historic and scenic character that reflects the agricultural, rural origins of the county. According to the Rustic Roads Functional Master Plan, rustic roads must maintain narrow widths and follow natural historic alignments to “encourage slower speeds and increase safety” (M-NCPPC 2023). In addition, MDOT and SHA are instructed to “maintain the current surface of a rustic road to preserve the character of the road to the extent practicable” and most rustic roads do not have storm drains and ditches (Montgomery Planning 2023). Finally, Martinsburg Road has a gross vehicle weight limit of 10,000 pounds, which further limits what kinds of vehicles can use it. The haul road between the RRF rail yard and Site 2 would also require significant investment before it could accommodate

increased traffic. However, this would allow transportation on internal access roads not relying on the public roadways adjacent to the site.

While Site 2 is being held in reserve for use as a landfill, construction of a compost or AD facility at Site 2 should not impact the landfill permit so long as at least 125 acres and additional setbacks are left for landfill development. Effort for permit review and modification will be required with MDE.

The Montgomery County Executive has expressed interest in developing an agrivoltaics system on the property. Agrivoltaics is the use of land for both solar photovoltaic energy generation and food production. Agrivoltaics systems maximize land use and the solar panels and crops offer symbiotic cooling benefits. Montgomery County's Department of General Services is in conversations with a solar power company which has speed grid access to lease part of Site 2 for solar installations. MDE would need to review the future landfill permit to determine the potential impact of solar collectors.

Based on the EA Team review of the site, the pros and cons regarding the development of the site for supporting an organics processing facility are provided in Table 5-7 below.

**Table 5-7. MCYTCF at Dickerson Pros and Cons for Site 2 Development**

| Pros                                                                                                                                                                                                                                                                                                                    | Cons                                                                                                                                                                                                                                                                                                                            |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"> <li>• Large site area could provide adequate space for all facility operations</li> <li>• Some effort to obtain compost facility permit; however, effort may differ siting on a permitted solid waste management facility</li> <li>• Limited residential receptors nearby</li> </ul> | <ul style="list-style-type: none"> <li>• Roadway access limitations, rustic roads between RRF and Site 2</li> <li>• No existing solid waste infrastructure or electricity, water, or sewage—high up-front costs</li> <li>• Located on key aquifer, groundwater protection infrastructure and systems would be needed</li> </ul> |

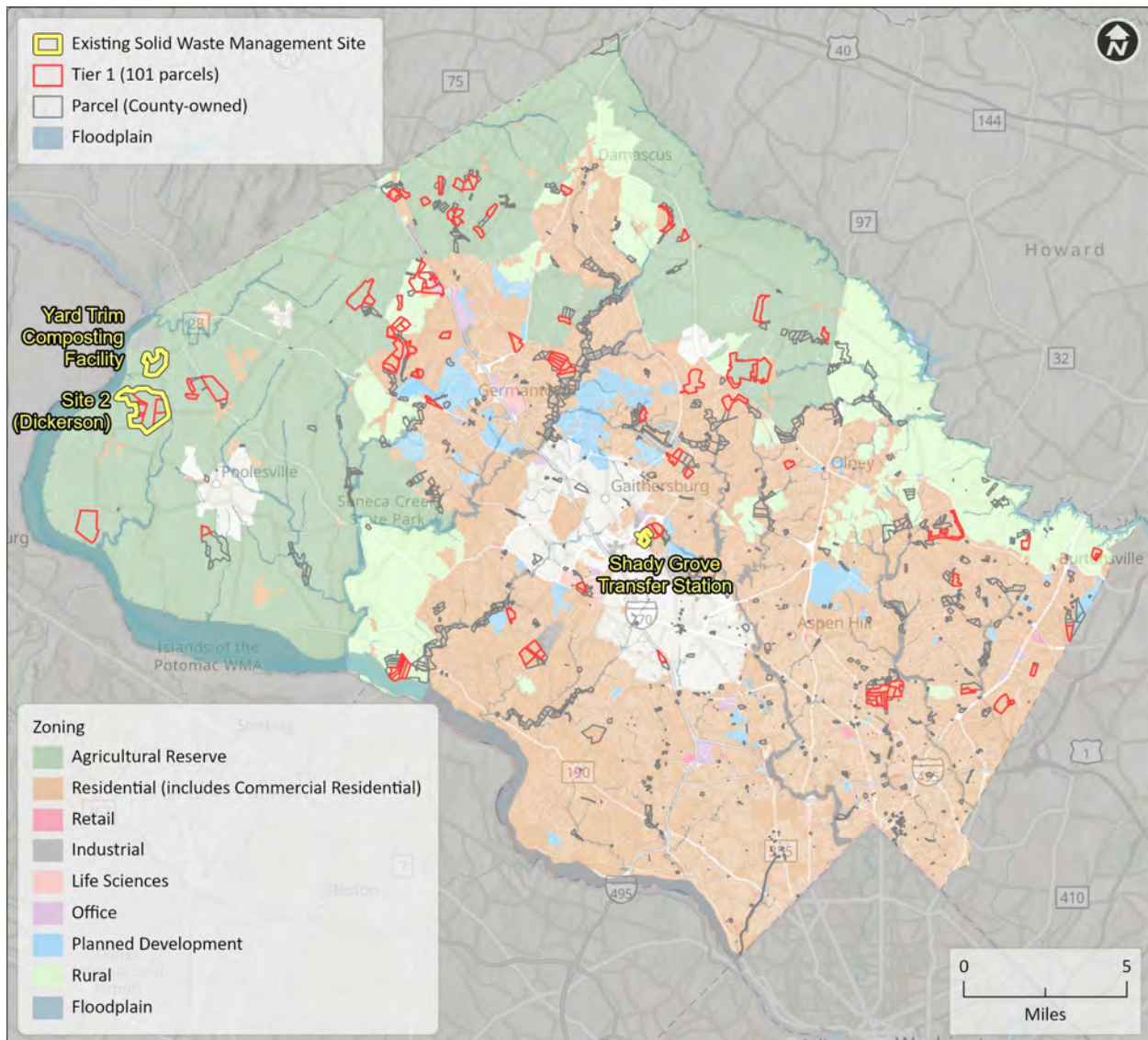
## 5.4 GIS REVIEW

To evaluate additional potential siting locations for an organics processing facility within the County, the EA Team performed a GIS-based desktop review of County-owned parcels based on publicly available data.

As initial screening criteria, County-owned parcels not containing floodplains nor Chesapeake Bay Critical Areas and greater than 25 acres in size were considered suitable for further consideration. Parcels already owned by the County were deemed to be an important initial screening criterion, as using an existing County-owned parcel would reduce facility development costs. Privately owned parcels requiring County purchase for development were not included in this desktop review. Exclusionary criteria for floodplains and critical areas were applied based on COMAR 26.04.11.08, Composting Facility Siting and Design Requirements, which notes that a composting facility may not be in a floodplain nor in conflict with critical areas. In addition, with County agreement, a minimum size of 25 acres was deemed necessary to support processing facility site operational needs. Parcels previously considered by the County for potential organics facility development were included in the initial evaluation, subject to the initial screening

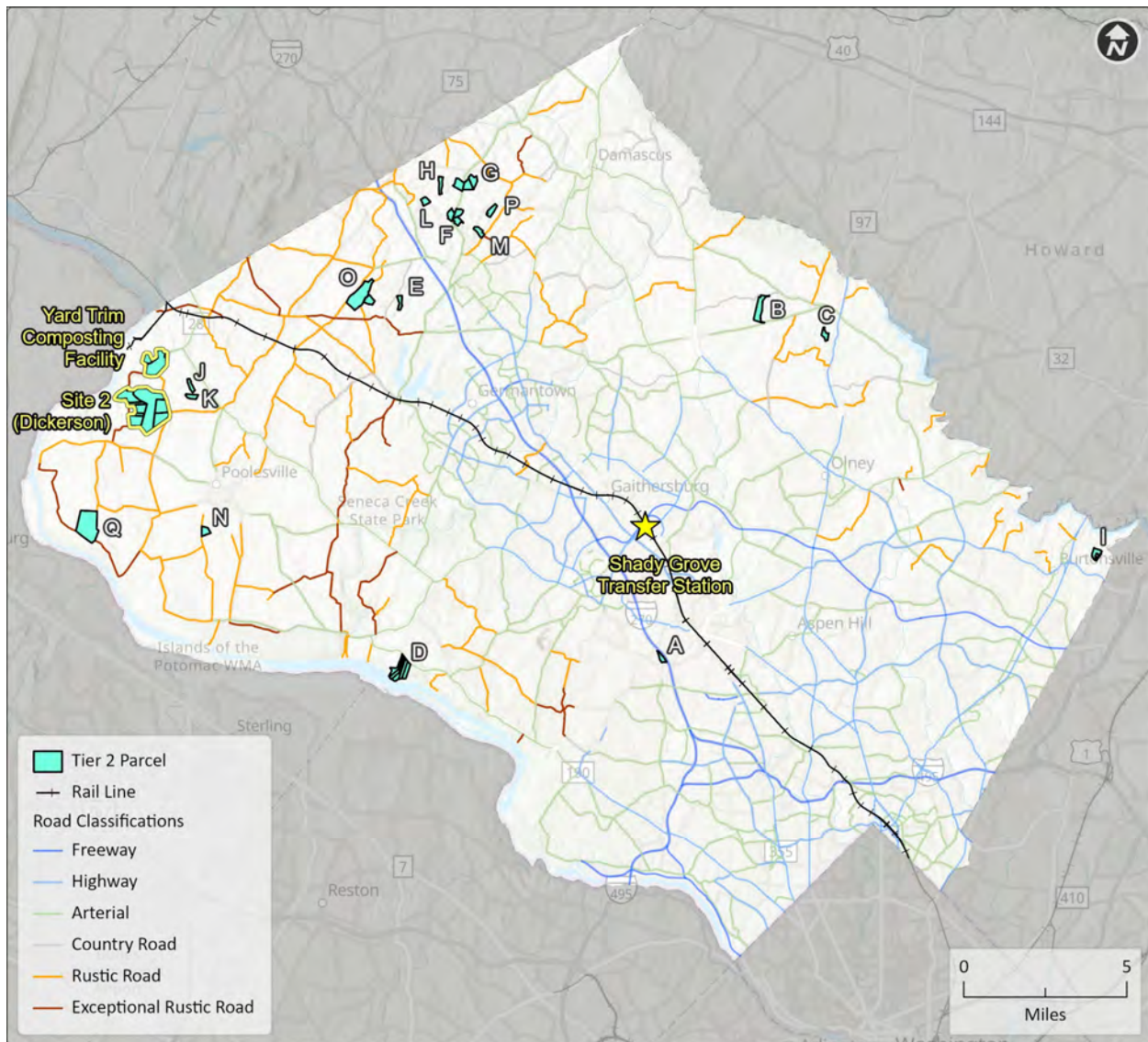


criteria noted (Montgomery County DEP 2015). Initial screening criteria yielded a listing of 101 parcels for further review, as shown in Figure 5-4.



**Figure 5-4. GIS Desktop Findings from Initial (Tier 1) Screening**

Secondary screening criteria were then applied to further refine the parcel search, including the application of zoning criteria. Based on correspondence with the County's Office of Law, the County is not subject to the zoning code in developing its owned land (Montgomery County 2015). However, the County would be affected by public opinion from residents in proximity to the proposed facility development project. Given that, any parcels from the initial screening that were located less than 1,000 ft from a residential zoned area were removed from the search. Secondary screening yielded a listing of 25 total parcels for further review, or 17 parcel sets, as some parcels identified were located adjacent to one another, as shown in Figure 5-5.



**Figure 5-5. GIS Desktop Findings from Secondary (Tier 2) Screening**

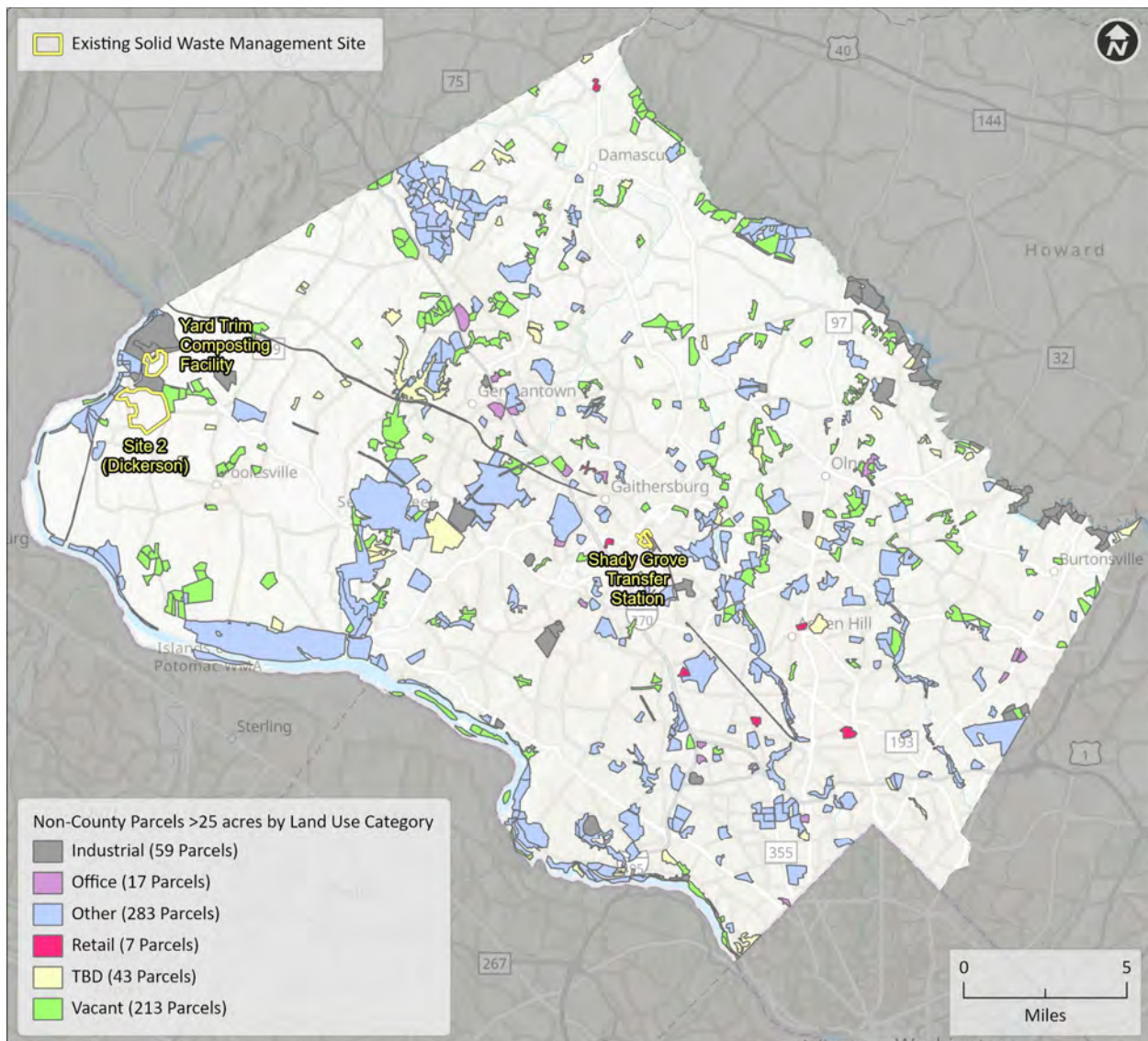
As a tertiary screening, the parcels were provided to Montgomery County's Department of General Services to verify parcel availability for future site development. Based on the Department of General Services review, it was found that of the 25 parcels previously identified:

- 22 parcels are located in recreational, regional and conservation parks deeded to M-NCPPC, including one parcel which is located in an Equity Emphasis Area (Montgomery County DEP 2023b), and three parcel sets that were identified as being accessible only from rustic or exceptionally rustic roads
- 2 parcels are located on County parcels, currently developed as the Montgomery County Detention Center and the Police Firearms Range
- 1 parcel is located in the Poolesville Golf Course owned by the Revenue Authority



#### 5.4.1 Non-County Owned Parcels

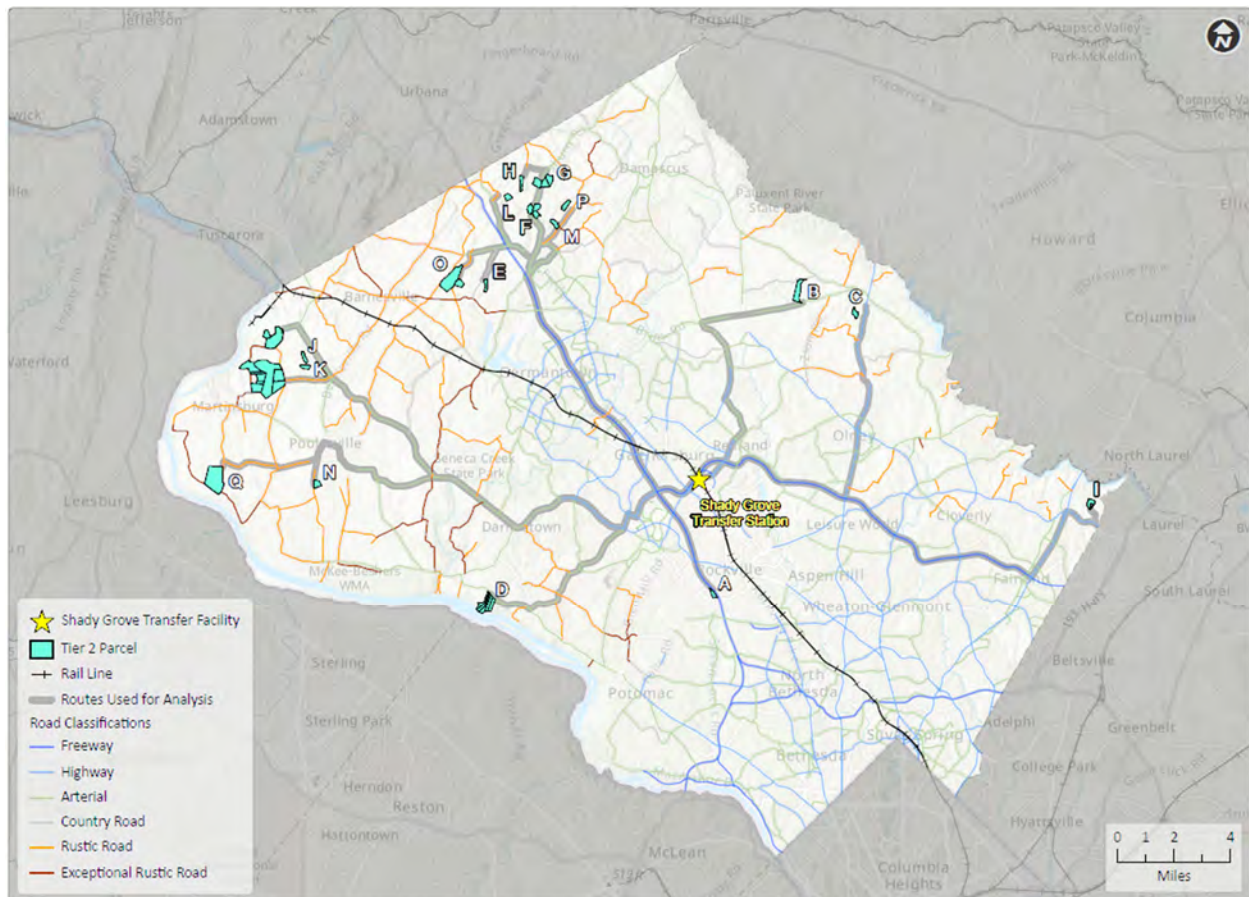
As findings from review of County-owned parcels did not identify sites meriting further review, a GIS review of non-County-owned parcels was conducted. While this included a cursory screening for parcels over 25 acres, additional consideration for zoning and land use will be required, in addition to the County's considerations regarding property value and appropriate costs. Additional GIS review is required; however, Figure 5-6 identifies 59 parcels of adequate size in an industrial and use category that may be appropriate for further consideration.



**Figure 5-6. GIS Desktop Findings of Non-County-Owned Parcels**

## 5.4.2 Transportation Analysis

Given the current reliance on truck and rail haul of waste within the County, a transportation analysis was conducted for 25 parcels previously identified. Transportation criteria considered include the distance from the Shady Grove TS, as the current County collection point for solid waste; and the amount of travel distance required on freeways, highways, arterials, and rustic roads. There were no sites identified in the desktop study that could be accessed only via exceptionally rustic roads. Seven sites identified in the desktop study required up to 3.8 miles of travel on a rustic roadway.



**Figure 5-7. Transportation Analysis of Remaining Sites**

## 5.5 SITE DEVELOPMENT REQUIREMENTS

Organics processing facilities in the state of Maryland are regulated by MDE. The regulations include requirements for composting facility operations, contact water and stormwater collection and discharge, air emissions, compost product quality, recordkeeping and reporting, and site setbacks. For AD, no permit program currently exists; however, MDE has provided guidance to outline the permitting pathway. In addition, County requirements for site development must be met.



### 5.5.1 Federal Requirements – Composting Facilities

MCYTFC and Site 2 are in an area identified by EPA as a Sole Source Aquifer system, the Poolesville Area Aquifer Extension of the Maryland Piedmont Aquifer. This designation is given to aquifers that supply at least 50% of the drinking water for its service area, with no reasonably available alternative drinking water sources should the aquifer become contaminated (EPA 2023). The program enables EPA to review proposed projects that will be located within the review area, to ensure there is no contamination possible to the aquifer from the project's design, construction, and operation that could create a significant hazard to public health.

### 5.5.2 State Requirements – Composting Facilities

COMAR 26.04.11, Composting Facilities, in effect since 1 January 2017, includes requirements for the design and operation of composting facilities, classified based on feedstock type (Type 1 – yard trim only, and Type 2 – food scraps and animal manure) and facility size (Small – producing less than 10,000 CY per year, or Large – producing more than 10,000 CY per year). Based on proposed feedstocks including food waste and projected capture volumes for processing greater than 10,000 CY annually, a Tier 2 Large facility permit is likely to be required. A pathogen reduction process, consisting of a minimum processing time and temperature combination, is required for Tier 1 and Tier 2 facilities. The process, known as the Process to Further Reduce Pathogens, is widely used in the composting industry and is derived from EPA regulations on sewage sludge. The federal Process to Further Reduce Pathogens for composting is incorporated by reference in the MDE regulations. For ASPs, the temperature of compost is required to be maintained at 55 degrees Celsius or higher for 3 days. If food scraps are comprised of meat, dairy, grease, fats, oils, and other non-vegetative organics, which can contain foodborne pathogens, pathogen reduction processes are required.

A general composting facility permit is sufficient for a facility that complies with all regulations without variance, while an individual permit is needed if site-specific variances are necessary. To initiate application of a composting facility permit, a Notice of Intent form and Composting Facility Operations Plan are required for submission to MDE, per COMAR 26.04.11.09. The Composting Facility Operations Plan must be kept on-site and reviewed annually and must include plans for preventing and responding to complaints of nuisances such as odors. Per COMAR 26.04.11.12, annual reporting to MDE will be required, including provision of detail regarding quantities and types of feedstocks, county of origin of feedstocks, and quantities and types of compost and residues produced at and removed from the site. A proposed composting facility can likely be covered under a General Permit if no exceptions are anticipated.

A Permit to Construct is required for compost facilities with sources of air emissions. This applies to internal combustion engines with at least 500-brake horsepower and may be relevant for aeration systems, sorting systems, grinders, shredders, drying and bagging equipment, and other machinery. A Permit to Operate may be required for specific air emissions sources, per COMAR 26.11.02.13. Facilities that create a nuisance or air pollution are prohibited by COMAR 26.11.06.08.

Per COMAR 15.18.04, Compost Registration is required for each brand or classification of compost before it can be sold or distributed in Maryland. This certification must be renewed annually, and includes compost testing, labeling, recordkeeping requirements, and a semiannual report submitted with a \$0.25 fee for each ton of compost distributed in the state.

#### **5.5.2.1 Facility Siting**

Per COMAR 26.04.11, feedstock receipt, feedstock storage, active composting, curing, and compost storage areas of a composting facility may not be located closer than 50 ft to the property boundary; 300 ft to a dwelling; 100 ft to a domestic well; and 100 ft to a stream, lake, or other body of water except an impoundment for use in the composting process. The composting facility may not be in a floodplain, or in conflict with the Chesapeake Bay Critical Area or nontidal and tidal wetlands.

#### **5.5.2.2 Facility Design and Construction**

Compost facility design and construction must be in accordance with the requirements of COMAR 26.04.11.08. For a Tier 2 – Large facility, this includes requirements for the following:

- A 2- to 4-ft distance from the water table, depending on location within the Coastal Plain province and other factors, must be maintained.
- Curing and compost storage areas must be on an all-weather pad with slopes no greater than 6%.
- Feedstock receiving/storage and active composting areas must maintain compost on a low-permeability pad (e.g., concrete, cement, and compacted clay), with permeability of less than or equal to  $10^{-5}$  centimeters per second.
- Containment structures must be designed for 25-year, 24-hour storm events for stormwater and contact water. Covered Tier 2 facilities need only size containment structures for contact water generated.
- Site stormwater discharges shall adhere to the General Permit for Stormwater Discharges Associated with Industrial Activity.
- A National Pollutant Discharge Elimination System permit for stormwater discharges associated with construction activity is required.

#### **5.5.3 Local Requirements – Composting Facilities**

Montgomery County requirements are derived from County Code, including Chapter 48 of the Code of Montgomery County Regulations regulating solid waste, including siting of solid waste facilities; and Chapter 59 of the County Code, containing the County's zoning ordinances.

As noted previously, the County is not required to adhere to zoning requirements with its owned land; however, discussion for select zoning ordinances is included here to demonstrate that zoning regulations do not provide specific guidance for where private or County composting facilities may be sited. The Montgomery County Zoning Ordinance specifies that landfills, incinerators, and transfer stations may only be sited in heavy industrial (IH) zones. Recycling collection and processing facilities are permitted in IH zones and have limited use in light industrial (IL) and moderate industrial (IM) zones. This does not directly apply to composting facilities, but composting facilities may be considered processing facilities, which could require industrial zoning. For agricultural reserve (AR), this zoning category is intended “to promote agriculture as the primary land use in areas of the County designated for agricultural preservation in the general plan by providing large areas of generally contiguous properties suitable for agricultural and related uses and permitting the transfer of development rights from properties in this zone to properties in designated receiving areas.

While composting through decentralized means is an important component of a County organic waste diversion approach, it is not specifically encouraged by Montgomery County Code. Portions of Montgomery County Code Chapter 48 restrict the backyard composting of food scraps. Chapter 48 allows for the use of compost piles to dispose of food scraps if each compost pile is completely rodent-proofed. Zoning code for community gardens does not address composting as a recognized activity of the garden. The zoning ordinance does include composting as an accessory use for on-farm composting, allowing for the production and manufacturing of compost on farms where up to 50% of the materials can come from off-site sources. This limits the amount of feedstock generated off-site that can be composted at any one farm. Current Montgomery County zoning codes and other applicable County codes, regulations, and policies do not specifically encourage the on-site composting of food scraps on farms, especially if the composting activities are not a direct result of on-farm operations. In addition, existing County zoning requirements limit the amount of on-farm composting activities within the Agricultural Reserve and indicate that composting is permitted only as an accessory use in these areas. The zoning ordinance states on-site composting must be permitted on-site at the business/commercial property/institution.

#### **5.5.4 State Requirements – Anaerobic Digestion Facilities**

The State of Maryland has no formal permitting path for anaerobic digestion facilities. However, there are suggested permits depending on the location, purpose, and type of facility (MDE 2022). These permits fall under MDE for solid waste and recycling, water, and air; MDA for soil conditioner or fertilizer; and the Maryland Public Service Commission for renewable energy generation. A summary table of potential permitting requirements for anaerobic digestion operations is included in Table 5-8.

**Table 5-8. Anaerobic Digestion Permitting Summary Table**

| <b>Subject/Activity</b>                                                        | <b>Department Permits and Approvals</b>                                              | <b>COMAR</b> |
|--------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|--------------|
| <b><i>MDE – Solid Waste and Recycling</i></b>                                  |                                                                                      |              |
| Solid Waste Acceptance Facility                                                | Refuse Disposal Permit                                                               | 26.04.07     |
| Sewage Sludge Management                                                       | Sewage Sludge Utilization Permit                                                     | 26.04.06     |
| <b><i>MDE – Water</i></b>                                                      |                                                                                      |              |
| Storm Water Discharge from Industrial Activities                               | General Permit For Discharges From Storm Water Associated with Industrial Activities | 26.08.04     |
| Groundwater Discharges                                                         | State Groundwater Discharge Permit                                                   | 26.08.04     |
| Surface Water Discharges                                                       | State/National Pollutant Discharge Elimination System Surface Water Discharge Permit | 26.08.04     |
| Discharges to Publicly Owned Wastewater Treatment Systems                      | Pretreatment Permit                                                                  | 26.08.08     |
| Water and Sewerage Treatment Infrastructure Construction                       | Water and Sewerage Construction Permit                                               | 26.03.12     |
| <b><i>MDE – Air</i></b>                                                        |                                                                                      |              |
| Sources of Air Pollution                                                       | Air Quality State Permit to Construct                                                | 26.11.02     |
|                                                                                | Air Quality State Permit to Operate                                                  | 26.11.02     |
| <b><i>MDA – State Chemist</i></b>                                              |                                                                                      |              |
| Digestate Quality                                                              | Soil Conditioner or Fertilizer Registration                                          | 15.18.04     |
| <b><i>Maryland Public Service Commission – Renewable Energy Generation</i></b> |                                                                                      |              |
| Construct Electric Generating System                                           | Certificate of Public Convenience and Necessity Exemption                            | 20.79.01     |
| Interconnection to an Electric Utility Distribution System                     | Standard Small Generator Interconnection Agreement                                   | 20.50.09     |
| Generate Renewable Energy Credits                                              | Certification of a Renewable Energy Generating Facility                              | 20.61.02     |
| Trade Renewable Energy Credits                                                 | Renewable Energy Credit Account                                                      | 20.61.02     |

## 5.6 ANALYSIS

Processing facility site locations are assessed and ranked in this section using the weighted criteria decision matrix approach evaluating alternatives based on specific evaluation criteria, weighted by the importance of each criterion. This decision-making tool treats each criterion independently, which helps avoid bias or emphasis on a specific criterion.

### 5.6.1 Siting Evaluation Criteria

To evaluate the sites most suitable for the development of a County facility, the EA Team and the County developed criteria against which to evaluate each site. As discussed previously, Montgomery County DEP personnel in management, planning, and operational roles assigned weighting factors on a scale of 1 to 5 to indicate the relative importance of each criterion. Average weighting factors are presented in Table 5-9 and are applied in the weighted matrix discussed later in this chapter.

**Table 5-9. Facility Siting – Evaluation Criteria**

| <b>Criteria</b>                                                     | <b>Definitions</b>                                                                                                                                                                                                                                                                                                                                                                                                                   | <b>Weighting Factor<br/>(Scale of 1-5)</b> |
|---------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------|
| <b><i>Site Characteristics that May Affect Site Development</i></b> |                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                            |
| 1 – Site Size                                                       | A larger site area available for facility development will score higher.                                                                                                                                                                                                                                                                                                                                                             | 4.8                                        |
| 2 – Site Topography                                                 | A more dissected site will score lower.                                                                                                                                                                                                                                                                                                                                                                                              | 3.5                                        |
| 3 – Site Soils                                                      | A site with existing site soil requiring removal or amendment to support facility development (e.g., rock, karst, etc.) will score lower.                                                                                                                                                                                                                                                                                            | 3.5                                        |
| 4 – Depth to Groundwater                                            | A site with greater depth to groundwater will score higher.                                                                                                                                                                                                                                                                                                                                                                          | 3.8                                        |
| 5 – Electric Service                                                | A site with existing three-phase (460-volt) electric service on-site or within proximity (considered 2,500 ft) to the site will score higher.                                                                                                                                                                                                                                                                                        | 4.0                                        |
| 6 – Water and Sewer Service                                         | A site with existing water and/or sewer service on-site or within proximity (considered 2,500 ft) to the site will score higher.                                                                                                                                                                                                                                                                                                     | 4.0                                        |
| 7 – Existing Infrastructure                                         | A site with existing on-site infrastructure with the potential for re-use (e.g., internal access roads, paved working surfaces, buildings, etc.) will score higher.                                                                                                                                                                                                                                                                  | 4.0                                        |
| 8 – Permitting                                                      | A site with an existing solid waste permit issued by MDE will score higher. A site with no existing permits and/or requiring additional permitting effort will score lower.                                                                                                                                                                                                                                                          | 3.8                                        |
| <b><i>Conditions Local to Site</i></b>                              |                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                            |
| 9 – Population Density                                              | A site with higher population density surrounding the site will score lower.                                                                                                                                                                                                                                                                                                                                                         | 5.0                                        |
| 10 – Site Access                                                    | A site with proximity (considered 5 miles) to existing transportation routes and networks appropriate for truck haul (e.g., four-lane arterial or interstate highway) will score higher. A site requiring extensive (more than 5 miles) travel on roadways not ideal for truck haul (e.g., rustic or exceptionally rustic roadways) will score lower.                                                                                | 5.0                                        |
| 11 – Quality of Existing Vehicular Traffic                          | Traffic quality along material receiving and product distribution routes, and intersections within 1,000 ft of site access, will be considered. Traffic quality with an AASHTO Level of Service of A (free flow traffic), B (reasonably free flow traffic, or C (stable flow traffic) will score higher. A Level of Service D (approaching unstable flow) or below will score lower.                                                 | 3.8                                        |
| 12 – Feedstock Sources                                              | A site with greater proximity to major sources of organic waste will score higher. Organic waste sources may be considered relative to the centralized locations of waste collection (e.g., Shady Grove TS), as appropriate. Proximity to Subdistrict A, B, or municipalities may also be considered for decentralized management approaches. Assume that material receiving can be collocated with material processing and storage. | 4.5                                        |
| 13 – Natural gas transmission lines                                 | A site with greater proximity (considered 1 mile) to natural gas transmission lines will score higher.                                                                                                                                                                                                                                                                                                                               | 3.3                                        |
| <b><i>Community Considerations</i></b>                              |                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                            |
| 14 – Proximity to Sensitive Receptors                               | A site located in proximity (considered 1,500 ft) to hospitals, schools, daycare facilities, elderly housing and convalescent facilities, churches, parks, and shopping centers, will score lower.                                                                                                                                                                                                                                   | 4.5                                        |
| 15 – Equity Emphasis Areas                                          | A site located in an Equity Emphasis Area will score lower.                                                                                                                                                                                                                                                                                                                                                                          | 3.5                                        |
| 16 – Environmental Justice                                          | A site located in an Environmental Justice Area will score lower.                                                                                                                                                                                                                                                                                                                                                                    | 3.3                                        |

| Criteria                                                            | Definitions                                                                                                                            | Weighting Factor<br>(Scale of 1-5) |
|---------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------|------------------------------------|
| <b><i>Site Characteristics that May Affect Site Development</i></b> |                                                                                                                                        |                                    |
| 17 – Environmental History                                          | A site with a history of environmental issues, or within 0.25 mile of a site with a history of environmental issues, will score lower. | 4.0                                |

Note:

AASHTO = American Association of State Highway and Transportation Officials

### 5.6.2 Site Scoring

To provide an independent assessment of each siting option, the EA Team scored each technology against the evaluation criteria, independent of technology or other detailed County considerations. Based on the EA Team’s organics industry experience and familiarity with site development needs for organics processing facilities, a score was assigned to each site reflecting the merits and challenges of each site. Annotations for each score are provided in Table 5-10 to provide additional information underlining each assigned score.

Table 5-10. Siting Scoring

| Criteria                                              | County Sites                                                                                               |                                                                                                            |                                                                                      |
|-------------------------------------------------------|------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|
|                                                       | Shady Grove TS                                                                                             | MCYTCF                                                                                                     | Site 2                                                                               |
| Site Characteristics that May Affect Site Development |                                                                                                            |                                                                                                            |                                                                                      |
| 1 – Site Size                                         | 1 – Limited Site Area                                                                                      | 4 – Large Site Area (~70 acres)                                                                            | 5 – Large site area                                                                  |
| 2 – Site Topography                                   | 4 – Existing developed areas have limited slope                                                            | 4 – Existing developed areas have limited slope                                                            | 2 – Slope varies across parcel, including stream channel                             |
| 3 – Site Soils                                        | 5 – No soil removal nor amendment required                                                                 | 5 – No soil removal nor amendment required                                                                 | 2- Groundwater concerns will require impervious areas over imported structural fill. |
| 4 – Depth to Groundwater                              | 3 – Over 10 ft to groundwater                                                                              | 5 – Over 30 ft to groundwater                                                                              | 5 – Over 30 ft to groundwater                                                        |
| 5 – Electric Service                                  | 5 – Three-phase power available at site                                                                    | 5 – Three-phase power available at site                                                                    | 2 – No three-phase power available, would have to be brought in from MCYTCF or RRF   |
| 6 – Water and Sewer Service                           | 5 – Public service approved with service to main (Category S-1)                                            | 2 – On-site water and sanitation only available                                                            | 1 – Private on-site service only, likely uses well/septic (S-6)                      |
| 7 – Existing Infrastructure                           | 4 – High potential for re-use of existing developed site areas, although some modification may be required | 4 – High potential for re-use of existing developed site areas, although some modification may be required | 1 – Limited/no existing development on site                                          |
| 8 – Permitting                                        | 5 – Existing MDE Solid waste facility permit                                                               | 5 – Existing MDE yard trim facility permit                                                                 | 5 – Existing MDE Solid waste facility permit                                         |
| Conditions Local to Site                              |                                                                                                            |                                                                                                            |                                                                                      |
| 9 – Population Density                                | 1 – High population density surrounding site                                                               | 5 – Limited population density surrounding site                                                            | 5 – Limited population density surrounding site                                      |
| 10 – Site Access                                      | 5 – Freeway and highway easily accessible from site                                                        | 3 – Site accessible from arterial road                                                                     | 2 – Site access requires traversing rustic road                                      |
| 11 – Quality of Existing Vehicular Traffic            | 2 – Level of service D/E                                                                                   | 4 – Reasonably free traffic flow                                                                           | 4 – Reasonably free traffic flow                                                     |
| 12 – Feedstock Sources                                | 4 – Closer proximity to organic sources                                                                    | 2 – Limited proximity to organic sources                                                                   | 2 – Limited proximity to organic sources                                             |
| 13 – Natural gas transmission lines                   | 4 – Natural gas line within 3,000 ft                                                                       | 2 – Natural gas line within 8,000 ft                                                                       | 4 – Natural gas line within 3,000 ft                                                 |
| Community Considerations                              |                                                                                                            |                                                                                                            |                                                                                      |
| 14 – Proximity to Sensitive Receptors                 | 2 – Some proximity to sensitive receptors                                                                  | 4 – Limited proximity to sensitive receptors                                                               | 4 – Limited proximity to sensitive receptors                                         |
| 15 – Equity Emphasis Areas                            | 3 – Site within proximity of Equity Emphasis Areas                                                         | 5 – No site proximity to Equity Emphasis Areas                                                             | 5 – No site proximity to Equity Emphasis Areas                                       |
| 16 – Environmental Justice                            | 3 – Final Environmental Justice score 51.74                                                                | 4 – Final Environmental Justice score 46.89                                                                | 4 – Final Environmental Justice score 46.89                                          |
| 17 – Environmental History                            | 4 – Few known site environmental issues                                                                    | 4 – No adverse environmental impact from 40+ years of composting operations on-site                        | 2 – Site history of groundwater concerns                                             |

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### 5.6.3 Site Ranking

Organics processing sites ranked using a weighted criteria decision matrix technique are summarized in Table 5-11 and detailed in Table 5-12. To develop the weighted score, the score of each site was multiplied by the evaluation criteria weighting factor. The weighted score was totaled across all evaluation criteria for each site. The scores for each site were then compared to create a ranking among alternatives.

**Table 5-11. Site Ranking Summary Table**

| Site           | Weighted Score |
|----------------|----------------|
| MCYTCF         | 267.0          |
| Shady Grove TS | 236.0          |
| Site 2         | 219.8          |

Based on the sites presented and ranked applying the County's evaluation factors with the EA Team's site scoring, the weighted matrix approach identifies the ranking of potential organics facility sites. The EA Team will proceed with consideration of ranked sites in consideration of final processing facility alternatives presented in Chapter 6.

"Organics" refers to the combination of food waste and food-soiled paper. Food waste includes meat as well as vegetable waste from processing, distribution, and/or kitchen operations that can potentially be separated from other wastes at the point of generation, whether pre- or post-consumer. This does not include yard trimmings, which are part of the current County recycling program.

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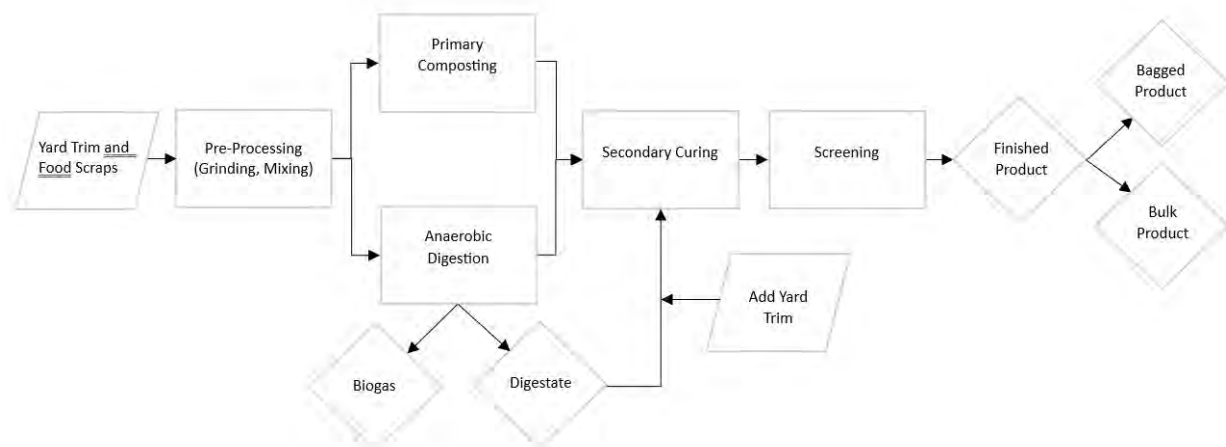
Table 5-12. Site Ranking Summary Table

| Criteria                                                     | Weighting Factor | County Sites   |                |           |                |           |                |
|--------------------------------------------------------------|------------------|----------------|----------------|-----------|----------------|-----------|----------------|
|                                                              |                  | Shady Grove TS |                | MCYTCF    |                | Site 2    |                |
|                                                              |                  | Raw Score      | Weighted Score | Raw Score | Weighted Score | Raw Score | Weighted Score |
| <i>Site Characteristics that May Affect Site Development</i> |                  |                |                |           |                |           |                |
| 1 – Site Size                                                | 4.75             | 1              | 4.8            | 4         | 19.0           | 5         | 23.8           |
| 2 – Site Topography                                          | 3.5              | 4              | 14.0           | 4         | 14.0           | 2         | 7.0            |
| 3 – Site Soils                                               | 3.5              | 5              | 17.5           | 5         | 17.5           | 2         | 7.0            |
| 4 – Depth to Groundwater                                     | 3.75             | 3              | 11.3           | 5         | 18.8           | 5         | 18.8           |
| 5 – Electric Service                                         | 4                | 5              | 20.0           | 5         | 20.0           | 2         | 8.0            |
| 6 – Water and Sewer Service                                  | 4                | 5              | 20.0           | 2         | 8.0            | 1         | 4.0            |
| 7 – Existing Infrastructure                                  | 4                | 4              | 16.0           | 4         | 16.0           | 1         | 4.0            |
| 8 – Permitting                                               | 3.75             | 5              | 18.8           | 5         | 18.8           | 5         | 18.8           |
| <i>Conditions Local to Site</i>                              |                  |                |                |           |                |           |                |
| 9 – Population Density                                       | 5                | 1              | 5.0            | 5         | 25.0           | 5         | 25.0           |
| 10 – Site Access                                             | 5                | 5              | 25.0           | 3         | 15.0           | 2         | 10.0           |
| 11 – Quality of Existing Vehicular Traffic                   | 3.75             | 2              | 7.5            | 4         | 15.0           | 4         | 15.0           |
| 12 – Feedstock Sources                                       | 4.5              | 4              | 18.0           | 2         | 9.0            | 2         | 9.0            |
| 13 – Natural Gas Transmission Lines                          | 3.25             | 4              | 13.0           | 2         | 6.5            | 4         | 13.0           |
| <i>Community Considerations</i>                              |                  |                |                |           |                |           |                |
| 14 – Proximity to Sensitive Receptors                        | 4.5              | 2              | 9.0            | 4         | 18.0           | 4         | 18.0           |
| 15 – Equity Emphasis Areas                                   | 3.5              | 3              | 10.5           | 5         | 17.5           | 5         | 17.5           |
| 16 – Environmental Justice                                   | 3.25             | 3              | 9.8            | 4         | 13.0           | 4         | 13.0           |
| 17 – Environmental History                                   | 4                | 4              | 16.0           | 4         | 16.0           | 2         | 8.0            |
| TOTAL WEIGHTED SCORE                                         |                  |                | 236.0          |           | 267.0          |           | 219.8          |

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## 6. DEVELOPMENT AND EVALUATION OF ALTERNATIVES (TASK 5)

As summarized in Section 2.5.4, the recipe for processing up to 97,400 tons (273,500 CY) of organic feedstocks including yard trim and food scrap is utilized as the basis for Phase I facility development detailed in this chapter. To meet the processing capacity needs identified in the mandatory program and some high capture scenarios (Table 2-20), costs are detailed for development of future facility expansion, identified as Phase II throughout this chapter. However, alternatives to centralized material receiving and processing at the Shady Grove TS will be required to meet processing capacity for these scenarios, in addition to the facility development proposed in the alternatives discussed herein.



**Figure 6-1. Organics Processing Flow Diagram**

Based on the technology review presented in Table 3-8, the highest-ranked technologies include ASP composting, in-vessel tunnel reactor composting, agitated bed composting, and dry fermentation AD. Based on the siting review presented in Table 5-11, the existing sites in ranked order for siting a future organics processing facility are the MCYTCTF, the Shady Grove TS, and Site 2; no additional parcels from the GIS study were identified for further review. The facility development alternatives outlined in this chapter pair the ranked technologies and sites; consider material hauling and transportation costs as necessary between material receipt and product distribution; and present capital and operations costs associated with development of each. Discussion of each alternative addresses infrastructure available or needed, phased implementation to meet processing needs, and preparation and distribution of end products. A weighted-criteria matrix is included later in this section for the alternatives presented.

As noted in the feedstock projections analysis in Chapter 2, this study has assumed that a new SSO diversion program in the County will be based on co-collection of food waste with yard trim. While voluntary sign-up programs usually have minimal contamination, mandatory programs do typically see higher contamination rates. While this equipment has not been assumed to be included in this analysis, depackagers or other material pre-processing equipment or steps may be necessary to address feedstock contamination. As a County food scrap diversion

program is developed, consideration given to outreach and education aimed at minimizing contamination during organics capture will be critical to ensuring a high-quality product can be produced in the alternatives as outlined. Key themes and best practices for minimizing plastic and other contaminants in food scrap diversion programs are included in Appendix E for the County's consideration.

## **6.1 ALTERNATIVES**

### **6.1.1 Option 1 – ASP Composting at Montgomery County Yard Trim Composting Facility (MCYTCF)**

Given the site rankings developed for processing technologies and sites, ASP composting, the highest ranked technology, at the MCYTCF, the highest ranked site, is presented as Option 1. Site development and annual operation and maintenance (O&M) costs for Phase I and Phase II facility development for this alternative are presented in Appendix F and vendor product information is included in Appendix G.

Receipt of co-collected yard trim and food scrap could be centralized at the Shady Grove TS as it is now. Material pre-processing would consist of material receipt and grinding in an enclosed building, equipped with aeration and process odor controls, in preparation for ASP composting. After grinding, this “pre-processed” compostable mix would be transported to MCYTCF, by rail in covered hopper rail cars that could minimize the potential for in-transit odors, or by truck. While the material receipt and grinding operation could be relocated to the MCYTCF, this would require the transport of unprocessed food waste and yard trim from Shady Grove TS to MCYTCF and was not considered to be a feasible approach due to the cost of transporting high volume, low bulk density material.

The ASP system implemented at the MCYTCF would be used for primary composting to create a biologically stable (i.e., all decomposition complete) compost prior to the finishing steps of curing, screening, and bagging. The ASP system at MCYTCF could be individually bunkered ASPs, similar to the ASP system at the Howard County Alpha Ridge Landfill, an extended aerated static pile configuration like the composting approach used at the MCYTCF when it was the Dickerson Interim Sewage Sludge Composting Facility (1981–1982), or a fabric-covered ASP system, similar to the ASP system at the Prince George's County Organics Compost Facility. ASP systems provide scalable approaches that allow efficient expansion of processing capacity given the additional site development and related capital costs. After primary composting is complete, the curing, screening, and bagging processes would be the same as what is currently done to make LeafGro®, with finished product distribution from the MCYTCF site.

The MCYTCF is an ideal site for ASP composting of co-collected food waste and yard trim, given the sites existing infrastructure for windrow composting of yard trim, and trained personnel familiar with composting process requirements. The existing 48-acre bituminous pavement pad would be adequate to meet permit requirements for an all-weather pad in the curing and compost storage areas. Limited repairs and upgrades to the existing pad for these process areas have been included in the site development costs. Upgrading the facility to Type 2 feedstocks (e.g., accepting food scraps) does require that feedstock receiving (at Shady Grove

TS) and primary composting (at MCYTCTF) areas must maintain processing on a low-permeability pad; the cost of surface upgrades to concrete for these process areas has been included in the site development costs.

Increased process water demand could be required based on the ASP system used, as bunker-style, extended aerated static pile, and bio- and fabric-covered aerated static pile systems all differ in their process water requirements during primary composting. If additional water service is required to accommodate an expanded composting facility, a public water main extension from the local water service provider, likely the Town of Poolesville for the MCYTCTF site, may require up to 4.5 miles of public water main extension along Maryland Route 107 (Whites Ferry Road) and Wasche Road. Given an estimated cost of water main construction of \$3–4 million per mile, an ASP system with minimal process water addition is recommended; instead, contact water, or runoff from the composting process, can be captured and re-applied for material wetting. Based on the approach of contact waste collection and re-use, the costs of contact water storage tanks have been included in site development costs, while additional costs for public sewer infrastructure are not included.

As an alternative to siting Option 1 at the MCYTCTF, ASP composting developed at the Shady Grove TS could be considered but would require acquisition of additional land (the Eugene Casey Foundation parcels), with additional costs estimated at \$12–15 million. ASP composting could also be developed on Site 2; however, the lack of existing infrastructure would elevate capital costs considerably, with additional costs estimated at \$10–25 million.

#### **6.1.1.1 Option 1.1 – Pilot Scale ASP at Montgomery County Yard Trim Composting Facility**

While ASP composting is well-proven in the U.S., and with the bunker-style and fabric-covered aerated static pile installations in neighboring Howard and Prince George’s counties used for composting SSO, a pilot test of ASP composting of co-collected yard trim and food scrap at the MCYTCTF is recommended. A multi-season food waste organics program could be designed to prove the process viability for food waste and yard trim, with an effective “recipe” tailored to the County’s feedstocks available for processing, and consideration of seasonal changes in weather and feedstock variability. A pilot program would also provide the County with the opportunity to test facility operations appropriate for meeting processing needs and regulatory requirements, and to reveal any operational challenges which could be addressed prior to embarking on a larger-scale implementation.

#### **6.1.2 Option 2 – In-Vessel Tunnel Reactor Composting at Shady Grove TS and Product Finishing at MCYTCTF**

In-vessel tunnel reactors, the second highest ranked organics processing technology, sited at the Shady Grove TS, the second highest ranked site, is presented as Option 2. Given the area constraints of the Shady Grove TS site, this alternative assumes material receipt, pre-processing, and primary composting processes at Shady Grove, followed by material hauling by truck and/or rail to the MCYTCTF for curing, screening, and bagging. Site development and annual O&M

costs for Phase I and Phase II facility development for this alternative are presented in Appendix F and vendor product information is included in Appendix G.

Material receipt and pre-processing at the Shady Grove TS would include receiving and grinding co-collected yard trim and food scrap in an enclosed building, equipped with aeration and process odor controls, in preparation for in-vessel tunnel reactor composting. Pre-processed feedstocks would be loaded into the tunnel reactor system for primary composting.

The in-vessel tunnel reactor approach for primary composting is effective in developed areas, where a higher degree of process and environmental controls are required. In-vessel tunnel reactor composting systems are currently installed in a dense environment for the City of Long Beach, California, and in a more rural setting for the Ottawa Valley Waste Recovery Centre in Canada. Concrete and stainless-steel construction on in-vessel tunnel reactors ensures a long installation service life. Tunnel reactor sizes can be configured to best meet the Shady Grove TS site layout, with construction assumed to occur in phases, as noted. The site constraints of the Shady Grove TS pose a significant challenge to siting a primary composting process at this location. While the tunnel reactors could be built out to up to 1 acre in Phase I and up to 3 acres in total in Phase II, existing site operations at the Shady Grove TS would require significant relocation to accommodate this. Given that no off-site areas have been identified to relocate existing operations, land acquisition and site development costs for the adjacent Eugene Casey Foundation parcels have been included in site development costs for this alternative.

After primary composting, the biologically stable, but immature compost would then be loaded into covered hopper rail cars for the product finishing steps at the MCYTCTF. As the MCYTCTF is already well-equipped for curing, screening, and bagging processes, this site is practical for product finishing. As material would be biologically stable after primary composting, curing could be conducted in windrows at MCYTCTF, requiring only minimal site upgrades to accommodate. Moving the finished compost to market would be the same method as is used now from the MCYTCTF.

It would be possible to develop primary composting via in-vessel tunnel reactors entirely at MCYTCTF or at Site 2 after material pre-processing; however, given the remote location of both sites, the additional capital cost for an enclosed facility with a high degree of process control may not be justifiable. In-vessel tunnel reactor composting developed at the MCYTCTF would require additional upgrades of existing site surfaces, with additional costs estimated at \$12–15 million. In-vessel tunnel reactor composting could also be developed on Site 2; however, the lack of existing infrastructure would elevate capital costs considerably, with additional costs estimated at \$10–25 million.

### **6.1.3 Option 3 – Agitated Bed Composting at Site 2**

Agitated bed composting, the third highest ranked organics processing technology, sited at Site 2, the third highest ranked site, is presented as Option 3. This alternative assumes that only material receipt and pre-processing are conducted at the Shady Grove TS before material transport to Site 2 for primary composting and product finishing. Site development and annual



O&M costs for Phase I and Phase II facility development for this alternative are presented in Appendix F and vendor product information is included in Appendix G.

Material receipt and pre-processing at the Shady Grove TS would include receiving and grinding co-collected yard trim and food scrap in an enclosed building, equipped with aeration and process odor controls, in preparation for agitated bed composting. After grinding, this “pre-processed” compostable mix would be transported by rail to the RRF rail yard adjacent to the MCYTFC in covered hopper rail cars that could minimize the potential for in-transit odors, then trucked to Site 2. Alternatively, material could be hauled entirely by truck to Site 2. Given that roadways in the vicinity of Site 2 are rustic roads not developed to support the gross vehicle weight of haul trucks, Site 2 access would require development and use of an internal roadway developed through the GenOn site. Costs of Site 2 access roads have been included in site development costs.

As with tunnel reactors, the agitated bed systems are used where the proximity of development or need to minimize nuisances calls for greater process and/or environmental control. Agitated bed composting systems are in operation for a biosolids composting operation in Burlington, New Jersey, and in various installations in Canada. The automated agitation and aeration systems minimize materials handling, requiring material loading and removal from process bays only. Housing of all primary composting within an enclosed facility equipped with biofilters ensures odor and process control to limit disturbance to receptors near Site 2. For the site development costs, it is assumed that the agitated bed compost building will be construction entirely in Phase I, with bays constructed in five-bay groups constructed with dedicated blowers for zone aeration, culminating in a total of 30 bays to meet the required capacity of Phase II by 2045. After primary composting, material would be cured, screened, and bagged as is currently done. As material would be biologically stable after primary composting, curing could be conducted on asphalt pads constructed at Site 2. Moving the finished compost to market would be the similar to the product distribution currently conducted from the nearby MCYTFC.

It would be possible to develop primary composting via an agitated bed system entirely at the MCYTFC after material pre-processing. This approach would require additional upgrades of existing site surfaces; however, it would not require the extensive site development of greenfield Site 2. Siting an agitated bed composting system at MCYTFC would save an estimated \$12–15 million over facility construction at Site 2.

#### **6.1.4 Option 4 – Dry Fermentation Anaerobic Digestion at Shady Grove TS with Product Finishing at MCYTFC via Tunnel Reactor Composting**

Dry fermentation AD, the fourth highest ranked technology, sited at the Shady Grove TS, is presented as Option 4. Despite the area constraints of the Shady Grove TS site, this pairing of technology and sites was selected based on the proximity of the Shady Grove TS to potential end uses for biogas generated from AD. As with previous alternatives at the Shady Grove TS, the site area allows only material receipt, pre-processing, and anaerobic digestion on-site; hauling of digestate by truck and/or rail to the MCYTFC will allow primary composting, assumed tunnel reactor composting for this alternative, prior to curing, screening, and bagging. Site development

and annual O&M costs for Phase I and Phase II facility development for this alternative are presented in Appendix F and vendor product information is included in Appendix G.

Material receipt and pre-processing at the Shady Grove TS would include receiving and grinding co-collected yard trim and food scrap in an enclosed building, equipped with aeration and process odor controls, in preparation for anaerobic digestion. Pre-processed feedstocks would be loaded into the digestors for processing and the resulting residual, or digestate, would look like the pre-processed SSO that went into the AD reactors, only wetter and with a higher odor profile than stable material after other primary composting processes. The digestate would be removed from the AD reactors, mixed with yard trim to increase the volatile solids content, and then loaded into covered hopper rail cars for primary composting and product finishing steps at the MCYTFC. The additional AD product of methane-rich biogas can be captured, cleaned, and stored, with additional purification for the conversion of the biogas to hydrogen fuel.

Dry fermentation AD systems, similar in process infrastructure to tunnel reactor composting, are currently installed at five California locations, including the City of Napa and for the Monterey Regional Waste Management District in Monterey. The site constraints of the Shady Grove TS pose a significant challenge to siting an AD process at this location. While the digesters could be built out to up to 1 acre in Phase I and up to 3 acres in total in Phase II, existing site operations at the Shady Grove TS would require significant relocation to accommodate this. Given that no off-site areas have been identified to relocate existing operations, land acquisition and site development costs for the adjacent Eugene Casey Foundation parcels have been included in site development costs for this alternative.

As the County is interested in evaluating options for producing hydrogen bus fleet fuel from biogas derived from SSO processing, an evaluation of energy consumption from methane to hydrogen conversion is summarized in Appendix D. Although commercial scale installations of conversion to hydrogen are limited, the capital cost of installation of a facility that can convert biogas to pipeline-quality methane to hydrogen may make economic sense if use of the hydrogen is paired with equipment that utilizes hydrogen as a fuel source. Siting of the dry fermentation AD system at Shady Grove TS provides the nearest proximity to the bus fleet headquarters in Silver Spring, Maryland, as compared to the other sites. Hydrogen produced for use by the bus fleet would need to be compressed and transported to the bus fleet headquarters in high-pressure tube trailers. Additional future considerations would be needed to address the carbon dioxide byproduct from hydrogen production.

As AD is solely extracting the energy value from SSO before it is further processed, coupling with a composting system is necessary for processing the digestate. The MCYTFC would require upgrades for development of in-vessel tunnel reactor for primary composting of the digestate and yard trim mix, but is already well-equipped for curing, screening, and bagging processes. Moving the finished compost to market would be the same method as is used now from the MCYTFC.

It would be possible to develop dry fermentation AD and primary composting via in-vessel tunnel reactors entirely at MCYTFC or at Site 2 after material pre-processing; however, given

the remote location of both sites, the additional capital cost for an enclosed facility with a high degree of process control may not be justifiable. In addition, longer compressed hydrogen gas transport times and routes would be needed. Developing this processing technology implementation at the MCYTCTF would incur additional costs estimated at \$15–20 million. Dry fermentation AD and primary composting via in-vessel tunnel reactor composting could also be developed entirely at Site 2; however, the lack of existing infrastructure would elevate capital costs and transportation costs of end product considerably, with additional costs estimated at \$15–35 million.

### **6.1.5 Option 5 – Dry Fermentation Anaerobic Digestion at Shady Grove Transfer Station with Product Finishing at MCYTCTF via Windrow Composting**

Option 5 combines hydrogen fuel-producing AD at the Shady Grove TS with windrow composting of the digestate in the existing windrow composting operation at the MCYTCTF. Despite the area constraints of the Shady Grove TS site, this pairing of technology and sites was selected based on the proximity of the Shady Grove TS to potential end uses for biogas generated from AD. As with previous alternatives at the Shady Grove TS, the site area allows only material receipt, pre-processing, and anaerobic digestion on-site; hauling of digestate by truck and/or rail to the MCYTCTF for windrow composting prior to curing, screening, and bagging. Site development and annual O&M costs for Phase I and Phase II facility development for this alternative are presented in Appendix F.

Similar to Option 4, material receipt and pre-processing at the Shady Grove TS would include receiving and grinding co-collected yard trim and food scrap in an enclosed building, equipped with aeration and process odor controls, in preparation for anaerobic digestion. Pre-processed feedstocks would be loaded into the digestors for processing and the resulting residual, or digestate, would look like the pre-processed SSO that went into the AD reactors, only wetter and with a higher odor profile than stable material after other primary composting processes. The digestate would be removed from the AD reactors, mixed with yard trim to increase the volatile solids content, and then loaded into covered hopper rail cars for primary composting and product finishing steps at the MCYTCTF. The additional AD product of methane-rich biogas can be captured, cleaned, and stored, with additional purification for the conversion of the biogas to hydrogen fuel.

The site constraints of the Shady Grove TS pose a significant challenge to siting an AD process at this location; however, as with Option 4, siting of the dry fermentation AD system at Shady Grove TS provides the nearest proximity to the bus fleet headquarters in Silver Spring, Maryland. While the digesters could be built out to up to 1 acre in Phase I and up to 3 acres in total in Phase II, existing site operations at the Shady Grove TS would require significant relocation to accommodate this. Given that no off-site areas have been identified to relocate existing operations, land acquisition and site development costs for the adjacent Eugene Casey Foundation parcels have been included in site development costs for this alternative. Hydrogen produced for use by the bus fleet would need to be compressed and transported to the bus fleet headquarters in high-pressure tube trailers. Additional future considerations would be needed to address the carbon dioxide byproduct from hydrogen production.

As AD is solely extracting the energy value from SSO before it is further processed, coupling with a composting system is necessary for processing the digestate. The MCYTCTF would require only limited upgrades to conduct primary composting via windrows, and is well-equipped for curing, screening, and bagging processes. Moving the finished compost to market would be the same method as is used now from the MCYTCTF.

It would be possible to develop dry fermentation AD and windrow composting entirely at MCYTCTF or at Site 2 after material pre-processing; however, given the remote location of both sites, the additional capital cost for an enclosed facility with a high degree of process control may not be justifiable. In addition, longer compressed hydrogen gas transport times and routes would be needed. Developing this processing technology implementation at the MCYTCTF would incur additional costs estimated at \$5–10 million. Dry fermentation AD and windrow composting could also be developed entirely at Site 2; however, the lack of existing infrastructure would elevate capital costs and transportation costs of end product considerably, with additional costs estimated at \$15–35 million.

## **6.2 ADDITIONAL PROGRAM DEVELOPMENT MODEL**

Consideration of a distributed approach to organics collection and processing, while it may require changes to organic waste collection and material receipt beyond the scope of this report, provides an alternative model for processing organics captured through the planning period.

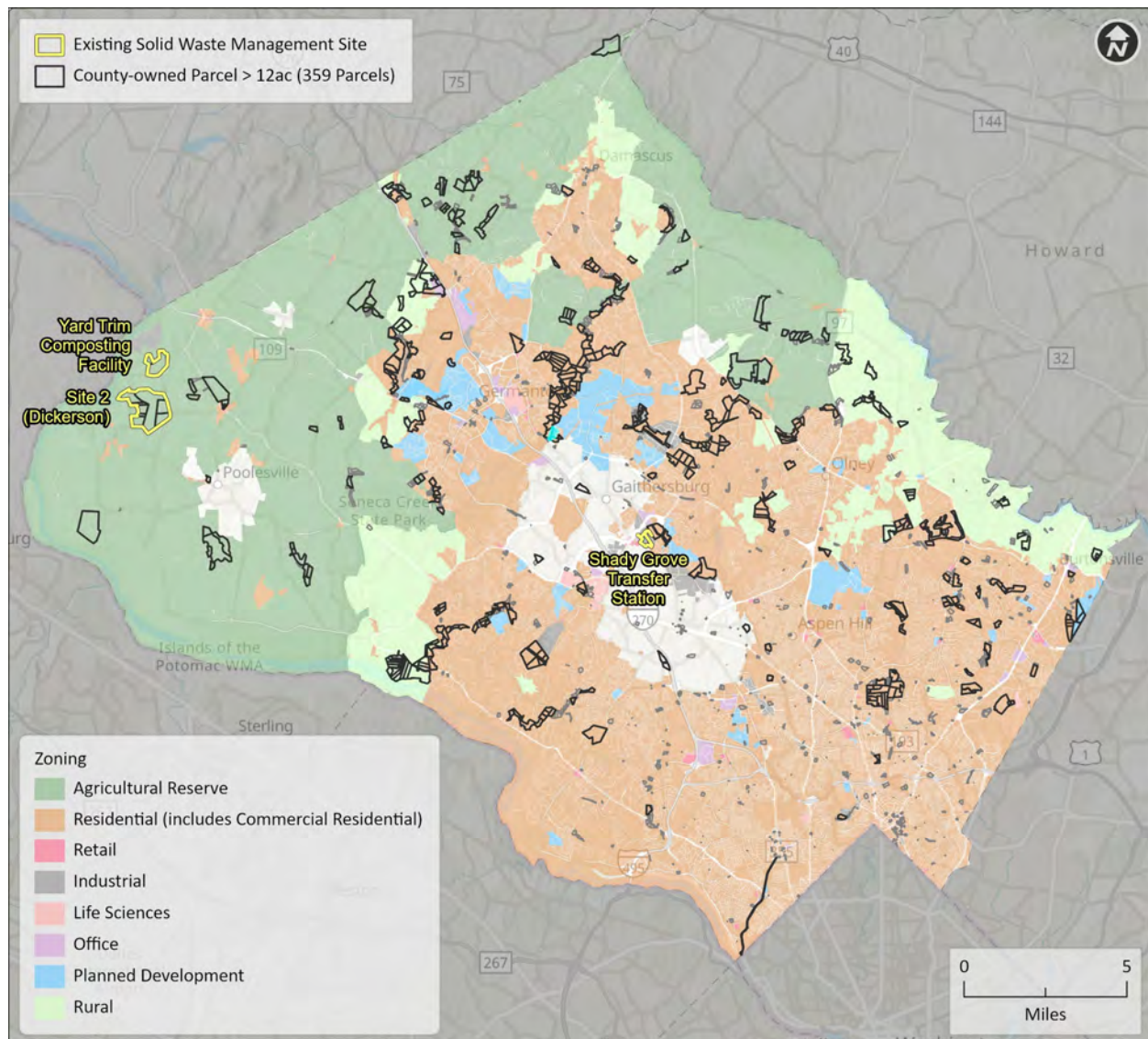
Advantages of processing at multiple smaller-scale sites allows for maintaining organic waste collection and processing more local to the points of waste generation, and potentially a more local pathway for product distribution, decreasing the carbon footprint overall for organic waste processing. Relieving the Shady Grove TS site as the centralized waste receiving and pre-processing location for organic waste, as included in assumptions in previous alternatives, may ease the processing capacity demand currently at the Shady Grove TS site. In addition, implementation of an ASP could provide effective control over odors and vectors while also providing a scalable approach where additional processing capacity can be integrated at a given site without significant additional capital costs.

Disadvantages of processing at multiple smaller-scale sites has the challenge of identifying multiple sites across the County for organics processing. While smaller parcels may be easier to locate within proximity to the dense population areas, and thus more concentrated organic waste generation areas of the County, there may be increased opposition from residents to multiple sites as well as additional cumbersome site permitting processes. In addition, processing at multiple sites requires additional machinery (e.g., loaders), processing equipment (e.g., grinders, screening, bagging) and personnel to manage the composting process at multiple sites.

Shown in Figure 6-2 are 359 County-owned parcels that may be considered further for smaller 12-acre-footprint distributed ASP composting sites. While these sites were screened only by size and County-ownership, a more detailed GIS review will be necessary to determine site suitability considering zoning, required setbacks, and other exclusionary criteria. In addition, a future GIS review of transportation routes can be conducted to optimize the locations of smaller processing facilities.

Although no County-owned parcels are currently identified for development of a decentralized model, conceptual site development and annual O&M costs have been developed for future consideration.

Costs assume ASP composting systems are developed at distributed installations of up to four 12-acre sites across the County, considering phased development, and are presented in Appendix F as Option 6. Note that as available parcels which could potentially require land acquisition have not been identified, this option is not included in analysis later in this chapter.



**Figure 6-2. GIS Screening of County-Owned Sites for Distributed Composting**

### 6.3 LIFE-CYCLE COST ANALYSIS

The EA Team has developed a Cost Analysis that compares the relative costs for the five alternatives noted, including assessment of capital costs and O&M costs of alternatives over the project planning period. This analysis will be utilized to provide insights into the project's economic feasibility given the previously evaluated alternatives in projected waste generation, processing approaches, end-product usage, and facility location. Costs provided were developed to compare and support selection of the option.

#### 6.3.1 Conceptual Cost Estimates

Conceptual-level relative cost estimates have been prepared for each alternative, considering site development costs to implement organics processing technologies over a phased construction at each site, and annual O&M costs. Costs have been developed for the purposes of comparing alternatives only, and additional cost estimation will be necessary in the future during facility design. Costs have been developed based on vendor quotes, contractor bid pricing, RS Means national average data for construction costs, and the MDOT SHA Price Index for costs by Maryland county. Costs are presented with a 30% contingency appropriate for the concept-level nature of the evaluation without design layout or detailed planning. A summary of facility capital costs is included in Table 6-1.

**Table 6-1. Conceptual Facility Capital Costs**

| Option | Option Description                                                                                                    | Capital Cost |              |               |
|--------|-----------------------------------------------------------------------------------------------------------------------|--------------|--------------|---------------|
|        |                                                                                                                       | Phase I      | Phase II     | Total         |
| 1      | ASP Composting at MCYTCF                                                                                              | \$16,318,000 | \$14,917,000 | \$31,235,000  |
| 2      | In-Vessel Tunnel Reactor Composting at Shady Grove TS and Product Finishing At MCYTCF                                 | \$42,315,000 | \$20,496,000 | \$62,811,000  |
| 3      | Agitated Bed Composting at Site 2                                                                                     | \$71,315,000 | \$18,317,000 | \$89,632,000  |
| 4      | Dry Fermentation Anaerobic Digestion at Shady Grove TS with Product Finishing at MCYTCF via Tunnel Reactor Composting | \$75,166,000 | \$67,122,000 | \$142,288,000 |
| 5      | Dry Fermentation Anaerobic Digestion at Shady Grove TS with Product Finishing at MCYTCF                               | \$58,425,000 | \$49,441,000 | \$107,866,000 |

A summary of annual O&M costs is included in Table 6-2. Note that O&M costs include costs for all labor and equipment necessary for site operations, and do not consider where existing labor or equipment on-site may be reused.



**Table 6-2. Conceptual Facility Annual O&M Costs**

| Option | Option Description                                                                                                     | Capital Cost |              |
|--------|------------------------------------------------------------------------------------------------------------------------|--------------|--------------|
|        |                                                                                                                        | Phase I      | Phase II     |
| 1      | ASP Composting at (MCYTCTF                                                                                             | \$3,470,000  | \$7,580,000  |
| 2      | In-Vessel Tunnel Reactor Composting at Shady Grove TS and Product Finishing At MCYTCTF                                 | \$4,640,000  | \$9,130,000  |
| 3      | Agitated Bed Composting at Site 2                                                                                      | \$3,830,000  | \$8,430,000  |
| 4      | Dry Fermentation Anaerobic Digestion at Shady Grove TS with Product Finishing at MCYTCTF via Tunnel Reactor Composting | \$6,310,000  | \$11,640,000 |
| 5      | Dry Fermentation Anaerobic Digestion at Shady Grove TS with Product Finishing at MCYTCTF                               | \$5,270,000  | \$10,180,000 |

## 6.4 ANALYSIS

Project alternatives are assessed and ranked in this section using the weighted criteria decision matrix approach evaluating alternatives based on specific evaluation criteria, weighted by the importance of each criterion. This decision-making tool treats each criterion independently, which helps avoid bias or emphasis on a specific criterion.

### 6.4.1 Alternatives Evaluation Criteria

To evaluate the alternative most suitable for development for a County facility, the EA Team and the County developed criteria against which to evaluate each alternative. As discussed previously, County DEP personnel in management, planning, and operational roles assigned weighting factors on a scale of 1 to 5 to indicate the relative importance of each criterion. Average weighting factors are presented in Table 6-3 and are applied in the weighted matrix discussed later in this section. Among respondents, considerations regarding the ability of one site to accommodate all processing was the most heavily weighted evaluation criteria.

**Table 6-3. Alternatives – Evaluation Criteria**

| Criteria                                               | Definitions                                                                                                                             | Weighting Factor (Scale of 1-5) |
|--------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|
| 1 – Facility Capital Costs                             | An alternative with a higher facility capital cost will score lower.                                                                    | 3.5                             |
| 2 – Facility O&M Costs                                 | An alternative with a higher annual O&M cost will score lower.                                                                          | 4.0                             |
| 3 – All Processing Conducted on One Site               | A site that can accommodate all processing (e.g., material receipt to bagging operations) on-site will score higher.                    | 5.0                             |
| 4 – Ease of Implementation                             | A site with greater local support for development will score higher.                                                                    | 4.0                             |
| 5 – Ease of Construction                               | A site with more complex site development requirements and/or installation of more complex processing equipment will score lower.       | 3.8                             |
| 6 – Proven System Implementation                       | A site with proven installations will score higher, considering both the processing technology and facility parameters.                 | 4.3                             |
| 7 – Transportation Resilience                          | A site that has multiple transportation options (e.g., rail, truck, etc.) for material receiving and/or distribution will score higher. | 3.8                             |
| 8 – Viability of renewable energy production and usage | A site with a viable pathway for renewable energy production and end use will score higher.                                             | 3.8                             |

## 6.4.2 Alternatives Scoring

To provide an independent assessment of each alternative, the EA Team scored each alternative against the evaluation criteria, considering holistically the organics processing technology, site, and ability to meet County processing needs. Based on the EA Team's organics industry experience and familiarity with organics processing facilities, a score was assigned to each alternative reflecting the merits and challenges of each.

**Table 6-4. Alternatives Scoring**

| <b>Criteria</b>                                        | <b>Option 1 – ASP Composting at MCYTCF</b> | <b>Option 2 – In-Vessel Tunnel Reactor Composting at Shady Grove TS and Product Finishing at MCYTCF</b> | <b>Option 3 – Agitated Bed Composting at Site 2</b> | <b>Option 4 – Dry Fermentation AD at Shady Grove TS with Product Finishing at MCYTCF via Tunnel Reactor Composting</b> | <b>Option 5 – Dry Fermentation AD at Shady Grove TS with Product Finishing at MCYTCF</b> |
|--------------------------------------------------------|--------------------------------------------|---------------------------------------------------------------------------------------------------------|-----------------------------------------------------|------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------|
| 1 – Facility Capital Costs                             | 5                                          | 4                                                                                                       | 3                                                   | 1                                                                                                                      | 2                                                                                        |
| 2 – Facility O&M Costs                                 | 5                                          | 4                                                                                                       | 3                                                   | 1                                                                                                                      | 2                                                                                        |
| 3 – All Processing Conducted on One Site               | 3                                          | 2                                                                                                       | 3                                                   | 2                                                                                                                      | 2                                                                                        |
| 4 – Ease of Implementation                             | 1                                          | 2                                                                                                       | 4                                                   | 2                                                                                                                      | 2                                                                                        |
| 5 – Ease of Construction                               | 4                                          | 2                                                                                                       | 4                                                   | 2                                                                                                                      | 2                                                                                        |
| 6 – Proven System Implementation                       | 5                                          | 2                                                                                                       | 2                                                   | 2                                                                                                                      | 2                                                                                        |
| 7 – Transportation Resilience                          | 3                                          | 2                                                                                                       | 3                                                   | 2                                                                                                                      | 2                                                                                        |
| 8 – Viability of renewable energy production and usage | 1                                          | 1                                                                                                       | 1                                                   | 4                                                                                                                      | 4                                                                                        |

## 6.4.3 Alternatives Ranking

Organics processing technologies ranked using a weighted criteria decision matrix technique are summarized in Table 6-5 and detailed in Table 6-6. To develop the weighted score, the score of each alternative was multiplied by the evaluation criteria weighting factor. The weighted score was totaled across all evaluation criteria for each technology. The scores for each technology were then compared to create a ranking among alternatives.



Based on the alternatives presented and ranked applying the County's evaluation factors with the EA Team's alternative scoring, the weighted matrix approach identifies the ranking of alternatives based on consistency with the County's stated goals.

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Table 6-5. Alternatives Ranking Summary Table

| Alternative                                                                                                     | Weighted Score |
|-----------------------------------------------------------------------------------------------------------------|----------------|
| Option 1 – ASP Composting at MCYTCF                                                                             | 103.8          |
| Option 3 – Agitated Bed Composting at Site 2                                                                    | 92.0           |
| Option 2 – In-Vessel Tunnel Reactor Composting at Shady Grove TS and Product Finishing at MCYTCF                | 75.3           |
| Option 5 – Dry Fermentation AD at Shady Grove TS with Product Finishing at MCYTCF                               | 71.5           |
| Option 4 – Dry Fermentation AD at Shady Grove TS with Product Finishing at MCYTCF via Tunnel Reactor Composting | 64.0           |

Table 6-6. Alternatives Weighted Matrix

| Criteria                                               | Weighting Factor | Option 1 – ASP Composting at MCYTCF |                | Option 2 – In-Vessel Tunnel Reactor Composting at Shady Grove TS and Product Finishing at MCYTCF |                | Option 3 – Agitated Bed Composting at Site 2 |                | Option 4 – Dry Fermentation AD at Shady Grove TS with Product Finishing at MCYTCF via Tunnel Reactor Composting |                | Option 5 – Dry Fermentation AD at Shady Grove TS with Product Finishing at MCYTCF |                |
|--------------------------------------------------------|------------------|-------------------------------------|----------------|--------------------------------------------------------------------------------------------------|----------------|----------------------------------------------|----------------|-----------------------------------------------------------------------------------------------------------------|----------------|-----------------------------------------------------------------------------------|----------------|
|                                                        |                  | Raw Score                           | Weighted Score | Raw Score                                                                                        | Weighted Score | Raw Score                                    | Weighted Score | Raw Score                                                                                                       | Weighted Score | Raw Score                                                                         | Weighted Score |
| 1 – Facility Capital Costs                             | 3.5              | 5                                   | 17.5           | 4                                                                                                | 14.0           | 3                                            | 10.5           | 1                                                                                                               | 3.5            | 2                                                                                 | 7.0            |
| 2 – Facility O&M Costs                                 | 4                | 4                                   | 16.0           | 4                                                                                                | 16.0           | 3                                            | 12.0           | 1                                                                                                               | 4.0            | 2                                                                                 | 8.0            |
| 3 – All Processing Conducted on One Site               | 5                | 3                                   | 15.0           | 2                                                                                                | 10.0           | 3                                            | 15.0           | 2                                                                                                               | 10.0           | 2                                                                                 | 10.0           |
| 4 – Ease of Implementation                             | 4                | 1                                   | 4.0            | 2                                                                                                | 8.0            | 4                                            | 16.0           | 2                                                                                                               | 8.0            | 2                                                                                 | 8.0            |
| 5 – Ease of Construction                               | 3.75             | 4                                   | 15.0           | 2                                                                                                | 7.5            | 4                                            | 15.0           | 2                                                                                                               | 7.5            | 2                                                                                 | 7.5            |
| 6 – Proven System Implementation                       | 4.25             | 5                                   | 21.3           | 2                                                                                                | 8.5            | 2                                            | 8.5            | 2                                                                                                               | 8.5            | 2                                                                                 | 8.5            |
| 7 – Transportation Resilience                          | 3.75             | 3                                   | 11.3           | 2                                                                                                | 7.5            | 3                                            | 11.3           | 2                                                                                                               | 7.5            | 2                                                                                 | 7.5            |
| 8 – Viability of renewable energy production and usage | 3.75             | 1                                   | 3.8            | 1                                                                                                | 3.8            | 1                                            | 3.8            | 4                                                                                                               | 15.0           | 4                                                                                 | 15.0           |
| TOTAL WEIGHTED SCORE                                   |                  |                                     | 103.8          |                                                                                                  | 75.3           |                                              | 92.0           |                                                                                                                 | 64.0           |                                                                                   | 71.5           |

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## 7. SUMMARY AND CONCLUSIONS

The EA Team was contracted by MES for Montgomery County to prepare this organics siting study plan to evaluate the siting, technology, and capacity planning for a County-owned organics processing facility in Montgomery County to meet the food scrap, non-recyclable paper, and yard trim diversion needs of the County for the next 20 years. The EA Team completed the evaluation as outlined below.

### 7.1 SUMMARY

#### 7.1.1 Source Separated Organics Processing Options Materials Feedstock Projections

The County has a long-standing yard trim diversion program, capturing around 90% of the yard trim generated, and processing up to the processing limit of 77,000 tons of yard trim per year at the MCYTCF. In contrast, food waste and non-recyclable paper present organic waste streams with significant opportunity to improve upon historically low capture rates.

Projections for capture of food waste and non-recyclable paper were developed based on eight scenarios considering the potential of low, medium, high, and mandatory participation by single-family, multi-family, and non-residential sectors in the County. Survey response data were used to inform the projections for single-family households, by creating an understanding for the potential for future public engagement. In four of the scenarios, decentralized processing strategies, including backyard, community, and on-farm composting were considered to understand the extent to which these pathways may process food scraps and offset the processing capacity required by the County. Projected food scrap capture quantities varied from 8,800 to 65,800 tons per year in low to mandatory scenarios, and up to 58,300 tons per year captured where diversionary measures through decentralized processing were in place. The food scrap capture projections were presented in Chapter 2 (Table 2-20), as noted in Table 7-1 below.

**Table 7-1. Projected Food Scraps Capture (Tons) by Year**

| Scenario | 2025  | 2030   | 2035   | 2040   | 2045   |
|----------|-------|--------|--------|--------|--------|
| 1        | 4,600 | 5,700  | 6,700  | 7,700  | 8,800  |
| 2        | 6,400 | 10,700 | 15,100 | 19,600 | 24,100 |
| 3        | 7,300 | 18,500 | 30,000 | 41,900 | 54,000 |
| 4        | 7,300 | 35,500 | 45,300 | 55,400 | 65,800 |
| 5        | 4,600 | 5,700  | 6,700  | 7,700  | 8,800  |
| 6        | 4,800 | 7,600  | 11,900 | 16,500 | 21,100 |
| 7        | 5,700 | 15,400 | 26,900 | 38,800 | 51,000 |
| 8        | 3,500 | 28,100 | 37,700 | 47,900 | 58,300 |

#### 7.1.2 Source Separated Organics Processing Options

Organics processing technologies were reviewed, focusing on the current state-of-practice technologies and their potential to support municipal-scale processing of food scrap and yard trim. Several aerobic processing technologies were evaluated in this study, including ASP, enclosed in-vessel tunnel reactors, rotating drums, and agitated bed composting systems. In addition, anaerobic processing technologies were evaluated, including wet (low-solids)

continuous-stirred tank reactor anaerobic digestion, high-solids dry fermentation AD, and high-solids plug flow AD. Technology review included discussion of pre- and post-treatment processing; pollutants of concern, including PFAS, MP, and PH; and GHG emissions assessment. To discern the most suitable organics processing technology, the EA Team used a weighted matrix approach to rank each technology with County input on 20 evaluation criteria considering systems factors, operations, end products, and environmental concerns. The technologies were ranked in Chapter 3 (Table 3-8), as noted in Table 7-2 below.

**Table 7-2. Technology Ranking Summary Table**

| <b>Technology</b>     | <b>Weighted Score</b> |
|-----------------------|-----------------------|
| ASP                   | 269.8                 |
| Tunnel Reactor        | 253.5                 |
| Agitated Bed          | 227.5                 |
| Dry Fermentation      | 225.9                 |
| Rotating Drum         | 212.9                 |
| High Solids Plug Flow | 201.5                 |
| Wet (low-solids) CSTR | 185.3                 |

### 7.1.3 Recycled Organics Product Usage Options

As all organics processing end products must have viable end markets to be successful, a review of the potential end products and capacities of end markets in the County to absorb recycled organics products from aerobic and anaerobic organics processing technologies was conducted. End products reviewed included compost, biogas, and digestate. Market capacity by sector was considered for landscaping, agriculture, and stormwater management for new construction/redevelopment, with an estimated market capacity of 276,600 CY per year, or 69,800 CY per year for the County's market share. Although not quantified, additional emerging discussion included erosion and sediment control applications, development of soil organic matter content, and climate sequestration and climate action plans. Markets were discussed, but not quantified.

### 7.1.4 Siting Evaluation

To support an organics processing facility, a site must meet the needs to receive, process, and distribute organic feedstocks and finished products. The siting evaluation examined the feasibility of using County-owned property for the development of an organics management facility, including review of the Shady Grove TS, the MCYTFC at Dickerson, and the tract of land known as Site 2 in Dickerson. In addition, the EA Team performed a desktop analysis based on publicly available GIS data to determine whether any additional County-owned parcels merit further review as potential locations for facility siting. Site development and permitting requirements are reviewed later in the chapter. To discern the most suitable site, the EA Team used a weighted matrix to rank each technology with County input, using 17 evaluation criteria for evaluating each site, including site characteristics that may affect site development, conditions local to each site, and community considerations. The technologies were ranked in Chapter 5 (Table 5-11), as noted in Table 7-3 below.

**Table 7-3. Site Ranking Summary Table**

| <b>Technology</b> | <b>Weighted Score</b> |
|-------------------|-----------------------|
| MCYTCF            | 267.0                 |
| Shady Grove TS    | 236.0                 |
| Site 2            | 219.8                 |

### 7.1.5 Evaluation of Alternatives

The projections, the technology evaluation, and the siting study were combined into five alternatives for consideration, based on rankings previously developed in this report. The alternatives presented considered a phased processing facility development, with adequate capacity to process up to 97,400 tons (273,500 CY) of yard trim and food scrap in Phase I, and to meet the future processing capacity needs identified in the mandatory program and some high capture scenarios in Phase II. Conceptual capital and O&M costs were developed for the purposes of comparing alternatives. To discern the preferred alternative, the EA Team used a weighted matrix to rank each alternative, with County input, using eight evaluation criteria important for facility development. The alternatives were ranked in Chapter 6 (Table 6-3), as noted in Table 7-4 below.

**Table 7-4. Alternatives Ranking Summary Table**

| <b>Alternative</b>                                                                                              | <b>Weighted Score</b> |
|-----------------------------------------------------------------------------------------------------------------|-----------------------|
| Option 1 – ASP Composting at MCYTCF                                                                             | 103.8                 |
| Option 3 – Agitated Bed Composting at Site 2                                                                    | 92.0                  |
| Option 2 – In-Vessel Tunnel Reactor Composting at Shady Grove TS and Product Finishing at MCYTCF                | 75.3                  |
| Option 5 – Dry Fermentation AD at Shady Grove TS with Product Finishing at MCYTCF                               | 71.5                  |
| Option 4 – Dry Fermentation AD at Shady Grove TS with Product Finishing at MCYTCF via Tunnel Reactor Composting | 64.0                  |

### 7.1.6 Next Steps

While the alternatives presented require significant capital and operational investment, proceeding with a pilot program to test various composting technologies may be advantageous, to determine how best to tailor an organics processing facility to the County's needs. Where it is not possible to pilot test a particular technology, such as agitated bed, in-vessel tunnel reactor, or dry fermentation AD, it may benefit the County to conduct site visits to locally operating installations in order to evaluate their technologies and adapt them to suit specific requirements.

Additional steps the County may consider prior to developing an alternative considered in this report:

- Gathering additional community input and/or conducting engagement with local community organizations that may be invested in developing a given site
- Conducting an additional siting study of non-County-owned parcels

- Considering land acquisition of privately owned parcels considered in this report, or conducting additional study to identify other privately owned properties for County purchase
- Conducting additional program planning to determine a suitable re-location of processing activities currently located at the Shady Grove TS
- Conducting a study of material receiving and processing through multiple smaller sites

Upon determining a path forward for development of an organics processing technology at a particular site, an approximate timeline of site development steps is outlined below.

Development of a County-owned organics processing facility may require approximately 2.5 to 4 years prior to completion of an operable facility.

- Issue Request for Quotation/Request for Proposal for site design and permitting – 3–6months
- Develop Site Investigation and Site Design – 12–18 months
- State and Local Permitting – 12–18 months
- Project Bidding – 3 months
- Facility Construction – 12–18 months

As outlined in this report, defining programmatic considerations, such as considering material collection methods, encouraging public participation, and conducting outreach and education prior to expanding organics programs are critical to ensure programmatic success.

#### **7.1.7 Conclusions**

The County has a demonstrated need for organics processing capacity to meet the yard trim and food scrap generation and capture projected over the planning period. Final alternatives provide the outline of facility site development alternatives that utilize proven organics processing technologies at County-owned sites. Achieving food scrap diversion at low, medium, or high capture levels will continue to require rigorous program development and public engagement.

While all alternatives presented rely on a centralized processing approach concentrating processing capacity at a single site, it is noted that a distributed processing approach merits further evaluation by the County, including identification of suitable land area for development. While pursuing a distributed processing approach would require further study, it may provide the County with an avenue to address its already burdened solid waste management facilities. Moreover, implementation of decentralized processing approaches may be effective for geographic regions of the County, while a centralized processing option located at an existing



County facility may also be an effective systems approach. Further, where diversionary measures, such as expanded backyard, community, and on-farm composting are utilized, the viable capacity life of proposed organics processing alternatives developed in this study may be extended beyond the planning period.

Developing a successful long-term organics diversion program requires a balance between collection strategies, processing methods, and end-product marketing and sales. This study has considered how a program may be successful, by developing organics generation and capture projections, reviewing organics processing technologies, assessing end-product markets, and evaluating County sites for facility siting, over the planning period 2025 to 2045. The County is encouraged to investigate multiple programmatic implementation considerations prior to expanding the food scrap diversion program beyond its current pilot phase:

- Evaluate the feasibility of and continue to develop programmatic support for decentralized organics processing, such as through backyard, community, and on-farm composting; to continue to develop food scrap diversion “know how” throughout the County.
- Benchmark actual food scrap generation and capture against projections as developed, to re-baseline for planning purposes, as needed.
- Evaluate the feasibility of converting yard trim collection to a cart-based system to facilitate the co-collection of yard trim and food scraps.
- Evaluate alternative food-scraps-only collection methods, including curbside collection, drop-off stations, and durable compost-bag programs.
- Coordinate with municipalities in the County to capture those organics for processing at a County-owned facility.
- As the County evaluates alternatives to processing MSW at the RRF, consider how non-diverted organics could be co-processed with diverted SSO.
- Explore how to develop a fundamentally structural demand for compost usage in the County through mechanisms such as minimum soil organic matter content for new development and soil profile rebuilding requirements for redevelopment.

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# **Appendix A:**

## **Organic Waste Projections**

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| APPENDIX A1 - Organic Waste Generation, by Material Type |                                        |         |         |         |         |         |           |           |           |           |           |           |           |           |           |           |           |           |           |           |           |           |           |           |           |           |
|----------------------------------------------------------|----------------------------------------|---------|---------|---------|---------|---------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| Projection Basis                                         | Year                                   | 2021    | 2022    | 2023    | 2024    | 2025    | 2026      | 2027      | 2028      | 2029      | 2030      | 2031      | 2032      | 2033      | 2034      | 2035      | 2036      | 2037      | 2038      | 2039      | 2040      | 2041      | 2042      | 2043      | 2044      | 2045      |
|                                                          | SFA Housecount (1)                     | 92,418  | 93,478  | 92,615  | 92,901  | 93,186  | 93,651    | 94,115    | 94,544    | 95,008    | 95,472    | 95,937    | 96,437    | 96,901    | 97,401    | 97,865    | 98,348    | 98,830    | 99,312    | 99,794    | 100,276   | 100,759   | 101,241   | 101,723   | 102,205   | 102,687   |
|                                                          | SFB Housecount (1)                     | 126,315 | 127,674 | 129,028 | 129,426 | 129,824 | 130,471   | 131,118   | 131,715   | 132,362   | 133,009   | 133,656   | 134,352   | 134,999   | 135,696   | 136,343   | 137,014   | 137,686   | 138,358   | 139,030   | 139,702   | 140,373   | 141,045   | 141,717   | 142,389   | 143,060   |
|                                                          | SFM Housecount (1)                     | 38,845  | 39,361  | 39,674  | 39,796  | 39,919  | 40,118    | 40,317    | 40,500    | 40,699    | 40,898    | 41,097    | 41,311    | 41,510    | 41,724    | 41,923    | 42,130    | 42,336    | 42,543    | 42,749    | 42,956    | 43,162    | 43,369    | 43,576    | 43,782    | 43,989    |
|                                                          | SF Total Housecount (1)                | 257,578 | 260,513 | 261,317 | 262,123 | 262,929 | 264,240   | 265,550   | 266,759   | 268,069   | 269,379   | 270,689   | 272,100   | 273,410   | 274,821   | 276,131   | 277,492   | 278,852   | 280,213   | 281,573   | 282,934   | 284,294   | 285,655   | 287,015   | 288,376   | 289,736   |
|                                                          | MF Housecount (1)                      | 140,272 | 140,882 | 143,104 | 145,241 | 147,379 | 149,516   | 151,654   | 153,689   | 155,827   | 157,964   | 159,796   | 161,628   | 163,460   | 165,292   | 167,124   | 168,956   | 170,788   | 172,620   | 174,453   | 176,285   | 178,117   | 179,949   | 181,781   | 183,613   | 185,445   |
|                                                          | Montgomery County Total Housecount (1) | 397,850 | 401,395 | 404,421 | 407,365 | 410,308 | 413,756   | 417,203   | 420,448   | 423,896   | 427,343   | 430,485   | 433,728   | 436,871   | 440,113   | 443,256   | 446,448   | 449,641   | 452,833   | 456,026   | 459,218   | 462,411   | 465,604   | 468,796   | 471,989   | 475,181   |
|                                                          | Employment (1)                         | 549,300 | 555,100 | 560,900 | 566,700 | 572,500 | 578,900   | 585,300   | 591,700   | 598,100   | 604,500   | 609,100   | 613,600   | 618,200   | 622,800   | 627,400   | 631,950   | 636,500   | 641,050   | 645,600   | 650,150   | 654,700   | 659,250   | 663,800   | 668,350   | 672,900   |
|                                                          | Total County-Managed MSW (Tons) (2)(3) | 910,928 | 988,658 | 991,528 | 994,398 | 997,268 | 1,000,138 | 1,003,008 | 1,005,878 | 1,008,748 | 1,011,618 | 1,014,488 | 1,017,358 | 1,020,228 | 1,023,098 | 1,025,968 | 1,028,838 | 1,031,708 | 1,034,578 | 1,037,448 | 1,040,318 | 1,043,188 | 1,046,058 | 1,048,928 | 1,051,798 | 1,054,668 |
| Single-Family Subdistrict A                              | Yard Trim                              | 28,129  | 30,532  | 30,245  | 30,332  | 30,420  | 30,507    | 30,595    | 30,682    | 30,770    | 30,857    | 30,945    | 31,032    | 31,120    | 31,208    | 31,295    | 31,383    | 31,470    | 31,558    | 31,645    | 31,733    | 31,820    | 31,908    | 31,995    | 32,083    | 32,170    |
|                                                          | Food Scrap                             | 17,568  | 19,069  | 18,889  | 18,944  | 18,999  | 19,053    | 19,108    | 19,163    | 19,217    | 19,272    | 19,327    | 19,381    | 19,436    | 19,491    | 19,545    | 19,600    | 19,655    | 19,709    | 19,764    | 19,819    | 19,873    | 19,928    | 19,983    | 20,038    | 20,092    |
|                                                          | Non-Recyclable Paper                   | 6,777   | 7,355   | 7,286   | 7,307   | 7,328   | 7,349     | 7,371     | 7,392     | 7,413     | 7,434     | 7,455     | 7,476     | 7,497     | 7,518     | 7,539     | 7,560     | 7,581     | 7,603     | 7,624     | 7,645     | 7,666     | 7,687     | 7,708     | 7,729     | 7,750     |
|                                                          | Manure                                 | -       | -       | -       | -       | -       | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         |
|                                                          | Animal Protein                         | -       | -       | -       | -       | -       | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         |
|                                                          | SFA Subtotal (Tons)                    | 52,474  | 56,956  | 56,420  | 56,583  | 56,747  | 56,910    | 57,073    | 57,237    | 57,400    | 57,563    | 57,727    | 57,890    | 58,053    | 58,216    | 58,380    | 58,543    | 58,706    | 58,870    | 59,033    | 59,196    | 59,360    | 59,523    | 59,686    | 59,850    | 60,013    |
| Single-Family Subdistrict B                              | Yard Trim                              | 38,447  | 41,701  | 42,136  | 42,258  | 42,380  | 42,502    | 42,623    | 42,745    | 42,867    | 42,989    | 43,111    | 43,233    | 43,355    | 43,477    | 43,599    | 43,721    | 43,843    | 43,965    | 44,087    | 44,209    | 44,331    | 44,453    | 44,575    | 44,697    | 44,819    |
|                                                          | Food Scrap                             | 24,012  | 26,045  | 26,316  | 26,392  | 26,468  | 26,544    | 26,621    | 26,697    | 26,773    | 26,849    | 26,925    | 27,002    | 27,078    | 27,154    | 27,230    | 27,306    | 27,382    | 27,459    | 27,535    | 27,611    | 27,687    | 27,763    | 27,839    | 27,916    | 27,992    |
|                                                          | Non-Recyclable Paper                   | 9,262   | 10,046  | 10,151  | 10,180  | 10,210  | 10,239    | 10,268    | 10,298    | 10,327    | 10,357    | 10,386    | 10,415    | 10,445    | 10,474    | 10,503    | 10,533    | 10,562    | 10,592    | 10,621    | 10,650    | 10,680    | 10,709    | 10,738    | 10,768    | 10,797    |
|                                                          | Manure                                 | -       | -       | -       | -       | -       | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         |
|                                                          | Animal Protein                         | -       | -       | -       | -       | -       | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         |
|                                                          | SFB Subtotal (Tons)                    | 71,721  | 77,792  | 78,602  | 78,830  | 79,057  | 79,285    | 79,513    | 79,740    | 79,968    | 80,195    | 80,423    | 80,650    | 80,878    | 81,105    | 81,333    | 81,560    | 81,788    | 82,015    | 82,243    | 82,470    | 82,698    | 82,925    | 83,153    | 83,380    | 83,608    |
| Single-Family Municipalities                             | Yard Trim                              | 11,823  | 12,856  | 12,956  | 12,994  | 13,031  | 13,069    | 13,106    | 13,144    | 13,181    | 13,219    | 13,256    | 13,294    | 13,331    | 13,369    | 13,406    | 13,444    | 13,481    | 13,519    | 13,556    | 13,594    | 13,631    | 13,669    | 13,706    | 13,744    | 13,781    |
|                                                          | Food Scrap                             | 7,384   | 8,029   | 8,092   | 8,115   | 8,139   | 8,162     | 8,185     | 8,209     | 8,232     | 8,256     | 8,279     | 8,303     | 8,326     | 8,349     | 8,373     | 8,396     | 8,420     | 8,443     | 8,466     | 8,490     | 8,513     | 8,537     | 8,560     | 8,584     | 8,607     |
|                                                          | Non-Recyclable Paper                   | 2,848   | 3,097   | 3,121   | 3,130   | 3,139   | 3,148     | 3,157     | 3,166     | 3,175     | 3,184     | 3,193     | 3,203     | 3,212     | 3,221     | 3,230     | 3,239     | 3,248     | 3,257     | 3,266     | 3,275     | 3,284     | 3,293     | 3,302     | 3,311     | 3,320     |
|                                                          | Manure                                 | -       | -       | -       | -       | -       | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         |
|                                                          | Animal Protein                         | -       | -       | -       | -       | -       | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         |
|                                                          | SFM Subtotal (Tons)                    | 22,056  | 23,983  | 24,169  | 24,239  | 24,309  | 24,379    | 24,449    | 24,519    | 24,589    | 24,659    | 24,729    | 24,799    | 24,869    | 24,939    | 25,008    | 25,078    | 25,148    | 25,218    | 25,288    | 25,358    | 25,428    | 25,498    | 25,568    | 25,638    | 25,708    |
| Single-Family (Subtotal)                                 | Yard Trim                              | 78,399  | 85,089  | 85,336  | 85,583  | 85,830  | 86,077    | 86,324    | 86,571    | 86,818    | 87,065    | 87,312    | 87,559    | 87,806    | 88,053    | 88,300    | 88,547    | 88,794    | 89,041    | 89,288    | 89,535    | 89,782    | 90,029    | 90,276    | 90,523    | 90,770    |
|                                                          | Food Scrap                             | 48,965  | 53,143  | 53,297  | 53,451  | 53,606  | 53,760    | 53,914    | 54,068    | 54,223    | 54,377    | 54,531    | 54,685    | 54,840    | 54,994    | 55,148    | 55,303    | 55,457    | 55,611    | 55,765    | 55,920    | 56,074    | 56,228    | 56,382    | 56,537    | 56,691    |
|                                                          | Non-Recyclable Paper                   | 18,887  | 20,499  | 20,558  | 20,618  | 20,677  | 20,737    | 20,796    | 20,856    | 20,915    | 20,975    | 21,034    | 21,094    | 21,153    | 21,213    | 21,272    | 21,332    | 21,391    | 21,451    | 21,510    | 21,570    | 21,629    | 21,689    | 21,748    | 21,808    | 21,867    |
|                                                          | Manure                                 | -       | -       | -       | -       | -       | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         |
|                                                          | Animal Protein                         | -       | -       | -       | -       | -       | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         | -         |
|                                                          | SF Subtotal (Tons)                     | 146,251 | 158,731 | 159,191 | 159,652 | 160,113 | 160,574   | 161,035   | 161,495   | 161,956   | 162,417   | 162,878   | 163,339   | 163,799   | 164,260   | 164,721   | 165,182   | 165,642   | 166,103   | 166,564   | 167,025   | 167,486   | 167,946   | 168,407   | 168,868   | 169,329   |
| Multi-Family                                             | Yard Trim                              | 4,280   | 4,646   | 4,659   | 4,673   | 4,686   | 4,700     | 4,713     | 4,727     | 4,740     | 4,754     | 4,767     | 4,780     | 4,794     | 4,807     | 4,821     | 4,834     | 4,848     | 4,861     | 4,875     | 4,888     | 4,902     | 4,915     | 4,929     | 4,942     | 4,956     |
|                                                          | Food Scrap                             | 16,516  | 17,925  | 17,977  | 18,029  | 18,081  | 18,133    | 18,185    | 18,237    | 18,289    | 18,341    | 18,393    | 18,446    | 18,498    | 18,550    | 18,602    | 18,654    | 18,706    | 18,758    | 18,810    | 18,862    | 18,914    | 18,966    | 19,018    | 19,070    | 19,122    |
|                                                          | Non-Recyclable Paper                   | 7,747   | 8,408   | 8,432   | 8,457   | 8,481   | 8,506     | 8,530     | 8,554     | 8,579     | 8,603     | 8,628     | 8,652     | 8,677     | 8,701     | 8,725     | 8,750     | 8,774     | 8,799     | 8,823     | 8,847     | 8,872     | 8,896     | 8,921     | 8,945     | 8,969     |
|                                                          | Manure                                 | -       | -       | -       | -       | -       | -         | -         | -         | -         | -         | -         | -         | -         | -</       |           |           |           |           |           |           |           |           |           |           |           |

| APPENDIX A2 - Organic Waste Capture, Food Scrap Only |                                                                             |         |         |         |         |         |           |           |           |           |           |           |           |           |           |           |           |           |           |           |           |           |           |           |           |           |
|------------------------------------------------------|-----------------------------------------------------------------------------|---------|---------|---------|---------|---------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| Projection Basis                                     | Year                                                                        | 2021    | 2022    | 2023    | 2024    | 2025    | 2026      | 2027      | 2028      | 2029      | 2030      | 2031      | 2032      | 2033      | 2034      | 2035      | 2036      | 2037      | 2038      | 2039      | 2040      | 2041      | 2042      | 2043      | 2044      | 2045      |
|                                                      | SFA Housecount (1)                                                          | 92,418  | 93,478  | 92,615  | 92,901  | 93,186  | 93,651    | 94,115    | 94,544    | 95,008    | 95,472    | 95,937    | 96,437    | 96,901    | 97,401    | 97,865    | 98,348    | 98,830    | 99,312    | 99,794    | 100,276   | 100,759   | 101,241   | 101,723   | 102,205   | 102,687   |
|                                                      | SFB Housecount (1)                                                          | 126,315 | 127,674 | 129,028 | 129,426 | 129,824 | 130,471   | 131,118   | 131,715   | 132,362   | 133,009   | 133,656   | 134,352   | 134,999   | 135,696   | 136,343   | 137,014   | 137,686   | 138,358   | 139,030   | 139,702   | 140,373   | 141,045   | 141,717   | 142,389   | 143,060   |
|                                                      | SFM Housecount (1)                                                          | 38,845  | 39,361  | 39,674  | 39,796  | 39,919  | 40,118    | 40,317    | 40,500    | 40,699    | 40,898    | 41,097    | 41,311    | 41,510    | 41,724    | 41,923    | 42,130    | 42,336    | 42,543    | 42,749    | 42,956    | 43,162    | 43,369    | 43,576    | 43,782    | 43,989    |
|                                                      | SF Total Housecount (1)                                                     | 257,578 | 260,513 | 261,317 | 262,123 | 262,929 | 264,240   | 265,550   | 266,759   | 268,069   | 269,379   | 270,689   | 272,100   | 273,410   | 274,821   | 276,131   | 277,492   | 278,852   | 280,213   | 281,573   | 282,934   | 284,294   | 285,655   | 287,015   | 288,376   | 289,736   |
|                                                      | MF Housecount (1)                                                           | 140,272 | 140,882 | 143,104 | 145,241 | 147,379 | 149,516   | 151,654   | 153,689   | 155,827   | 157,964   | 159,796   | 161,628   | 163,460   | 165,292   | 167,124   | 168,956   | 170,788   | 172,620   | 174,453   | 176,285   | 178,117   | 179,949   | 181,781   | 183,613   | 185,445   |
|                                                      | Montgomery County Total Housecount (1)                                      | 397,850 | 401,395 | 404,421 | 407,365 | 410,308 | 413,756   | 417,203   | 420,448   | 423,896   | 427,343   | 430,485   | 433,728   | 436,871   | 440,113   | 443,256   | 446,448   | 449,641   | 452,833   | 456,026   | 459,218   | 462,411   | 465,604   | 468,796   | 471,989   | 475,181   |
|                                                      | Employment (1)                                                              | 549,300 | 555,100 | 560,900 | 566,700 | 572,500 | 578,900   | 585,300   | 591,700   | 598,100   | 604,500   | 609,100   | 613,600   | 618,200   | 622,800   | 627,400   | 631,950   | 636,500   | 641,050   | 645,600   | 650,150   | 654,700   | 659,250   | 663,800   | 668,350   | 672,900   |
|                                                      | Total County-Managed MSW (Tons) (2)(6)                                      | 910,928 | 988,658 | 991,528 | 994,398 | 997,268 | 1,000,138 | 1,003,008 | 1,005,878 | 1,008,748 | 1,011,618 | 1,014,488 | 1,017,358 | 1,020,228 | 1,023,098 | 1,025,968 | 1,028,838 | 1,031,708 | 1,034,578 | 1,037,448 | 1,040,318 | 1,043,188 | 1,046,058 | 1,048,928 | 1,051,798 | 1,054,668 |
| Single-Family Subdistrict A                          | Capture Model Generation (Tons)                                             | 17,627  | 19,131  | 18,889  | 18,944  | 18,999  | 19,053    | 19,108    | 19,163    | 19,217    | 19,272    | 19,327    | 19,381    | 19,436    | 19,491    | 19,545    | 19,600    | 19,655    | 19,709    | 19,764    | 19,819    | 19,873    | 19,928    | 19,983    | 20,038    | 20,092    |
|                                                      | Capture Model Capture (Tons)                                                | 501     | 521     | 581     | 640     | 700     | 759       | 819       | 878       | 938       | 997       | 1,057     | 1,116     | 1,176     | 1,235     | 1,295     | 1,354     | 1,414     | 1,473     | 1,533     | 1,592     | 1,652     | 1,711     | 1,771     | 1,830     | 1,890     |
|                                                      | Percent Capture (%)                                                         | 2.84%   | 2.72%   | 3.07%   | 3.38%   | 3.68%   | 3.98%     | 4.28%     | 4.58%     | 4.88%     | 5.17%     | 5.47%     | 5.76%     | 6.05%     | 6.34%     | 6.62%     | 6.91%     | 7.19%     | 7.48%     | 7.76%     | 8.03%     | 8.31%     | 8.59%     | 8.86%     | 9.14%     | 9.41%     |
|                                                      | Low Scenario: Current Trends (%)                                            |         |         | 3.07%   | 3.38%   | 3.68%   | 3.98%     | 4.28%     | 4.58%     | 4.88%     | 5.17%     | 5.47%     | 5.76%     | 6.05%     | 6.34%     | 6.62%     | 6.91%     | 7.19%     | 7.48%     | 7.76%     | 8.03%     | 8.31%     | 8.59%     | 8.86%     | 9.14%     | 9.41%     |
|                                                      | Medium Scenario: Current Trends + New Programs (%)                          |         |         | 3.77%   | 4.37%   | 4.97%   | 5.57%     | 6.16%     | 6.75%     | 7.33%     | 7.91%     | 8.49%     | 9.06%     | 9.64%     | 10.20%    | 10.77%    | 11.33%    | 11.89%    | 12.45%    | 13.00%    | 13.55%    | 14.09%    | 14.64%    | 15.18%    | 15.72%    | 16.25%    |
|                                                      | High Scenario : Current Trends + New Programs + Projected Participation (%) |         |         |         |         |         |           |           |           |           |           |           |           |           |           |           |           |           |           |           |           |           |           |           |           |           |
| Single-Family Subdistrict B                          | Capture Model Generation (Tons)                                             | 24,012  | 26,045  | 26,316  | 26,392  | 26,468  | 26,544    | 26,621    | 26,697    | 26,773    | 26,849    | 26,925    | 27,002    | 27,078    | 27,154    | 27,230    | 27,306    | 27,382    | 27,459    | 27,535    | 27,611    | 27,687    | 27,763    | 27,839    | 27,916    | 27,992    |
|                                                      | Capture Model Capture (Tons)                                                | 682     | 709     | 790     | 871     | 952     | 1,033     | 1,114     | 1,195     | 1,276     | 1,357     | 1,438     | 1,519     | 1,600     | 1,681     | 1,762     | 1,843     | 1,924     | 2,005     | 2,086     | 2,167     | 2,248     | 2,329     | 2,410     | 2,491     | 2,572     |
|                                                      | Percent Capture (%)                                                         | 2.84%   | 2.72%   | 3.00%   | 3.30%   | 3.60%   | 3.89%     | 4.19%     | 4.48%     | 4.77%     | 5.06%     | 5.34%     | 5.63%     | 5.91%     | 6.19%     | 6.47%     | 6.75%     | 7.03%     | 7.30%     | 7.58%     | 7.85%     | 8.12%     | 8.39%     | 8.66%     | 8.93%     | 9.19%     |
|                                                      | Low Scenario: Current Trends (%)                                            |         |         | 3.00%   | 3.30%   | 3.60%   | 3.89%     | 4.19%     | 4.48%     | 4.77%     | 5.06%     | 5.34%     | 5.63%     | 5.91%     | 6.19%     | 6.47%     | 6.75%     | 7.03%     | 7.30%     | 7.58%     | 7.85%     | 8.12%     | 8.39%     | 8.66%     | 8.93%     | 9.19%     |
|                                                      | Medium Scenario: Current Trends + New Programs (%)                          |         |         | 3.25%   | 3.61%   | 3.97%   | 4.32%     | 4.68%     | 5.03%     | 5.38%     | 5.72%     | 6.07%     | 6.41%     | 6.75%     | 7.09%     | 7.43%     | 7.77%     | 8.10%     | 8.43%     | 8.76%     | 9.09%     | 9.42%     | 9.74%     | 10.06%    | 10.38%    | 10.70%    |
|                                                      | High Scenario : Current Trends + New Programs + Projected Participation (%) |         |         |         |         |         |           |           |           |           |           |           |           |           |           |           |           |           |           |           |           |           |           |           |           |           |
| Single-Family Municipalities                         | Capture Model Generation (Tons)                                             | 17,568  | 19,069  | 18,889  | 18,944  | 18,999  | 19,053    | 19,108    | 19,163    | 19,217    | 19,272    | 19,327    | 19,381    | 19,436    | 19,491    | 19,545    | 19,600    | 19,655    | 19,709    | 19,764    | 19,819    | 19,873    | 19,928    | 19,983    | 20,038    | 20,092    |
|                                                      | Capture Model Capture (Tons)                                                | 209     | 217     | 242     | 267     | 291     | 316       | 341       | 366       | 391       | 415       | 440       | 465       | 490       | 515       | 539       | 564       | 589       | 614       | 639       | 663       | 688       | 713       | 738       | 763       | 787       |
|                                                      | Percent Capture (%)                                                         | 1.19%   | 1.14%   | 1.28%   | 1.41%   | 1.53%   | 1.66%     | 1.79%     | 1.91%     | 2.03%     | 2.16%     | 2.28%     | 2.40%     | 2.52%     | 2.64%     | 2.76%     | 2.88%     | 3.00%     | 3.11%     | 3.23%     | 3.35%     | 3.46%     | 3.58%     | 3.69%     | 3.81%     | 3.92%     |
|                                                      | Low Scenario: Current Trends (%)                                            |         |         | 1.28%   | 1.41%   | 1.53%   | 1.66%     | 1.79%     | 1.91%     | 2.03%     | 2.16%     | 2.28%     | 2.40%     | 2.52%     | 2.64%     | 2.76%     | 2.88%     | 3.00%     | 3.11%     | 3.23%     | 3.35%     | 3.46%     | 3.58%     | 3.69%     | 3.81%     | 3.92%     |
|                                                      | Medium Scenario: Current Trends + New Programs (%)                          |         |         | 1.28%   | 1.41%   | 1.53%   | 1.66%     | 1.79%     | 1.91%     | 2.03%     | 2.16%     | 2.28%     | 2.40%     | 2.52%     | 2.64%     | 2.76%     | 2.88%     | 3.00%     | 3.11%     | 3.23%     | 3.35%     | 3.46%     | 3.58%     | 3.69%     | 3.81%     | 3.92%     |
|                                                      | High Scenario : Current Trends + New Programs + Projected Participation (%) |         |         |         |         |         |           |           |           |           |           |           |           |           |           |           |           |           |           |           |           |           |           |           |           |           |
| Single-Family (Subtotal)                             | Capture Model Generation (Tons)                                             | 48,965  | 53,143  | 53,297  | 53,451  | 53,606  | 53,760    | 53,914    | 54,068    | 54,223    | 54,377    | 54,531    | 54,685    | 54,840    | 54,994    | 55,148    | 55,303    | 55,457    | 55,611    | 55,765    | 55,920    | 56,074    | 56,228    | 56,382    | 56,537    | 56,691    |
|                                                      | Capture Model Capture (Tons)                                                | 1,393   | 1,447   | 1,613   | 1,778   | 1,943   | 2,109     | 2,274     | 2,439     | 2,605     | 2,770     | 2,935     | 3,101     | 3,266     | 3,431     | 3,597     | 3,762     | 3,927     | 4,093     | 4,258     | 4,423     | 4,589     | 4,754     | 4,919     | 5,085     | 5,250     |
|                                                      | Percent Capture (%)                                                         | 2.84%   | 2.72%   | 3.03%   | 3.33%   | 3.63%   | 3.92%     | 4.22%     | 4.51%     | 4.80%     | 5.09%     | 5.38%     | 5.67%     | 5.96%     | 6.24%     | 6.52%     | 6.80%     | 7.08%     | 7.36%     | 7.64%     | 7.91%     | 8.18%     | 8.45%     | 8.72%     | 8.99%     | 9.26%     |
|                                                      | Low Scenario: Current Trends (%)                                            |         |         | 3.03%   | 3.33%   | 3.63%   | 3.92%     | 4.22%     | 4.51%     | 4.80%     | 5.09%     | 5.38%     | 5.67%     | 5.96%     | 6.24%     | 6.52%     | 6.80%     | 7.08%     | 7.36%     | 7.64%     | 7.91%     | 8.18%     | 8.45%     | 8.72%     | 8.99%     | 9.26%     |
|                                                      | Medium Scenario: Current Trends + New Program Participation                 |         |         | 3.22%   | 4.60%   | 5.98%   | 7.36%     | 8.74%     | 10.11%    | 11.49%    | 12.86%    | 14.23%    | 15.60%    | 16.97%    | 18.33%    | 19.70%    | 21.06%    | 22.42%    | 23.78%    | 25.14%    | 26.50%    | 27.85%    | 29.21%    | 30.56%    | 31.91%    | 33.26%    |
|                                                      | High Scenario : Survey Data (%)                                             |         |         | 3.22%   | 5.34%   | 7.47%   | 9.60%     | 11.72%    | 13.85%    | 15.98%    | 18.10%    | 20.23%    | 22.35%    | 24.48%    | 26.61%    | 28.73%    | 30.86%    | 32.99%    | 35.11%    | 37.24%    | 39.37%    | 41.49%    | 43.62%    | 45.75%    | 47.87%    | 50.00%    |
|                                                      | Mandatory Diversion Requirement                                             |         |         |         |         | 7.47%   | 10.10%    | 12.72%    | 28.93%    | 30.76%    | 32.59%    | 34.41%    | 36.24%    | 38.07%    | 39.90%    | 41.72%    | 43.55%    | 45.38%    | 47.21%    | 49.03%    | 50.86%    | 52.69%    | 54.52%    | 56.34%    | 58.17%    | 60.00%    |
| Multi-Family                                         | Capture Model Generation (Tons)                                             | 16,516  | 17,925  | 17,977  | 18,029  | 18,081  | 18,133    | 18,185    | 18,237    | 18,289    | 18,341    | 18,393    | 18,446    | 18,498    | 18,550    | 18,602    | 18,654    | 18,706    | 18,758    | 18,810    | 18,862    | 18,914    | 18,966    | 19,018    | 19,070    | 19,122    |
|                                                      | Capture Model Capture (Tons)                                                | 32      | 134     | 141     | 147     | 154     | 160       | 166       | 173       | 179       | 185       | 192       | 198       | 204       | 211       | 217       | 224       | 230</     |           |           |           |           |           |           |           |           |

| APPENDIX A3 - Organic Waste Capture, Other Material Types |                                                 |         |         |         |         |         |           |           |           |           |           |           |           |           |           |           |           |           |           |           |           |           |           |           |           |           |
|-----------------------------------------------------------|-------------------------------------------------|---------|---------|---------|---------|---------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| Projection Basis                                          | Year                                            | 2021    | 2022    | 2023    | 2024    | 2025    | 2026      | 2027      | 2028      | 2029      | 2030      | 2031      | 2032      | 2033      | 2034      | 2035      | 2036      | 2037      | 2038      | 2039      | 2040      | 2041      | 2042      | 2043      | 2044      | 2045      |
|                                                           | SFA Housecount (1)                              | 92,418  | 93,478  | 92,615  | 92,901  | 93,186  | 93,651    | 94,115    | 94,544    | 95,008    | 95,472    | 95,937    | 96,437    | 96,901    | 97,401    | 97,865    | 98,348    | 98,830    | 99,312    | 99,794    | 100,276   | 100,759   | 101,241   | 101,723   | 102,205   | 102,205   |
|                                                           | SFB Housecount (1)                              | 126,315 | 127,674 | 129,028 | 129,426 | 129,824 | 130,471   | 131,118   | 131,715   | 132,362   | 133,009   | 133,656   | 134,352   | 134,999   | 135,696   | 136,343   | 137,014   | 137,686   | 138,358   | 139,030   | 139,702   | 140,373   | 141,045   | 141,717   | 142,389   | 142,389   |
|                                                           | SFM Housecount (1)                              | 38,845  | 39,361  | 39,674  | 39,796  | 39,919  | 40,118    | 40,317    | 40,500    | 40,699    | 40,898    | 41,097    | 41,311    | 41,510    | 41,724    | 41,923    | 42,130    | 42,336    | 42,543    | 42,749    | 42,956    | 43,162    | 43,369    | 43,576    | 43,782    | 43,782    |
|                                                           | SF Total Housecount (1)**                       | 257,578 | 260,513 | 261,317 | 262,123 | 262,929 | 264,240   | 265,550   | 266,759   | 268,069   | 269,379   | 270,689   | 272,100   | 273,410   | 274,821   | 276,131   | 277,492   | 278,852   | 280,213   | 281,573   | 282,934   | 284,294   | 285,655   | 287,015   | 288,376   | 288,376   |
|                                                           | MF Housecount (1)                               | 140,272 | 140,882 | 143,104 | 145,241 | 147,379 | 149,516   | 151,654   | 153,689   | 155,827   | 157,964   | 159,796   | 161,628   | 163,460   | 165,292   | 167,124   | 168,956   | 170,788   | 172,620   | 174,453   | 176,285   | 178,117   | 179,949   | 181,781   | 183,613   | 183,613   |
|                                                           | Montgomery County Total Housecount (1)          | 397,850 | 401,395 | 404,421 | 407,365 | 410,308 | 413,756   | 417,203   | 420,448   | 423,896   | 427,343   | 430,485   | 433,728   | 436,871   | 440,113   | 443,256   | 446,448   | 449,641   | 452,833   | 456,026   | 459,218   | 462,411   | 465,604   | 468,796   | 471,989   | 471,989   |
|                                                           | Employment (NR proxy) (1)                       | 549,300 | 555,100 | 560,900 | 566,700 | 572,500 | 578,900   | 585,300   | 591,700   | 598,100   | 604,500   | 609,100   | 613,600   | 618,200   | 622,800   | 627,400   | 631,950   | 636,500   | 641,050   | 645,600   | 650,150   | 654,700   | 659,250   | 663,800   | 668,350   | 668,350   |
|                                                           | Total County Managed Waste CY2021 (Tons) (2)(3) | 910,928 | 988,658 | 991,528 | 994,398 | 997,268 | 1,000,138 | 1,003,008 | 1,005,878 | 1,008,748 | 1,011,618 | 1,014,488 | 1,017,358 | 1,020,228 | 1,023,098 | 1,025,968 | 1,028,838 | 1,031,708 | 1,034,578 | 1,037,448 | 1,040,318 | 1,043,188 | 1,046,058 | 1,048,928 | 1,051,798 | 1,054,668 |
| Non Recyclable Paper                                      | Generation (tons/yr)                            | 37,002  | 40,159  | 40,276  | 40,392  | 40,509  | 40,625    | 40,742    | 40,859    | 40,975    | 41,092    | 41,208    | 41,325    | 41,441    | 41,558    | 41,675    | 41,791    | 41,908    | 42,024    | 42,141    | 42,257    | 42,374    | 42,491    | 42,607    | 42,724    | 42,840    |
|                                                           | Low Scenario (tons/yr)                          |         |         | 1,669   | 1,750   | 1,832   | 1,913     | 1,995     | 2,076     | 2,158     | 2,240     | 2,321     | 2,403     | 2,485     | 2,567     | 2,649     | 2,731     | 2,813     | 2,895     | 2,977     | 3,060     | 3,142     | 3,225     | 3,307     | 3,390     | 3,472     |
|                                                           | Medium Scenario (tons/yr)                       |         |         | 1,877   | 2,217   | 2,559   | 2,902     | 3,246     | 3,593     | 3,940     | 4,289     | 4,639     | 4,991     | 5,343     | 5,698     | 6,054     | 6,411     | 6,769     | 7,129     | 7,490     | 7,853     | 8,217     | 8,582     | 8,949     | 9,317     | 9,687     |
|                                                           | High Scenario (tons/yr)                         |         |         | 769     | 1,227   | 2,875   | 3,754     | 4,638     | 5,527     | 6,422     | 7,321     | 8,225     | 9,134     | 10,048    | 10,967    | 11,891    | 12,820    | 13,753    | 14,692    | 15,636    | 16,585    | 17,538    | 18,497    | 19,461    | 20,429    | 21,403    |
|                                                           | Percent Capture - Low Scenario (%)              |         |         | 4.14%   | 4.33%   | 4.52%   | 4.71%     | 4.90%     | 5.08%     | 5.27%     | 5.45%     | 5.63%     | 5.82%     | 6.00%     | 6.18%     | 6.36%     | 6.53%     | 6.71%     | 6.89%     | 7.07%     | 7.24%     | 7.42%     | 7.59%     | 7.76%     | 7.93%     | 8.10%     |
|                                                           | Percent Capture - Medium Scenario (%)           |         |         | 4.66%   | 5.49%   | 6.32%   | 7.14%     | 7.97%     | 8.79%     | 9.62%     | 10.44%    | 11.26%    | 12.08%    | 12.89%    | 13.71%    | 14.53%    | 15.34%    | 16.15%    | 16.96%    | 17.77%    | 18.58%    | 19.39%    | 20.20%    | 21.00%    | 21.81%    | 22.61%    |
|                                                           | Percent Capture - High Scenario (%)             |         |         | 1.91%   | 3.04%   | 7.10%   | 9.24%     | 11.38%    | 13.53%    | 15.67%    | 17.82%    | 19.96%    | 22.10%    | 24.25%    | 26.39%    | 28.53%    | 30.68%    | 32.82%    | 34.96%    | 37.10%    | 39.25%    | 41.39%    | 43.53%    | 45.67%    | 47.82%    | 49.96%    |
| Manure                                                    | Generation (tons/yr)                            | 4,386   | 4,760   | 4,774   | 4,787   | 4,801   | 4,815     | 4,829     | 4,843     | 4,857     | 4,870     | 4,884     | 4,898     | 4,912     | 4,926     | 4,939     | 4,953     | 4,967     | 4,981     | 4,995     | 5,009     | 5,022     | 5,036     | 5,050     | 5,064     | 5,078     |
|                                                           | Capture (tons/yr): Assume 100% Maintained       | 4,386   | 4,760   | 4,774   | 4,787   | 4,801   | 4,815     | 4,829     | 4,843     | 4,857     | 4,870     | 4,884     | 4,898     | 4,912     | 4,926     | 4,939     | 4,953     | 4,967     | 4,981     | 4,995     | 5,009     | 5,022     | 5,036     | 5,050     | 5,064     | 5,078     |
|                                                           | Percent Capture (%)                             | 100%    | 100%    | 100%    | 100%    | 100%    | 100%      | 100%      | 100%      | 100%      | 100%      | 100%      | 100%      | 100%      | 100%      | 100%      | 100%      | 100%      | 100%      | 100%      | 100%      | 100%      | 100%      | 100%      | 100%      | 100%      |
| Yard Trim                                                 | Generation (tons/yr)                            | 204,293 | 221,725 | 222,369 | 223,013 | 223,656 | 224,300   | 224,944   | 225,587   | 226,231   | 226,875   | 227,518   | 228,162   | 228,806   | 229,449   | 230,093   | 230,737   | 231,380   | 232,024   | 232,668   | 233,311   | 233,955   | 234,599   | 235,242   | 235,886   | 236,529   |
|                                                           | Capture (tons/yr): Assume 90% maintained        | 181,588 | 199,553 | 200,132 | 200,711 | 201,291 | 201,870   | 202,449   | 203,029   | 203,608   | 204,187   | 204,766   | 205,346   | 205,925   | 206,504   | 207,084   | 207,663   | 208,242   | 208,822   | 209,401   | 209,980   | 210,559   | 211,139   | 211,718   | 212,297   | 212,877   |
|                                                           | Percent Capture (%)                             | 89%     | 90%     | 90%     | 90%     | 90%     | 90%       | 90%       | 90%       | 90%       | 90%       | 90%       | 90%       | 90%       | 90%       | 90%       | 90%       | 90%       | 90%       | 90%       | 90%       | 90%       | 90%       | 90%       | 90%       | 90%       |
| Animal Protein                                            | Generation (tons/yr)                            | 697     | 756     | 758     | 761     | 763     | 765       | 767       | 769       | 772       | 774       | 776       | 778       | 780       | 783       | 785       | 787       | 789       | 791       | 794       | 796       | 798       | 800       | 802       | 805       | 807       |
|                                                           | Capture (tons/yr): Assumed 100% maintained      | 697     | 756     | 758     | 761     | 763     | 765       | 767       | 769       | 772       | 774       | 776       | 778       | 780       | 783       | 785       | 787       | 789       | 791       | 794       | 796       | 798       | 800       | 802       | 805       | 807       |
|                                                           | Percent Capture (%)                             | 100%    | 100%    | 100%    | 100%    | 100%    | 100%      | 100%      | 100%      | 100%      | 100%      | 100%      | 100%      | 100%      | 100%      | 100%      | 100%      | 100%      | 100%      | 100%      | 100%      | 100%      | 100%      | 100%      | 100%      | 100%      |

Sources:

(1) "Housecount Data CY for ML." Montgomery County. 04/21/2023. Housecount and employment data extrapolated from County projections for 2041-2045.

(2) "CY2021CaptureModel." Montgomery County. 5/16/2022. Waste categories and CY21 tons.

(3) "CY22 MRA Workbook" MMS. 08/17/2023. CY22 Total County-Managed MSW Only.

|                                                                            |                                                                                      | Year                                                                   | 2021    | 2022    | 2023    | 2024    | 2025    | 2026      | 2027      | 2028      | 2029      | 2030      | 2031      | 2032      | 2033      | 2034      | 2035      | 2036      | 2037      | 2038      | 2039      | 2040      | 2041      | 2042      | 2043      | 2044      | 2045      |
|----------------------------------------------------------------------------|--------------------------------------------------------------------------------------|------------------------------------------------------------------------|---------|---------|---------|---------|---------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| Projection Basis                                                           | SFA Housecount (1)                                                                   |                                                                        | 92,418  | 93,478  | 92,615  | 92,901  | 93,186  | 93,651    | 94,115    | 94,544    | 95,008    | 95,472    | 95,937    | 96,437    | 96,901    | 97,401    | 97,865    | 98,348    | 98,830    | 99,312    | 99,794    | 100,276   | 100,759   | 101,241   | 101,723   | 102,205   | 102,205   |
|                                                                            | SFB Housecount (1)                                                                   |                                                                        | 126,315 | 127,674 | 129,028 | 129,426 | 129,824 | 130,471   | 131,118   | 131,715   | 132,362   | 133,009   | 133,656   | 134,352   | 134,999   | 135,696   | 136,343   | 137,014   | 137,686   | 138,358   | 139,030   | 139,702   | 140,373   | 141,045   | 141,717   | 142,389   | 142,389   |
|                                                                            | SFM Housecount (1)                                                                   |                                                                        | 38,845  | 39,361  | 39,674  | 39,796  | 39,919  | 40,118    | 40,317    | 40,500    | 40,699    | 40,898    | 41,097    | 41,311    | 41,510    | 41,724    | 41,923    | 42,130    | 42,336    | 42,543    | 42,749    | 42,956    | 43,162    | 43,369    | 43,576    | 43,782    | 43,782    |
|                                                                            | SF Total Housecount (1)**                                                            |                                                                        | 257,578 | 260,513 | 261,317 | 262,123 | 262,929 | 264,240   | 265,550   | 266,759   | 268,069   | 269,379   | 270,689   | 272,100   | 273,410   | 274,821   | 276,131   | 277,492   | 278,852   | 280,213   | 281,573   | 282,934   | 284,294   | 285,655   | 287,015   | 288,376   | 288,376   |
|                                                                            | MF Housecount (1)                                                                    |                                                                        | 140,272 | 140,882 | 143,104 | 145,241 | 147,379 | 149,516   | 151,654   | 153,689   | 155,827   | 157,964   | 159,796   | 161,628   | 163,460   | 165,292   | 167,124   | 168,956   | 170,788   | 172,620   | 174,453   | 176,285   | 178,117   | 179,949   | 181,781   | 183,613   | 183,613   |
|                                                                            | Montgomery County Total Housecount (1)                                               |                                                                        | 397,850 | 401,395 | 404,421 | 407,365 | 410,308 | 413,756   | 417,203   | 420,448   | 423,896   | 427,343   | 430,485   | 433,728   | 436,871   | 440,113   | 443,256   | 446,448   | 449,641   | 452,833   | 456,026   | 459,218   | 462,411   | 465,604   | 468,796   | 471,989   | 471,989   |
|                                                                            | Employment (NR proxy) (1)                                                            |                                                                        | 549,300 | 555,100 | 560,900 | 566,700 | 572,500 | 578,900   | 585,300   | 591,700   | 598,100   | 604,500   | 609,100   | 613,600   | 618,200   | 622,800   | 627,400   | 631,950   | 636,500   | 641,050   | 645,600   | 650,150   | 654,700   | 659,250   | 663,800   | 668,350   | 668,350   |
|                                                                            | Total County Managed Waste CY2021 (Tons) (2)                                         |                                                                        | 910,928 | 988,658 | 991,528 | 994,398 | 997,268 | 1,000,138 | 1,003,008 | 1,005,878 | 1,008,748 | 1,011,618 | 1,014,488 | 1,017,358 | 1,020,228 | 1,023,098 | 1,025,968 | 1,028,838 | 1,031,708 | 1,034,578 | 1,037,448 | 1,040,318 | 1,043,188 | 1,046,058 | 1,048,928 | 1,051,798 | 1,054,668 |
|                                                                            | Backyard                                                                             | Low Scenario (tons/yr): Assume 5.0 lbs captured for household per week |         |         |         | 1,699   | 1,704   | 1,709     | 1,718     | 1,726     | 1,734     | 1,742     | 1,751     | 1,759     | 1,769     | 1,777     | 1,786     | 1,795     | 1,804     | 1,813     | 1,821     | 1,830     | 1,839     | 1,848     | 1,857     | 1,866     | 1,874     |
| Medium Scenario (tons/yr): Assume 6.75 lbs captured for household per week |                                                                                      |                                                                        |         |         | 2,293   | 2,760   | 3,230   | 3,710     | 4,194     | 4,682     | 4,705     | 4,728     | 4,751     | 4,775     | 4,798     | 4,823     | 4,846     | 4,870     | 4,894     | 4,918     | 4,942     | 4,965     | 4,989     | 5,013     | 5,037     | 5,061     | 5,061     |
| High Scenario (tons/yr): Assume 8.5 lbs captured for household per week    |                                                                                      |                                                                        |         |         | 2,888   | 4,055   | 5,230   | 6,424     | 7,629     | 8,843     | 8,886     | 8,930     | 8,973     | 9,020     | 9,064     | 9,110     | 9,154     | 9,199     | 9,244     | 9,289     | 9,334     | 9,379     | 9,424     | 9,469     | 9,515     | 9,560     | 9,560     |
| Community                                                                  | Low Scenario (tons/yr): Assume 5 composting sites                                    |                                                                        |         |         | 40      | 40      | 41      | 41        | 41        | 41        | 42        | 42        | 42        | 43        | 43        | 43        | 44        | 44        | 44        | 44        | 44        | 45        | 45        | 45        | 45        | 45        | 46        |
|                                                                            | Medium Scenario (tons/yr): Assume 15 composting sites                                |                                                                        |         |         | 120     | 121     | 122     | 123       | 123       | 124       | 125       | 126       | 127       | 128       | 129       | 130       | 131       | 131       | 132       | 133       | 133       | 134       | 134       | 134       | 134       | 134       | 137       |
|                                                                            | High Scenario (tons/yr): Assume 30 composting sites                                  |                                                                        |         |         | 240     | 242     | 243     | 245       | 247       | 249       | 251       | 252       | 254       | 256       | 258       | 259       | 261       | 262       | 264       | 265       | 266       | 268       | 268       | 268       | 268       | 268       | 274       |
| On Farm                                                                    | Low Scenario (tons/yr): Assume on-farm production is 0.01 tons per acre per month    |                                                                        |         |         |         | 425     | 425     | 425       | 425       | 425       | 425       | 425       | 425       | 425       | 425       | 425       | 425       | 425       | 425       | 425       | 425       | 425       | 425       | 425       | 425       | 425       | 425       |
|                                                                            | Medium Scenario (tons/yr): Assume on-farm production is 0.05 tons per acre per month |                                                                        |         |         |         | 2,124   | 2,124   | 2,124     | 2,124     | 2,124     | 2,124     | 2,124     | 2,124     | 2,124     | 2,124     | 2,124     | 2,124     | 2,124     | 2,124     | 2,124     | 2,124     | 2,124     | 2,124     | 2,124     | 2,124     | 2,124     | 2,124     |
|                                                                            | High Scenario (tons/yr): Assume on-farm production is 0.07 tons per acre per month   |                                                                        |         |         |         | 2,974   | 2,974   | 2,974     | 2,974     | 2,974     | 2,974     | 2,974     | 2,974     | 2,974     | 2,974     | 2,974     | 2,974     | 2,974     | 2,974     | 2,974     | 2,974     | 2,974     | 2,974     | 2,974     | 2,974     | 2,974     | 2,974     |
| Private                                                                    | Low Scenario (tons/yr): Assume annual growth of 4%                                   |                                                                        | 2,500   | 2,569   | 2,672   | 2,779   | 2,890   | 3,006     | 3,126     | 3,251     | 3,381     | 3,516     | 3,657     | 3,803     | 3,955     | 4,114     | 4,278     | 4,449     | 4,627     | 4,812     | 5,005     | 5,205     | 5,413     | 5,630     | 5,855     | 6,089     |           |
|                                                                            | Medium Scenario (tons/yr): Assume annual growth of 6%                                |                                                                        | 2,500   | 2,619   | 2,776   | 2,943   | 3,119   | 3,306     | 3,505     | 3,715     | 3,938     | 4,174     | 4,424     | 4,690     | 4,971     | 5,270     | 5,586     | 5,921     | 6,276     | 6,653     | 7,052     | 7,475     | 7,924     | 8,399     | 8,903     | 9,437     |           |
|                                                                            | High Scenario (tons/yr): Assume annual growth of 8%                                  |                                                                        | 2,500   | 2,668   | 2,882   | 3,112   | 3,361   | 3,630     | 3,921     | 4,234     | 4,573     | 4,939     | 5,334     | 5,761     | 6,221     | 6,719     | 7,257     | 7,837     | 8,464     | 9,141     | 9,873     | 10,662    | 11,515    | 12,437    | 13,431    | 14,506    |           |

Sources:  
(1) "Housecount Data CY for ML" provided by the county 04/21/2023. Housecount and employment data extrapolated from County projections for 2041-2045.  
(2) Waste categories and CY21 tons from CY2021CaptureModel, Montgomery County, 5/16/2022.

Notes:  
(1) Backyard composting scenarios assume participation only by Single-family households.



## **Appendix B:**

# **Current County Food Scrap Diversion Efforts**

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# Food Scraps Programs and Initiatives



**April 2023**

# Food Scraps

## The Next Opportunity

- Recycling food scraps provides our next greatest opportunity to reduce waste and recycle more
- Important part of the County's waste diversion and recycling efforts, aiming towards zero waste
- Important element in fighting climate change



**Fruits, Vegetables,  
Meats, Fish,  
& Bones**

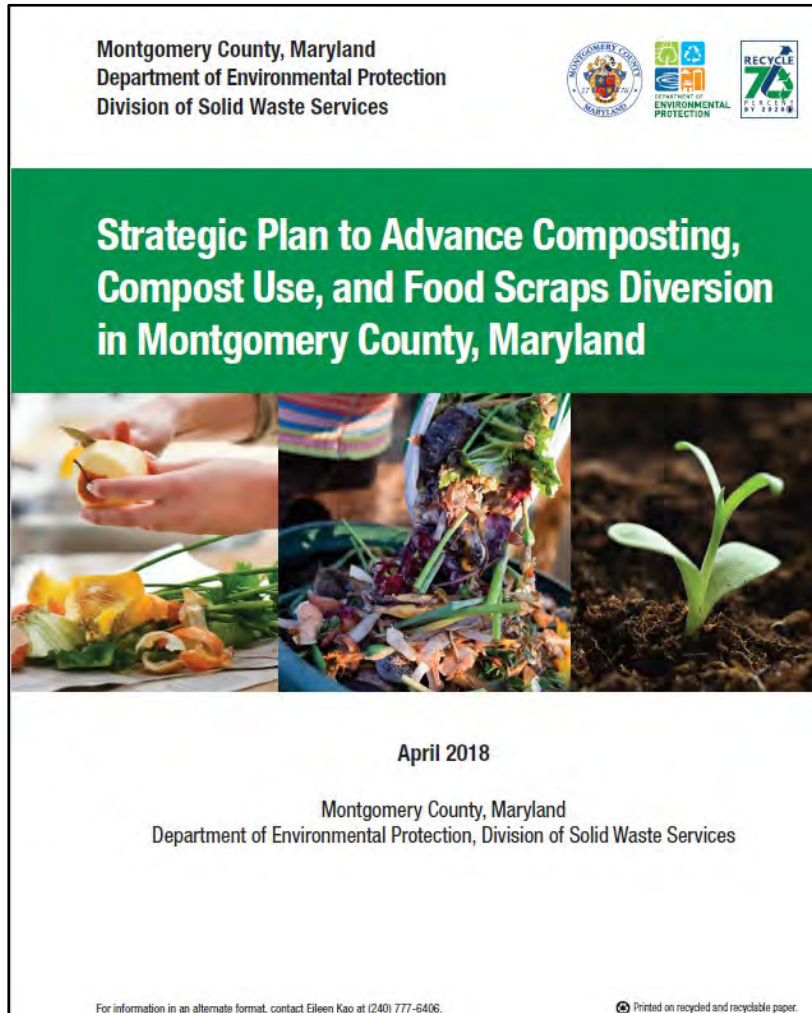


**Breads, Grains,  
Baked Goods,  
& Dairy Products**



**Soiled Paper Products  
& Compostable  
Containers**

# Implementation of The Strategic Plan



Reducing Wasted Food/Channeling Food to Others



In-Home, Backyard, and Community-Scale Composting



On-Site Institutional and On-Site Business Composting



On-Farm Composting



Composting Capacity to Serve Montgomery County



Strategies to Maximize Food Scraps Collection at the Curb



# Reducing Wasted Food & Channeling Food to Others



**Michael Rehm, Head Chef**  
Hilton Washington DC/Rockville Hotel



# Reducing Wasted Food

- Developed additional outreach and educational materials to reduce wasted food
  - Brochure
  - Magnet
- Expanded education and training opportunities to include:
  - More mindful purchasing;
  - Meal preparation tips;
  - Food storage recommendations; etc.
- Translated information into Spanish, Mandarin and French





# Reducing Wasted Food & Channeling Food to Others

## Developed/Updated Educational Materials





# Food is Too Good to Waste Education Campaign



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## FOOD IS TOO GOOD TO WASTE

Reducing food waste  
begins with you.

**DON'T WASTE IT!**

## LA COMIDA ES DEMASIADO BUENA PARA DESPERDICIARLA

La reducción  
del desperdicio  
de alimentos  
comienza contigo.

**¡NO LA  
DESPERDICIES!**

## LA NOURRITURE EST TROP BONNE POUR ÊTRE GASPILLÉE

Réduire le gaspillage  
alimentaire commence  
avec vous.

**NE LE GASPILLEZ  
PAS!**

## 食物很宝贵， 不能浪费

减少食物浪费从你做起

**不要浪费食物！**

## BUY IT

**CÓMPRALA • 购买  
ACHÈTEZ-LE**



## COOK IT

**COCÍNALA • 烹饪  
CUISEZ-LE**



## ENJOY IT

**DISFRÚTALA • 享受食物  
DÉGUSTEZ-LE**



## SAVE IT

**GUÁRDALA • 保存  
CONSERVEZ-LE**



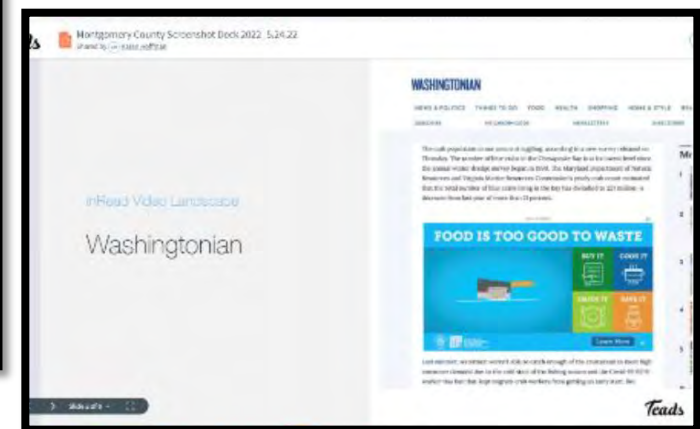
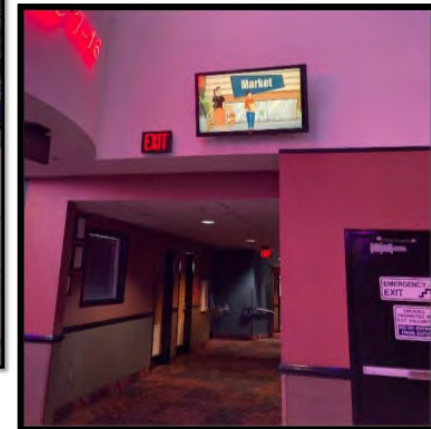
[MontgomeryCountyMD.gov/ReduceFoodWaste](http://MontgomeryCountyMD.gov/ReduceFoodWaste) • 311 or 240-777-0311



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# Food is Too Good to Waste Education Campaign

- Cable television
- Streaming radio
- Bus advertising
- Bike kiosks
- Mobile
- Social media
- Web streaming
- Chamber of Commerce websites
- Cinema
- Insert in weekly Food Section of *The Washington Post*



# Food Waste Prevention Week



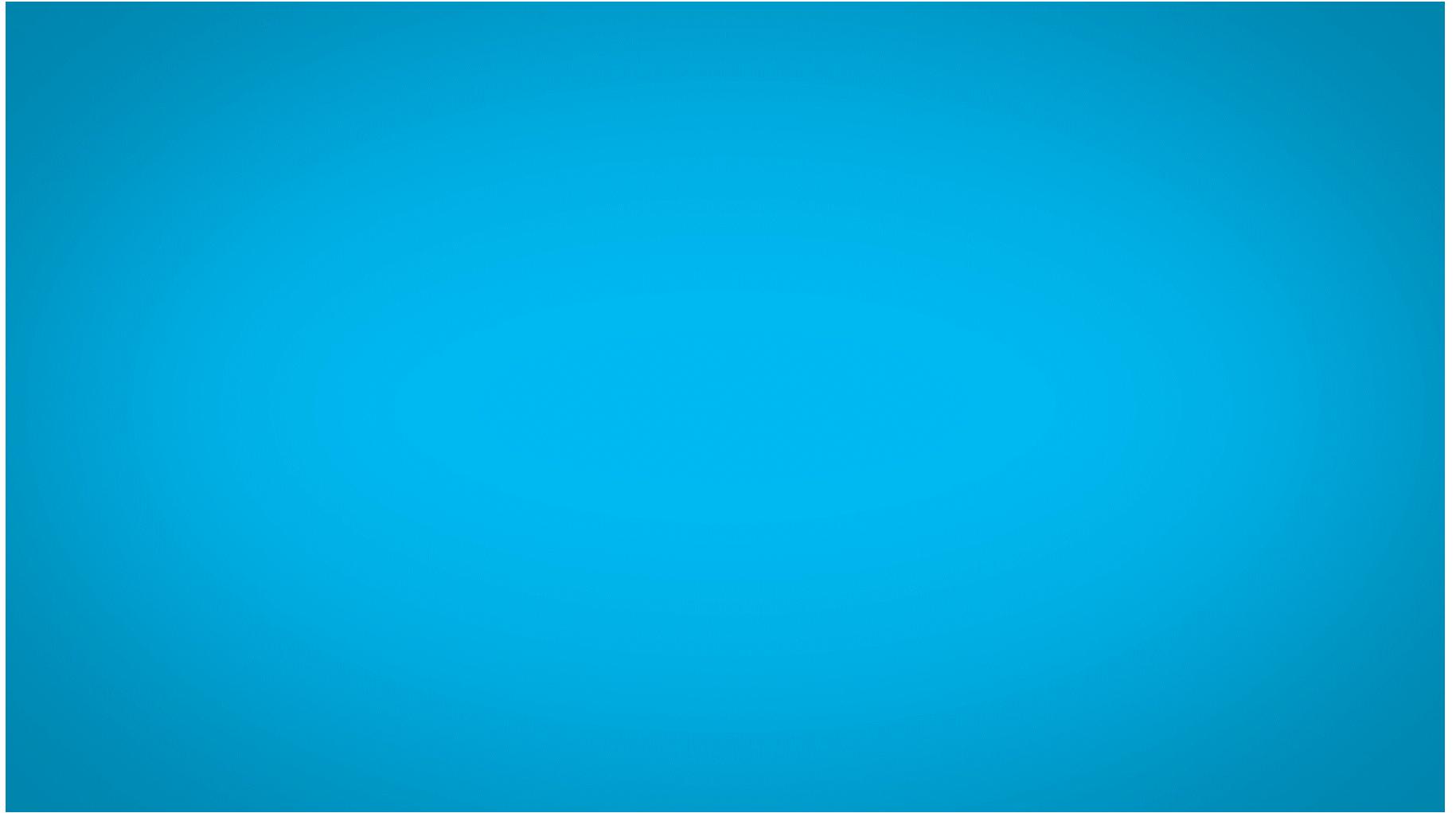
- Increase community awareness regarding the amount of food waste generated and how to take action to reduce wasted food at home, work and school
- Dedicated national Food Waste Prevention Week from April 10-16, 2023
- DEP/RRMD is a registered Food Waste Prevention Week Partner
- Broad-based multi-media educational campaign with heightened level of focus during Food Waste Prevention Week
- Daily social media posts during week
- Focused multi-lingual outreach at three shopping centers providing information in English, Spanish and Mandarin

# Reducing Wasted Food & Channeling Food to Others

- Increase Awareness of Reducing Wasted Food and Food Donations
  - Educational Materials
    - Tips to Reduce Wasted Food by Business Type
    - Update information in existing educational materials
  - Broad-Based Awareness Campaign
    - Tips to reduce wasted food
    - Tips to donate and channel food to those in need
  - Seminars and Webinars
    - Presentations
    - Guest speakers/Case Studies
- Review current efforts undertaken by businesses and organizations and multi-family properties to identify and encourage best practices







# Edible Food Recovery

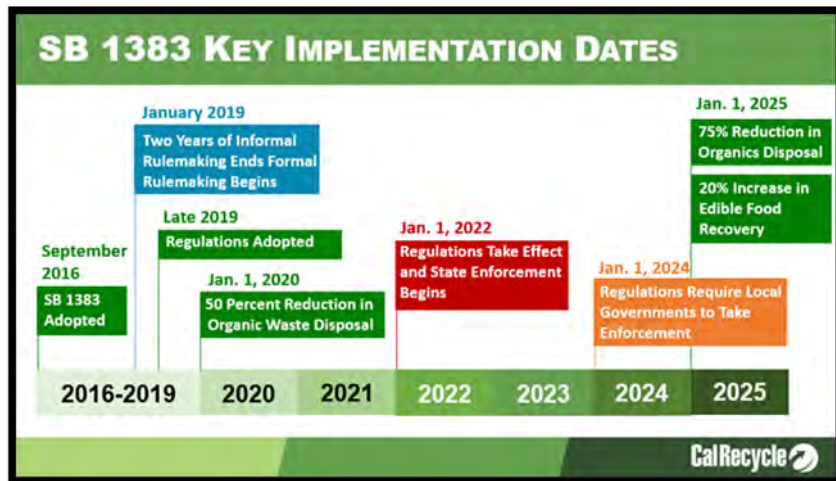


- Channel edible food in excess of generators' needs to others with unmet needs
- Increase donation of edible food to organizations that distribute/provide food to community members experiencing food insecurity
- Created/convened Working Group of County agencies and community partners to develop recommendations





# Edible Food Recovery



- Reviewed edible food recovery aspects of California SB 1383
- Benchmarked edible food recovery requirements in other states
- Work to define what makes sense for Montgomery County
- Developing policy recommendations to present to County Executive

# Backyard Composting of Food Scraps





# Backyard Composting of Food Scraps

Test a variety of backyard compost bins designed to include certain types of food scraps for composting:

- ~ 1,000 resident volunteers
- Developed educational materials, including best management practices
- Conduct virtual training workshops
- Provide backyard compost bins and educational materials/resources to resident volunteers
- Monitor and provide troubleshooting techniques
- Use data and feedback to build program
- Additional survey tool to obtain feedback from residents

# Commercial Food Scraps Recycling Partnership Program



# Commercial Food Scraps Recycling Partnership Program

## Program Objectives:

Facilitate & increase food scraps recycling by generators, collectors, and processors; and document and demonstrate these efforts through measurement, feedback, and data.

## Program Status:

- 34 partners have participated or currently are in the Program
- 1 drop out (for specific reason)
- 6 on deck for future start dates
- All graduates continue recycling their food scraps







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- Technical assistance
- Educational materials
- Staff training
- Food scraps recycling containers and compostable bags
- Food scraps recycling collection service
- Food scraps recycling processing
- Tracking amounts of food scraps recycled

# THE NEXT STEP —FOR YOUR— BUSINESS

CAFES • RESTAURANTS  
HOTELS • CAFETERIAS  
GROCERY STORES

A collection of 20 food icons arranged in a grid-like pattern. The icons include: a slice of pizza, a banana, a hot dog, a slice of Swiss cheese, a burger, a slice of bread, a chicken drumstick, a piece of steak, a whole tomato, a head of broccoli, a carrot, an onion, another tomato, another burger, another slice of pizza, another hot dog, and a drink in a cup with a straw. The icons are drawn in a simple, stylized manner with a limited color palette.

EL SIGUIENTE PASO  
— PARA SU —  
NEGOCIO

CAFÉS • RESTAURANTES  
HOTELES • CAFETERÍAS  
TIENDAS DE COMESTIBLES

# Commercial Food Scraps Recycling Partnership Program

## Updated and Developed Educational Materials

- Educational Materials
  - Brochures
  - Posters
  - Labels
  - Manuals
  - Videos



**Track Your Food Scrap Recycling Program**

Food Scrap Recycling Collection Days: \_\_\_\_\_ Weight of the Empty Food Scrap Central Container: \_\_\_\_\_

1. Tie bag when container is no more than 80% full. 2. Remove bag and transfer bag to central container. 3. Weigh the full container. 4. Remove the food scrap container. Weekly: Clean and disinfect the container.

Follow the steps above and complete the chart below.

| Date | Time | Weight of Full Container | Staff Initials |
|------|------|--------------------------|----------------|
|      |      |                          |                |
|      |      |                          |                |
|      |      |                          |                |
|      |      |                          |                |
|      |      |                          |                |
|      |      |                          |                |
|      |      |                          |                |
|      |      |                          |                |
|      |      |                          |                |

| Date | Time | Weight of Full Container | Staff Initials |
|------|------|--------------------------|----------------|
|      |      |                          |                |
|      |      |                          |                |
|      |      |                          |                |
|      |      |                          |                |
|      |      |                          |                |
|      |      |                          |                |
|      |      |                          |                |
|      |      |                          |                |
|      |      |                          |                |

**Recycling Food Scraps is Easy! Remember to Recycle...**

- Meats, Fish, and Bones
- Fruits and Vegetables
- Breads, Grains, and Pasta
- Dairy Products
- Coffee Grounds and Tea Bags
- Baked Goods
- Compostable or Biodegradable Items (Bags, Utensils, Takeout Containers, etc.)
- Soiled Paper and Cardboard Products with Food

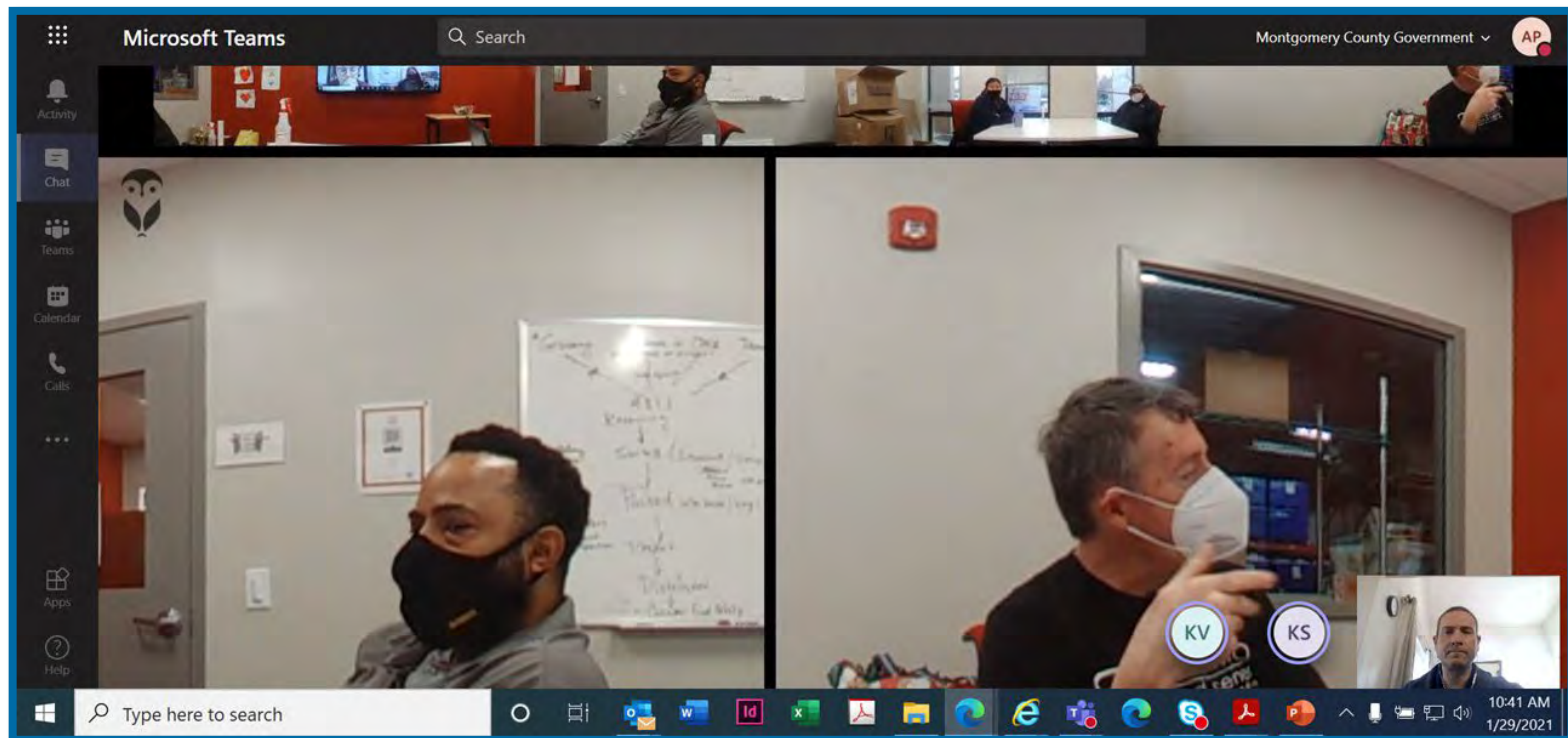
For more information on recycling food scraps and other materials, please visit [www.montgomerycountymd.gov/recycling](http://www.montgomerycountymd.gov/recycling).



# Commercial Food Scraps Recycling Partnership Program

## Tools and Resources for Partners

- Training
  - On-site or virtual training opportunities
  - Bi-lingual as needed





# Single-Family Curbside Collection of Food Scraps



# Single-Family Curbside Collection of Food Scraps

## Phase I: Single-Family Curbside Food Scraps Recycling Pilot

- Maximum 1,700 total volunteer households in 2 pilot areas
  - 701 homes in area of Silver Spring in Subdistrict A
  - 348 homes in area of Potomac in Subdistrict B
- Weekly pickup
- Each household testing:
  - 35-gallon wheeled cart with locking lid
  - 2-gallon in-kitchen container
  - Compostable liners for in-kitchen container
  - Instructional & education materials





# Single-Family Curbside Collection of Food Scraps

## Monitoring and Evaluations

- Participation/set out rates
- Pounds of food scraps set-out by each household each collection
- Scale house tickets
- Total tonnages by area
- Contamination issues

## Feedback and Assessment

- Participant surveys (3-month, 6-month, 1-year)
- Focus Group research (1-year)



**Pilot experience, data and feedback will inform planning for future countywide program**

# Single-Family Curbside Collection of Food Scraps

## Phase II: Single-Family Curbside Food Scraps Recycling Pilot

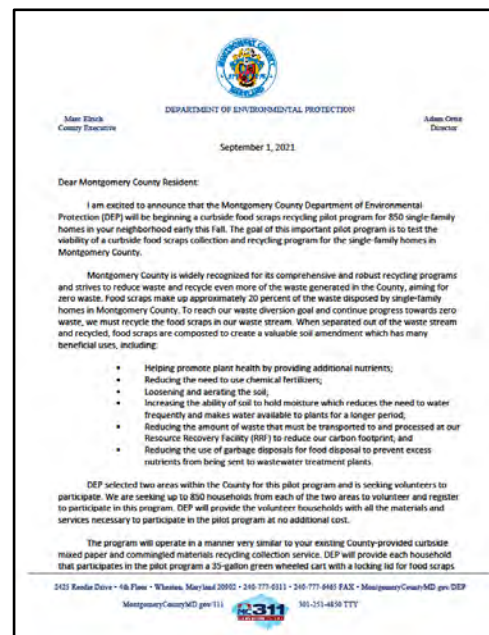
- Maximum 1,700 total volunteer households in 2 additional pilot areas
  - Area of Bethesda in Subdistrict A
  - Area of Montgomery Village/Gaithersburg in Subdistrict B
- Currently have 324 households registered in Bethesda
- Collection began March 27
- Currently have 139 households registered in Montgomery Village/Gaithersburg



# Single-Family Curbside Collection of Food Scraps

## Phase II: Single-Family Curbside Food Scraps Recycling Pilot

- Recruiting volunteer households that have never separated food scraps for recycling collection before in each of 2 areas
- Conducting targeted outreach to raise awareness and solicit participation
  - Letter from RRMD
  - Doorhangers
  - Outreach via any HOA's or Civic Associations within areas
  - Outreach by staff in the communities



# Questions?

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# **Appendix C:**

## **Single-Family Survey**

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## Public Participation Assessment

### Background:

As part of the feasibility study, the EA Team conducted a brief, online survey to:

- Help inform high capture tonnage projections for forecasting the adoption of food scraps and food waste diversion practices among single-family households. The aim was to develop a more realistic understanding of the rate at which households might embrace diversion approaches. This involved assessing the current and potential engagement of residents in various food scraps and food waste diversion approaches.

The survey targeted residents living in single-family houses, townhouses, or small apartment buildings with six or fewer units (collectively referred to as SFH population).<sup>1</sup> The survey gathered insights and perceptions about food waste diversion approaches such as curbside food scraps collection, food scraps drop-off stations, backyard composting, and edible food donation to food banks and shelters.

Qualitative input from this survey complemented the EA Team's quantitative data that is the foundation for forecasting tonnage projections. Asking residents about their current habits to reduce and divert food waste and their likelihood to adopt new behaviors provided the EA Team information on emerging trends not present in historical data. Survey findings were incorporated into the EA Team's food waste management scenario projections.

### Methodology:

#### Survey Development Process

The EA Team met with MES and Montgomery County staff to review and confirm project goals and obtain relevant materials and resources to review prior to developing the survey. In this meeting, MES and Montgomery County staff shared information about the extensive work the Recycling Resource Management Division (RRMD) has conducted on initiatives to reduce food waste and support food scraps recycling in residential and business settings. The EA Team reviewed several RRMD products (e.g., food scraps recycling presentation, webinar, County-wide waste survey, reports) and met with the RRMD team to learn more about past, current, and upcoming food scraps and food waste recycling initiatives. After reviewing this input and the team's experience developing similar surveys in other municipalities, the EA Team created a brief survey that explored residents' current habits regarding food scraps and food waste, and their level of interest in a variety of different approaches to reduce and divert food waste from trash (see Appendix C-1). The EA Team, MES and Montgomery County staff agreed that to maximize response for a voluntary survey, it was important to keep the survey short. Once the survey was finalized by the County and EA Team, the County translated the survey into

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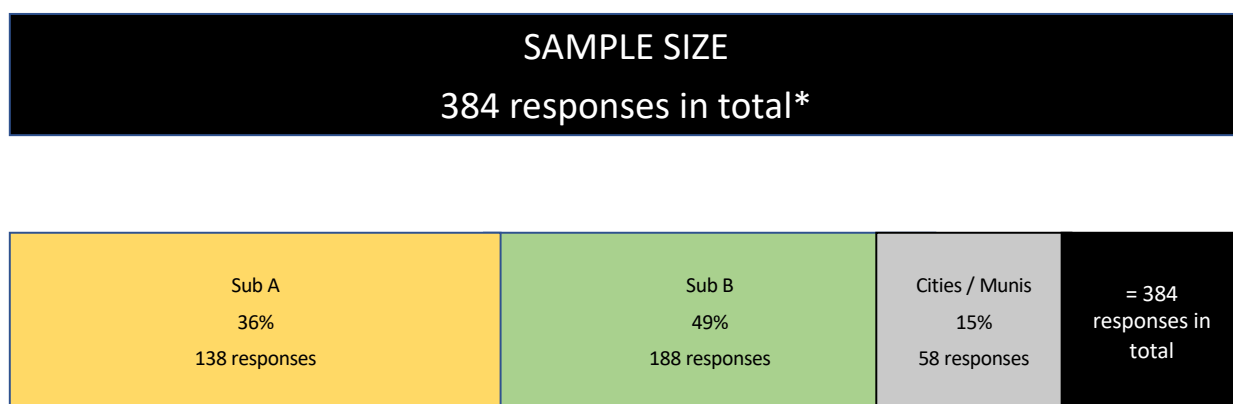
<sup>1</sup> Montgomery County chose not to deploy surveys to multi-family owners/operators and business and institution managers.

Spanish. Shareable links to both the English and Spanish survey were included in County communications to residents, giving them the option to respond to either one.

#### Sample Sizes for Target Populations

The EA Team calculated smaller target sample sizes which enabled us to gather data efficiently while meeting the budget and time requirements of the project. The Team determined the appropriate sample sizes (i.e., completed survey responses) for four target populations of interest for the County: 1) total survey responses, 2) responses from municipalities, 3) responses from Subdistrict A, and 4) responses from Subdistrict B. Chart 1-1 shows the sample sizes, which were determined based on a 95% confidence level and a 5% margin of error.

Chart 1-1. Desired Sample Sizes for Study's Populations of Interest



\* Sample size is based on total SFH with less than or equal to six units in Subdistrict A, Subdistrict B, Cities/Municipalities from CY 2022

Because County-provided background reports (see bulleted list below) for each target population were zip code based, the EA Team matched survey respondents with their respective target populations using the zip codes they provided in response to a survey question. This match was done using the following County-provided sources:

- GIS map of County zip codes
- Zip code information from a table listed in the 'Comprehensive Solid Waste Management Plan 2020-2029' (Table 3.4 Materials Management in Incorporated Cities and Municipalities)
- Detailed County map illustrating distinct regions for each municipality, Subdistrict A, and Subdistrict B; and House Count Data from 2022

By tracking the zip codes of incoming survey respondents, the EA Team was able to monitor at what point the survey had reached the target sample size for each population.

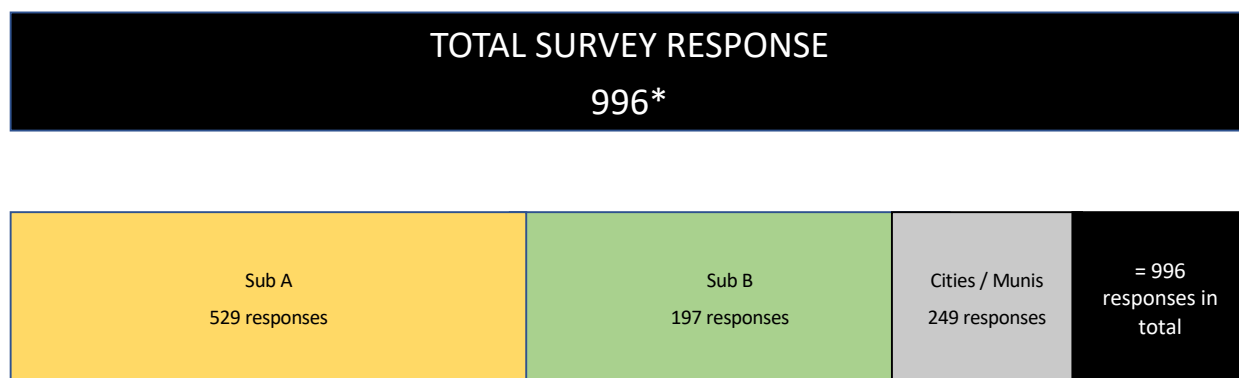
#### Survey Distribution



The surveys were distributed by the County via multiple channels through messages that included a shareable link sending respondents to the SurveyMonkey platform. The EA Team developed content to support promoting the survey in email, newsletters, social media, and other distribution channels. DEP's Partnership and Engagement Program Manager distributed the survey link and QR code to multiple email lists and networks over the course of four weeks, June 8 through July 6, 2023. For a more comprehensive list of the promotion channels, see Appendix C-2.

To increase responses in particular regions when numbers were lower than in other areas, the County's Partnership and Engagement Program Manager targeted outreach to those areas. In this way, additional outreach assisted in achieving the desired sample size for all areas. Once the sample sizes were reached, the EA Team closed the survey (see Chart 1-2).

Chart 1-2. Sample Sizes Reached for Each Target Population



\* Sample size is based on total SFH with less than or equal to six units in Subdistrict A, Subdistrict B, Cities/Municipalities from CY 2022

### Data Limitations

It is important to note that while small sample sizes have limitations, they can still be appropriate and informative in certain contexts, such as for this forecasting tonnage projections study. As discussed with MES and the County, with a small sample size and a shareable link survey, however, it becomes difficult to perform statistically significant, meaningful analysis on subgroups within the sample (i.e., by race, income, language, etc.). Subgroup analyses with a small sample and a shareable link survey size lack statistical power and result in unreliable conclusions. Therefore, the EA Team cautions against generalizing survey subgroup findings to the broader County population.

## Results and Analysis

Listed below are highlights of survey results:

- In total, 996 residents responded to the survey (992 took the English survey and four residents took the Spanish survey).
- Over 90% respondents agreed that getting edible food waste and food scraps out of the waste stream is the right thing to do for the environment.
- There was strong support for the idea of participating in a County-sponsored curbside collection program. Fewer than 10% of residents said they would *not* participate, except for Subdistrict B respondents, where that number was higher (18% of residents).
- Responses to questions were frequently similar across all target populations.

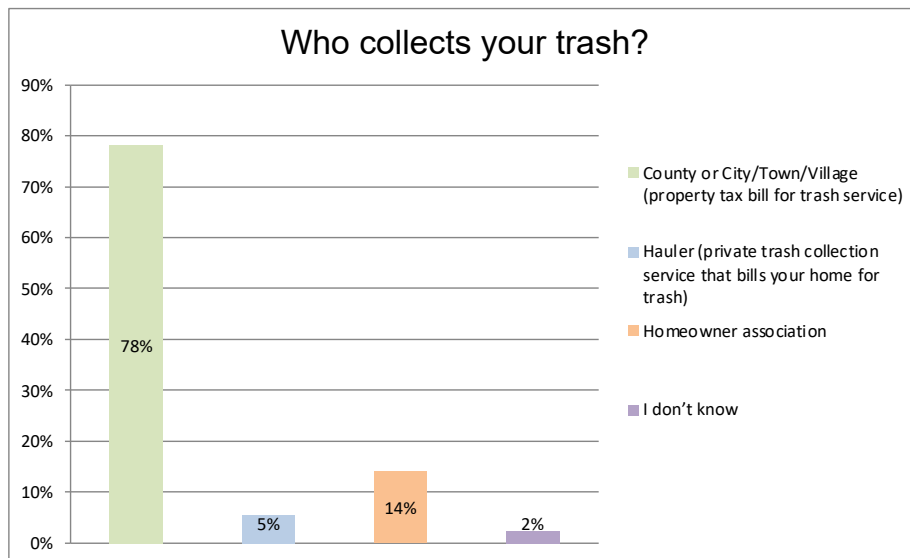
The intent of the resident survey was to gather information about residents' attitudes and behaviors regarding food waste and food scraps management to help inform tonnage projections. It assessed current practices and gauged interest in potential programs like curbside food scraps collection or backyard food scraps composting. The survey aimed to understand residents' concerns and level of agreement with making food scraps separation and collection mandatory. Additionally, the survey determined the frequency of food donations to shelters or food banks and the likelihood of residents using nearby drop-off locations for such donations if available.

Responses to all survey questions and respondents' demographic data are provided in Appendix C-3. Survey comments are provided in Appendix C-4. Below are responses and a brief analysis of the questions that most pertain to the tonnage projections.

### Residential Trash Collection

78% of survey participants' trash is collected by the County or a City, Town or Village (see Chart 1-3).

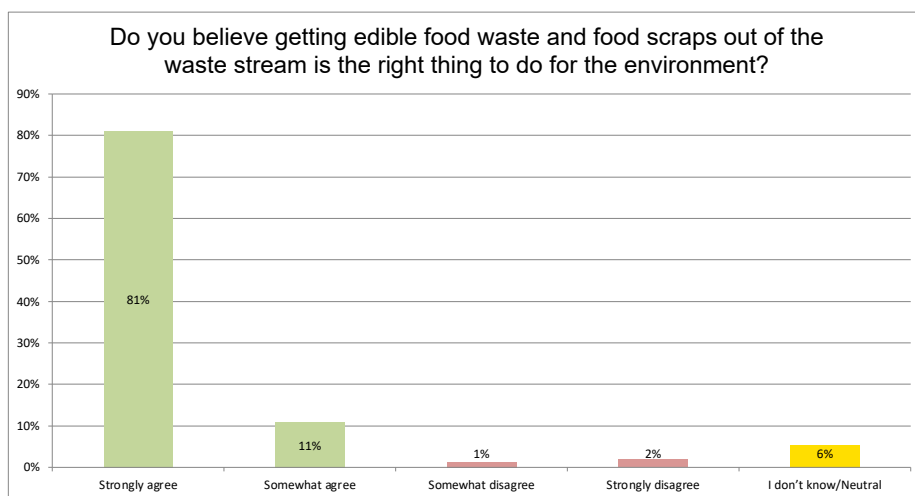
Chart 1-3. Majority of Respondents Indicate Their Trash is Collected by the County, or a City, Town or Village.



#### Diverting Food Scraps and Food Waste from Waste Stream

Over 90% of respondents agreed that getting edible food waste and food scraps out of the waste stream is the right thing to do for the environment (Chart 1-4). This aligns with other waste management studies conducted by the County, including the Montgomery County 'Aiming for Zero Waste Plan Baseline Survey Summary'. Many County residents have said in surveys they place value on “doing the right thing” for the natural environment.

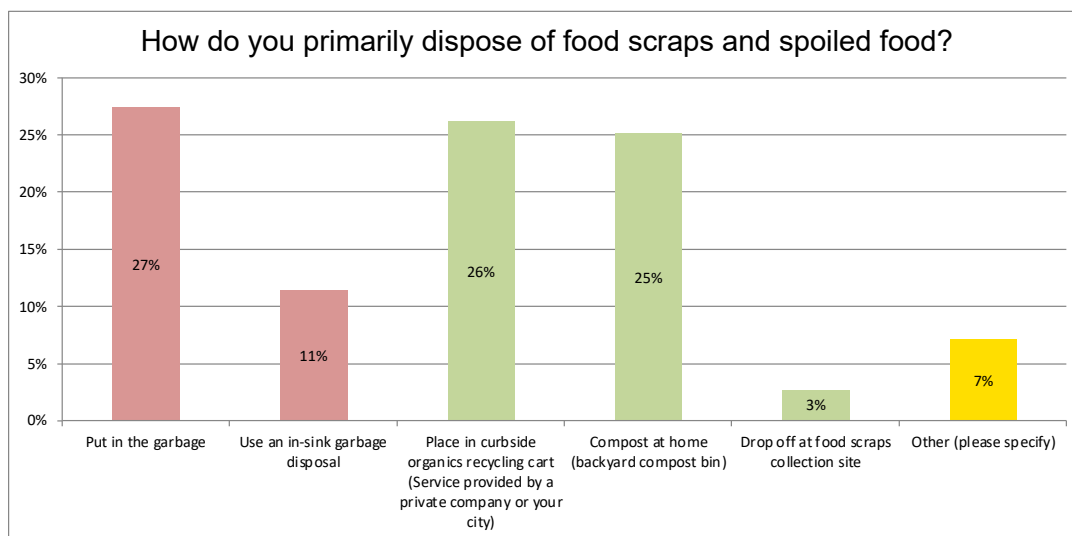
Chart 1-4. High Level of Support for Diverting Food Scraps and Food Waste from Waste Stream



## Current Habits for Food Waste Disposal

More than 50% of survey respondents reported they backyard compost, use a private collection service (e.g., Compost Crew), or drop off food scraps at a collection site (see Chart 1-5).

Chart 1-5. Survey Respondents Included Current Composters and Non-Composters



Many of the respondents who selected the option 'other' used the comments field to describe their approach to food scraps and spoiled food disposal. The majority of commenters already do some type of composting. Some respondents said they only compost fruits and vegetables; others said they use grocery store drop-off sites such as at Mom's Organics or Whole Foods; and, others drop off food scraps at a farmer's market during the summer. Other comments described the use of food planning strategies to minimize waste. Comments also revealed topics that could be addressed in awareness and education materials. Some respondents noted they use the garbage disposal for food scraps to "keep it out of the landfill," which can be an issue for public utility pipes. Another stated that they have no food waste because "they eat everything."

Responses to this question reveal an opportunity for the County to deploy outreach/education to help all residents understand the definition of food scraps and edible food waste. Educating on the compost process, as well as on what constitutes edible food waste (leftovers) versus food scraps (e.g., banana peels, orange rinds, coffee grounds, etc.) would likely broaden participation in currently available composting programs and prepare residents for a future County-wide program.

## Curbside Food Scraps Collection

In general, there was strong support for the idea of participating in a County-sponsored curbside food scraps collection program. This is evident in that fewer than 10% of residents said they would not participate, except for Subdistrict B respondents, where the number who indicated they would not

participate was higher (18%). Nonetheless, more than half of Subdistrict B respondents indicated they would participate in a County-wide program.

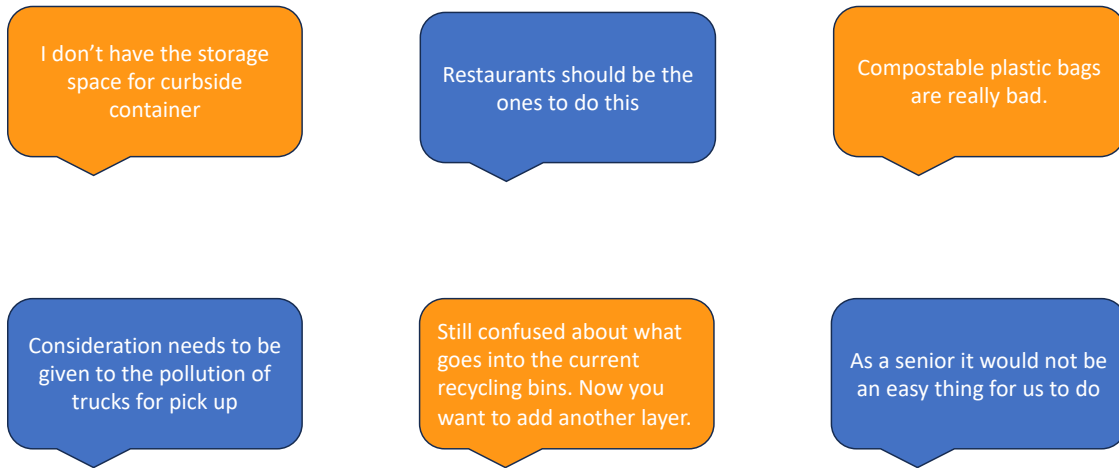
Of the total responses for Subdistrict B, 29% answered ‘no’ or ‘I don’t know’ in response to the prompt asking if they would participate in a voluntary curbside collection program (Table 1-1). Subdistrict B residents’ interest could be explored further to better understand their perceived barriers. This could be done through focus groups or in-person surveying at highly frequented venues such as libraries, local coffee shops, kids’ sporting events, and community events.

Table 1-1. Willingness to Participate in a Curbside Food Scraps Collection Program If Offered<sup>2</sup>

| Q8                                                                                                                                                                           |              | Subdistrict A | Subdistrict B | Municipalities | All Respondents |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|---------------|---------------|----------------|-----------------|
| If the County offered curbside food scraps collection, would you participate? You would separate food scraps from your garbage and place them in a curbside bin for pick up. | Yes          | 83%           | 58%           | 74%            | 82%             |
|                                                                                                                                                                              | No           | 5%            | 18%           | 9%             | 10%             |
|                                                                                                                                                                              | I don't know | 7%            | 11%           | 8%             | 9%              |

For residents who stated they would not or were unsure if they would participate in a curbside food scraps collection program, the survey included a follow up question exploring their concerns. 25% of respondents were concerned about food scraps attracting insects and vermin. In the ‘Other’ option regarding respondents’ apprehension, respondents wrote specific concerns about attracting rats, raccoons, and “having a street filled with 100% food scraps on pick-up day, that will most certainly attract wildlife.” Concern about odor was also frequently listed. Additional reasons to not participate that were captured in the comments included:

<sup>2</sup> Subgroup percentages were calculated based on the number of people in that subgroup who took the survey. Some questions had fewer respondents. For this reason, the percentages in each subgroup column do not sum to 100.



It should also be noted, however, that in response to the follow-up question “What are your concerns about participating in a curbside food scraps program?”, 55% of the 66 respondents who commented in the ‘other’ option stated they currently compost and/or like the ability to create and use their own compost in their garden/yard.

80% of participants agreed with a potential proposed mandatory County food scraps separation and curbside collection program (Table 1-2). Like the voluntary curbside food scraps collection question (Table 1-1), fewer Subdistrict B respondents favored this idea. However, this does not mean that Subdistrict B is opposed to a mandatory program. It would be worth investigating this further by asking Subdistrict B residents in focus groups about a mandatory food scraps collection program. Insights from these conversations could help with the development of outreach and education materials if the County were to make curbside food scraps collection mandatory.

Table 1-2. Level of Agreement with a County Mandated Food Scraps Separation and Curbside Collection Program<sup>3</sup>

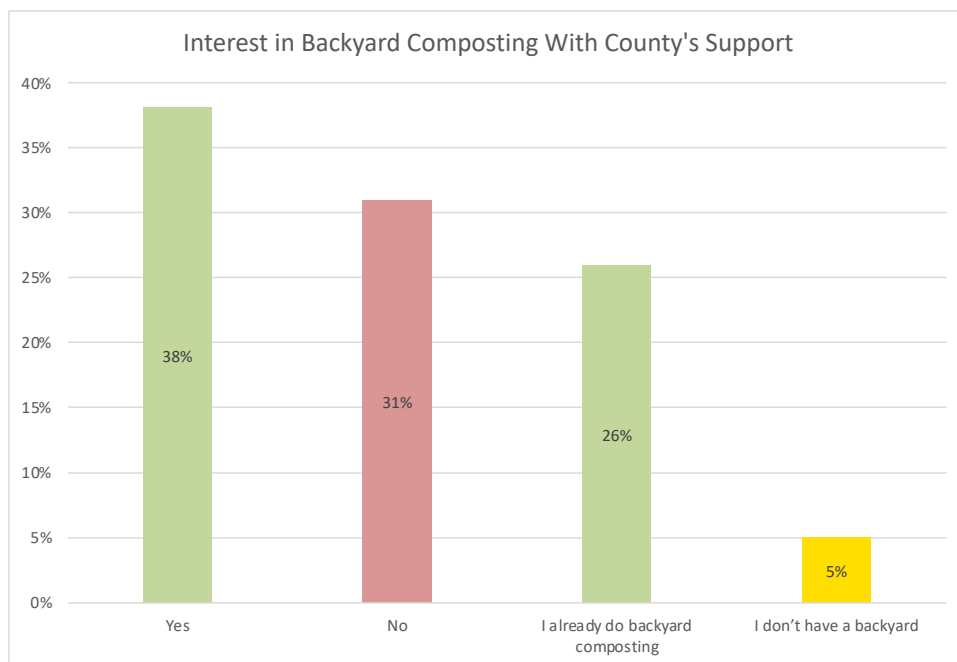
| Q10                                                                                                                                                                     |                    | Subdistrict A | Subdistrict B | Municipalities | All Respondents |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|---------------|---------------|----------------|-----------------|
| The County is considering making food scraps separation and curbside collection mandatory for households. What is your level of agreement with this potential approach? | Strongly agree     | 59%           | 34%           | 55%            | 57%             |
|                                                                                                                                                                         | Somewhat agree     | 21%           | 23%           | 19%            | 23%             |
|                                                                                                                                                                         | Somewhat disagree  | 6%            | 10%           | 6%             | 7%              |
|                                                                                                                                                                         | Strongly disagree  | 6%            | 18%           | 5%             | 9%              |
|                                                                                                                                                                         | Don't know/Neutral | 3%            | 3%            | 6%             | 4%              |

<sup>3</sup> Subgroup percentages were calculated based on the number of people in that subgroup who took the survey. Some questions had fewer respondents. For this reason, the percentages in each subgroup column do not sum to 100.

## Backyard Composting

Montgomery County currently has a backyard composting program in place. This survey probed interest in backyard composting for food scraps and yard waste. Close to 40% of 902 respondents expressed interest in participating in backyard composting if the County provided them support (see Chart 1-6). However, 30% of respondents were not interested in backyard composting. While the County currently has a backyard composting program for yard waste, there may be an opportunity to promote it more and provide materials and support on backyard food scraps and yard waste composting.

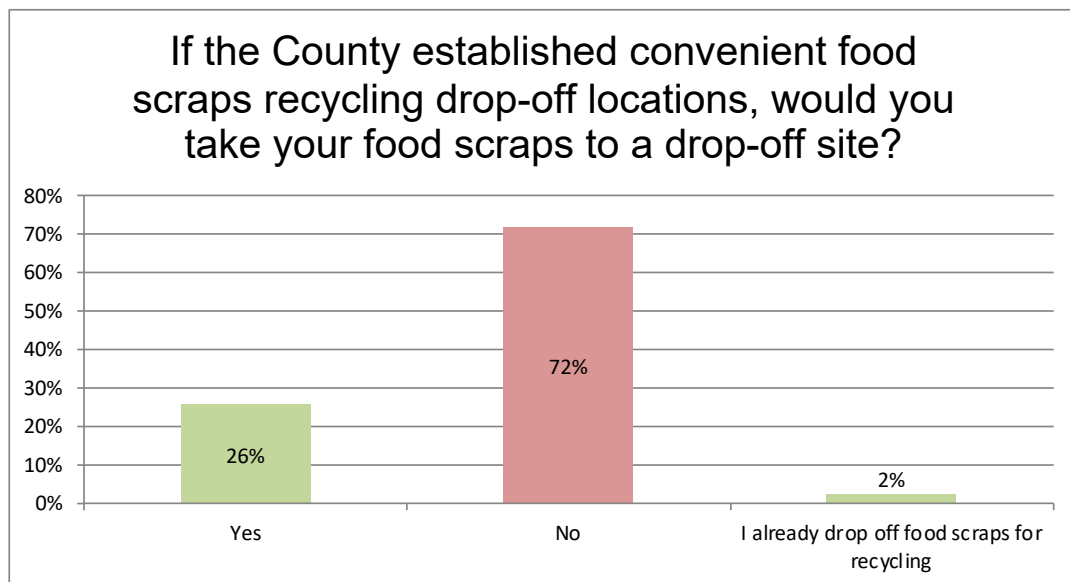
Chart 1-6. Moderate Interest Backyard Composting of Food Scraps and Yard Waste



## Drop-off Locations and Donation Centers

Generally, respondents across all sub-groups expressed low interest in dropping off food scraps, even at conveniently located sites (Chart 1-7). This is not surprising as the extra step of transporting food scraps to a drop-off location is a challenge people reference in most communities. However, it should be noted that residents of Takoma Park who use the local food scrap drop off site expressed strong support for this option.

Chart 1-7. Majority of Respondents Are Not Interested in Drop-off Locations



#### Edible Food Recovery

Currently, 3% of survey respondents donate excess edible food (e.g., to a shelter or local food bank) once a month. 78% either rarely or never donate their excess edible food (see Appendix C-3). It should be noted that when presented with the idea of donating excess edible foods at a nearby drop-off location, 19% of respondents indicated greater interest and that they would donate edible food frequently (once a month).

#### **Recommendations:**

Below is a list of recommendations the County may want to consider if it opts to develop a curbside food scraps collection program:

- 1) **Continue to collect input about a curbside food scraps collection program, particularly among residents in equity emphasis areas and more rural parts of the County.** This does not have to be a costly effort. Asking residents about curbside composting during community events and identifying topics of concern offers an opportunity to informally gauge interest and field questions residents have about a potential program.
- 2) **Determine if a County curbside food scraps collection program will produce compost available for the community's use.** Residents who currently compost in their backyard or with a private companies said they liked having access to the finished product.
- 3) **Provide clarity on how this program will co-exist with privately run food scraps collection programs.** Be prepared to respond to questions about how a County food scraps collection program will work with private service offerings such as Compost Crew, Takoma Park food scraps drop off sites, etc. Because people can feel loyal towards their private compost service or comfortable with an established routine, communication will need to address that.



- 4) **Develop more than one message for building community support.** While much of the County's residents will agree that composting is the right thing to do for the environment, additional messages – such as ones that mention the economic benefits to the County or that local parks and gardens will see improved soil – will appeal to other residents.
- 5) **Learn more about Takoma Park's drop-off site.** If the County is interested in drop-off sites, the Takoma Park location is one to investigate. Variables such as how much volume is received, percentage of contamination, hours of operation, and frequency of drop-offs can help the County plan additional drop-off sites.

## Conclusion

As stated previously, the EA team used survey response data to help inform high capture tonnage projections for the widespread adoption of food scraps and food waste diversion practices among single-family households.

The survey findings demonstrate there is interest in food scraps collection in the County. While a concerted effort was made to reach a variety of audiences using a shareable link survey distributed through County e-newsletters, emails, and social media, many of the respondents either already compost food scraps or are supportive of composting. This might be due to the explosive growth in awareness of composting and in availability of private haulers servicing the County in recent years; or, that those who believe in the value of composting felt compelled to respond to the survey to ensure their voices are heard. As previously stated, due to the small sample size and the shareable link survey method, the County should continue to explore the community's interest in composting while simultaneously raising awareness of the benefits of developing a food scraps program.

As the County explores the optimal approach for food waste diversion through a curbside collection program, it is advisable to maintain an ongoing dialogue with residents to further explore the level of interest in such a program. RRMD could capitalize on current outreach activities (e.g., backyard composting, single-family household food scraps and recycling collection pilot, and promotion of reducing wasted food and edible food recovery) underway by the Waste Recycling and Resource Management Division. RRMD could also engage residents at local events, conduct community conversations, or organize focus groups to expand engagement. This proactive outreach and continued community input will raise awareness about curbside food scraps collection and other diversion approaches. It will also serve to identify potential partners and influential groups throughout the County to support curbside collection program promotion in the future. Sustained community engagement will be invaluable should the County decide to advance a County-wide food scraps collection program, as resident feedback can serve as the foundation for a well-defined strategy that effectively addresses the questions and concerns of many residents.

## Appendix C-1.

### Montgomery County Survey

We want to hear from our residents!

**Montgomery County is a national leader in reducing waste and improving recycling. Together we can go further! Reducing food waste and separating food scraps from the trash is the next greatest opportunity for the County to address its sustainable waste management goals.**

**We want to hear from residents to help inform policies and programs. The survey should take approximately 10 minutes to complete. Survey responses are anonymous.**

**Thank you for taking the survey and supporting our County!**

## Montgomery County Survey

1. Do you live in Montgomery County?

☐ Yes

☐ No

Montgomery County Survey

2. What is your home zip code in Montgomery County? [fill in blank]

## Montgomery County Survey

3. Do you live in a single-family house, townhouse, or a small apartment building (6 units or less)?

☐ Yes

☐ No

## Montgomery County Survey

### 4. Who collects your trash?

- ☐ County or City/Town/Village (property tax bill for trash service)
- ☐ Hauler (private trash collection service that bills your home for trash)
- ☐ Homeowner association
- ☐ I don't know

## Montgomery County Survey

5. Do you believe getting edible food waste and food scraps out of the waste stream is the right thing to do for the environment?

- ☐ Strongly agree
- ☐ Somewhat agree
- ☐ Somewhat disagree
- ☐ Strongly disagree
- ☐ I don't know/Neutral

## Montgomery County Survey

6. Do you practice any of the following habits to reduce your household's food waste? Select all that apply.

- ☐ Buy smaller quantities of fruits and vegetables
- ☐ Buy smaller quantities of prepared foods
- ☐ Freeze food, including leftovers
- ☐ Donate uneaten, edible food to local food banks and shelters
- ☐ All of the above
- ☐ None
- ☐ Other (please specify)



## Montgomery County Survey

### 7. How do you primarily dispose of food scraps and spoiled food?

- ☐ Put in the garbage
- ☐ Use an in-sink garbage disposal
- ☐ Place in curbside organics recycling cart (Service provided by a private company or your city)
- ☐ Compost at home (backyard compost bin)
- ☐ Drop off at food scraps collection site
- ☐ Other (please specify)

## Montgomery County Survey

**Montgomery County is considering new approaches for residents to reduce food waste. We would like your opinion on possible approaches.**

## Montgomery County Survey

8. If the County offered curbside food scraps collection, would you participate? You would separate food scraps from your garbage and place them in a curbside bin for pick up.

- ☐ Yes
- ☐ No
- ☐ I don't know

## Montgomery County Survey

9. What are your concerns about participating in a curbside food scraps program? Select your top concern.

- ☐ Too much trouble
- ☐ Need more information before making a decision
- ☐ Not enough space in my house to separate food scraps
- ☐ Potential odors
- ☐ Collecting food scraps attracts insects and vermin
- ☐ Concerned about the added cost associated with this
- ☐ Other (please specify)

## Montgomery County Survey

10. The County is considering making food scraps separation and curbside collection mandatory for households. What is your level of agreement with this potential approach?

- ☐ Strongly agree
- ☐ Somewhat agree
- ☐ Somewhat disagree
- ☐ Strongly disagree
- ☐ Don't know/Neutral

## Montgomery County Survey

11. If the County provided support to interested households for starting backyard composting, would you participate? You would separate food scraps and place them in a backyard rodent-proof compost bin.

- ☐ Yes
- ☐ No
- ☐ I already do backyard composting
- ☐ I don't have a backyard

## Montgomery County Survey

12. If the County established convenient food scraps recycling drop-off locations, would you take your food scraps to a drop-off site?

- ☐ Yes
- ☐ No
- ☐ I already drop off food scraps for recycling

## Montgomery County Survey

13. How often do you donate excess edible food (e.g., to a shelter or local food bank)?

- ☐ Frequently (once a month)
- ☐ Occasionally (several times a year)
- ☐ Rarely (once a year)
- ☐ Never



## Montgomery County Survey

14. How often would you donate excess edible foods to a nearby drop-off location if it were available?

- ☐ Frequently (once a month)
- ☐ Occasionally (several times a year)
- ☐ Rarely (once a year)
- ☐ Never

## Montgomery County Survey

**Almost done! Final three questions.**

## Montgomery County Survey

15. In what language do you prefer to receive written information?

- ☐ English
- ☐ Spanish
- ☐ Chinese
- ☐ French
- ☐ I prefer not to answer
- ☐ Other (please specify)

## Montgomery County Survey

### 16. What is your race or ethnicity? (Select all that apply)

- ☐ American Indian, Alaska Native, Native American, or Indigenous
- ☐ Asian
- ☐ Black or African American
- ☐ Middle Eastern or North African
- ☐ Native Hawaiian or Pacific Islander
- ☐ White
- ☐ Hispanic or Latino/Latina/Latine/Latinx
- ☐ I prefer not to answer
- ☐ I prefer to self-describe

## Montgomery County Survey

17. How much do you anticipate is your household's total income before taxes for the current year? (Please include in your total income money from all sources for all persons living in your household.)

- ☐ Less than \$25,000
- ☐ \$25,000 to \$49,999
- ☐ \$50,000 to \$74,999
- ☐ \$75,000 to \$99,999
- ☐ \$100,000 to \$149,999
- ☐ \$150,000 or more
- ☐ I prefer not to answer

## Montgomery County Survey

Thank you for your interest!

**Thank you for your interest in participating in our survey. This survey only targets residents who live in Montgomery County. We appreciate your time and apologize for any inconvenience.**

## Montgomery County Survey

Thank you for your interest!

**Thank you for your interest in participating in our survey. This survey only targets residents who live in a single-family house, townhouse, or small apartment building with six units or less. Future surveys will target additional County residents. We appreciate your time and apologize for any inconvenience.**

Montgomery County Survey

Thank you for your time!



## Encuesta del Condado de Montgomery

¡Queremos conocer la opinión de nuestros residentes!

**El Condado de Montgomery es líder nacional en la reducción de residuos y en promover el reciclaje. ¡Juntos podemos cuidar nuestra comunidad al máximo! Reducir el desperdicio de alimentos y separar los restos de comida de la basura es una gran oportunidad para la gestión sostenible de la basura.**

**Queremos escuchar a los residentes para formar el futuro de las políticas y los programas. La encuesta toma aproximadamente 10 minutos. Las respuestas de la encuesta son anónimas.**

**¡Gracias por participar en la encuesta y por apoyar a nuestro Condado!**

## Encuesta del Condado de Montgomery

1. ¿Vive usted en el Condado de Montgomery?

- ☐ Sí
- ☐ No

## Encuesta del Condado de Montgomery

2. ¿Cuál es el código postal de su casa en el Condado de Montgomery? [entre el numero en el espacio en blanco]

## Encuesta del Condado de Montgomery

3. ¿Vive usted en una casa unifamiliar, en un townhouse o un edificio pequeño de apartamentos (6 unidades o menos)?

☐ Sí

☐ No

## Encuesta del Condado de Montgomery

### 4. ¿Quién le recoge la basura de su casa?

- ☐ El Condado o Ciudad (servicio de basura incluido en la factura de impuestos de la propiedad)
- ☐ Una compañía privada de servicios de recolección de basura que factura a su hogar
- ☐ Asociación de propietarios (una HOA)
- ☐ No lo sé

## Encuesta del Condado de Montgomery

5. ¿Cree usted que separar de la basura los residuos de comida comestibles y no comestibles ayuda a proteger el medio ambiente?

- ☐ Totalmente de acuerdo
- ☐ Algo de acuerdo
- ☐ Algo en desacuerdo
- ☐ Totalmente en desacuerdo
- ☐ No lo sé/Neutral

## Encuesta del Condado de Montgomery

6. ¿Practica alguno de los siguientes hábitos para reducir el desperdicio de alimentos de su hogar? Seleccione todas las opciones que correspondan.

- ☐ Compro cantidades más pequeñas de frutas y verduras
- ☐ Compro cantidades más pequeñas de alimentos preparados
- ☐ Congelo los alimentos, incluyendo las sobras
- ☐ Hago donaciones de alimentos comestibles (que no se han tocado) a los bancos de alimentos y refugios locales
- ☐ Todo lo anterior
- ☐ Ninguno
- ☐ Otros:

## Encuesta del Condado de Montgomery

7. ¿Cómo se deshace principalmente de los restos de comida y los alimentos en mal estado?

- ☐ Los pongo en la basura
- ☐ Uso un triturador de basura en el fregadero/lavaplatos
- ☐ Los separo en un carrito de reciclaje para productos orgánicos en la acera (servicio proporcionado por una empresa privada o del Condado)
- ☐ Los pongo en un contenedor en el patio trasero para hacer compost en casa
- ☐ Los llevo a un sitio de recolección de restos de comida
- ☐ Otros:



Encuesta del Condado de Montgomery

**Condado de Montgomery está considerando nuevas formas para que los residentes reduzcan el desperdicio de alimentos. Nos gustaría conocer su opinión.**

## Encuesta del Condado de Montgomery

8. Si el Condado ofreciera recolección de restos de comida en la acera de donde usted vive, ¿Usted participaría? ¿Separaría los restos de comida de su basura y los colocaría en un contenedor junto a la acera para que el Condado lo recoja?

- ☐ Sí
- ☐ No
- ☐ No lo sé

## Encuesta del Condado de Montgomery

9. ¿Cuáles son sus preocupaciones acerca de participar en un programa de restos de comida en la acera? Seleccione su principales preocupaciones.

- ☐ Mucho trabajo
- ☐ No tengo suficiente información
- ☐ No hay suficiente espacio en mi casa para separar los restos de comida
- ☐ Posibles malos olores
- ☐ La recolección de restos de comida puede atraer insectos y alimañas
- ☐ Me preocupa el costo adicional asociado con esto
- ☐ Otros:

## Encuesta del Condado de Montgomery

10. El Condado está considerando hacer que la separación de restos de comida y la recolección en la acera sean obligatorias para los hogares. ¿Qué tan de acuerdo esta con este enfoque?

- ☐ Totalmente de acuerdo
- ☐ Algo de acuerdo
- ☐ Algo en desacuerdo
- ☐ Totalmente en desacuerdo
- ☐ No lo sé/Neutral

## Encuesta del Condado de Montgomery

11. ¿Si el Condado le apoya a usted en comenzar el compostaje en su patio trasero, usted separaría los restos de comida y los colocaría en un contenedor de compost a prueba de roedores?

- ☐ Sí
- ☐ No
- ☐ Ya hago compostaje en el patio trasero
- ☐ No tengo patio o jardín dónde hacer compostaje

## Encuesta del Condado de Montgomery

12. ¿Si el Condado estableciera lugares convenientes para llevar los restos de comida para ser reciclados, usted los llevaría?

- ☐ Sí
- ☐ No
- ☐ Ya los estoy llevando

## Encuesta del Condado de Montgomery

13. ¿Con qué frecuencia dona usted el exceso de alimentos comestibles (por ejemplo, a un refugio o banco de alimentos local)?

- ☐ Con frecuencia (una vez al mes)
- ☐ Ocasionalmente (varias veces al año)
- ☐ Raramente (una vez al año)
- ☐ Nunca

## Encuesta del Condado de Montgomery

14. ¿Con qué frecuencia donaría el exceso de alimentos comestibles a un lugar de entrega cercano si estuviera disponible?

- ☐ Con frecuencia (una vez al mes)
- ☐ Ocasionalmente (varias veces al año)
- ☐ Raramente (una vez al año)
- ☐ Nunca



Encuesta del Condado de Montgomery

¡Casi listo! Las ultimas tres preguntas.

## Encuesta del Condado de Montgomery

15. ¿En qué idioma prefiere recibir información escrita?

- ☐ Inglés
- ☐ Español
- ☐ Chino
- ☐ Frances
- ☐ Prefiero no responder
- ☐ Otros:

## Encuesta del Condado de Montgomery

16. ¿Cuál es su raza o etnicidad? Seleccione todas las opciones que correspondan.

☐ Indio americano, nativo de Alaska, nativo americano o indígena

☐ Asiático

☐ Negro o afroamericano

☐ Oriente Medio o África del Norte

☐ Nativo de Hawái o de las islas del Pacífico

☐ Blanco

☐ Hispano o Latino/Latina/Latine/Latinx

☐ Prefiero no responder

☐ Prefiero autodescribir:

## Encuesta del Condado de Montgomery

17. ¿Cuánto anticipa que sea el ingreso total de su hogar antes de impuestos para el año en curso? (Por favor, incluya en su ingreso total dinero de todas las fuentes para todas las personas que viven en su hogar.)

- ☐ Menos de \$25,000
- ☐ \$25,000 a \$49,999
- ☐ \$50,000 a \$74,999
- ☐ \$75,000 a \$99,999
- ☐ \$100,000 a \$149,999
- ☐ \$150,000 o más
- ☐ Prefiero no decir

## Encuesta del Condado de Montgomery

¡Gracias!

**Mensaje emergente: Gracias por su interés en participar en nuestra encuesta. Esta encuesta solo se dirige a las personas que viven en el Condado de Montgomery. Agradecemos su tiempo y nos disculpamos por cualquier inconveniente.**

## Encuesta del Condado de Montgomery

¡Gracias!

**Cerrar encuesta. Mensaje emergente:** Gracias por su interés en participar en nuestra encuesta. Esta encuesta solo se dirige a los residentes que viven en una casa unifamiliar, casa adosada o edificio de apartamentos pequeños con seis unidades o menos. Las encuestas futuras se dirigirán a residentes adicionales del Condado. Agradecemos su tiempo y nos disculpamos por cualquier inconveniente.

Encuesta del Condado de Montgomery

¡Gracias por su tiempo!

## Appendix C-2.

### DEP's Partnership and Engagement Program Manager Outreach Efforts

| <b><u>Date</u></b> | <b><u>Action</u></b> | <b><u>Format</u></b>                   | <b><u>Channel</u></b>                                                                                                       |
|--------------------|----------------------|----------------------------------------|-----------------------------------------------------------------------------------------------------------------------------|
| 6/8                | Survey Distribution  | By email (AA)                          | Shared to County's email list (50 people; includes representatives from 38 different organizations/community groups)        |
| 6/8                | Survey Distribution  | By email (AA)                          | MCPS Director of Sustainability and Compliance (not confirmed whether POC distributed more widely within MCPS)              |
| 6/8                | Survey Distribution  | Electronic Newsletter                  | Silver Spring, Bethesda Chevy Chase, and Mid county regional centers                                                        |
| 6/12               | Survey Distribution  | Electronic Newsletter                  | Up County and East County Regional Centers                                                                                  |
| 6/15               | Survey Distribution  | By email (AA)                          | Public Libraries POC (was not distributed more widely within Public Libraries)                                              |
| 6/16               | Survey Distribution  | Radio Show and Social Media (Facebook) | County Council en Español segment                                                                                           |
| 6/16               | Survey Distribution  | Social Media (ME)                      | NextDoor post by Marilu                                                                                                     |
| 6/16               | Survey Distribution  | Electronic Newsletter                  | Upcounty Citizens Advisory Board Newsletter                                                                                 |
| 6/16               | Survey Distribution  | Electronic Newsletter                  | East County Newsletter                                                                                                      |
| 6/23               | Survey Distribution  | Electronic Newsletter                  | Montgomery Village Foundation (encompassing 40,000 homes – distributed electronically to at least one of their newsletters) |
| 6/23               | Survey Distribution  | Electronic Newsletter                  | Upcounty Citizens Advisory Board Newsletter                                                                                 |
| 6/24               | Survey Distribution  | Flyer In-Person (AA)                   | Caribbean American Heritage Celebration and Resource Fair (Wheaton)                                                         |
| 6/24               | Survey Distribution  | Electronic Newsletter                  | East County Newsletter                                                                                                      |
| 6/29               | Survey Distribution  | Electronic Newsletter                  | Bethesda Chevy Chase Regional Services Center Newsletter                                                                    |
| 7/4                | Survey Distribution  | Flyer In-Person (D. Frank)             | Montgomery Village 4th of July Celebration                                                                                  |
| 7/5                | Survey Distribution  | Social Media (DEP)                     | DEP Social Media - Facebook                                                                                                 |
| 7/6                | Survey Distribution  | Social Media (DEP)                     | DEP Social Media - Twitter                                                                                                  |



# Montgomery County Community Assessment

Single-Family Home Residents

Survey Results

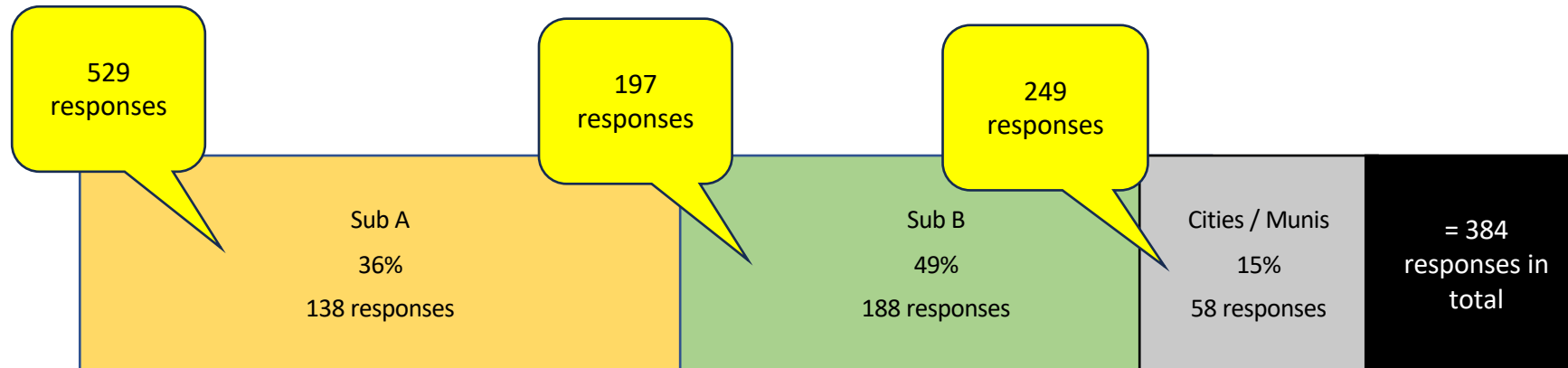
August 15, 2023

# Notes:

- Intent of study:
  - Help inform tonnage projections for organics generation and capture in Montgomery County by gathering information about residents' attitudes and behaviors regarding food waste and food scraps management.
- 996 responses in total
- Target sample size was reached for each subgroup
- Number of respondents per subgroup varied (see slide 4)
- Response rate per question varied since all questions were voluntary
- It is important to exercise caution when comparing across subgroups because of these variations

# Data Limitations

- It is important to note that while small sample sizes have limitations, they can still be appropriate and informative in certain contexts, such as for this forecasting tonnage projections study. As discussed with MES and the County, with a small sample size and a shareable link survey, however, it becomes difficult to perform statistically significant, meaningful analysis on subgroups within the sample (i.e., by race, income, language, etc.). Subgroup analyses with a small sample and a shareable link survey size lack statistical power and result in unreliable conclusions. Therefore, the EA Team cautions against generalizing survey subgroup findings to the broader County population.
- As a result of these data limitations, the EA Team cautions against generalizing survey subgroup findings to the broader County population.



\* Sample size is based on total SFH with less than or equal to six units in Subdistrict A, Subdistrict B, Cities/Municipalities from CY 2022

| Q4                       |                                                                          | Subdistrict A | Subdistrict B | Municipalities | All Respondents |
|--------------------------|--------------------------------------------------------------------------|---------------|---------------|----------------|-----------------|
| Who collects your trash? | County or City/Town/Village (property tax bill for trash service)        | 95%           | 12%           | 78%            | 78%             |
|                          | Hauler (private trash collection service that bills your home for trash) | 1%            | 12%           | 9%             | 5%              |
|                          | Homeowner association                                                    | 1%            | 60%           | 4%             | 14%             |
|                          | I don't know                                                             | 1%            | 8%            | 2%             | 2%              |

Note: Subgroup percentages were calculated based on the number of people in that subgroup who took the survey. Some questions had fewer respondents. For this reason, the percentages in each subgroup column do not sum to 100.

| Q5                                                                                                                             |                      | Subdistrict A | Subdistrict B | Municipalities | All Respondents |
|--------------------------------------------------------------------------------------------------------------------------------|----------------------|---------------|---------------|----------------|-----------------|
| Do you believe getting edible food waste and food scraps out of the waste stream is the right thing to do for the environment? | Strongly agree       | 83%           | 55%           | 77%            | 81%             |
|                                                                                                                                | Somewhat agree       | 7%            | 17%           | 11%            | 11%             |
|                                                                                                                                | Somewhat disagree    | 1%            | 3%            | 0%             | 1%              |
|                                                                                                                                | Strongly disagree    | 1%            | 7%            | 0%             | 2%              |
|                                                                                                                                | I don't know/Neutral | 5%            | 10%           | 4%             | 6%              |

Note: Subgroup percentages were calculated based on the number of people in that subgroup who took the survey. Some questions had fewer respondents. For this reason, the percentages in each subgroup column do not sum to 100.

| Q6                                                                                 |                                                              | Subdistrict A | Subdistrict B | Municipalities | All Respondents |
|------------------------------------------------------------------------------------|--------------------------------------------------------------|---------------|---------------|----------------|-----------------|
| Do you practice any of the following habits to reduce your household's food waste? | Buy smaller quantities of fruits and vegetables              | 58%           | 51%           | 54%            | 60%             |
|                                                                                    | Buy smaller quantities of prepared foods                     | 47%           | 49%           | 45%            | 50%             |
|                                                                                    | Freeze food, including leftovers                             | 69%           | 60%           | 65%            | 71%             |
|                                                                                    | Donate uneaten, edible food to local food banks and shelters | 8%            | 9%            | 7%             | 9%              |
|                                                                                    | All of the above                                             | 10%           | 11%           | 11%            | 11%             |
|                                                                                    | None                                                         | 4%            | 8%            | 3%             | 4%              |
|                                                                                    | Other                                                        | 29%           | 20%           | 29%            | 28%             |

Note: Subgroup percentages were calculated based on the number of people in that subgroup who took the survey. Some questions had fewer respondents. For this reason, the percentages in each subgroup column do not sum to 100.

| Q7                                                            |                                                                                                | Subdistrict A | Subdistrict B | Municipalities | All Respondents |
|---------------------------------------------------------------|------------------------------------------------------------------------------------------------|---------------|---------------|----------------|-----------------|
| How do you primarily dispose of food scraps and spoiled food? | Put in the garbage                                                                             | 23%           | 41%           | 19%            | 27%             |
|                                                               | Use an in-sink garbage disposal                                                                | 9%            | 19%           | 10%            | 12%             |
|                                                               | Place in curbside organics recycling cart (Service provided by a private company or your city) | 33%           | 2%            | 25%            | 26%             |
|                                                               | Compost at home (backyard compost bin)                                                         | 23%           | 20%           | 27%            | 25%             |
|                                                               | Drop off at food scraps collection site                                                        | 2%            | 4%            | 4%             | 3%              |
|                                                               | Other                                                                                          | 7%            | 5%            | 7%             | 7%              |

Note: Subgroup percentages were calculated based on the number of people in that subgroup who took the survey. Some questions had fewer respondents. For this reason, the percentages in each subgroup column do not sum to 100.



| Q8                                                                                                                                                                           |              | Subdistrict A | Subdistrict B | Municipalities | All Respondents |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|---------------|---------------|----------------|-----------------|
| If the County offered curbside food scraps collection, would you participate? You would separate food scraps from your garbage and place them in a curbside bin for pick up. | Yes          | 83%           | 58%           | 74%            | 82%             |
|                                                                                                                                                                              | No           | 5%            | 18%           | 9%             | 10%             |
|                                                                                                                                                                              | I don't know | 7%            | 11%           | 8%             | 9%              |

Note: Subgroup percentages were calculated based on the number of people in that subgroup who took the survey. Some questions had fewer respondents. For this reason, the percentages in each subgroup column do not sum to 100.

| Q9                                                                            |                                                      | Subdistrict A | Subdistrict B | Municipalities | All Respondents |
|-------------------------------------------------------------------------------|------------------------------------------------------|---------------|---------------|----------------|-----------------|
| What are your concerns about participating in a curbside food scraps program? | Too much trouble                                     | 1%            | 1%            | 1%             | 5%              |
|                                                                               | Need more information before making a decision       | 3%            | 1%            | 2%             | 12%             |
|                                                                               | Not enough space in my house to separate food scraps | 0%            | 2%            | 0%             | 4%              |
|                                                                               | Potential odors                                      | 0%            | 3%            | 1%             | 6%              |
|                                                                               | Collecting food scraps attracts insects and vermin   | 2%            | 10%           | 4%             | 25%             |
|                                                                               | Concerned about the added cost associated with this  | 2%            | 2%            | 1%             | 9%              |
|                                                                               | Other                                                | 5%            | 11%           | 7%             | 40%             |

Note: Subgroup percentages were calculated based on the number of people in that subgroup who took the survey. Some questions had fewer respondents. For this reason, the percentages in each subgroup column do not sum to 100.

| Q10                                                                                                                                                                     |                    | Subdistrict A | Subdistrict B | Municipalities | All Respondents |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|---------------|---------------|----------------|-----------------|
| The County is considering making food scraps separation and curbside collection mandatory for households. What is your level of agreement with this potential approach? | Strongly agree     | 59%           | 34%           | 55%            | 57%             |
|                                                                                                                                                                         | Somewhat agree     | 21%           | 23%           | 19%            | 23%             |
|                                                                                                                                                                         | Somewhat disagree  | 6%            | 10%           | 6%             | 7%              |
|                                                                                                                                                                         | Strongly disagree  | 6%            | 18%           | 5%             | 9%              |
|                                                                                                                                                                         | Don't know/Neutral | 3%            | 3%            | 6%             | 4%              |

Note: Subgroup percentages were calculated based on the number of people in that subgroup who took the survey. Some questions had fewer respondents. For this reason, the percentages in each subgroup column do not sum to 100.

| Q11                                                                                                                                                                                                    |                                  | Subdistrict A | Subdistrict B | Municipalities | All Respondents |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------|---------------|---------------|----------------|-----------------|
| If the County provided support to interested households for starting backyard composting, would you participate? You would separate food scraps and place them in a backyard rodent-proof compost bin. | Yes                              | 35%           | 32%           | 36%            | 38%             |
|                                                                                                                                                                                                        | No                               | 31%           | 22%           | 29%            | 31%             |
|                                                                                                                                                                                                        | I already do backyard composting | 27%           | 20%           | 20%            | 26%             |
|                                                                                                                                                                                                        | I don't have a backyard          | 2%            | 11%           | 5%             | 5%              |

Note: Subgroup percentages were calculated based on the number of people in that subgroup who took the survey. Some questions had fewer respondents. For this reason, the percentages in each subgroup column do not sum to 100.

| Q12                                                                                                                                |                                              | Subdistrict A | Subdistrict B | Municipalities | All Respondents |
|------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------|---------------|---------------|----------------|-----------------|
| If the County established convenient food scraps recycling drop-off locations, would you take your food scraps to a drop-off site? | Yes                                          | 24%           | 30%           | 18%            | 26%             |
|                                                                                                                                    | No                                           | 70%           | 53%           | 67%            | 72%             |
|                                                                                                                                    | I already drop off food scraps for recycling | 0%            | 3%            | 5%             | 2%              |

Note: Subgroup percentages were calculated based on the number of people in that subgroup who took the survey. Some questions had fewer respondents. For this reason, the percentages in each subgroup column do not sum to 100.

| Q13                                                                                 |                                     | Subdistrict A | Subdistrict B | Municipalities | All Respondents |
|-------------------------------------------------------------------------------------|-------------------------------------|---------------|---------------|----------------|-----------------|
| How often do you donate excess edible food (e.g., to a shelter or local food bank)? | Frequently (once a month)           | 3%            | 3%            | 3%             | 3%              |
|                                                                                     | Occasionally (several times a year) | 17%           | 19%           | 17%            | 19%             |
|                                                                                     | Rarely (once a year)                | 35%           | 31%           | 33%            | 37%             |
|                                                                                     | Never                               | 39%           | 34%           | 37%            | 41%             |

Note: Subgroup percentages were calculated based on the number of people in that subgroup who took the survey. Some questions had fewer respondents. For this reason, the percentages in each subgroup column do not sum to 100.

| Q14                                                                                                |                                     | Subdistrict A | Subdistrict B | Municipalities | All Respondents |
|----------------------------------------------------------------------------------------------------|-------------------------------------|---------------|---------------|----------------|-----------------|
| How often would you donate excess edible foods to a nearby drop-off location if it were available? | Frequently (once a month)           | 18%           | 18%           | 16%            | 19%             |
|                                                                                                    | Occasionally (several times a year) | 36%           | 32%           | 36%            | 38%             |
|                                                                                                    | Rarely (once a year)                | 26%           | 18%           | 26%            | 27%             |
|                                                                                                    | Never                               | 16%           | 19%           | 12%            | 17%             |

Note: Subgroup percentages were calculated based on the number of people in that subgroup who took the survey. Some questions had fewer respondents. For this reason, the percentages in each subgroup column do not sum to 100.

| Q15                                                            |                        | Subdistrict A | Subdistrict B | Municipalities | All Respondents |
|----------------------------------------------------------------|------------------------|---------------|---------------|----------------|-----------------|
| In what language do you prefer to receive written information? | English                | 93%           | 86%           | 87%            | 99%             |
|                                                                | Spanish                | 0%            | 0%            | 0%             | 0.2%            |
|                                                                | Chinese                | 0%            | 0%            | 0%             | 0.1%            |
|                                                                | French                 | 0%            | 0%            | 0%             | 0.2%            |
|                                                                | I prefer not to answer | 0%            | 1             | 1%             | 1%              |
|                                                                | Other                  | 0%            | 0%            | 0%             | 0.1%            |

Note: Subgroup percentages were calculated based on the number of people in that subgroup who took the survey. Some questions had fewer respondents. For this reason, the percentages in each subgroup column do not sum to 100.



| Q16                                                     |                                                                | Subdistrict A | Subdistrict B | Municipalities | All Respondents |
|---------------------------------------------------------|----------------------------------------------------------------|---------------|---------------|----------------|-----------------|
| What is your race or ethnicity? (Select all that apply) | American Indian, Alaska Native, Native American, or Indigenous | 1%            | 1%            | 0%             | 0.8%            |
|                                                         | Asian                                                          | 3%            | 7%            | 7%             | 6%              |
|                                                         | Black or African American                                      | 2%            | 5%            | 1%             | 2%              |
|                                                         | Middle Eastern or North African                                | 0%            | 2%            | 0%             | 0.7%            |
|                                                         | Native Hawaiian or Pacific Islander                            | 0%            | 0%            | 1%             | 0.3%            |
|                                                         | White                                                          | 78%           | 62%           | 69%            | 80%             |
|                                                         | Hispanic or Latino/Latina/Latine/Latinx                        | 3%            | 7%            | 3%             | 5%              |
|                                                         | I prefer not to answer                                         | 8%            | 10%           | 10%            | 10%             |
|                                                         | I prefer to self-describe                                      | 2%            | 2%            | 1%             | 2%              |

Note: Subgroup percentages were calculated based on the number of people in that subgroup who took the survey. Some questions had fewer respondents. For this reason, the percentages in each subgroup column do not sum to 100.

| Q16                                                                                                                                                                                                   |                        | Subdistrict A | Subdistrict B | Municipalities | All Respondents |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|---------------|---------------|----------------|-----------------|
| How much do you anticipate is your household's total income before taxes for the current year? (Please include in your total income money from all sources for all persons living in your household.) | Less than \$25,000     | 1%            | 3%            | 0%             | 0.9%            |
|                                                                                                                                                                                                       | \$25,000 to \$49,999   | 3%            | 4%            | 1%             | 2%              |
|                                                                                                                                                                                                       | \$50,000 to \$74,999   | 2%            | 6%            | 3%             | 5%              |
|                                                                                                                                                                                                       | \$75,000 to \$99,999   | 0%            | 11%           | 8%             | 8%              |
|                                                                                                                                                                                                       | \$100,000 to \$149,999 | 0%            | 17%           | 16%            | 19%             |
|                                                                                                                                                                                                       | \$150,000 or more      | 78%           | 25%           | 39%            | 45%             |
|                                                                                                                                                                                                       | I prefer not to answer | 3%            | 22%           | 21%            | 21%             |

Note: Subgroup percentages were calculated based on the number of people in that subgroup who took the survey. Some questions had fewer respondents. For this reason, the percentages in each subgroup column do not sum to 100.

## Appendix C-4.

**Q6. Do you practice any of the following habits to reduce your household's food waste?**

**OTHER:**

compost  
Compost  
We have a small electric composter  
Compost vegetable scraps  
compost  
Make meal plans. Use leftovers.  
Compost  
Compost some food scraps  
Backyard compost  
Composting  
compost at home  
plan meals and only buy what we will use  
compost all food scraps  
Compost  
never eat out, or buy prepared or processed foods, buy for meal plan, freeze proteins until needed, head to hoof  
I collect food waste and take it to a compostable waste bin in Gaithersburg.  
Only buy what we expect to consume in the next week  
Compost  
use the garbage disposal to keep wastes out of landfill  
Compost  
we compost  
Home compost  
We use a private composte service  
freeze food scraps for drop in Mom's food recycling bins  
Compost food waste  
We pay for a third-party composting service  
Compost  
Throw into our woods for wildlife  
Give away food purchases that aren't what we thought they were on Buy Nothing  
buy only what i know the household will eat.  
Compost  
Pay for private collection of food waste for composting.  
Compost fruit and vegetables  
Use Buy Nothing group to distribute unwanted, unexpired food.  
compost food waste  
Composting at home  
participate in private compost service  
Compost  
Compost

Compost  
Compost  
I compost with a private service  
compost  
Buy only as much as our family can reasonably consume before the next grocery store run  
Compost  
Compost at home. Save veg scraps for broth. Try to use all parts (e.g. tops of beets)  
we eat everything we make, waste nothing.  
Try to buy smaller but not always successful  
Compost waste  
Compost  
Compost in back yard  
Compost, grow our own  
compost food waste  
compost  
Compost at home.  
we cook according to the number residents, only what we will consume to avoid waste.  
Compost  
Garden  
Compost  
Compost  
Compost  
Compost  
Recycle at farmers market in summer  
Compost  
Compost  
Eat leftovers  
Private composting service  
was composting on my own. My composter is full and I need to purchase a new one.  
Periodically have a refrigerator meal from foods on hand  
composting  
Eat leftovers for lunch the next day.  
Compost food waste  
keep leftovers to be eaten in a few days  
Drop off compostables at MV Farmers' Market or MOMS grocery store  
Eat all my leftovers and compost what I can.  
i rarely waste food  
we compost fruit and vegetable scraps  
Donate food to neighbors in our Buy Nothing group.  
compost  
Grow much of our own food and compost as much as we can  
I prepare all meals from scratch. Typically waste is generated from cutting vegetables  
Compost  
Compost

compost  
take food waste to Whole Foods to vompost  
Compost  
Compost coffee grinds, corn cobs, etc.  
Pay a private contractor who specializes in compost  
Compost non-meat in backyard  
Pay for a composting service  
Compost  
Private compost pile, reduce food waste with proper storage  
We compost in our backyard.  
Compost  
Compost  
I eat grasshoppers  
Compost  
compost  
take waste to Mom's market for recycling  
We size our purchases so that very little food is thrown out.  
Compost  
Compost  
Composting  
Compost what is inedible or goes bad  
Compost  
compost!  
Compost vegetable waste  
Compost  
Compost  
compost food scraps  
subscribe to Compost Crew  
Compost food scraps  
Many scraps go to the dogs!  
composting  
Grow my own vegetables. I only pick what I need that day. Compost food scraps in a two-chamber tumbling composter.  
compost in back yard  
compost raw vegetable trimmings  
compost  
Use a private composting service  
Curbside composting  
buy from Hungry Harvest  
I eat almost all of the fruits and vegetables that I buy!

Compost at home  
Compost  
compost  
Pay for composting  
Pay for compost crew service  
Give leftovers to friends & neighbors  
compost  
Compost  
be aware of what's in the fridge  
use a compost service  
Compost with Compost Crew  
We home compost vegetable waste  
Recycle compostable waste  
compost crew service  
My city does curbside compost  
Household compost  
Compost  
Compost  
Compost  
Pay Compost Crew weekly pickup of all food waste  
Compost  
Use commercial compost service  
Compost!  
pay for weekly compost pick-up, share food with neighbors  
compost  
Compost waste  
I pay for composting, but strongly believe this should be a county-provided service that all residents get for free but most adhere to. We save on so much garbage that way!!  
We are pretty good about eating all leftovers. We try not to buy more than we need.  
Compost  
Use composting service  
I ate leftovers unless they are absolutely rotten  
Eat up all leftovers all the time  
Donate at DC markets to DC food scrap collection program  
Eat leftover food  
We compost in the backyard, but have had trouble with rats.  
Compost  
we use a weekly commercial compost service that we pay for  
backyard composting  
only buy what I will eat  
compost

Compost  
 Compost  
 Eat our leftovers right away  
 Subscribe to compost service and to Hungry Harvest  
 Compost  
 We don't buy small quantities. But we never throw food out. We always consume what we buy or donate it in a very few instances if there's extra.  
 compost  
 Compost fruit and veggie scraps  
 I save vegetable scraps for stock, and we compost the rest here at home.  
 compost  
 Compost  
 Compost  
 participate in Takoma Park composting program, and compost in my own yard also  
 Mulch food scraps at home  
 We buy appropriate amounts of fruits and veggies and pay for a compost service.  
 We also currently participate in the pilot food scrap composting program run by county.  
 compost pick up  
 I recycle all food scraps, except meat, fish, egg shells, cheese and mushrooms in my garden.  
 Compost some raw fruits and vegetables  
 re-purpose food scraps, i.e. make my own stock and dog food.  
 Pay for composting service (Veteran Compost)  
 Buy at Farmer's Markets  
 Compost scraps; eat what we buy  
 Compost through a private company  
 Take fruit and veggies to be composted  
 Consume all edibles  
 Pay for composting  
 Cook so that fresh ingredients are used up.  
 Compost food scraps  
 Compost  
 compost  
 I make smoothies or soup with veggie parts. Add fruit, etc. Good fiber and less waste.  
 Compost veggie and fruit waste  
 Compost  
 Compost coffee grounds, fruits, vegetables and breads  
 compost  
 Compost our left over food waste  
 We participate in the residential food scraps collection pilot program.  
 Compost and feed leftovers to hens  
 Composting  
 Compost

Compost in a rotating composter  
refrigerate leftovers and eat the next day or two  
pay monthly for Compost Crew  
compost food scraps in back yard  
compost at home  
Compost  
Compost  
We compost vegetables and fruit  
Compost leftover and spoiled food  
Use compost crew for my compost  
Compost food scraps through county program  
worm compost  
Buy a weekly compost pickup  
Compost food scraps  
Compost  
compost  
Buy smaller quantities of all fresh food  
Composting for reuse on plant beds  
Contract with Compost Crew to pick up my food scraps every week.  
Households are greatly restricted on donation  
Grow some vegetables and herbs for my own consumption  
Compost  
Compost  
Grow some of our food so we can harvest when we will eat it  
backyard compost pile  
Composting food scraps  
Make sure we use what we buy and freeze when necessary.  
we plan meals to use up leftovers; food scraps we can't eat go in the compost  
compost  
Compost; grow our own fruits and vegetables  
use compost bin  
Compost in rat-proof tumbler  
home composting, but can't compost everything, alas  
I am single and buy only what I think I can consume. So I'm not buying "smaller" quantities of anything. I don't have uneaten or edible food and do freeze food. I contribute \$100/month to Manna.  
Compost Crew  
Buy frozen vegies  
Compost food scraps in my yard  
Pay for composting service--Compost Crew  
Home Composting Bin  
Compost fruits and vegetables  
Home Compost  
Compost it (doesn't reduce waste but reduces food trash)



Home compost  
Compost in our backyard  
Compost crew composting  
Compost and participate in Takoma Park's food waste collection program.  
Give food prep waste to Compost Crew  
Use leftovers in other dishes  
Compost food waste  
cook more at home than buying out to be efficient with food  
Share with neighbors  
Pay separately for a private composting service to pick up food waste  
I compost all possible food scraps so there \*is\* no food waste beyond chicken bones  
COMPOST!  
compost waste food items in our own bins

**Q7. How do you primarily dispose of food scraps and spoiled food?**

**OTHER:**

We have a small electric composter that composts within hours  
eat next day, rarely frozen  
Put in compost pail, which city picks up weekly.  
Also compost  
Loki scrap composter  
Compost bin that is picked up weekly  
Pay for compost pickup service  
Compost the compostable but also use disposal and put some things in the garbage too  
Compost Crew  
Indoor composter  
I rarely have either food scraps or spoiled food  
Food scraps: compost. Spoiled food: trash.  
I have done both composting at home and food scrap collection site for many, many years.  
signed up for compost collection  
combination of garbage, garbage disposal, and backyard compost bin  
drop at Whole Foods  
Compost bin that gets picked up by a private service on a weekly basis  
Feed to dog or wildlife.  
Commercial compost service  
Pay private compost company -compost crew  
feed to the rats  
Compost pilot program  
County food scraps  
County pilot curbside compost program  
Compost produce in worm bin  
We have a compost collection service  
pay for private compost service  
We participate in the county pilot project on composting.  
pay for compost service with the Compost Crew  
Curbside compost Takoma park  
Worm bin  
Takoma Park has a municipal food waste collection. I wish the whole county had this service.  
we pay for a service to pick up our compost  
Used a compost company before, but now use garbage (waiting for county to start program)  
Pay for Compost Crew services  
Equal parts garbage, disposal and compost  
both backyard and through MOCO compost pilot program  
We take in bucket to Koiner Farms in Silver Spring for composting.  
County compost pilot

Drop off at my mother's house - she is part of the moco food scraps composting program. I can't wait for it to come to our part of the neighborhood!

I blend all good scraps in the blender and dig into my composting holes.

Put in county provided compost bin

Freeze until trash collection day

Food scraps pilot program

Veterans compost

County pilot

County collection pilot program

Pay for weekly Compost Crew collection

Compost through town

Compost vegetable scraps, trash for the rest

Participate in county food scraps program

Kitchen compost bin for weekly curbside collection

Food scraps are collected by the county on a weekly basis as compost

Compost some, feed some to animals, throw some away.

Combination of compost, disposal and trash.

Compost waste what I eat at work in our compost bin.. Attempted compost at home but did not keep up with it. Paid for compost pickup at one point but found it expensive. So at home a mix of throwing it away and compost. We do not use a garbage disposal.

Pay compost collection company for weekly pickup

multiple answers: compost bin (rat-proof), garbage disposal, or double-bagged in trash.

I put it with mixed with yardtrim

collected by City of Takoma Park

separate coffee grounds and tea from bags and add to soil in garden.

aaa

Compost Crew

depends; fruits and vegs are home composted; meat is discarded

Both put in trash and use compost (depending on the food)

**Q9. What are your concerns about participating in a curbside food scraps program? Select your top concern.**

**OTHER:**

prefer to compost it by myself

I don't have much good scrapes

already compost at home

My city, Takoma Park, already provides this service.

most of the above

There will be some that store scraps outside. This will attract RATS! No, just No.

All of the above

Both odors, wildlife, and potentially not separating the scraps appropriately

As a senior it would not be an easy thing for us to do.

No concerns

keeping animals out of a whole street filled with 100% food scrap bins

Don't need such a program because I compost.

I'm all for doing curbside pick up and would love my taxes to go for that. But for me personally, I'd miss out on the compost I now make at home. Also, consideration of pollution of trucks to pick up

any food scraps/waste go in our compost pile

We already compost all of our food scraps, and use the finished compost as a resource on our property.

Already composting in backyard

Already compost most of our food waste

Storage space for curbside container.

Still confused about what goes into the current recycling bins. Now you want to add another layer.

Already compost all food scraps except meat

No scraps leftover

Restaurant should be the ones to do this

Many of the above as well as "compostable" plastic bag are really bad.

my pets

toom much trouble, do not want another bin to collect garbage/recycling that might attract pests and I think food in garbage dumps only helps in decomposition of trash.

i do some composting. meat scraps cannot be composted, but have little of that. proposed container size is much too big to be useful to me. question all the above potential problems.

I live in a townhouse community and am constantly picking up trash after recycling day. Haveing another truck come through our neighborhood would only cause more confusion as trash is left behind after recycling. I can only imagine what it would be like if we had food scrap collection.

A central location for dropping off food scraps such as the City of Gaithersburg would make more sense to me than individual bins. If residents were more consciotious, it might work. But centralizing it is the only way I can see it working. Until recently I composted in my back yard and took food scraps to the City of Gaithersburg food scrap pickup.

Waste discarded on walkway or in street. Residents having to clean it up. Odors, critters, & vermin.

you are waisting your resources, it is not a problem to be concerned

Don't need it. We compost everything we can.

I already compost. Any edible scraps are fed to my dogs or chickens.

I compost food scraps on my own property

Only that we usually have very little spoiled and wasted food that it might not make sense for us.

I'm already doing backyard composting which I use on my garden. For those not already composting, curbside collection would be great.

We already compost food scraps in our backyard.

I LIKE composting and would miss it! :-)

I already compost in my back yard. But I think it is great that the County is considering adding that service.

Would lead to fights with my husband who would not remember to separate out food scraps and would resent reminders

Two members of household don't want to

already compost our food scraps

Have a composting area

Takoma Park already provides this service

I already use all my food scraps in my gardening composting.

I plan to start composting

we will continue backyard composting. But many won't do it on their own, so please offer curbside foodscraps pickup!

racoons

Probably don't have enough compostable scraps to participate in curbside because I already compost

On 3 acres. Already compost

I like Compost Crew.

We already compost if the county where to pick up a little bit of meat and fish bones then I would put them out but as far as vegetables and fruits, etc. that is all come posted in our own yard

I have a very restricted diet, eat little regular food (mostly liquids)

Leaving scraps curbside rather than in a private protected bin could lead to real messes from animals and people

Attracts rodents. Every time I compost I get mice in my shed and kitchen. I tried moving recycling bin far away from my house then I get mice in my shed

We compost our own

We use ours in our compost.

MDUs @ Avenel have a hard time with recycling, horrible problem with dumpster collection for all others (HOC tenants do not follow rules)

We like generating compost for yard. Also more efficient than hauling to Dickerson.

We do our own composting for our vegetable gardens.

1 person household, few food scraps

I compost in my yard. The City of Takoma Pk has program.  
Spend our tax money elsewhere .i.e where it is NEEDED  
I compost in my yard. Would probably continue with that  
No concerns - I already participate in Takoma Park's food waste collection program.  
I already said: I compost my own  
Composting myself for my garden

## **Appendix D:**

# **Biogas and Hydrogen Yield Analysis from Food Waste**

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**Commentary**  
**for**  
**Biogas to Hydrogen Conversion**  
for EA Engineering  
March 18, 2024

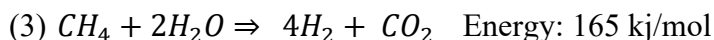
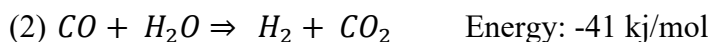
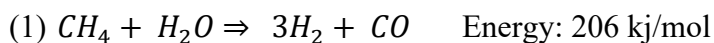
**OBJECTIVE**

Montgomery County, Maryland, is interested in evaluating the feasibility of conversion of biogas produced in anaerobic digesters into hydrogen gas. This hydrogen could be readily stored and used to fuel vehicles and other hydrogen-burning equipment for the county.

This analysis presents a high-level analysis and commentary about the biogas-to-hydrogen conversion with respect to gas mass balance and energy balance. Vendors have been contacted to develop an estimate of CAPEX and OPEX of a conversion system. Currently an estimate of CAPEX for the methane-to-hydrogen equipment only and exclusive of installation and operating costs has been received and will be presented.

**Methane to Hydrogen Energy Evaluation**

The process of steam reforming methane (SRM) is a mature technology in the oil and gas industry.<sup>1,2</sup> In this method, methane that is captured from subsurface hydrocarbon repositories is reacted at high temperatures (700 °C – 1000 °C) and with water. This reaction produces hydrogen gas and carbon monoxide. A further reaction is then performed on the gas which transforms carbon monoxide into carbon dioxide and nets one more molecule of hydrogen. In these reactions, 1 mole of methane is transformed into four moles of hydrogen gas while some energy is consumed. The stoichiometric reactions and the overall reaction are presented in equations 1-3 below.



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<sup>1</sup> Song H. et al. 2022. Energy, environment, and economic analyses on a novel hydrogen production method by electrified steam methane reforming with renewable energy accommodation. Energy Conversion Management, 258

<sup>2</sup> Challiwala M.S. et al. 2017. A combined thermos-kinetic analysis of various methane reforming technologies: Comparison with dry reforming. Journal of CO2 Utilization, 17, 99-111.

As the equations show, the process requires an input of energy. The net energy required for both reactions is 165 kJ/mol of CH<sub>4</sub> converted into hydrogen.

There are other methods such as dry reforming methane (DRM) that produce a similar gas mixture with the goal of producing hydrogen gas from organic precursors.<sup>3</sup>

For this analysis, we considered only SRM for hydrogen formation as it is the most mature and commercially available method. The other methods may be worth investigation if vendor with suitably mature technology could be identified.

Data about system operation was taken from the websites of Linde Engineering and HyGear. The energy requirements reported by HyGear are significantly lower than what is expected from the stoichiometry. It is possible that the HyGear process is able to incorporate efficiencies in their design that lower the net energy cost for conversion using SRM. EA is still working with HyGear to understand the energy balance in their process and those results are not presented here. Several things are apparent from an evaluation of the stoichiometry:

- 1) There is a net gain in energy contained in the hydrogen gas after conversion from methane. The net gain in 1000 SCF of methane gas is approximately 46 KWh.
- 2) There is a net negative balance of energy over the whole reaction. Approximately 8 KWh of energy are required for the conversion of 1,000 SCF of methane to 4,000 SCF of hydrogen.
- 3) The net energy contained in 1000 SCF of methane gas drops from 270 KWh to 79 KWh (316/4).

Table 1. Energy balance for conversion of methane to hydrogen.

| Item                            | Unit | per m3 of gas | per 1000 SCF Methane** |
|---------------------------------|------|---------------|------------------------|
| Methane Energy                  | KWh  | 10            | 270                    |
| Hydrogen Energy                 | KWh  | 11.2          | 316                    |
| Energy Consumed (Stoichiometry) | KWh  | 1.9           | 55                     |
| Net Energy Stiochiometry        | KWh  | -0.3          | -8                     |

\*SCF = Standard cubic foot = 1 ft<sup>3</sup> of gas at 1 atm and 15 C

For conversion of methane gas to hydrogen, high purity is required of the initial gas. This will require removal of hydrogen sulfide primarily. Ammonia and other trace impurities such as siloxanes also likely will need to be addressed in systems burning either methane or with conversion to hydrogen. Therefore, there is no difference in cost for the pretreatment of biogas for use as methane or for use after conversion to hydrogen.

There will be a capital expense for the methane conversion equipment. Base equipment cost for the methane-to-hydrogen conversion equipment will be \$3,175,000 for a system capable of converting 177 SCFM of methane to hydrogen. With engineering and installation, the total cost will likely be ~\$9,525,000. Additional costs associated with pressurization equipment, gas storage equipment, gas purification equipment, and finished gas transportation equipment will

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<sup>3</sup> Song et al.

need to be added for a final cost of the system. There will also be operating expenses for conversion equipment. Operating expenses are not known at this time.

With respect to carbon emissions, one carbon dioxide molecule is produced from burning a single molecule of methane. One carbon dioxide molecule is also produced during the conversion of methane to hydrogen. Therefore, there is no reduction in carbon dioxide or carbon emissions when converting methane to hydrogen.

There are some advantages to conversion of methane to hydrogen:

- 1) Convenient storage and unlimited shelf life of hydrogen gas.
- 2) Use of hydrogen in equipment that is designed to burn hydrogen gas.
- 3) No carbon emissions at the point of use of the hydrogen gas.

### **Methane to Production Evaluation**

Methane production depends on the organic content of the feedstocks to the anaerobic digester as well as the availability of the feedstocks for conversion to methane. Organic molecules contain differing amounts of energy depending on their type. For example, carbohydrates have much less energy than fats. Therefore, much more methane is produced per gram of material by the digester when the feedstock has larger proportions of fats than carbohydrates. The county would like to have a general estimate of expected gas production based on the feedstocks that will be digested in the reactor. This section provides very general estimates for methane production values and is based on value available in the literature. Actual values should be determined by performing a biochemical methane potential (BMP) test for each feedstock. A BMP test prior to accepting a feedstock is standard practice for facilities that wish to implement anaerobic digestion processes.

Because BMP testing was not performed, a number of assumptions were made for this analysis. These are:

- 1) There will be 70,000 tons, wet weight, of yard trim per year.
- 2) There will be 27,400 tons, wet weight, of food scraps per year.
- 3) Biogas production from food scraps is 110 m<sup>3</sup>/2,200 lbs @35 °C.
- 4) Biogas production from yard trim is 33 m<sup>3</sup>/2,200 lbs @35 °C.
- 5) Electricity cost is \$0.10/kWh.
- 6) Hydrogen value is \$1.36/lb.

Table 2 presents the results of the analysis based on the above assumptions. It is anticipated that digestion of the yard trim/food scraps waste will produce 3,369,027 pounds of hydrogen per year. This process will consume 8,773,515 kWh of electricity to convert the methane produced to hydrogen.

Table 2. Analysis of hydrogen production and energy consumption of a digester converting a mix of yard trim and food scraps.

| Waste Type  | Yearly Disposal, Ton | Yearly Disposal, lbs | Yearly Biogas, m3 | H2 gas production, lbs/year | Energy Consumption, kWh/year |
|-------------|----------------------|----------------------|-------------------|-----------------------------|------------------------------|
| Food Scraps | 27,400               | 54,800,000           | 2,740,000         | 1,907,259                   | 4,966,825                    |
| Yard Trim   | 70,000               | 140,000,000          | 2,100,000         | 1,461,768                   | 3,806,691                    |
| Total       | 97,400               | 194,800,000          | 4,840,000         | 3,369,027                   | 8,773,515                    |

Based on the above productions and assumed prices for hydrogen and energy, the net value of hydrogen produced each year will be \$3,716,776 (Table 3).

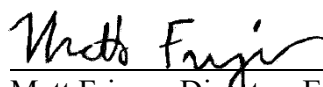
Table 3. Net value of conversion of methane to hydrogen with respect to energy cost only.

|                                     |           |
|-------------------------------------|-----------|
| Value of Hydrogen Produced, \$/year | 4,594,128 |
| Energy Cost to Produce, \$/year     | 877,352   |
| Net Value, \$                       | 3,716,776 |

### CONCLUSIONS

1. There is a consumption of energy from conversion of methane to hydrogen due to energy consumed in the reaction. Energy consumption will be >8 KWh/1000 SCF of methane.
2. There is no advantage to conversion of methane to hydrogen with respect to carbon emissions.
3. Both gas products (e.g. methane or hydrogen) will require similar pretreatment of the raw biogas prior to use.
4. There are costs associated with the purchase and upkeep of methane-to-hydrogen conversion equipment.
5. Treating 97,400 tons of mixed waste could produce 3,369,027 lbs of hydrogen per year.
6. The process would consume 8,773,515 kWh of energy per year.
7. The net value of hydrogen produced considering energy costs only will be \$3,716,776.

Methane-to-hydrogen conversion is a common and cost-effective way of generating hydrogen gas from fossil fuel. There is a relatively small consumption of energy for conversion of methane to hydrogen. Capital cost of installation of a facility that can convert 177 SCFM of methane to hydrogen may make economic sense if use of the hydrogen is paired with equipment that uses hydrogen, not methane, as a fuel source.



March 18, 2024

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## **Appendix E:**

# **Outreach and Education – Minimizing Contamination**

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## Montgomery County Feasibility Study

### Outreach and Education: Minimizing Contamination

#### Overview

Contamination is a pervasive issue for municipalities implementing composting initiatives. Many communities address this challenge by initially establishing voluntary composting programs, which attract the most dedicated composters, those most inclined to follow composting guidelines. By fostering awareness and promoting education, communities can progressively broaden these programs to boost participation and ensure correct composting practices.

The focus of this memo is to provide a recommended approach to outreach and education to reduce contamination in compost. It particularly emphasizes the operational consequences of contamination, including its impact on facility equipment, operations staff, and related aspects.

#### Outreach and Education Components

To ensure an impactful public education and awareness program roll-out:

- **Deploy visually striking educational materials** featuring clear lists of compostable and non-compostable items, incorporating vivid photo images for quick comprehension.
- **Utilize visual aids** that vividly depict the detrimental consequences of contamination, such as compost windrows marred by plastics.
- **Employ straightforward, simple symbols** (i.e., checks and x's) to ensure the material is easily understood by anyone in the community.
- **Consistently and repetitively deliver messaging** to enhance memorability.
- **Emphasize the importance of sustained public education** and motivation, as one-time-only approaches will fail.
- **Equip elected officials, senior staff, and others with well-crafted communication materials**, including talking points and social media posts, to bolster the anti-contamination cause.



Composting Do's and Don'ts list (Hutchinson, MN)

- **Maintain an ongoing process of monitoring and evaluation**, focusing on problematic areas through cart inspections, waste auditing, and community assessments, adapting outreach and education strategies as necessary.

#### Four Themes for Outreach and Education on Contamination

It is crucial to give people a clear understanding of why contamination is a problem in food scraps collection/compost programs, so they can grasp its significant impact. This section presents four themes for all messages associated with contamination. Effective communication campaigns are based on a concise set of messages. This ensure the messaging is focused, memorable, and consistent.

Theme One: Plastic bags and other non-organic contaminants wreak havoc on compost facility machinery.

Theme Two: Because plastic disintegrates into tiny fragments, complete removal during processing is impossible, thus creating non-usable compost.

Theme Three: Screening to remove contaminants involves manual and machine removal. This is resource-intensive and costly for the County.

Theme Four: Prevention is up to you. The ideal way to manage contamination is to prevent it from entering the compost stream in the first place.

#### Outreach and Education Messages for Each Theme

The goal of outreach messaging is to motivate the community to compost correctly. The key to good messaging is to present compelling information that is easy to understand coupled with a clear call to action. To help ensure that selected messages resonate for the County's target audience, it's important to test a few messages with sample audiences. Refine and then use the messages that appeal to the broadest number of people.

##### **Theme One: Plastic bags and glass wreak havoc on compost facility machinery.**

- Compost facilities deal with costly machinery and contamination. Let's make our County investments last by not jamming up the machinery with plastic or glass.
- Plastic bags and glass jam and break the moving parts of our County's compost facility equipment, leading to costly and frequent breakdowns and damage. Do your part, don't put plastic or glass in your organics cart!
- Removing plastic bag remnants from compost machinery is a time-consuming and costly process. Plastic bags cause frequent maintenance and repair issues, driving up operational



expenses for compost facilities. Have a heart, keep the plastic and glass out of your organics cart!

- Plastic bags love to jam, making compost facility staff say, "Oh, damn!" So, be the change, it's not a big ask – leave out the plastic, it's an easy task!

**Theme Two: Plastic disintegrates into tiny fragments making complete removal from compost impossible.**

- Help keep Montgomery County's compost stream contamination-free! Recycle your plastics or toss them in your garbage can. Keep all plastic out of your organics carts.
- Plastic breaks down into stubborn bits, a composting facility nightmare. Protect our County's compost's value - no plastic in your cart!
- Out with the plastics! Wrap, elastics, ties, straws, and stir sticks spell chaos for the County's compost facility. Keep our organics pristine!
- Compost facilities grapple with trying to screen out disintegrating plastic. Do your part, remove even those tiny plastics from your food scraps!
- Contaminated compost affects our County's haulers, gardeners, farmers, and more. Be part of the solution, don't put plastics into your organics cart!

**Theme Three: Screening to remove contaminants is costly for the County.**

- While the County employs both manual and mechanical methods to remove plastic and other contaminants from organics carts, the best method is what you can do at home. Make sure only organics material goes into your food scraps and yard waste cart. When in doubt, leave it out. Be a contamination-fighting hero - keep your organics pure!
- Did you know? Plastic bags wreak havoc on compost facility machinery. They clog up the equipment, causing it to shut down. This can damage the equipment and lead to higher costs. Do your part, keep plastic bags out of your organics cart!
- Our County grapples with the financial burden of purchasing and maintaining expensive compost facility machinery and dedicating staff to contamination removal. Help keep costs in check by keeping plastics and other contaminants out of your organics cart. Be a cost-conscious champion - keep your organics clean!
- Compost is an amazing material that benefits soil by providing nutrients, microbes, and improved soil structure. The County can generate revenue from the sale of our finished compost as long as we keep plastic and other contaminants out of it. Keep plastic out, and let's turn compost into cash!
- Glass is a safety concern for our compost haulers and facility staff. Be a safety ally, keep glass out of your organics cart!

**Theme Four: It's up to you: preventing contaminants from entering organic waste bins is an individual responsibility.**

- While the County employs both manual and mechanical methods to remove contaminants, this is expensive and imperfect! Contamination removal is best done at home. As you collect your household's food scraps, remember that proper sorting is key to clean compost. Ensure only organic waste goes into your compost bin. Take action today to be a clean compost champion!
- While the County employs both manual and mechanical methods to remove contaminants, this is expensive! The ideal way to manage contamination is to prevent it from entering the compost stream in the first place. Make sure only organics material goes into your food scraps and yard waste cart. When in doubt, leave it out!
- To create quality compost at the end of our County's food waste recycling process, it needs to be free of non-compostable material. The compost quality journey starts with you. As you collect your food scraps, remember - no plastics or non-organics allowed. Be the change at home and keep your compost stream clean!

#### **Evaluation of Outreach and Education**

Periodically evaluate whether your messaging is reaching and impacting your target community. This could be done through measuring outputs (reach and engagement indicators) through activities such as social media (likes, shares), and tracking materials messaging (number of recipients). Additionally, measure outcomes such the amount of food waste diverted from landfills, the percentage of contamination over time, the number of individuals who signed up for service or started putting food scraps in their composting bins, and shifts in awareness and attitudes towards to compost participation. This can be done through surveys that track awareness, attitudes and behaviors, and waste audits for a comprehensive understanding. The ultimate goal is to ensure that your messaging fosters improved public comprehension of key points and drives positive change in composting practices.

## **Appendix F:**

# **Capital and O&M Cost Estimates**

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Montgomery County Siting Study  
Engineer's Estimate of Probable Capital Costs  
Option 1 - ASP Composting at Montgomery County Yard Trim Composting Facility (MCYTCF)  
October 2023

| Item                   | Cost Categories and Items               | Description                                                                                                                                                                                                 | Unit Cost           | Units | Ph I Qty | Ph I Cost    | Ph II Qty | Ph II Cost   |
|------------------------|-----------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|-------|----------|--------------|-----------|--------------|
| FACILITY CAPITAL COSTS |                                         |                                                                                                                                                                                                             |                     |       |          |              |           |              |
| 1                      | Construction Mobilization               | Site mobilization, including equipment, office trailer establishment, submittals, bonding, and construction administration. Assume 5% of facility capital costs.                                            | \$628,000           | LS    | 1        | \$628,000    | 0.9       | \$574,100    |
| 2                      | Site Preparation at Shady Grove TS      | Site preparation for material receiving on-site, including relocation of existing site activities and minor site demolition in Upper Lot or other area for siting of material receiving and pre-processing. | \$500,000           | LS    | 1.0      | \$500,000    | 1.0       | \$500,000    |
| 3                      | Site Preparation at MCYTCF              | Site preparation including topographic survey and minor site demolition.                                                                                                                                    | \$5,000             | AC    | 10.5     | \$52,700     | 7.7       | \$38,700     |
| 4                      | Erosion and Sediment Controls at MCYTCF | Site controls, including silt fence, diversion fence, stabilized construction entrances, rip rap, stabilization, etc.                                                                                       | \$150,000           | LS    | 1.0      | \$150,000    | 0.7       | \$110,200    |
| 5                      | Stormwater Management at MCYTCF         | Stormwater management facility repair, including retrofit to existing SWM ponds.                                                                                                                            | \$300,000           | LS    | 0.75     | \$225,000    | 0.25      | \$75,000     |
| 6                      | Site Access Road Improvements at MCYTCF | Improvements to 30 ft two-lane asphalt access road.                                                                                                                                                         | \$200,000           | LS    | 0.75     | \$150,000    | 0.25      | \$50,000     |
| 7                      | Concrete Pad at Shady Grove TS          | 12" thick reinforced concrete pad with 12" no. 57 stone, in area of feedstock receiving.                                                                                                                    | \$101.00            | SY    | 6,800    | \$686,800    | 16,200    | \$1,636,200  |
| 8                      | Receiving Building at Shady Grove TS    | Pre-engineered steel building, 120' width clear, span rigid frame, for feedstock receiving. Includes aeration and biofilter. Includes SWM facility construction and E&SC.                                   | \$30.00             | SF    | 61,000   | \$1,830,000  | -         | \$0          |
| 9                      | Concrete Pad at MCYTCF                  | 12" thick reinforced concrete pad with 12" no. 57 stone, in area of active composting.                                                                                                                      | \$101.00            | SY    | 5,570    | \$562,570    | 12,280    | \$1,240,300  |
| 10                     | ASP Composting Equipment                | Assume covered aerated static pile compost system featuring high flow aeration and automated controls, covers, monitoring equipment, installation guide, and operations training.                           | \$13,824,700        | LS    | 0.5      | \$6,912,400  | 0.5       | \$6,912,400  |
| 11                     | Asphalt Pad Improvements at MCYTCF      | Improvements to 25% of existing bituminous pavement pad in compost curing, screening, storage and distribution areas. Assume 7" HMA and 4" GAB section.                                                     | \$60.00             | SY    | 10,080   | \$604,800    | 4,050     | \$243,000    |
| 12                     | Contact Water Storage Tanks             | 2-15k gallon storage tanks for contact water holding and reuse as process water.                                                                                                                            | \$30,900            | EA    | 2.00     | \$61,800     | 1.00      | \$30,900     |
| 13                     | Electrical and Communications           | Electrical site service and communication connections upgrades, including telecom and system commissioning; excluding primary cables and BGE charges.                                                       | \$250,000           | LS    | 0.75     | \$187,500    | 0.25      | \$62,500     |
|                        |                                         |                                                                                                                                                                                                             |                     |       |          |              |           |              |
|                        |                                         |                                                                                                                                                                                                             | SUBTOTAL            |       |          | \$12,552,000 |           | \$11,474,000 |
|                        |                                         |                                                                                                                                                                                                             | CONTINGENCY (30%)   |       |          | \$3,766,000  |           | \$3,443,000  |
|                        |                                         |                                                                                                                                                                                                             | TOTAL CAPITAL COSTS |       |          | \$16,318,000 |           | \$14,917,000 |

| Item                                    | Cost Categories and Items | Description                                                                                                                  | Unit Cost              | Units      | Ph I Qty  | Ph I Cost   | Ph II Qty  | Ph II Cost  |
|-----------------------------------------|---------------------------|------------------------------------------------------------------------------------------------------------------------------|------------------------|------------|-----------|-------------|------------|-------------|
| ANNUAL OPERATIONS AND MAINTENANCE COSTS |                           |                                                                                                                              |                        |            |           |             |            |             |
| 1                                       | Labor and Utilities Cost  |                                                                                                                              |                        |            |           |             |            |             |
|                                         |                           | Full-time Facility Supervisor at Shady Grove TS.                                                                             | \$105,300.00           | EA         | 1         | \$105,300   | 1          | \$105,300   |
|                                         |                           | Full-time Facility Operators at Shady Grove TS.                                                                              | \$70,200.00            | EA         | 2         | \$140,400   | 5          | \$351,000   |
|                                         |                           | Part-time Facility Technician at Shady Grove TS.                                                                             | \$84,240.00            | EA         | 1         | \$84,300    | 1          | \$84,300    |
|                                         |                           | Full-time Facility Supervisor at MCYTCF.                                                                                     | \$105,300.00           | EA         | 1         | \$105,300   | 1          | \$105,300   |
|                                         |                           | Full-time Facility Operators at MCYTCF.                                                                                      | \$70,200.00            | EA         | 2         | \$140,400   | 5          | \$351,000   |
|                                         |                           | Full-time Bagging Operators at MCYTCF.                                                                                       | \$70,200.00            | EA         | 1         | \$70,200    | 3          | \$210,600   |
|                                         |                           | Electrical.                                                                                                                  | \$0.15                 | \$/kWh     | 23,200    | \$3,500     | 63,900     | \$9,600     |
|                                         |                           | Water addition during material pre-processing.                                                                               | \$0.02                 | \$/gallons | 5,051,500 | \$100,100   | 13,966,500 | \$276,600   |
| 2                                       | Equipment                 |                                                                                                                              |                        |            |           |             |            |             |
|                                         | Grinder                   | Annual cost, assuming 5 yr service life.                                                                                     | \$220,000.00           | \$/Year    | 2         | \$440,000   | 4          | \$880,000   |
|                                         | Loader                    | Annual cost, assuming 8 yr service life.                                                                                     | \$37,500.00            | \$/Year    | 4         | \$150,000   | 10         | \$375,000   |
|                                         | Screener                  | Annual cost, assuming 5 yr service life.                                                                                     | \$30,000.00            | \$/Year    | 1         | \$30,000    | 2          | \$60,000    |
|                                         | Replacement Covers        | Annual cost, assuming 7 yr service life.                                                                                     | \$291,428.57           | \$/Year    | 1         | \$291,429   | 2          | \$582,857   |
|                                         | Cover Winder Machine      | Annual cost, assuming 15 yr service life.                                                                                    | \$23,333.33            | \$/Year    | 1         | \$23,333    | 1          | \$23,333    |
|                                         | Misc Maintenance Costs    | Replacement cables, sensors, probes, etc.                                                                                    | \$60,000.00            | \$/Year    | 1         | \$60,000    | 1          | \$60,000    |
|                                         | Equipment Repairs         |                                                                                                                              | \$175,000.00           | \$/Year    | 1         | \$175,000   | 1          | \$175,000   |
|                                         | Fuel                      | Fuel for Grinder, Loaders, Screener and Cover Winder.                                                                        | \$4.00                 | GAL        | 26,700    | \$106,800   | 56,700     | \$226,800   |
| 3                                       | Service                   |                                                                                                                              |                        |            |           |             |            |             |
|                                         |                           | Annual Software Subscription Service, and Annual Support Contract with On-Site Service Check & Report.                       | \$74,800.00            | \$/Yr      | 1         | \$74,800    | 1          | \$74,800    |
| 4                                       | Material Transportation   |                                                                                                                              |                        |            |           |             |            |             |
|                                         |                           | Assume 25% increase over average truck haul cost (\$12.72/ton, \$17.61 from Silver Spring) and rail haul cost (\$15.02/ton). | \$18.90                | \$/Ton     | 67,600    | \$1,277,700 | 186,900    | \$3,532,500 |
|                                         |                           | Covered hopper rail cars for yard trim and food scrap transport to MCYTCF.                                                   | \$10,000.00            | \$/Year    | 10        | \$100,000   | 10         | \$100,000   |
|                                         |                           |                                                                                                                              |                        |            |           |             |            |             |
|                                         |                           |                                                                                                                              | TOTAL ANNUAL O&M COSTS |            |           | \$3,470,000 |            | \$7,580,000 |

Montgomery County Siting Study  
Engineer's Estimate of Probable Capital Costs  
Option 2 - In-Vessel Tunnel Reactor Composting at Shady Grove TS and Product Finishing at MCYTCF  
October 2023

| Item                   | Cost Categories and Items                        | Description                                                                                                                                                                                          | Unit Cost           | Units | Ph I Qty | Ph I Cost    | Ph II Qty | Ph II Cost   |
|------------------------|--------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|-------|----------|--------------|-----------|--------------|
| FACILITY CAPITAL COSTS |                                                  |                                                                                                                                                                                                      |                     |       |          |              |           |              |
| 1                      | Construction Mobilization                        | Site mobilization, including equipment, office trailer establishment, submittals, bonding, and construction administration. Assume 5% of facility capital costs.                                     | \$1,628,000         | LS    | 1        | \$1,628,000  | 0.5       | \$788,600    |
| 2                      | Land Acquisition of Casey Parcels                | Acquisition of 13.2 ac adjacent parcels. Market value assumed at double 2023 property valuation of \$6M.                                                                                             | \$12,000,000        | LS    | 1        | \$12,000,000 | 0.0       | \$0          |
| 3                      | Site Preparation at Casey Parcels                | Site preparation including wetland and stream delineation, forest conservation and additional site permitting and development.                                                                       | \$1,500,000         | LS    | 1.0      | \$1,500,000  | 0.5       | \$750,000    |
| 4                      | Site Preparation at Shady Grove TS               | Site preparation including relocation of existing site activities and minor site demolition in area of material receipt and active composting.                                                       | \$500,000           | LS    | 1.0      | \$500,000    | 1.0       | \$500,000    |
| 5                      | Site Preparation at MCYTCF                       | Site preparation including topographic survey and minor site demolition.                                                                                                                             | \$5,000             | AC    | 9.6      | \$48,200     | 5.6       | \$28,300     |
| 6                      | Erosion and Sediment Controls at Shady Grove TS  | Site controls, including silt fence, diversion fence, stabilized construction entrances, rip rap, stabilization, etc. Includes Casey parcels.                                                        | \$400,000           | LS    | 0.75     | \$300,000    | 0.25      | \$100,000    |
| 7                      | Erosion and Sediment Controls at MCYTCF          | Site controls, including silt fence, diversion fence, stabilized construction entrances, rip rap, stabilization, etc.                                                                                | \$150,000           | LS    | 1.0      | \$150,000    | 0.6       | \$88,000     |
| 8                      | Stormwater Management at Shady Grove TS          | Existing Stormwater management facility upgrades. New stormwater management facilities for Casey parcels.                                                                                            | \$450,000           | LS    | 0.75     | \$337,500    | 0.25      | \$112,500    |
| 9                      | Stormwater Management at MCYTCF                  | Stormwater management facility repair, including retrofit to existing SWM ponds.                                                                                                                     | \$300,000           | LS    | 0.75     | \$225,000    | 0.25      | \$75,000     |
| 10                     | Site Access Road Improvements at MCYTCF          | Improvements to 30 ft two-lane asphalt access road.                                                                                                                                                  | \$300,000           | LS    | 0.75     | \$225,000    | 0.25      | \$75,000     |
| 11                     | Concrete Pad at Shady Grove TS                   | 12" thick reinforced concrete pad with 12" no. 57 stone, in area of feedstock receiving and active composting. Includes incidental earthwork.                                                        | \$101.00            | SY    | 10,620   | \$1,072,620  | 9,200     | \$929,200    |
| 12                     | Receiving Building at Shady Grove TS             | Pre-engineered steel building, 120' width clear, span rigid frame, for feedstock receiving. Includes aeration and biofilter. Includes SWM facility construction and E&SC.                            | \$30.00             | SF    | 61,000   | \$1,830,000  | -         | \$0          |
| 13                     | In-Vessel Composting Equipment at Shady Grove TS | Includes concrete and stainless steel tunnel-type composting components, aeration system, control and monitoring system, motorized doors, and biofilter system. Includes equipment and construction. | \$23,692,800        | LS    | 0.5      | \$11,846,400 | 0.5       | \$11,846,400 |
| 14                     | Asphalt Pad Improvements at MCYTCF               | Improvements to 25% of existing bituminous pavement pad in compost curing, screening, storage and distribution areas. Assume 7" HMA and 4" GAB section.                                              | \$60.00             | SY    | 11,650   | \$699,000    | 6,830     | \$409,800    |
| 15                     | Electrical and Communications                    | Electrical site service and communication connections upgrades at Shady Grove TS, including telecom and system commissioning; excluding primary cables and BGE charges.                              | \$250,000           | LS    | 0.75     | \$187,500    | 0.25      | \$62,500     |
|                        |                                                  |                                                                                                                                                                                                      |                     |       |          |              |           |              |
|                        |                                                  |                                                                                                                                                                                                      | SUBTOTAL            |       |          | \$32,550,000 |           | \$15,766,000 |
|                        |                                                  |                                                                                                                                                                                                      | CONTINGENCY (30%)   |       |          | \$9,765,000  |           | \$4,730,000  |
|                        |                                                  |                                                                                                                                                                                                      | TOTAL CAPITAL COSTS |       |          | \$42,315,000 |           | \$20,496,000 |

| Item                                    | Cost Categories and Items | Description                                                                                                                  | Unit Cost              | Units      | Ph I Qty   | Ph I Cost   | Ph II Qty  | Ph II Cost  |
|-----------------------------------------|---------------------------|------------------------------------------------------------------------------------------------------------------------------|------------------------|------------|------------|-------------|------------|-------------|
| ANNUAL OPERATIONS AND MAINTENANCE COSTS |                           |                                                                                                                              |                        |            |            |             |            |             |
| 1                                       | Labor and Utilities Cost  |                                                                                                                              |                        |            |            |             |            |             |
|                                         |                           | Full-time Facility Supervisor at Shady Grove TS.                                                                             | \$105,300.00           | EA         | 1          | \$105,300   | 1          | \$105,300   |
|                                         |                           | Full-time Facility Operators at Shady Grove TS.                                                                              | \$70,200.00            | EA         | 5          | \$351,000   | 7          | \$491,400   |
|                                         |                           | Full-time Facility Technician at Shady Grove TS.                                                                             | \$168,480.00           | EA         | 1          | \$168,500   | 2          | \$337,000   |
|                                         |                           | Full-time Facility Supervisor at MCYTCF.                                                                                     | \$105,300.00           | EA         | 1          | \$105,300   | 1          | \$105,300   |
|                                         |                           | Full-time Facility Operators at MCYTCF.                                                                                      | \$70,200.00            | EA         | 3          | \$210,600   | 7          | \$491,400   |
|                                         |                           | Full-time Bagging Operators at MCYTCF.                                                                                       | \$70,200.00            | EA         | 1          | \$70,200    | 3          | \$210,600   |
|                                         |                           | Electrical at Shady Grove TS.                                                                                                | \$0.15                 | \$/kWh     | 2,104,400  | \$315,700   | 4,208,800  | \$631,400   |
|                                         |                           | Water addition during active composting.                                                                                     | \$0.02                 | \$/gallons | 10,989,800 | \$217,600   | 12,569,900 | \$248,900   |
| 2                                       | Equipment                 |                                                                                                                              |                        |            |            |             |            |             |
|                                         | Grinder                   | Annual cost, assuming 5 yr service life.                                                                                     | \$220,000.00           | \$/Year    | 2          | \$440,000   | 3          | \$660,000   |
|                                         | Loader                    | Annual cost, assuming 8 yr service life.                                                                                     | \$37,500.00            | \$/Year    | 8          | \$300,000   | 14         | \$525,000   |
|                                         | Screener                  | Annual cost, assuming 5 yr service life.                                                                                     | \$30,000.00            | \$/Year    | 1          | \$30,000    | 2          | \$60,000    |
|                                         | Misc Maintenance Costs    | Replacement cables, sensors, probes, etc.                                                                                    | \$250,000.00           | \$/Year    | 1          | \$250,000   | 1          | \$250,000   |
|                                         | Equipment Repairs         |                                                                                                                              | \$250,000.00           | \$/Year    | 1          | \$250,000   | 2          | \$500,000   |
|                                         | Fuel                      | Fuel for Grinder, Loaders, and Screener.                                                                                     | \$4.00                 | GAL        | 36,700     | \$146,800   | 63,400     | \$253,600   |
| 3                                       | Service                   |                                                                                                                              |                        |            |            |             |            |             |
|                                         |                           | Annual Support.                                                                                                              | \$125,000.00           | LS         | 1          | \$125,000   | 1          | \$125,000   |
| 4                                       | Material Transportation   |                                                                                                                              |                        |            |            |             |            |             |
|                                         |                           | Assume 25% increase over average truck haul cost (\$12.72/ton, \$17.61 from Silver Spring) and rail haul cost (\$15.03/ton). | \$18.90                | \$/Ton     | 77,300     | \$1,461,000 | 213,700    | \$4,039,000 |
|                                         |                           | Covered hopper rail cars for yard trim and food scrap transport to MCYTCF.                                                   | \$10,000.00            | \$/Year    | 10         | \$100,000   | 10         | \$100,000   |
|                                         |                           |                                                                                                                              |                        |            |            |             |            |             |
|                                         |                           |                                                                                                                              | TOTAL ANNUAL O&M COSTS |            |            | \$4,640,000 |            | \$9,130,000 |

Montgomery County Siting Study

Engineer's Estimate of Probable Capital Costs

Option 3 - Agitated Bed Composting at Site 2

October 2023

| Item                   | Cost Categories and Items                   | Description                                                                                                                                                                                                 | Unit Cost           | Units | Ph I Qty | Ph I Cost    | Ph II Qty | Ph II Cost   |
|------------------------|---------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|-------|----------|--------------|-----------|--------------|
| FACILITY CAPITAL COSTS |                                             |                                                                                                                                                                                                             |                     |       |          |              |           |              |
| 1                      | Construction Mobilization                   | Site mobilization, including equipment, office trailer establishment, submittals, bonding, and construction administration. Assume 5% of facility capital costs.                                            | \$2,743,000         | LS    | 1        | \$2,743,000  | 0.3       | \$704,600    |
| 2                      | Site Preparation at Shady Grove TS          | Site preparation for material receiving on-site, including relocation of existing site activities and minor site demolition in Upper Lot or other area for siting of material receiving and pre-processing. | \$500,000           | LS    | 1.0      | \$500,000    | 1.0       | \$500,000    |
| 3                      | Site Preparation at Site 2                  | Site preparation including topographic survey, wetland and stream delineation, tree removal, site permitting and site development.                                                                          | \$50,000            | AC    | 9.6      | \$481,300    | 5.6       | \$282,200    |
| 4                      | Erosion and Sediment Controls at Site 2     | Site controls, including silt fence, diversion fence, stabilized construction entrances, rip rap, stabilization, etc.                                                                                       | \$300,000           | LS    | 1.0      | \$300,000    | 0.6       | \$175,900    |
| 5                      | Stormwater Management at Site 2             | Stormwater management facility construction. Includes storm drain piping, manholes, fittings and appurtenances.                                                                                             | \$550,000           | LS    | 0.75     | \$412,500    | 0.25      | \$137,500    |
| 6                      | Site Access Road Development at Site 2      | Development of internal roadway from RRF railyard to Site 2 through GeoOn site.                                                                                                                             | \$1,000,000         | MILE  | 1.55     | \$1,550,000  | 0.45      | \$450,000    |
| 7                      | Concrete Pad at Shady Grove TS              | 12" thick reinforced concrete pad with 12" no. 57 stone, in area of feedstock receiving and active composting.                                                                                              | \$101.00            | SY    | 6,800    | \$686,800    | -         | \$0          |
| 8                      | Receiving Building at Shady Grove TS        | Pre-engineered steel building, 120' width clear, span rigid frame, for feedstock receiving. Includes aeration and biofilter. Includes SWM facility construction and E&SC.                                   | \$30.00             | SF    | 61,000   | \$1,830,000  | -         | \$0          |
| 9                      | Concrete Pad at Site 2                      | 12" thick reinforced concrete pad with 12" no. 57 stone, in area of feedstock receiving and active composting.                                                                                              | \$101.00            | SY    | 32,500   | \$3,282,500  | -         | \$0          |
| 10                     | Agitated Bed Compost Building at Site 2     | 120,000 SF Insulated coated steel structure, ventilated to house full build out (Phase I and II) of agitated bed equipment, including material receiving and active composting areas.                       | \$150               | SF    | 118,500  | \$17,775,000 | -         | \$0          |
| 11                     | Agitated Bed Composting Equipment at Site 2 | 30 compost bays, 5-100 HP agitators, aeration equipment for four aeration zones per bay; biofilter, including concrete, ductwork, fans and media.                                                           | \$20,100,000        | LS    | 0.5      | \$10,050,000 | 0.5       | \$10,050,000 |
| 12                     | Asphalt Pad Construction at Site 2          | Installation of bituminous pavement pad in compost curing, screening, storage and distribution areas. Assume 7" HMA and 4" GAB section.                                                                     | \$60.00             | SY    | 46,590   | \$2,795,400  | 27,320.00 | \$1,639,200  |
| 13                     | Electrical and Communications               | Electrical site service and communication establishment at Site 2, including telecom and system commissioning; excluding primary cables and BGE charges.                                                    | \$600,000           | LS    | 0.75     | \$450,000    | 0.25      | \$150,000    |
| 14                     | Water                                       | Public water main extension approximately 4.0 miles in length along MD 107 (Whites Ferry Road) and Wasche Road.                                                                                             | \$3,000,000         | MILE  | 4.00     | \$12,000,000 | -         | \$0          |
|                        |                                             |                                                                                                                                                                                                             |                     |       |          |              |           |              |
|                        |                                             |                                                                                                                                                                                                             | SUBTOTAL            |       |          | \$54,857,000 |           | \$14,090,000 |
|                        |                                             |                                                                                                                                                                                                             | CONTINGENCY (30%)   |       |          | \$16,458,000 |           | \$4,227,000  |
|                        |                                             |                                                                                                                                                                                                             | TOTAL CAPITAL COSTS |       |          | \$71,315,000 |           | \$18,317,000 |

| Item                                    | Cost Categories and Items | Description                                                                                                                 | Unit Cost              | Units      | Ph I Qty  | Ph I Cost   | Ph II Qty  | Ph II Cost  |
|-----------------------------------------|---------------------------|-----------------------------------------------------------------------------------------------------------------------------|------------------------|------------|-----------|-------------|------------|-------------|
| ANNUAL OPERATIONS AND MAINTENANCE COSTS |                           |                                                                                                                             |                        |            |           |             |            |             |
| 1                                       | Labor and Utilities Cost  |                                                                                                                             |                        |            |           |             |            |             |
|                                         |                           | Full-time Facility Supervisor at Shady Grove TS.                                                                            | \$105,300.00           | EA         | 1         | \$105,300   | 1          | \$105,300   |
|                                         |                           | Full-time Facility Operators at Shady Grove TS.                                                                             | \$70,200.00            | EA         | 2         | \$140,400   | 5          | \$351,000   |
|                                         |                           | Part-time Facility Technician at Shady Grove TS.                                                                            | \$84,240.00            | EA         | 1         | \$84,300    | 1          | \$84,300    |
|                                         |                           | Full-time Facility Supervisor at Site 2.                                                                                    | \$105,300.00           | EA         | 1         | \$105,300   | 1          | \$105,300   |
|                                         |                           | Full-time Facility Operators at Site 2.                                                                                     | \$70,200.00            | EA         | 4         | \$280,800   | 9          | \$631,800   |
|                                         |                           | Full-time Bagging Operators at Site 2.                                                                                      | \$70,200.00            | EA         | 1         | \$70,200    | 3          | \$210,600   |
|                                         |                           | Electrical at Site 2.                                                                                                       | \$0.15                 | \$/kWh     | 2,104,400 | \$315,700   | 4,208,800  | \$631,400   |
|                                         |                           | Water addition during active composting.                                                                                    | \$0.02                 | \$/gallons | 4,546,400 | \$90,100    | 12,569,900 | \$248,900   |
| 2                                       | Equipment                 |                                                                                                                             |                        |            |           |             |            |             |
|                                         | Grinder                   | Annual cost, assuming 5 yr service life.                                                                                    | \$220,000.00           | \$/Year    | 2         | \$440,000   | 4          | \$880,000   |
|                                         | Loader                    | Annual cost, assuming 8 yr service life.                                                                                    | \$37,500.00            | \$/Year    | 6         | \$225,000   | 14         | \$525,000   |
|                                         | Screener                  | Annual cost, assuming 5 yr service life.                                                                                    | \$30,000.00            | \$/Year    | 1         | \$30,000    | 2          | \$60,000    |
|                                         | Misc Maintenance Costs    | Replacement cables, sensors, probes, etc.                                                                                   | \$150,000.00           | \$/Year    | 1         | \$150,000   | 1          | \$150,000   |
|                                         | Equipment Repairs         |                                                                                                                             | \$250,000.00           | \$/Year    | 1         | \$250,000   | 2          | \$500,000   |
|                                         | Fuel                      | Fuel for Grinder, Loaders, and Screener.                                                                                    | \$4.00                 | GAL        | 30,000    | \$120,000   | 66,700     | \$266,800   |
| 3                                       | Service                   |                                                                                                                             |                        |            |           |             |            |             |
|                                         |                           | Annual Support.                                                                                                             | \$50,000.00            | LS         | 1         | \$50,000    | 1          | \$50,000    |
| 4                                       | Material Transportation   |                                                                                                                             |                        |            |           |             |            |             |
|                                         |                           | Assume 25% increase over average truck haul cost (\$12.72/ton, \$17.61 from Silver Spring) and rail haul cost (\$15.02/ton) | \$18.90                | \$/Ton     | 67,600    | \$1,277,700 | 186,900    | \$3,532,500 |
|                                         |                           | Covered hopper rail cars for yard trim and food scrap transport to Site 2.                                                  | \$10,000.00            | \$/Year    | 10        | \$100,000   | 10         | \$100,000   |
|                                         |                           |                                                                                                                             |                        |            |           |             |            |             |
|                                         |                           |                                                                                                                             | TOTAL ANNUAL O&M COSTS |            |           | \$3,830,000 |            | \$8,430,000 |

Montgomery County Siting Study

Engineer's Estimate of Probable Capital Costs

Option 4 - Dry Fermentation Anaerobic Digestion at Shady Grove TS with Product Finishing at MCYTCF via Tunnel Reactor Composting

October 2023, Revised March 2024

| Item                   | Cost Categories and Items                              | Description                                                                                                                                                                                          | Unit Cost           | Units | Ph I Qty | Ph I Cost    | Ph II Qty | Ph II Cost   |
|------------------------|--------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|-------|----------|--------------|-----------|--------------|
| FACILITY CAPITAL COSTS |                                                        |                                                                                                                                                                                                      |                     |       |          |              |           |              |
| 1                      | Construction Mobilization                              | Site mobilization, including equipment, office trailer establishment, submittals, bonding, and construction administration. Assume 5% of facility capital costs.                                     | \$2,891,000         | LS    | 1        | \$2,891,000  | 0.9       | \$2,625,300  |
| 2                      | Land Acquisition of Casey Parcels                      | Acquisition of 13.2 ac adjacent parcels. Market value assumed at double 2023 property valuation of \$6M.                                                                                             | \$12,000,000        | LS    | 1        | \$12,000,000 | 0.0       | \$0          |
| 3                      | Site Preparation at Casey Parcels                      | Site preparation including wetland and stream delineation, forest conservation and additional site permitting and development.                                                                       | \$1,500,000         | LS    | 1.0      | \$1,500,000  | 0.5       | \$750,000    |
| 4                      | Site Preparation at Shady Grove TS                     | Site preparation including relocation of existing site activities and minor site demolition in area of material receipt and AD.                                                                      | \$500,000           | LS    | 1.0      | \$500,000    | 1.0       | \$500,000    |
| 5                      | Site Preparation at MCYTCF                             | Site preparation including topographic survey and minor site demolition.                                                                                                                             | \$5,000             | AC    | 9.6      | \$48,200     | 5.6       | \$28,300     |
| 6                      | Erosion and Sediment Controls at Shady Grove TS        | Site controls, including silt fence, diversion fence, stabilized construction entrances, rip rap, stabilization, etc. Includes Casey parcels.                                                        | \$400,000           | LS    | 0.75     | \$300,000    | 0.25      | \$100,000    |
| 7                      | Erosion and Sediment Controls at MCYTCF                | Site controls, including silt fence, diversion fence, stabilized construction entrances, rip rap, stabilization, etc.                                                                                | \$150,000           | LS    | 1.0      | \$150,000    | 0.6       | \$88,000     |
| 8                      | Stormwater Management at Shady Grove TS                | Existing Stormwater management facility upgrades. New stormwater management facilities for Casey parcels.                                                                                            | \$450,000           | LS    | 0.75     | \$337,500    | 0.25      | \$112,500    |
| 9                      | Stormwater Management at MCYTCF                        | Stormwater management facility repair, including retrofit to existing SWM ponds.                                                                                                                     | \$300,000           | LS    | 0.75     | \$225,000    | 0.25      | \$75,000     |
| 10                     | Site Access Road Improvements at MCYTCF                | Improvements to 30 ft two-lane asphalt access road.                                                                                                                                                  | \$300,000           | LS    | 0.75     | \$225,000    | 0.25      | \$75,000     |
| 11                     | Concrete Pad at Shady Grove TS                         | 12" thick reinforced concrete pad with 12" no. 57 stone, in area of feedstock receiving and AD.                                                                                                      | \$101.00            | SY    | 14,460   | \$1,460,460  | 21,220    | \$2,143,300  |
| 12                     | Receiving Building at Shady Grove TS                   | Pre-engineered steel building, 120' width clear, span rigid frame, for feedstock receiving. Includes aeration and biofilter. Includes SWM facility construction and E&SC.                            | \$30.00             | SF    | 61,000   | \$1,830,000  | -         | \$0          |
| 13                     | Dry Fermentation Anaerobic Digestion at Shady Grove TS | Dry fermentation AD reactors, controls, and equipment.                                                                                                                                               | \$45,000,000        | LS    | 0.35     | \$15,750,000 | 0.65      | \$29,250,000 |
| 14                     | Hydrogen Conversion Equipment                          | Methane to hydrogen conversion equipment. Assume 180 SCFM capacity.                                                                                                                                  | \$9,525,000.00      | LS    | 0.75     | \$7,143,800  | 0.25      | \$2,381,250  |
| 15                     | Concrete Pad at MCYTCF                                 | 12" thick reinforced concrete pad with 12" no. 57 stone, in area of feedstock receiving and active composting.                                                                                       | \$101.00            | SY    | 3,840    | \$387,840    | 10,610    | \$1,071,700  |
| 16                     | In-Vessel Composting Equipment at MCYTCF               | Includes concrete and stainless steel tunnel-type composting components, aeration system, control and monitoring system, motorized doors, and biofilter system. Includes equipment and construction. | \$23,692,800        | LS    | 0.5      | \$11,846,400 | 0.5       | \$11,846,400 |
| 17                     | Asphalt Pad Improvements at MCYTCF                     | Improvements to 25% of existing bituminous pavement pad in compost curing, screening, storage and distribution areas. Assume 7" HMA and 4" GAB section.                                              | \$60.00             | SY    | 11,650   | \$699,000    | 6,830     | \$409,800    |
| 18                     | Electrical and Communications at Shady Grove TS        | Electrical site service and communication connections upgrades at Shady Grove TS, including telecom and system commissioning; excluding primary cables and BGE charges.                              | \$400,000           | LS    | 0.75     | \$300,000    | 0.25      | \$100,000    |
| 19                     | Electrical and Communications at MCYTCF                | Electrical site service and communication connections upgrades at MCYTCF, including telecom and system commissioning; excluding primary cables and BGE charges.                                      | \$300,000           | LS    | 0.75     | \$225,000    | 0.25      | \$75,000     |
|                        |                                                        |                                                                                                                                                                                                      |                     |       |          |              |           |              |
|                        |                                                        |                                                                                                                                                                                                      | SUBTOTAL            |       |          | \$57,820,000 |           | \$51,632,000 |
|                        |                                                        |                                                                                                                                                                                                      | CONTINGENCY (30%)   |       |          | \$17,346,000 |           | \$15,490,000 |
|                        |                                                        |                                                                                                                                                                                                      | TOTAL CAPITAL COSTS |       |          | \$75,166,000 |           | \$67,122,000 |

| Item                                    | Cost Categories and Items | Description                                                                                                                  | Unit Cost              | Units      | Ph I Qty   | Ph I Cost   | Ph II Qty  | Ph II Cost   |
|-----------------------------------------|---------------------------|------------------------------------------------------------------------------------------------------------------------------|------------------------|------------|------------|-------------|------------|--------------|
| ANNUAL OPERATIONS AND MAINTENANCE COSTS |                           |                                                                                                                              |                        |            |            |             |            |              |
| 1                                       | Labor and Utilities Cost  |                                                                                                                              |                        |            |            |             |            |              |
|                                         |                           | Full-time Facility Supervisor at Shady Grove TS.                                                                             | \$105,300.00           | EA         | 1          | \$105,300   | 1          | \$105,300    |
|                                         |                           | Full-time Facility Operators at Shady Grove TS.                                                                              | \$70,200.00            | EA         | 6          | \$421,200   | 8          | \$561,600    |
|                                         |                           | Full-time Facility Technician at Shady Grove TS.                                                                             | \$168,480.00           | EA         | 1          | \$168,500   | 2          | \$337,000    |
|                                         |                           | Full-time Facility Supervisor at MCYTCF.                                                                                     | \$105,300.00           | EA         | 1          | \$105,300   | 1          | \$105,300    |
|                                         |                           | Full-time Facility Operators at MCYTCF.                                                                                      | \$70,200.00            | EA         | 5          | \$351,000   | 7          | \$491,400    |
|                                         |                           | Full-time Bagging Operators at MCYTCF.                                                                                       | \$70,200.00            | EA         | 1          | \$70,200    | 3          | \$210,600    |
|                                         |                           | Full-time Facility Technician at MCYTCF.                                                                                     | \$168,480.00           | EA         | 1          | \$168,500   | 2          | \$337,000    |
|                                         |                           | Electrical at Shady Grove TS.                                                                                                | \$0.15                 | \$/kWh     | 2,104,400  | \$315,700   | 4,208,800  | \$631,400    |
|                                         |                           | Electrical at MCYTCF.                                                                                                        | \$0.15                 | \$/kWh     | 2,104,400  | \$315,700   | 4,208,800  | \$631,400    |
|                                         |                           | Water addition during active composting.                                                                                     | \$0.02                 | \$/gallons | 10,989,800 | \$217,600   | 12,569,900 | \$248,900    |
| 2                                       | Equipment                 |                                                                                                                              |                        |            |            |             |            |              |
|                                         | Grinder                   | Annual cost, assuming 5 yr service life.                                                                                     | \$220,000.00           | \$/Year    | 2          | \$440,000   | 3          | \$660,000    |
|                                         | Loader                    | Annual cost, assuming 8 yr service life.                                                                                     | \$37,500.00            | \$/Year    | 11         | \$412,500   | 15         | \$562,500    |
|                                         | Screener                  | Annual cost, assuming 5 yr service life.                                                                                     | \$30,000.00            | \$/Year    | 1          | \$30,000    | 2          | \$60,000     |
|                                         | Misc Maintenance Costs    | Replacement cables, sensors, probes, etc.                                                                                    | \$350,000.00           | \$/Year    | 1          | \$350,000   | 1          | \$350,000    |
|                                         | Equipment Repairs         |                                                                                                                              | \$250,000.00           | \$/Year    | 1          | \$250,000   | 2          | \$500,000    |
|                                         | Fuel                      | Fuel for Grinder, Loaders, and Screener.                                                                                     | \$4.00                 | GAL        | 46,700     | \$186,800   | 66,700     | \$266,800    |
| 3                                       | Service                   |                                                                                                                              |                        |            |            |             |            |              |
|                                         |                           | Annual Support.                                                                                                              | \$250,000.00           | LS         | 1          | \$250,000   | 1          | \$250,000    |
| 4                                       | Material Transportation   |                                                                                                                              |                        |            |            |             |            |              |
|                                         |                           | Assume 25% increase over average truck haul cost (\$12.72/ton, \$17.61 from Silver Spring) and rail haul cost (\$15.02/ton). | \$18.90                | \$/Ton     | 77,300     | \$1,461,000 | 213,700    | \$4,039,000  |
|                                         |                           | Covered hopper rail cars for yard trim and food scrap transport to MCYTCF.                                                   | \$10,000.00            | \$/Year    | 10         | \$100,000   | 10         | \$100,000    |
|                                         |                           | High pressure tube trailer for Hydrogen gas transport.                                                                       | \$600,000.00           | EA         | 1          | \$600,000   | 2          | \$1,200,000  |
|                                         |                           |                                                                                                                              |                        |            |            |             |            |              |
|                                         |                           |                                                                                                                              | TOTAL ANNUAL O&M COSTS |            |            | \$6,310,000 |            | \$11,640,000 |



Montgomery County Siting Study  
Engineer's Estimate of Probable Capital Costs  
Option 5 - Dry Fermentation Anaerobic Digestion at Shady Grove TS with Product Finishing at MCYTCF  
October 2023, Revised March 2024

| Item                   | Cost Categories and Items                              | Description                                                                                                                                                               | Unit Cost           | Units | Ph I Qty | Ph I Cost    | Ph II Qty | Ph II Cost   |
|------------------------|--------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|-------|----------|--------------|-----------|--------------|
| FACILITY CAPITAL COSTS |                                                        |                                                                                                                                                                           |                     |       |          |              |           |              |
| 1                      | Construction Mobilization                              | Site mobilization, including equipment, office trailer establishment, submittals, bonding, and construction administration. Assume 5% of facility capital costs.          | \$2,248,000         | LS    | 1        | \$2,248,000  | 0.9       | \$1,942,700  |
| 2                      | Land Acquisition of Casey Parcels                      | Acquisition of 13.2 ac adjacent parcels. Market value assumed at double 2023 property valuation of \$6M.                                                                  | \$12,000,000        | LS    | 1        | \$12,000,000 | 0.0       | \$0          |
| 3                      | Site Preparation at Casey Parcels                      | Site preparation including wetland and stream delineation, forest conservation and additional site permitting and development.                                            | \$1,500,000         | LS    | 1.0      | \$1,500,000  | 0.5       | \$750,000    |
| 4                      | Site Preparation at Shady Grove TS                     | Site preparation including relocation of existing site activities and minor site demolition in area of material receipt and AD.                                           | \$500,000           | LS    | 1.0      | \$500,000    | 1.0       | \$500,000    |
| 5                      | Site Preparation at MCYTCF                             | Site preparation including topographic survey and minor site demolition.                                                                                                  | \$5,000             | AC    | 9.6      | \$48,200     | 5.6       | \$28,300     |
| 6                      | Erosion and Sediment Controls at Shady Grove TS        | Site controls, including silt fence, diversion fence, stabilized construction entrances, rip rap, stabilization, etc. Includes Casey parcels.                             | \$400,000           | LS    | 0.75     | \$300,000    | 0.25      | \$100,000    |
| 7                      | Erosion and Sediment Controls at MCYTCF                | Site controls, including silt fence, diversion fence, stabilized construction entrances, rip rap, stabilization, etc.                                                     | \$150,000           | LS    | 1.0      | \$150,000    | 0.6       | \$88,000     |
| 8                      | Stormwater Management at Shady Grove TS                | Existing Stormwater management facility upgrades. New stormwater management facilities for Casey parcels.                                                                 | \$450,000           | LS    | 0.75     | \$337,500    | 0.25      | \$112,500    |
| 9                      | Stormwater Management at MCYTCF                        | Stormwater management facility repair, including retrofit to existing SWM ponds.                                                                                          | \$300,000           | LS    | 0.75     | \$225,000    | 0.25      | \$75,000     |
| 10                     | Site Access Road Improvements at MCYTCF                | Improvements to 30 ft two-lane asphalt access road.                                                                                                                       | \$300,000           | LS    | 0.75     | \$225,000    | 0.25      | \$75,000     |
| 11                     | Concrete Pad at Shady Grove TS                         | 12" thick reinforced concrete pad with 12" no. 57 stone, in area of feedstock receiving and AD.                                                                           | \$101.00            | SY    | 14,460   | \$1,460,460  | 21,220    | \$2,143,300  |
| 12                     | Receiving Building at Shady Grove TS                   | Pre-engineered steel building, 120' width clear, span rigid frame, for feedstock receiving. Includes aeration and biofilter. Includes SWM facility construction and E&SC. | \$30.00             | SF    | 61,000   | \$1,830,000  | -         | \$0          |
| 13                     | Dry Fermentation Anaerobic Digestion at Shady Grove TS | Dry fermentation AD reactors, controls, and equipment.                                                                                                                    | \$45,000,000        | LS    | 0.35     | \$15,750,000 | 0.65      | \$29,250,000 |
| 14                     | Hydrogen Conversion Equipment at Shady Grove TS        | Methane to hydrogen conversion equipment. Assume 180 SCFM capacity.                                                                                                       | \$9,525,000.00      | LS    | 0.75     | \$7,143,800  | 0.25      | \$2,381,250  |
| 15                     | Asphalt Pad Improvements at MCYTCF                     | Improvements to 25% of existing bituminous pavement pad in compost curing, screening, storage and distribution areas. Assume 7" HMA and 4" GAB section.                   | \$60.00             | SY    | 11,650   | \$699,000    | 6,830     | \$409,800    |
| 16                     | Electrical and Communications at Shady Grove TS        | Electrical site service and communication connections upgrades at Shady Grove TS, including telecom and system commissioning; excluding primary cables and BGE charges.   | \$400,000           | LS    | 0.75     | \$300,000    | 0.25      | \$100,000    |
| 17                     | Electrical and Communications at MCYTCF                | Electrical site service and communication connections upgrades at MCYTCF, including telecom and system commissioning; excluding primary cables and BGE charges.           | \$300,000           | LS    | 0.75     | \$225,000    | 0.25      | \$75,000     |
|                        |                                                        |                                                                                                                                                                           |                     |       |          |              |           |              |
|                        |                                                        |                                                                                                                                                                           | SUBTOTAL            |       |          | \$44,942,000 |           | \$38,031,000 |
|                        |                                                        |                                                                                                                                                                           | CONTINGENCY (30%)   |       |          | \$13,483,000 |           | \$11,410,000 |
|                        |                                                        |                                                                                                                                                                           | TOTAL CAPITAL COSTS |       |          | \$58,425,000 |           | \$49,441,000 |

| Item                                    | Cost Categories and Items | Description                                                                                                                  | Unit Cost    | Units      | Ph I Qty   | Ph I Cost   | Ph II Qty  | Ph II Cost   |
|-----------------------------------------|---------------------------|------------------------------------------------------------------------------------------------------------------------------|--------------|------------|------------|-------------|------------|--------------|
| ANNUAL OPERATIONS AND MAINTENANCE COSTS |                           |                                                                                                                              |              |            |            |             |            |              |
| 1                                       | Labor and Utilities Cost  |                                                                                                                              |              |            |            |             |            |              |
|                                         |                           | Full-time Facility Supervisor at Shady Grove TS.                                                                             | \$105,300.00 | EA         | 1          | \$105,300   | 1          | \$105,300    |
|                                         |                           | Full-time Facility Operators at Shady Grove TS.                                                                              | \$70,200.00  | EA         | 6          | \$421,200   | 8          | \$561,600    |
|                                         |                           | Full-time Facility Technician at Shady Grove TS.                                                                             | \$168,480.00 | EA         | 1          | \$168,500   | 2          | \$337,000    |
|                                         |                           | Full-time Facility Supervisor at MCYTCF.                                                                                     | \$105,300.00 | EA         | 1          | \$105,300   | 1          | \$105,300    |
|                                         |                           | Full-time Facility Operators at MCYTCF.                                                                                      | \$70,200.00  | EA         | 2          | \$140,400   | 5          | \$351,000    |
|                                         |                           | Full-time Bagging Operators at MCYTCF.                                                                                       | \$70,200.00  | EA         | 1          | \$70,200    | 3          | \$210,600    |
|                                         |                           | Electrical at Shady Grove TS.                                                                                                | \$0.15       | \$/kWh     | 2,104,400  | \$315,700   | 4,208,800  | \$631,400    |
|                                         |                           | Water addition during active composting.                                                                                     | \$0.02       | \$/gallons | 12,569,900 | \$248,900   | 10,989,800 | \$217,600    |
| 2                                       | Equipment                 |                                                                                                                              |              |            |            |             |            |              |
|                                         | Grinder                   | Annual cost, assuming 5 yr service life.                                                                                     | \$220,000.00 | \$/Year    | 2          | \$440,000   | 3          | \$660,000    |
|                                         | Loader                    | Annual cost, assuming 8 yr service life.                                                                                     | \$37,500.00  | \$/Year    | 8          | \$300,000   | 13         | \$487,500    |
|                                         | Screener                  | Annual cost, assuming 5 yr service life.                                                                                     | \$30,000.00  | \$/Year    | 1          | \$30,000    | 2          | \$60,000     |
|                                         | Misc Maintenance Costs    | Replacement cables, sensors, probes, etc.                                                                                    | \$250,000.00 | \$/Year    | 1          | \$250,000   | 1          | \$250,000    |
|                                         | Equipment Repairs         |                                                                                                                              | \$250,000.00 | \$/Year    | 1          | \$250,000   | 2          | \$500,000    |
|                                         | Fuel                      | Fuel for Grinder, Loaders, and Screener.                                                                                     | \$4.00       | GAL        | 36,700     | \$146,800   | 60,000     | \$240,000    |
| 3                                       | Service                   |                                                                                                                              |              |            |            |             |            |              |
|                                         |                           | Annual Support.                                                                                                              | \$125,000.00 | LS         | 1          | \$125,000   | 1          | \$125,000    |
| 4                                       | Material Transportation   |                                                                                                                              |              |            |            |             |            |              |
|                                         |                           | Assume 25% increase over average truck haul cost (\$12.72/ton, \$17.61 from Silver Spring) and rail haul cost (\$15.02/ton). | \$18.90      | \$/Ton     | 77,300     | \$1,461,000 | 213,700    | \$4,039,000  |
|                                         |                           | Covered hopper rail cars for yard trim and food scrap transport to MCYTCF.                                                   | \$10,000.00  | \$/Year    | 10         | \$100,000   | 10         | \$100,000    |
|                                         |                           | High pressure tube trailer for Hydrogen gas transport.                                                                       | \$600,000.00 | EA         | 1          | \$600,000   | 2          | \$1,200,000  |
|                                         |                           |                                                                                                                              |              |            |            |             |            |              |
|                                         |                           | TOTAL ANNUAL O&M COSTS                                                                                                       |              |            |            | \$5,270,000 |            | \$10,180,000 |

# **Appendix G:**

## **Vendor Product Information**

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## Technical Memo

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**Attention:** Regina Cagle P.E.

**Date:** September 18, 2023

**From:** Brian Fuchs  
Brett Hoyt

**Purpose:** Maryland Project SSO 260k tons/ year  
SG Bunker® System with GORE® Cover Support Information

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**Project Description:** Sustainable Generation and GORE® Cover is providing system sizing, preliminary layout and budgetary information for processing of Source Separated organics (SSO) organic waste. For discussion purposes only.

Enclosed we will provide concepts for developing a compost facility based on experience from similar design concepts, similar feed stocks and similar climate conditions.

We are using our standard 2 Phase 6-week (42 days) process to achieve regulatory compliant stabilized high-quality compost. While achieving a high level of environmental controls for protection of air (odors and VOC emissions) and water (separation of leachate from storm water) quality.

Note: Our scope of supply is centered on the composting portion of the project for supply of equipment and services for the SG Bunker® System using GORE® Cover technology. All other critical components, scale, office buildings, receiving area (open or covered), biofilter and adjacent processing equipment and materials handling outside the composting pad to be supplied by other. We are happy to share our experience from relevant reference facilities.

### Key Assumptions:

- ~200,000-ton green organics (leaf & yard debris, landscaping and clean wood waste)
- ~60,000-ton food organics (residential and/or commercial)
- SG Bunker® System with GORE® Cover
- Power supply (clean power, solar, generator....)





## Mass Balance Calculations and Assumptions

| Assumptions                    | Project Information                        |                                     |
|--------------------------------|--------------------------------------------|-------------------------------------|
| Feed Stocks (Organics)         | SSO, Bulking Materials and Screened Over's |                                     |
| Total Throughput Volume / Year | Tons                                       | Cubic Yards @ 925lbs/y <sup>3</sup> |
| Design Capacity Required       | 260,000                                    | 562,162                             |
| Design Capacity Proposed       | 261,398                                    | 565,185                             |
| Total Compost Pad Footprint    | ~ 8.0 acres including driving area         |                                     |
| Treatment Time                 | 2 Phase Process – 42 Days*                 |                                     |
| Phase 1 Active Composting      | 21 Days (or 28 Days)                       |                                     |
| Phase 2 Maturation Composting  | 21 Days (or 14 Days)                       |                                     |

\*Mixed adjusted

## SG Bunker® System Sizing & Design Capacity:

|                            |               |             |                    |         |         |                       |
|----------------------------|---------------|-------------|--------------------|---------|---------|-----------------------|
| Process Time               |               | 6           | weeks              | Active  | Curing  | Finishing             |
|                            |               |             |                    | Phase 1 | Phase 2 | Phase 3               |
| Days per Week Operation    |               | 6           |                    |         |         |                       |
| # of Bunkers               |               | 48          |                    | 24      | 24      | 0                     |
| Heap Length                |               | 164         | ft                 |         |         |                       |
| Heap Width                 | inside wall   | 25.67       | ft                 |         |         |                       |
| Heap Height                |               | 12          | ft                 |         |         |                       |
| Actual Mix*                |               | 925         | lbs/y <sup>3</sup> |         | 0.46    | US ton/y <sup>3</sup> |
| Volume per bunker          |               | 1359        | y <sup>3</sup>     |         |         |                       |
| Volume on pad              | (if pad full) | 65214       | y <sup>3</sup>     |         |         |                       |
| Total Throughput Volume    |               |             |                    |         |         |                       |
|                            | per year      | 565185      | y <sup>3</sup>     |         |         |                       |
|                            | per week      | 10869       | y <sup>3</sup>     |         |         |                       |
|                            | per day       | 1811        | y <sup>3</sup>     |         |         |                       |
| Tons per bunker            |               | 628         | US ton             |         |         |                       |
| Tons per pad (if pad full) |               | 30161       | US ton             |         |         |                       |
| Total Throughput Tons      |               | Actual mix* |                    |         |         |                       |
|                            | per year      | 261398      | US ton             |         |         |                       |
|                            | per week      | 4189        | US ton             |         |         |                       |
|                            | per day       | 838         | US ton             |         |         |                       |
| Foot Print/ Space Required |               |             |                    |         |         |                       |
| Compost Pad Length         |               | 175         | ft                 |         |         |                       |
| Compost Pad Width          |               | 1647        | ft                 |         |         |                       |
| Compost Pad                |               | 288254      | sq ft              | 6.62    | acre    |                       |
| Driving Space              |               | 65887       | sq ft              |         |         |                       |
| Total Compost Pad          |               | 354141      | sq ft              | 8.13    | acre    |                       |

\*Actual Mix is mixed input material entering Phase 1; inclusive of screened overs and added process water to adjust moisture



The SG Bunker® System solution **Budgetary Pricing: Purchase**

| GORE® Cover System | Configuration                                                                           | Pricing (\$USD)  |
|--------------------|-----------------------------------------------------------------------------------------|------------------|
| SG Bunker® System  | 48 SG Bunker® with 48 GORE® Cover                                                       |                  |
|                    | 164ft Length x 27ft Width x 11.5ft Height                                               |                  |
|                    | SG Bunker® System                                                                       | Included         |
| SG SmartStart™     | Installation Guide, Pre-Design Support / Construction Support/ Installation Supervision |                  |
|                    |                                                                                         |                  |
| Service Package    | Commissioning, Start Up Services & Operating Training Module, Ongoing Technical Support | Included         |
|                    |                                                                                         |                  |
| CWM                | Cover Winding Machine                                                                   | Included         |
|                    |                                                                                         |                  |
|                    | Total                                                                                   | \$ 11,000,000.00 |

\*Engineering Design, Construction not part SG scope of supply – supplied by other.

- Prices include estimated Duty and Shipping delivered to project site.
- All other Taxes not included.
- Tariffs not included, if any
- State and Local Sales Tax payable by Buyer
- Subject to Terms and Conditions in the formal Quotation

For budgetary purposes only, pricing and configuration are subject to change. Upon agreed equipment configuration and determined scope of work for services, a formal quote will be developed. Any and all information in this **budgetary quotation shall be kept confidential and shall not be shared with third parties without the express written approval of Sustainable Generation.**

**Total Project Cost Summary Estimate: (See Capex Opex document September 18, 2023)**

|                                                      |                    |                                                                                                           |                             |                 |
|------------------------------------------------------|--------------------|-----------------------------------------------------------------------------------------------------------|-----------------------------|-----------------|
| Customer Worksheet:<br>Regina Cagle<br>EA Associates | September 18, 2023 | TOTAL CAPEX: SG BUNKER® System with Winder and SG Smartstart® Services (Civils & concrete works excluded) | All costs are in \$USD      |                 |
|                                                      |                    | TOTAL Annual Cost = OPEX                                                                                  | \$11,000,000                |                 |
|                                                      |                    | TOTAL Annual Cost = OPEX + Annual CAPEX Reserve                                                           | \$1,359,920                 | Years 1-4       |
|                                                      |                    |                                                                                                           | \$1,737,063                 | Starting Year 5 |
|                                                      |                    | Estimated Fully Constructed Cost for SG BUNKER® System only (includes SG CAPEX costs above)               | \$24,000,000 - \$30,000,000 |                 |

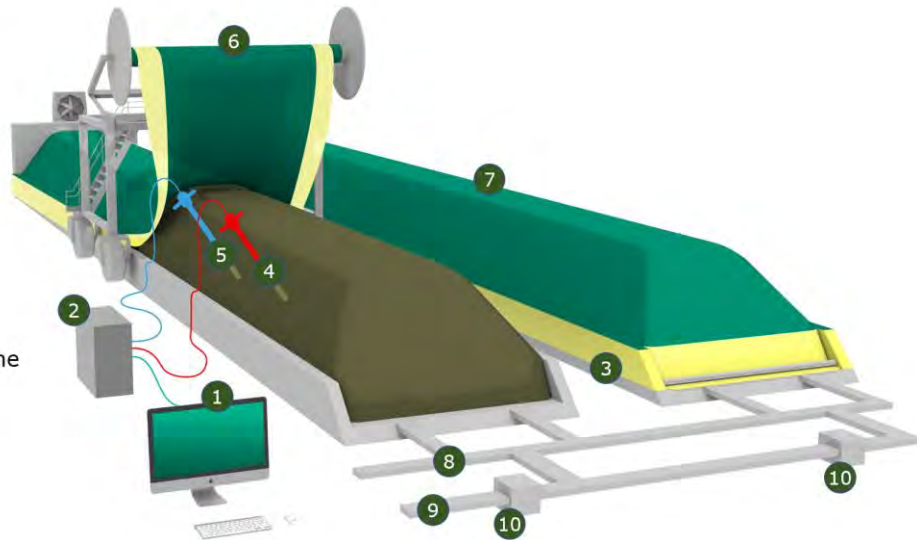


The SG Bunker® System using GORE® COVER is an innovative solution that include:

### Equipment and Service Supply Package



1. Control System
2. Server
3. Fastening System
4. Temperature Probe
5. Oxygen Probe
6. Cover Handling Machine
7. GORE® Cover
8. Aeration Blower
9. Trench System
10. Water Trap



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### SG Bunker® System Equipment Supply Package

- **GORE® Cover**
- **SG Compost Control** system inclusive of software, programing and hardware
  - Server, PC, Laptop or Bunker Device
  - Modes of Operation
    - Interval Mode
    - O2 Mode
    - Manual Mode
    - Safety Mode
- **Temperature Probes**
- **Oxygen Probes**
- **Blower**
- **Aeration System** consisting of:
  - Polymer Concrete Trench for SG Bunker®
    - Water Trap
    - Leachate Collection Pipe
- **Side Wall Fastening System**
- **Winding Machine** type for deployment and retracting the GORE® Cover.



## **SG Scope of Supply of Services**

The **SG Service** (SG SmartStart™ Service Package) includes a high level of interaction between the owners, engineering consultants and the construction company. It is very important that the installation of the GORE® Cover technology and Operating Manual be followed to insure a successful installation and sustainable operation.

### **Installation Guide: According to Final Agreement**

- Drawings, Component Specification, Detail and Installation Guidelines

### **Operations Manual: According to Final Agreement**

- SG Bunker® System using GORE® Cover technology
- Cover Winder Machine

### **Permitting Support Services: According to Final Agreement**

- Support permitting process with technical information

### **System Design Guidance / Support: As part of the Installation Guide Package**

- Preliminary Layout and Drawings as defined in the bid document
- Layout Drawings to handed over to the Buyer's Engineer for design and construction

### **Construction Guidance / Support: According to Final Agreement**

- Pre-Construction Meeting
- Installation Services/ Guidance
  - Aeration Trench Installation Support
  - Electronics Installation Support
- Portable Winding Machine Installation/Testing/Commissioning
- Compost Process Commissioning, Start Up and First Heap Construction
- Performance Test

### **Training for Site Management and Operators: According to Final Agreement**

- Classroom and On-site training
  - Training 1 - at reference site or on-site (up to 3 days)
    - Site Reference Visits (optional)
  - Training 2 – during system check and start-up (up to 3 days)
  - Training 3 – 12 weeks after commissioning (up to 3 days)







### Typical Facility and Process Flow including all pertinent steps (see diagram)

The overall design includes identifying the optimum layout for the facility and the best usage of available area. It is recommended that the layout of the compost pad be optimized taking into consideration:

- Practicality for the front-end loader to move between the heaps and to and from the pre-treatment to the compost pad and the screening/ storage area.
- Process water and storm water management.
- Likelihood of expanding the capacity of the facility.

### Mix Recipe - Pre-treatment

Feedstock must be adequately prepared for composting in the GORE® Cover system. To be properly prepared, the feedstock must be mixed together in the right ratio to obtain:

- A beginning carbon to nitrogen ratio (C: N) of approximately 25-35:1.
- A beginning moisture content of approximately 55-65%
- Adequate structure material to optimize the mixed material porosity, sized to approximately 80mm or 3 inch minus shredded green/leaf/yard waste or wood chips.

### Typical Compost Facility Layout and Process Flow Diagram



**Step 1: Receiving Area / Tipping Building: (supplied by other)**

The feedstock material will be received outdoors or inside a Tipping Building where it will be inspected for quality control. The feedstock materials will be mixed to create mix recipe.

**Step 2: Mixing / Grinding Equipment: (supplied by other)**

---

**See Typical Compost Facility Layout and Process Flow Diagram (previous page)****Step 3: Phase 1: Active / High-Rate Composting – 21 to 28 Days\***

The composting process begins with a front-end loader moving the material from the mixing area to a heap in the Phase I section to begin the active composting period. Once a heap is built, it is covered, the temperature and oxygen probes are installed and the software is turned on, which then controls the rate of aeration.

**Step 4: Phase 2: Maturation / Curing – 14 to 21 Days\***

After Phase I, the GORE® Cover is removed from the heap and the compost is moved by front- end loader to a heap in the Phase II area. Once a heap is built, it is covered, the temperature and oxygen probes are installed and the software is turned on, which then controls the rate of aeration.

**Step 5: Phase 3: Finishing/ Curing – 14 Days\*\* (optional) NOT PART OF THIS PROPOSAL**

After Phase II, the compost is moved by front- end loader to a heap in the Phase III area. Once a heap is built, covered or uncovered, only the temperature probe is installed and the software is turned on, which then controls the rate of aeration.

---

**Step 6: Screening Equipment (supplied by other)****Step 7: Storage: (supplied by other)**

Finished compost material can then be screened upon leaving Phase III of the process. Typically, the screened material can be sold directly or placed into storage for additional curing/aging.

**\* Phase 1 Active, Phase 2 Maturation / Curing treatment times are flexible depending on the quality of product being produced and the market that the finished compost is being applied.**

**\*\* Phase 3 Finishing / Curing treatment is optional and generally used for temperature and moisture management prior to screening and storage. Phases can also be covered.**





## SG Bunker® System using GORE® Cover



Typical Model for SG BUNKER® System for Planning Purposes only. Customer specific model to be confirmed by customer's design engineer and project team.

|                                                      |                    |                                                                                                           |                        |                              |
|------------------------------------------------------|--------------------|-----------------------------------------------------------------------------------------------------------|------------------------|------------------------------|
| Customer Worksheet:<br>Regina Cagle<br>EA Associates | September 18, 2023 | TOTAL CAPEX: SG BUNKER® System with Winder and SG Smartstart® Services (Civils & concrete works excluded) | All costs are in \$USD | Years 1-4<br>Starting Year 5 |
|                                                      |                    | TOTAL Annual Cost = OPEX                                                                                  | \$11,000,000           |                              |
|                                                      |                    | TOTAL Annual Cost = OPEX + Annual CAPEX Reserve                                                           | \$1,359,920            |                              |
|                                                      |                    |                                                                                                           | \$1,942,777            |                              |
|                                                      |                    | Estimated Fully Constructed Cost for SG BUNKER® System only (includes SG CAPEX costs above)               |                        |                              |

ASSUMPTIONS

Assumptions to be confirmed by Customer's Design Engineer and Project Team

|                                                                                                                                                                                                       |                                                                                    |  |                   |         |         |         |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------|--|-------------------|---------|---------|---------|
| SG BUNKER® System<br>Standard Bunker Design<br>Gore Covers for Phase 1 and 2<br>Compost Control System<br>In-Ground Trenching w/ Water Traps<br>Cover Fastening System<br>SG SmartStart® Service Pack | System Configuration- BATCH PROCESSING                                             |  | TOTAL             | Phase 1 | Phase 2 | Phase 3 |
|                                                                                                                                                                                                       | # of Windrows                                                                      |  | 48                | 24      | 24      | 0       |
|                                                                                                                                                                                                       | # of covers                                                                        |  | 48                | 24      | 24      | 0       |
|                                                                                                                                                                                                       | Design                                                                             |  | Bunker            |         |         |         |
|                                                                                                                                                                                                       | length (ft)                                                                        |  | 164               |         |         |         |
|                                                                                                                                                                                                       | width (ft)                                                                         |  | 27.0              |         |         |         |
|                                                                                                                                                                                                       | height (ft)                                                                        |  | 11.5              |         |         |         |
|                                                                                                                                                                                                       | Space between bunker (ft)                                                          |  | 7.0               |         |         |         |
|                                                                                                                                                                                                       | Driving Space (loader manauueving in front of bunker for loading & unloading) (ft) |  | 40                |         |         |         |
|                                                                                                                                                                                                       |                                                                                    |  |                   |         |         |         |
| System Throughput                                                                                                                                                                                     |                                                                                    |  | US-Tons per Year* |         |         |         |
|                                                                                                                                                                                                       |                                                                                    |  | 260,000           |         |         |         |
| *includes bulking agent                                                                                                                                                                               |                                                                                    |  |                   |         |         |         |

|                                                                                |      |         |
|--------------------------------------------------------------------------------|------|---------|
| Composting Pad Layout:                                                         | (ft) | (sq ft) |
| Length                                                                         | 175  |         |
| Width                                                                          | 1647 |         |
| Area                                                                           |      | 288254  |
| Driving Space (loader manauauveing in front of bunker for loading & unloading) |      | 65886   |
| TOTAL COMPOST PAD w/ Driving Alleyway                                          |      | 354,140 |

CAPITAL COSTS

|                                                                                                                              |               |
|------------------------------------------------------------------------------------------------------------------------------|---------------|
| SG BUNKER® System                                                                                                            | Price (\$USD) |
| Complete System: Includes SG BUNKER® System Equipment, GORE® Covers, Installation Guide, Installation Supervision, Training. | Included      |
| CWM Cover Winder Machine for Bunker Design                                                                                   | Included      |
| Subtotal: SG BUNKER® System with Winder (\$USD)                                                                              | \$11,000,000  |
| Customer responsible for Design, Engineering, Permitting and Construction costs                                              |               |

|                                                      |             |                                     |
|------------------------------------------------------|-------------|-------------------------------------|
| CAPEX Reserve                                        | (\$USD)     |                                     |
| Cover average life span in years                     | 7           | Typical Cover lifespan is 6-8 years |
| Replacement Cover Price(\$USD)                       | \$85,000    |                                     |
| Total Cap Ex Replacement Reserve each 7 years(\$USD) | \$4,080,000 |                                     |
| Annual CAPEX Reserve Fund(\$USD)                     | \$582,857   |                                     |

OPERATIONAL COSTS

TYPICAL OPEX (Composting Pad only- does not include scale, grinding/mixing/screening/storage/site housekeeping)

| Material Movement                                 | Units                | Total Hours |
|---------------------------------------------------|----------------------|-------------|
| Hours per Heap- (hr)                              | 5.0                  |             |
| Cover/Rim Placement (hr)                          | 1                    |             |
| Phase 1 (heaps/wk.)                               | 8.00                 | 48.0        |
| Phase 2 (heaps/wk.)                               | 8.00                 | 48.0        |
| Phase 3 (heaps/wk.)                               | 0.00                 | 0.0         |
| Material moved to screening                       | 8.00                 | 40.0        |
|                                                   | Total Hours per week | 136.00      |
| Cost Per Hour Loader+ Operator (\$USD)            | \$160                |             |
| Cost per week (\$USD)                             | \$21,760             |             |
| Sub-total - Annual Cost (Labor and Loader)(\$USD) |                      | \$1,131,520 |

Estimated Fully Loaded Cost Rate

|                                                     |       |          |
|-----------------------------------------------------|-------|----------|
| Control System Operator/Technician - Hours per week | 5     | (\$USD)  |
| Cost per Hour Control System Operator (\$USD)       | \$60  |          |
| Cost per week (\$USD)                               | \$300 |          |
| Annual Cost (Control System Operator)               |       | \$15,600 |

Estimated Fully Loaded Cost Rate

Estimated Fully Loaded Cost Rate

|                                          |  |          |
|------------------------------------------|--|----------|
| Power Consumption                        |  | (\$USD)  |
| cost of power \$/kWh                     |  | \$0.1500 |
| kWh/ton Use Factor (8 week process)      |  | 2        |
| Sub-total - Annual Cost - (Power)(\$USD) |  | \$78,000 |

Estimated Electrical Rate Cost

| Maintenance Costs                                           | Repair Costs/incident(\$USD) | Number of Repairs/yr. |
|-------------------------------------------------------------|------------------------------|-----------------------|
| Temperature Sensors                                         | \$400                        | 12                    |
| Oxygen Sensor                                               | \$600                        | 24                    |
| Probe Cables                                                | \$300                        | 12                    |
| Misc. Equipment Repairs                                     | \$3,000                      | 1                     |
| Cover Winder Machine Maintenance                            | \$3,000                      | 1                     |
| Annual Software Subscription Service                        | \$96,000                     | 1                     |
| Annual Support Contract with On-Site Service Check & Report | \$10,000                     | 1                     |
| Sub-Total - Annual Cost (Maintenance)(\$USD)                |                              | \$134,800             |



engineered**COMPOST**systems

## BUDGETARY QUOTATION

**Client:** EA Engineering

**Facility:** Maryland

**By:** Baraka Poulin

**Date:** 9/8/2023

**Basis:** Aerated static pile compost system featuring high air flow aeration and automated controls.

Option 1: in vessel composting followed by positively aerated static pile (ASP) composting.

Option 2: biolayer covered ASP with reversing aeration followed by unaerated windrow.

Option 1

| Sizing                | (US units) | Primary     | Secondary   |
|-----------------------|------------|-------------|-------------|
| Throughput            | TPY        | 90,000      | 76,214      |
| Throughput (365 d/yr) | TPD        | 247         | 209         |
| Density               | lb/CY      | 827         | 827         |
| Aeration Type         |            | Positive    | Positive    |
| Aeration Floor Type   |            | B/G Sparger | B/G Sparger |
| Pile Arrangement      |            | Vessel      | Mass Bed    |
| Retention Time        | days       | 13          | 24          |
| Independent Zones     | #          | 10          | 10          |
| Fan Groups            | #          | 10          | 1           |
| Zone Width            | ft         | 35          | 33          |
| Zone Length           | ft         | 80          | 120         |
| Pile Depth            | ft         | 8.2         | 8.6         |
| Cover Depth           | ft         | 0.0         | 0.0         |
| Time to Fill Zone     | days       | 1.4         | 2.4         |
| Total Volume Aerated  | CY         | 8,100       | 12,200      |

| Mechanical                    |        |           |         |
|-------------------------------|--------|-----------|---------|
| Aeration Rate - Peak          | CFM/CY | 4.5       | 2.5     |
| Fan Power - Installed (total) | HP     | 175       | 40      |
| Fan Energy (Annual)           | kWh/yr | 705,000   | 171,000 |
| Pile Surface Irrigation       |        | Automated |         |

| Process Area                             |       |        |        |
|------------------------------------------|-------|--------|--------|
| Paved Area (Process, Mechanical + Apron) | ft ^2 | 39,600 | 51,000 |

| Cost Estimate                   |  |               |            |
|---------------------------------|--|---------------|------------|
| Total ECS Scope of Work (\$USD) |  | \$ 2,660,000  | \$ 740,000 |
| Construction (ECS Guess)        |  | \$ 7,900,000  | included   |
| Constructed Price (ECS Guess)   |  | \$ 11,300,000 |            |

Option 2:

| Primary   | Secondary |
|-----------|-----------|
| 90,000    | 76,214    |
| 247       | 209       |
| 827       | 827       |
| Reversing | None      |
| Trench    | None      |
| Bunker    | Windrow   |
| 16        | 48        |
| 10        | 40        |
| 1         | 4         |
| 35        | 16        |
| 95        | 200       |
| 8.2       | 7.5       |
| 1.0       | 0.0       |
| 1.6       | 1.2       |
| 9,600     | 25,200    |

| 4.5       | 0.0 |
|-----------|-----|
| 125       | 0   |
| 478,000   | 0   |
| Automated |     |

| 45,000 | 193,200 |
|--------|---------|

| \$ 2,270,000 | \$ - |
|--------------|------|
| \$ 3,200,000 | n/a  |
| \$ 5,470,000 |      |



## ECS SCOPE OF WORK

**Client:** EA Engineering

**Date:** 9/8/2023

**Basis:** Aerated static pile compost system featuring high air flow aeration and automated controls.

| Aeration System (Above Grade)     | Description                                             | By     |
|-----------------------------------|---------------------------------------------------------|--------|
| Fans                              | Per ECS Spec                                            | ECS    |
| Aeration Ducting                  | Per ECS Spec                                            | ECS    |
| Duct Hangers and Supports         | Per ECS Spec                                            | ECS    |
| Zone Damper Assemblies            | Dampers per ECS Spec, Electric Actuators                | ECS    |
| Makeup Air Inlet Damper           | Per ECS Spec, Electric Actuators                        | ECS    |
| Balance Damper                    | per ECS Spec,                                           | ECS    |
| Irrigation - Control+Distribution | Control Valves, Integration to CompTrollers, Sprinklers | ECS    |
| Irrigation - Water Supply         | Pipe & Fittings to each zone.                           | OTHERS |
| Electrical                        | Wiring and Conduit                                      | OTHERS |
| Duct & Fan Condensate Drains      | Pipe & Fittings                                         | OTHERS |

| Aeration Floor System                | Description                                         | By     |
|--------------------------------------|-----------------------------------------------------|--------|
| HDPE Components                      | Fabricated HDPE Pipe & Fittings                     | ECS    |
| HDPE Pipe                            | DR17 HDPE Pipe, Pulling Ends, Duct to Flex Fittings | ECS    |
| HDPE Pipe                            | On-site fusing and drilling                         | OTHERS |
| Embedded Stainless Steel Components  | Trench Boots, hardware, SS304                       | ECS    |
| Surface Stainless Steel Components   | Trench Covers, Cover Clamps, SS304                  | ECS    |
| Drainage Line: Zones to Sump         | Pipe & Fittings, Level Maintained Sump              | OTHERS |
| Drainage Line: Sump to Re-use System | Pipe & Fittings                                     | OTHERS |

| Control System                  | Description                                  | By     |
|---------------------------------|----------------------------------------------|--------|
| CompTroller Hardware & Software | Web-based, distributed, ruggedized           | ECS    |
| Fan Drives                      | Variable frequency drives, filters           | ECS    |
| Process Sensors                 | Temperature, pressure                        | ECS    |
| Temp Probe Holders              | Mild Steel                                   | ECS    |
| Moisture Addition Control       | 1 per zone - control output and software     | ECS    |
| Electrical                      | Wiring and Conduit                           | OTHERS |
| Control Skid                    | Per ECS Spec                                 | ECS    |
| Electrical Service              | Fan Panel, MCC, Breakers, DCs, Fuse, Filters | OTHERS |
| Control Shed                    | Approximately 10x12ft shed                   | OTHERS |

| Vessel Components          | Description                               | By     |
|----------------------------|-------------------------------------------|--------|
| Vessel Doors               | Insulated panels, Stainless Steel, Manual | ECS    |
| Vessel Irrigation System   | Valves, Pipes, Nozzles                    | OTHERS |
| Vessel Exterior Insulation | Insulated Concrete Walls                  | OTHERS |



| Biofilter System                       | Description                                                                                                                                                               | By     |
|----------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|
| Air Temperature & Pressure Sensors     | Integrated with ECS Control System                                                                                                                                        | ECS    |
| Biofilter Media Temperature Probes     | Integrated with ECS Control System                                                                                                                                        | ECS    |
| Building & Process Air Mixing Controls | Integrated with ECS Control System                                                                                                                                        | ECS    |
| Exhaust Duct Humidification System     | Supply lines, filtration, pump, compressor, controls. Duct ring for nozzles.                                                                                              | ECS    |
| Control of Air Humidification          | Integrated with ECS Control System                                                                                                                                        | ECS    |
| Building Exhaust Fan VFDs              | Network Drives                                                                                                                                                            | ECS    |
| Building Makeup Air                    | MUA supply, Building Conditioning                                                                                                                                         | OTHERS |
| Suspended Aeration Floor               | Pre-stressed concrete panels, Rubber Pads                                                                                                                                 | ECS    |
| Exhaust Duct to Suspended Floor Inlets | SS304                                                                                                                                                                     | ECS    |
| HDPE Pipe                              | Pipe-on-Grade, Drilled with End Caps                                                                                                                                      | ECS    |
| Biofilter Plenum                       | SS304, per ECS Spec                                                                                                                                                       | ECS    |
| Biofilter media Irrigation System      | All mechanical components (installed by others)                                                                                                                           | ECS    |
| Biofilter Media (i.e. wood chips)      | Shredded wood per ECS spec                                                                                                                                                | OTHERS |
| Suspended Aeration Floor Pillars       | Concrete pillars formed in Sonotubes (~18" high x ~18" dia)                                                                                                               | OTHERS |
| Suspended Aeration Floor Basin         | Per ECS Design (~22" deep, area = BF footprint)                                                                                                                           | OTHERS |
| Electrical                             | MCC shed with thermostatically controlled cooling fans, inlet air filters, power distribution panels, conduit, power, disconnects. All power & control wiring to devices. | OTHERS |
| Biofilter Duct Supports                | Painted Steel, duct saddles                                                                                                                                               | OTHERS |
| Biofilter Basin, Floor Blocks & Apron  | Concrete                                                                                                                                                                  | OTHERS |
| Biofilter Drain                        | Drain to Sump                                                                                                                                                             | OTHERS |
| Media Containment Blocks & Curbs       | as needed                                                                                                                                                                 | OTHERS |

| Services                            | Description                                                           | By     |
|-------------------------------------|-----------------------------------------------------------------------|--------|
| Exhaust System/Biofilter M&E Design | System Description and Mechanical & Electrical Drawings (not stamped) | ECS    |
| Construction Technical Support      | On-site for key meetings, otherwise remote support                    | ECS    |
| System Start-up and Training        | Mostly on-site, follow up trainings via web and phone                 | ECS    |
| Biofilter Performance Testing's     | Odor measurements at start-up and after one year                      | ECS    |
| Operational Support                 | Per special warrantee and performance agreement                       | ECS    |
| Construction Services               | All phases                                                            | ECS    |
| Construction Engineering            | All permits and PE stamped drawings                                   | OTHERS |

| Other              | Description                                                                                                                                     | By  |
|--------------------|-------------------------------------------------------------------------------------------------------------------------------------------------|-----|
| System Engineering | Technical Submittal, CASP system installation drawings, construction support                                                                    | ECS |
| Startup            | ECS on site commissioning, operator training and unlimited 1 year remote support. M&E construction must be complete before ECS visits the site. | ECS |
| Freight            | Includes freight allowance FOB site                                                                                                             | ECS |
| Warranty           | 1yr equipment warranty                                                                                                                          | ECS |





|                          |                                                                   |        |
|--------------------------|-------------------------------------------------------------------|--------|
| Professional Services    | Permitting, Civil/Structural Design, Construction Management      | OTHERS |
| Concrete work            | Design, Reinforcement, Supply, Installation                       | OTHERS |
| Installation             | All ECS supplied equipment                                        | OTHERS |
| Surface Water Management | Leachate + Stormwater Storage and Distribution, Design and Supply | OTHERS |
| Rolling Stock            | Pre/post processing equipment, On-site material handling          | OTHERS |

## Budget Pricing

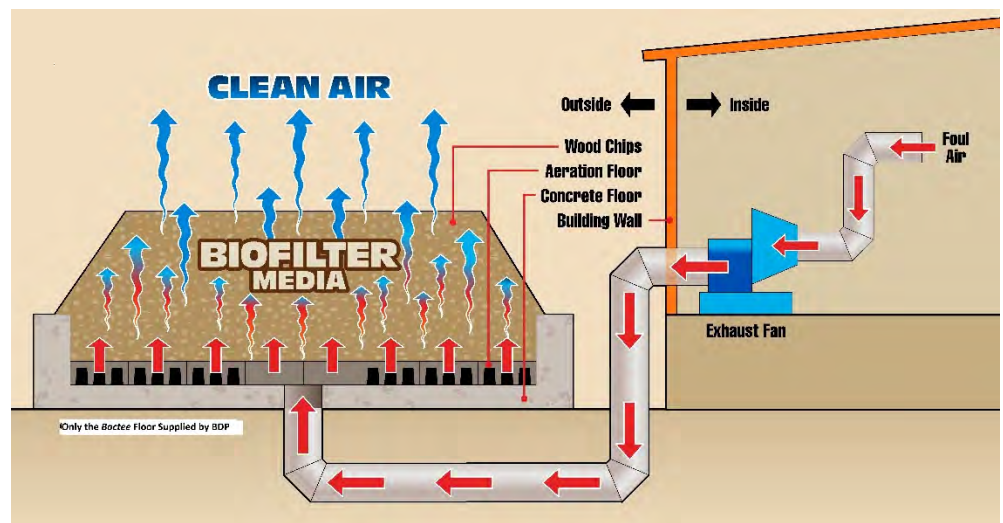
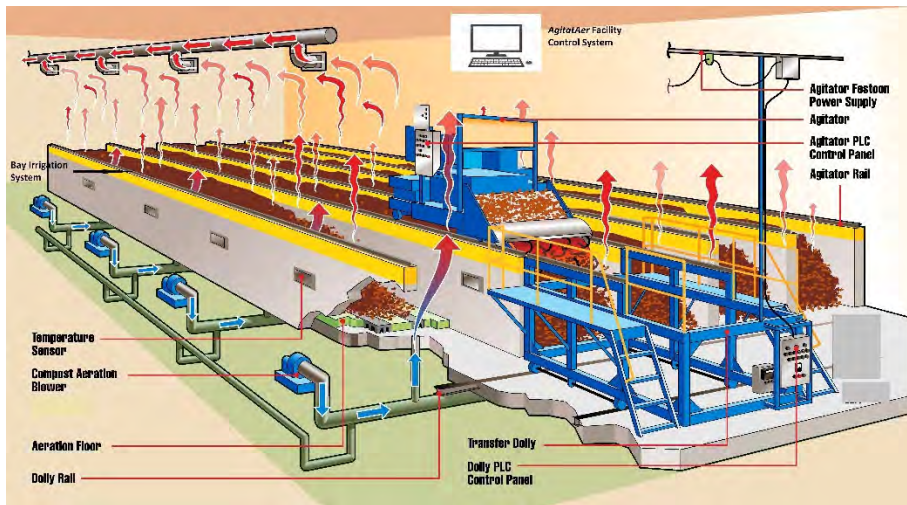
|                                  |              |
|----------------------------------|--------------|
| Budget Cost: ECS Scope of Supply | \$ 3,400,000 |
|----------------------------------|--------------|

OTHERS=Design and Supply by other team members

Note: ECS deliverables exclude: a lead role in obtaining permits, any professional engineering services required for permits or constructing the facility, construction management, any phase of construction or equipment installation, any equipment not specifically called out above, any local taxes or fees.



# Montgomery County, MD Budgetary Estimate 180,000 WTPY Food & Green Waste Enclosed, Agitated and Aerated Compost System



Submitted 19 September 2023 to:  
*Regina Cagle Irr, P.E.*

## EA Engineering, Science, and Technology, Inc., PBC

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20 SEP 23

Regina,

BDP Industries (BDP) offers this budgetary estimate for process design of, and select process equipment for an **automated, agitated bay with forced aeration type in-vessel compost system** (ICS) that provides the advantage of conserving energy, space, material handling, and manpower in the biological conversion of food and green waste to a compost product. The BDP ICS Technology is one of the few commercially available compost systems that includes all 3 mechanical methods of enhancing the compost process;

- 1) *Fully Enclosed.* To best prevent weather related negative impacts to the compost process as well as to contain liquid and gaseous emissions for treatment.
- 2) *Agitation.* Agitation of the compost material is proven to enhance the process by maintaining good porosity as well as for remixing of the materials to best allow microbes access to food, water, air and volatile solids for heat creation.
- 3) *Aeration.* Forced aeration ensures optimized aerobic and temperature conditions are maintained.

## EAEST DESIGN REQUIREMENTS

For the Montgomery County, MD project BDP understands the design requirements are as follows:

### CAPACITY:

- 80,000 WTPY of ground pre- and post- consumer food waste +
- 100,000 WTPY of ground leaf, yard and tree waste (Green Waste)  
The 2 streams will be co-ground prior to composting.

### COMPOST PROCESS DISCHARGE REQUIREMENTS:

- Maturity Index: *Not stated. As this project proceeds, BDP would recommend that EAEST include some metric for compost maturity in the design basis to ensure equivalent compost solutions are proposed by all bidders. E.g. 20 days in an enclosed, agitated and aerated process will produce a more mature end product than 20 days in an aerated static pile type process.*
- Pathogen Destruction (PFRP) *Required*
- Vector Attraction Reduction (VAR) *Required*

### SITE DETAILS:

- (2) *Potential Sites – one @ 15 acres and the other much larger.*
- *Both sites should be considered as high odor sensitivity locations such that only enclosed treatment processes are being considered.*

OPERATIONS: 6 days/week & 8 hrs/day

## **BDP DESIGN APPROACH**

BDP has selected a compost facility size of thirty (30) bays @ 10 Ft width x 8 ft Depth x 230 Ft length as shown on the drawings below. The bays are designed to retain the material for approximately 20 days to achieve Pathogen Destruction (3 days @  $\geq 55^{\circ}\text{C}$ ) and Vector Attraction Reduction (14 days at  $\geq 40^{\circ}\text{C}/45^{\circ}\text{C}$  Avg.) while also accommodating peak capacity days. **The ICS compost facility with biofilters, MCC and access areas fits within a 4 acre space which should leave sufficient remaining space on the 15 acre parcel for Waste Receipt/Processing and Compost Curing.**

BDP's scope includes the basic facility design for the Active Composting Bays area, MCC and Biofilters. Detailed design of these areas is by others as well as all other portions of the overall treatment facility, including:

- Raw Material Receipt, Storage and Preparation Areas
- Post Composting Curing, Screening/Refining Area
- Product Storage Area
- Office/Lab and Maintenance Spaces
- Ancillary requirements such as storm water retention ponds, pumping stations, truck scales, etc...

The BDP compost process, like all compost processes, is ultimately volume based. The compost bays are designed to receive and process a maximum quantity of 1,154 cubic yards per day of feedstock, 6 days per week as per the below Materials Balance. BDP requires that the maximum

density of the feedstock material will be 0.6 tons/yds<sup>3</sup> which should be well within actual conditions. All hard inorganic objects such as stones and metals shall be removed in the material preparation process. For protection of BDP's agitator equipment, as well as to maximize facility capacity, BDP requests that all Feedstock material be size reduced to 4" maximum in any direction with 2" being the preferable target.

**Table 1: Material Balance – 180,000 WTPY Food and Green Waste.**

**MATERIALS BALANCE**  
ICS Composting Facility  
**E&AEST Montgomery County, MD Organics Study**

| 80,000 WTPY Food Waste + 100,000 WTPY Green Waste   |                     |                                                         |                     |              |                         |
|-----------------------------------------------------|---------------------|---------------------------------------------------------|---------------------|--------------|-------------------------|
| MATERIALS                                           | WET TONS<br>PER DAY | PERCENT<br>DRY SOLIDS                                   | DRY TONS<br>PER DAY | VOLUME<br>CY | BULK DENSITY<br>TONS/CY |
| Food Waste                                          | 256                 | 25%                                                     | 64.1                | 366          | 0.70                    |
| Ground Green/Yard Waste                             | 321                 | 50%                                                     | 160.3               | 916          | 0.35                    |
| Recycled Overs                                      | 0                   | 60%                                                     | 0.0                 | 0            | 0.30                    |
| <b>INPUT TO BAYS</b>                                | <b>577</b>          | <b>39%</b>                                              | <b>224</b>          | <b>1154</b>  | <b>0.50</b>             |
| <b>OUTPUT to CURING</b>                             | <b>296</b>          | <b>55%</b>                                              | <b>163</b>          | <b>741</b>   | <b>0.40</b>             |
| Recycled Overs                                      | 0                   | 60%                                                     | 0                   | 0            | 0.30                    |
| <b>FINISHED COMPOST<br/>FOR DISTRIBUTION</b>        | <b>296</b>          | <b>60%</b>                                              | <b>163</b>          | <b>741</b>   | <b>0.40</b>             |
| <b>Agitated Bay Design Criteria and Assumptions</b> |                     |                                                         |                     |              |                         |
| 1.                                                  | 80000               | Wet Tons per Year (WTPY) of Food Waste Design Capacity. |                     |              |                         |
| 2                                                   | 100000              | WTPY of Ground Green Waste Design Capacity              |                     |              |                         |
| 3                                                   | 30                  | Bays at 230 ft long required                            |                     |              |                         |
| 4                                                   | 41                  | Cubic yard Charges per Agitation                        |                     |              |                         |
| 5                                                   | 28                  | Bays loaded and Agitated per day at 6 Days/week         |                     |              |                         |
| 6                                                   | 20                  | Days in the Bays Retention                              |                     |              |                         |
| 7                                                   | 26                  | Estimated Carbon to Nitrogen ratio of infeed mix        |                     |              |                         |

It is understood that the Compost Facility feedstock will be made up of:

**Ground Green Waste** at an average solids content of 50% and at a presumed density of 0.35 tons/yd post grinding. Acceptable Green Waste feedstock are presumed to be:

- Trees, Branches and Stumps
- Flowers, plants and shrubs
- Grass clippings and leaves
- Lumber, sawdust, wood chips and wood waste (untreated/unpainted)

**Food Scraps** at an average solids content of 25% and at a presumed density of 0.7 tons yard (post grinding). Acceptable Food Waste are presumed to contain:

- spoiled or unused food.
- food soiled paper (paper towels, plates, tissues, “to-go” packaging, and pizza boxes), and
- *compostable plastics* (compostable plastic bags, cutlery, and “to-go” packaging). BDP has piloted processing compostable plastics with good results. The combination of high heat and aggressive agitations will degrade this material much quicker than static type composting processes.

#### NOTES:

- 1) It is presumed the (2) feedstock components will be co-ground prior to being delivered to the Compost Facility which should also provide a rough mixing such that no dedicated mixer device is needed prior to loading the bays.
- 2) The proposed compost facility is a once thru type. I.e. no amount of Recycled Screening Overs is included in the materials balance as supplemental bulking agent nor are they required for proper compost feedstock conditions on average. However, it is expected that there will be seasonal periods where green waste material is limited and therefore stored Overs may need to be used to achieve an appropriate compost feedstock.
- 3) It is understood that there will be some inorganic contaminants in the feedstock to the compost facility. For discussion purposes BDP presumes these contaminants would be <5% by volume. As long as they are properly sized reduced BDP is not concerned with contamination level from an equipment damage standpoint. However, from a composting process standpoint, the issue becomes one of putting material in the bays that will have an adverse impact on the process and capacity.
- 4) It is expected that moisture addition will be required at some point in the process to keep it at optimal conditions. Provisions are included in this estimate for an in bay moisture addition system supplied by BDP to maintain compost DS content <= @ 65% DS. The feedstock goal is to achieve a solids content of 38% minimum - 45% maximum (seasonally dependent) for proper composting. It is presumed some sort of moisture addition system will be available during, or post, grinding prior to loading the bays. The attached Materials Balance indicates, based on BDP’s solids content assumptions, that



the feedstock will meet this moisture criteria on an average basis. The need for moisture addition in the bays will vary seasonally. For discussions purposes an estimate of 500 – 1000 GPD per bay should be considered. Moisture addition for the biofilter is also expected on a seasonal basis. It is understood that we will wish to utilize as much storm water and condensate as possible within the facility. We expect this can be done without significant issue other than perhaps screening for particulate removal.

- 5) For space optimization purposes, the @ 10,000 SF/side biofilter size shown is based on using synthetic media like that produced by Biorem Inc. If natural wood chip type media were to be used, the biofilter size would increase by approximately 50%. Biorem will also offer the Cty an odor guarantee.

Feedstock material is loaded into the front 20ft long portion of the bays in 40 cubic yard “charges” following an agitation. Charges can either be loaded via a front end loader or an overhead automated conveyance system. For this application BDP has presumed the bays will be loaded via front end loaders.

**Figure 1: Estimated Site Plan Illustration**

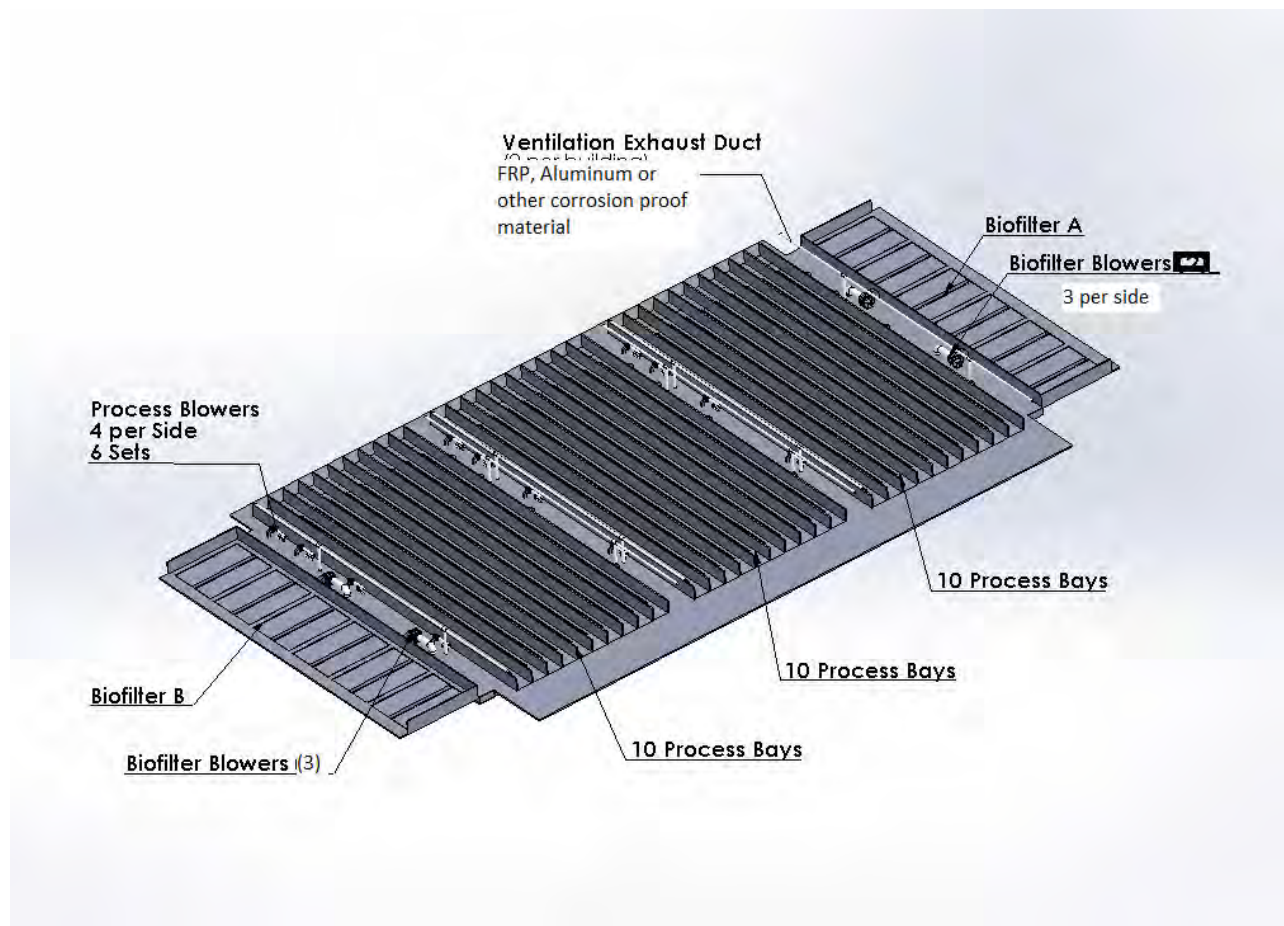
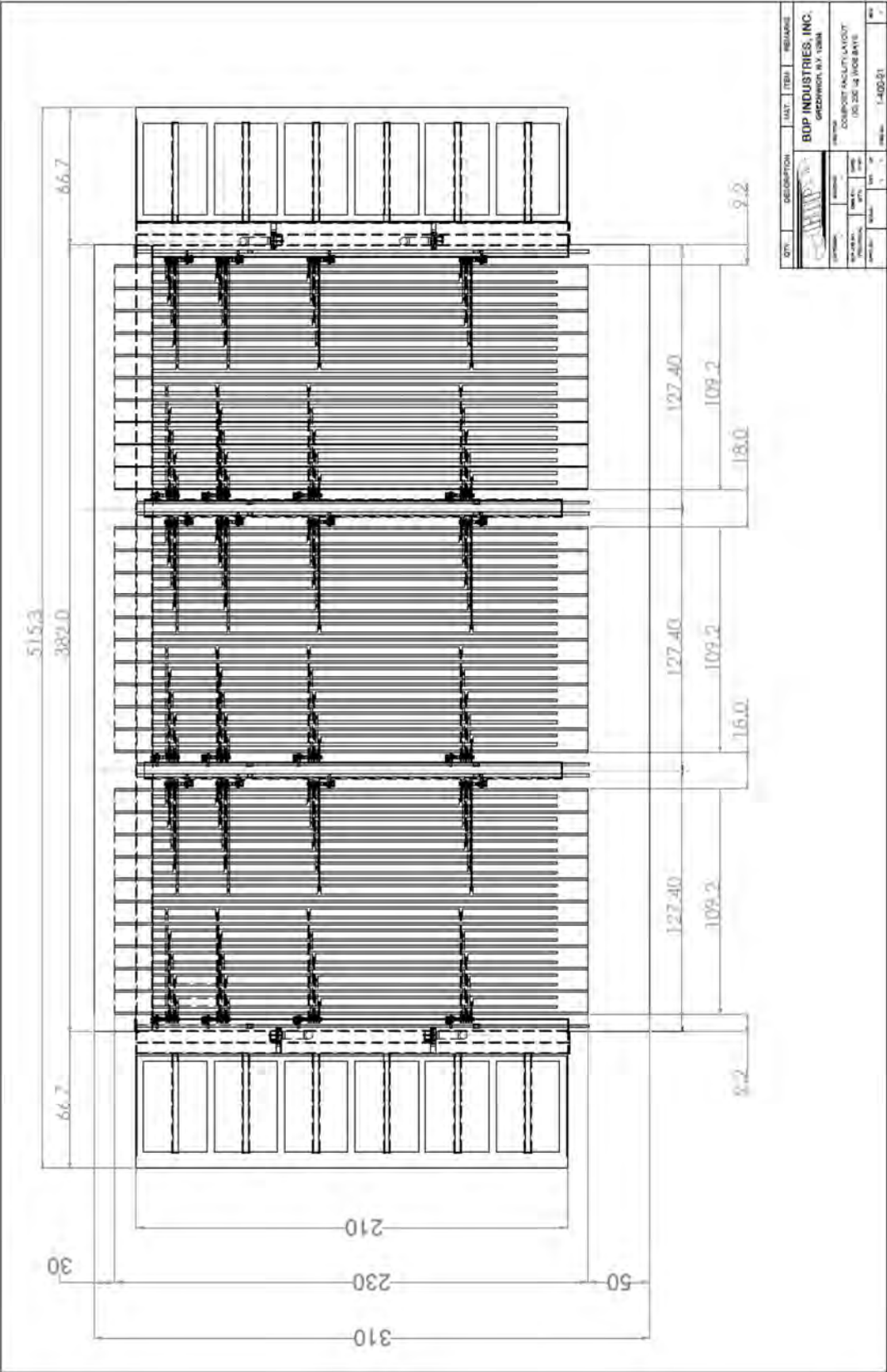


Figure 2: Estimated Facility Plan with Dimensions.





The @ 160,000 SF size compost facility would incorporate (30) 10ft wide (inside) x 8 ft high x 230 ft long bays as shown on the drawings above. There is a 50ft long x 315 ft wide open area in front of the bays for Feedstock Receipt. There is a 30ft long x 315 ft wide area at the back of the bays for locating the BDP supplied Transfer dollies and for loader access to unload the bays.

Five BDP 100 HPe Agitators are proposed to service the (30) bays. Each week, the facility will require that the bays be loaded and agitated 168 times to match incoming capacity. For a 6 day work week that would equate to 28 bays being loaded/agitated per day which can be done within an 8 hr work day with (5) agitators.

The bays are arranged in (3) 10 bay groups to accommodate interior aisles for roof supports and process equipment. Each 10 bay group is considered (2) 5 groups for process control purposes. Each bay would be divided into (4) independent Aeration Zones (A – D). Each (5) bay group would have (1) dedicated blower/zone to provide aeration needs across all 5 bays. Each zone would have a dedicated temperature probe located in the bay walls for blower control. So e.g. Bay/Zones 1A – 5A would be served by one blower (A1-5) and for a 5 bay group there would be 5 bays x 4 zones = 20 temp probes with probes 1A – 5A being averaged to control blower A1-5. Therefore each 5 bay group would have (4) blowers associated with them located in an aisle as shown on the drawings below.

Once a charge is loaded in the bay, it is translated down the bay length an average of 13 ft following an agitation. BDP includes a bay leveling device on the agitator conveyor assembly which modulates compost throw from 13 ft – 16 ft to offset pile height loss as the product composts thus maximizing bay capacity. Once an agitation is completed, the front 16 ft of the bay is open to accommodate the next charge of feedstock.

All compost movement within the bays is done by the agitator with the BDP supplied AgitatAer SCADA system tracking material movement and time at temperature for PFRP and VAR compliance. Following 20 days in the BDP bays, the compost material in the last 18 ft of the bay would be removed by front end loaders and moved to the Curing area. The bays could also be automatically discharged (by the agitators) onto a conveyor belt that runs below the bays if so desired by the Customer.

The facility could be housed in anything from a fabric roof to structure to an insulated/coated steel structure.

A detailed process description is included at the end of this document.

## TABLE 2 - CAPITAL COST ESTIMATE

## ICS COMPOSTING FACILITY

## E&AEST Montgomery County, MD Organics Study

## 30 WIDE BAYS

| ITEM                                                                 |                                                                                                                                                                                |  |  |           |    | BUDGETARY COST       |
|----------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--|-----------|----|----------------------|
| <b><u>CONSTRUCTION</u></b>                                           |                                                                                                                                                                                |  |  |           |    |                      |
|                                                                      | Site Work (4 Acres)                                                                                                                                                            |  |  |           | \$ | 400,000              |
|                                                                      | Compost Building (@ 120,000 SF Equipped Except for BDP Equipment)                                                                                                              |  |  |           |    | 23,200,000           |
|                                                                      | MCC Room (Equipped)                                                                                                                                                            |  |  |           |    | 2,000,000            |
|                                                                      | Drives - asphalt                                                                                                                                                               |  |  |           |    | 500,000              |
|                                                                      | Biofilter Odor Control incl, Concrete, Duct, Fans and Media <sup>1</sup>                                                                                                       |  |  |           |    | 6,000,000            |
|                                                                      | BDP Equipment and Services <sub>2</sub>                                                                                                                                        |  |  |           |    | 10,100,000           |
|                                                                      | Miscellaneous Equipment                                                                                                                                                        |  |  |           |    | 2,000,000            |
|                                                                      | Front End Loaders                                                                                                                                                              |  |  |           |    | 2,000,000            |
|                                                                      |                                                                                                                                                                                |  |  | SUBTOTAL: | \$ | 46,000,000           |
| <b><u>ENGINEERING AND SERVICES; Permitting thru Construction</u></b> |                                                                                                                                                                                |  |  |           |    | \$ 5,000,000         |
|                                                                      |                                                                                                                                                                                |  |  |           |    |                      |
| <b>ESTIMATED TOTAL PROJECT COST:</b>                                 |                                                                                                                                                                                |  |  |           |    | <b>\$ 51,000,000</b> |
| <sup>1</sup>                                                         | Biorem Media Estimate of \$1000/YD. Biofilter floor included in BDP Scope/Price                                                                                                |  |  |           |    |                      |
| <sup>2</sup>                                                         | BDP Equipment includes ICS Proprietary Equipment Package per Table 3                                                                                                           |  |  |           |    |                      |
|                                                                      | Technology Purchase Schedule. Services are provided during design, construction and operational start-up training. Also includes an estimate of shipping of ICS Equipment FOB. |  |  |           |    |                      |
|                                                                      | Miscellaneous Equipment (Outdoor Lights, Pumps, Tanks, etc...)                                                                                                                 |  |  |           |    |                      |

**NOTE:** The above is for equipment and structures shown on the attached BDP drawings only. Other areas, structures, equipment not included such as roads, scales, etc...

| Table 3 - BDP SCOPE of SUPPLY               |                                                                            |  |  |  |  |                  |
|---------------------------------------------|----------------------------------------------------------------------------|--|--|--|--|------------------|
| ICS COMPOSTING FACILITY                     |                                                                            |  |  |  |  |                  |
| E&AEST Montgomery County, MD Organics Study |                                                                            |  |  |  |  |                  |
|                                             |                                                                            |  |  |  |  |                  |
| 30 WIDE BAYS                                |                                                                            |  |  |  |  |                  |
| ITEM                                        |                                                                            |  |  |  |  | QUANTITY         |
| <u>EQUIPMENT</u>                            |                                                                            |  |  |  |  |                  |
|                                             | Agitator & Dolly - 100HP with Level Bed Device                             |  |  |  |  | 5 Each           |
|                                             | Agitator Bay Wall Rails with Wall Embeds and all Hardware                  |  |  |  |  | 7,590 Ft         |
|                                             | Dolly Rails                                                                |  |  |  |  | 760 Ft           |
|                                             | Bay Wall Temp Sensors and Mounting Boxes                                   |  |  |  |  | 120 Zones        |
|                                             | Bay Irrigation System                                                      |  |  |  |  | 30 Ea            |
|                                             | Bay Aeration Floors with Iris Valves                                       |  |  |  |  | 120 Zones        |
|                                             | AgitatAer™ Process and Facility Control System                             |  |  |  |  | 1 Each           |
|                                             | Biofilter Aeration Floor (Included in CAPEX estimate under "Odor Control") |  |  |  |  | 1 System         |
| <u>ENGINEERING AND SERVICES</u>             |                                                                            |  |  |  |  |                  |
|                                             | Internal Engineering Support                                               |  |  |  |  | As Required      |
|                                             | Design Engineering Support                                                 |  |  |  |  | 40 Days/8 Trips  |
|                                             | Construction Support                                                       |  |  |  |  | 20 Days/4 Trips  |
|                                             | Start Up Commissioning and Process Support                                 |  |  |  |  | 80 Days/12 Trips |
|                                             | Post Start Up Support                                                      |  |  |  |  | 10 Days/3 Trips  |
| ESTIMATED BDP PRICE INCLUDING FREIGHT:      |                                                                            |  |  |  |  | \$ 10,100,000    |

**NOTE:** The above BDP scope of supply is intended to include proprietary equipment only. For cost efficiency purposes “off the shelf” process related equipment such as fans, blowers, piping, ductwork, etc... are not included in BDP’s scope but are included in the overall CAPEX budget in Table 2.

BDP will provide design specifications for all process related equipment to be procured by others.

| Table 4 - ANNUAL O & M COST IMPACTS         |                               |                                      |  |  |     |               |  |
|---------------------------------------------|-------------------------------|--------------------------------------|--|--|-----|---------------|--|
| ICS COMPOSTING FACILITY                     |                               |                                      |  |  |     |               |  |
| E&AEST Montgomery County, MD Organics Study |                               |                                      |  |  |     |               |  |
| 30 WIDE BAYS                                |                               |                                      |  |  |     |               |  |
| Item                                        |                               |                                      |  |  |     | Annual Qty    |  |
|                                             | <b>Labor</b>                  |                                      |  |  |     |               |  |
|                                             |                               | Facility Manager                     |  |  | 1 @ | 260 Days/Yr   |  |
|                                             |                               | Loader Operators                     |  |  | 6 @ | 312 Days/Yr   |  |
|                                             |                               | Laborers                             |  |  | 2 @ | 312 Days/Yr   |  |
|                                             |                               | Maintenance/Weekend Spvrs            |  |  | 1 @ | 260 Days/Yr   |  |
|                                             | <b>Energy &amp; Utilities</b> |                                      |  |  |     |               |  |
|                                             |                               | Electrical                           |  |  |     | See Table 5   |  |
|                                             |                               | Fuel (diesel for Loaders)            |  |  |     | 20,000 gal/yr |  |
|                                             |                               | Water (Bay and Biofilter Irrigation) |  |  |     | TBD           |  |

**Table 5: Electrical Consumption Estimate**

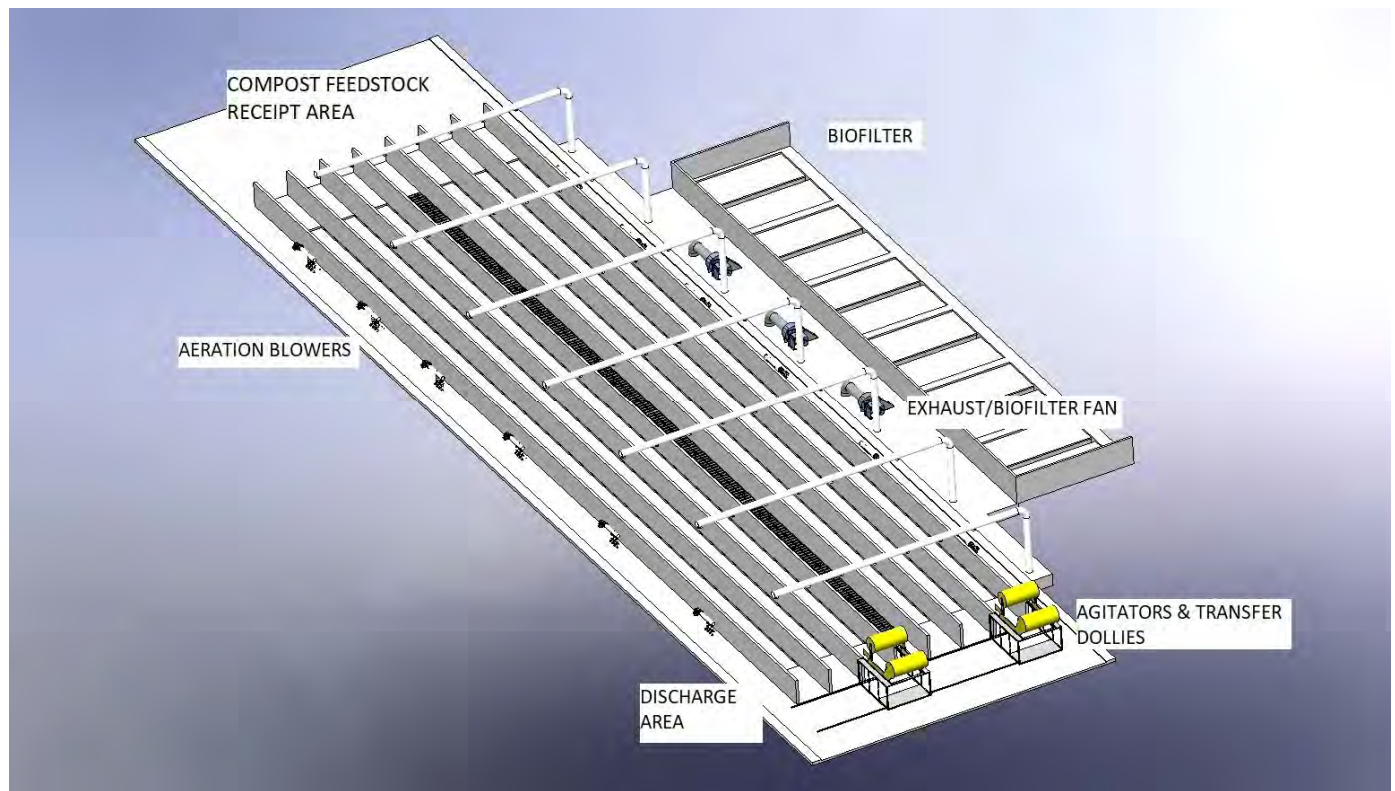
| Equipment                    | Blower   | Static Hd | Factor | Quantity | Motor     |     | Energy    | Connected |
|------------------------------|----------|-----------|--------|----------|-----------|-----|-----------|-----------|
|                              | Capacity | Head      |        |          | Rating    |     |           | Load      |
|                              | cfm      | in w.c.   | %      |          | kW        | HP  | kWh/yr    | kW        |
| Process Air Blowers - Zone A | 5,000    | 10        | 59%    | 6        | 11.2      | 15  | 347,472   | 67.23     |
| Proces Air Blowers - Zone B  | 5,000    | 10        | 59%    | 6        | 11.2      | 15  | 347,472   | 67.23     |
| Process Air Blower - Zone C  | 4,400    | 10        | 59%    | 6        | 7.5       | 10  | 231,648   | 44.82     |
| Process Air Blower - Zone D  | 3,500    | 10        | 62%    | 6        | 7.5       | 10  | 243,426   | 44.82     |
| Biofilter Blowers            | 40,000   | 8         | 49%    | 6        | 75        | 100 | 1,931,580 | 450.00    |
| Agitator                     |          |           | 25%    | 5        | 75        | 100 | 702,000   | 375.00    |
| Biofilter Pump               |          |           | 50%    | 2        | 1.5       | 2   | 13,140    | 3.00      |
| Control System               |          |           | 95%    | 1        | 1.125     | 1.5 | 9,362     | 1.13      |
|                              |          |           |        |          |           |     |           |           |
|                              |          |           |        |          | Sub-total |     | 3,826,099 | 1,053     |
|                              |          |           |        |          |           |     |           |           |
| Lights and Misc.             |          |           | 10%    |          |           |     | 382,610   |           |
| Annual Basis                 |          |           |        |          | Total     |     | 4,208,709 | 1053      |

# Montgomery County, MD Detailed Process Description

Prior to feedstock material being delivered to the Compost facility it will have gone thru a separate Materials Receipt and Preparation Facility where it inorganics will be removed as needed and the balance of organic waste will be co-ground at an approximate volume ratio of (1) food waste to (2.5) yard waste. By co-grinding the materials it eliminates the need for a dedicated mixer prior to composting. The rough mixing accomplished in the grinder is sufficient to load the bays. Within 2 – 3 agitations the feedstock should be well homogenized.

The individual process steps include (Refer to General Schematic below)

1. **Feedstock Receiving** – Each of the six working days per week, 1,154 cubic yards, will be delivered in some manner to the front 50 ft long x 315 ft wide „Receiving Area“ of the Compost Facility.
2. **Charging** or loading @ 40 yds of feedstock into the process bays in the front 20ft of the bays
3. **Active Composting** by agitating and aerating the material along the 230 ft bay length over 20 days
4. **Discharging** or unloading the processed material from the bays in the final 315 ft wide x 30 ft long area at the end of the bays.
5. **Odor control** – @ 20,000 sf biofiltration – for air from Receiving and Active Composting.





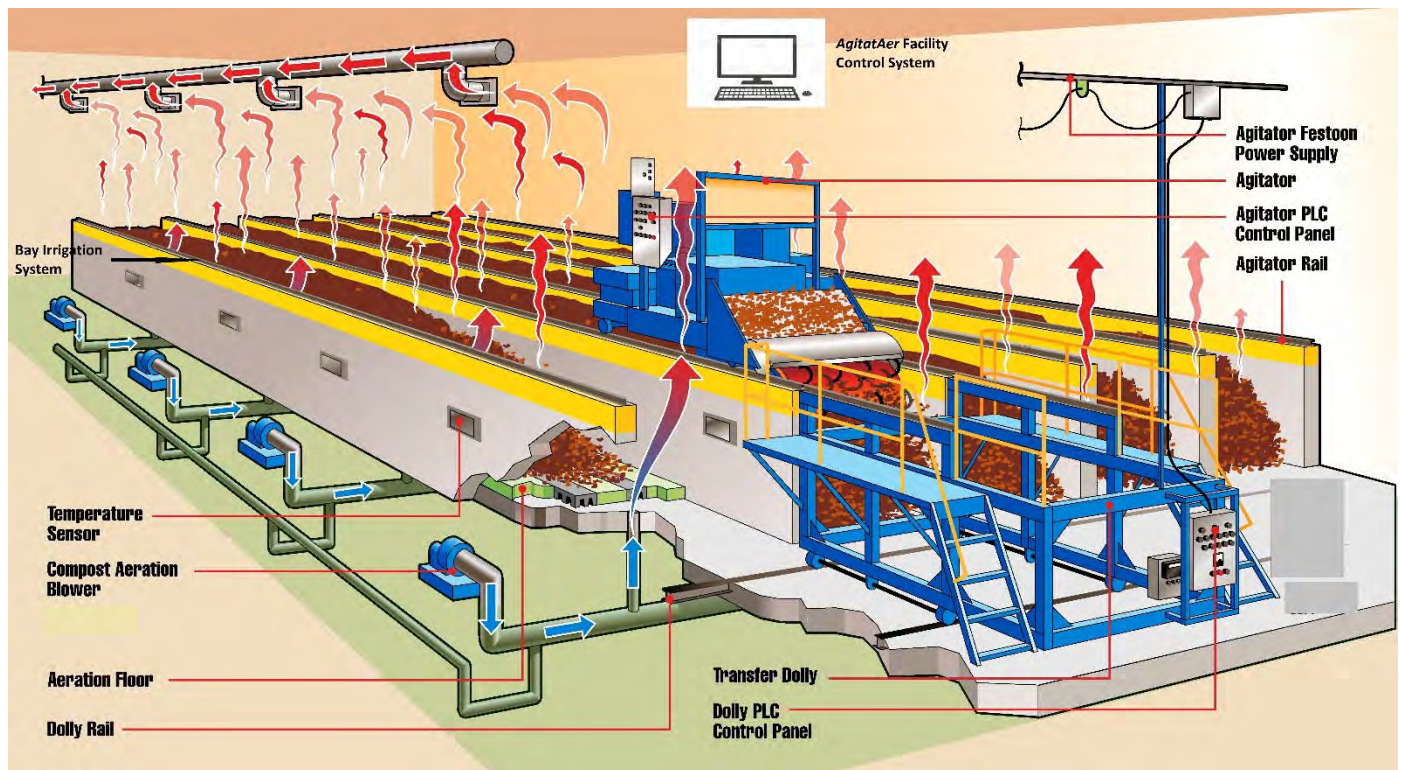




Photo 1 – Co-ground feedstock material belt conveyed to Compost Facility Feedstock Receipt Area

**Step 1 Feedstock Receipt** – Each of the six working days per week, 1,154 cubic yards, will be delivered in some manner to the front 50 ft long x 315 ft wide „Receiving Area“ of the Compost Facility. Feedstock Material can be delivered via Loaders, Truck or conveyor belt as shown above. Feedstock shall be in the 38% - 45% DS range depending on season.



## Step 2 – Bay Charging or Loading

The bays are designed to receive nominally 40 yds<sup>3</sup> of feedstock (or “charge”) following an agitation. The front 20 ft of each bay is a non-aerated concrete pad designated as the Loading Area of the bays. For this application BDP has presumed the bays will be loaded with a loader as shown in Photo 2 but could also be auto loaded as shown in Photo 3



Photo 2 - Front End Loader “Charging” Bays



Photo 3 –  
Automated  
Bay Loading  
technique.



**Step 3 – Active Composting** - For this application, the (30) bays are 10 ft wide x 8 ft high x 230 ft long for a retention time of 20 days. The (30) bays are separated into (3) contiguous groups of 10 bays. Each (10) bay group are cosidered as (2) 5 bay groups from a process perspective. Equipment and personnel access aisles are on each side of the outer bays. With each pass of the agitator along the length of the bay, the process material will be mixed and translated towards the bay discharge end an average of @ 13 ft with the agitator *Capacity Optimization Gate* device automatically modulating the agitator conveyor discharge throw between 10 ft and 16 ft to offset pile height loss as the material composts.



Photo 4 – Agitator on  
Transfer Dolly

Photo 5 – Agitator  
working in bay next  
to empty bay.





Photo 6 - Capacity Optimization Gate (COG) in closed position near bay discharge



Photo 7 - COG in full open position near bay loading

- i. **Aeration System** - Each of the (30) bays is divided into (4) separate aeration zones (A – D) for a total of 120 Aeration Zones (i.e. 4 aeration zones/bay x 30 bays) designed and equipped by BDP's partner BacTee Systems. The aeration system provides sufficient oxygen to the process between agitation cycles and removes condensate from the process bays. The BDP supplied *AgitatAer™* process control system (system) allows continuous modulation of process air based on temperature feedback from the process material. The system also allows high/low cyclical aeration control as a default control strategy in the event temperature inputs are inadvertently disabled.

The aeration zones in each set of (5) bays are linked by a common below-grade manifold to a blower for that particular zone. Thus for the (120) total aeration zones, (24) aeration blowers are being supplied and located in the aisles.

The BacTee floor system consists of BacTee's polymeric baseplates as shown below that are encased in the floor but can be removed for periodic full-access cleaning. The baseplates are adjacently located to a Cross-Arm which provides a plenum cavity between the baseplates and a spigot that transports air upward from a below-grade manifold pipe.



Photo 8 - BacTee Polymeric HT Baseplate



Photo 9 - Baseplate embedded in the tunnel floor

Process material temperature is continuously monitored and supplied to the control system from RTD type temperature sensors mounted in the bay walls of each aeration zone in each bay. The temperature inputs from the same aeration zone in each of the (5) bay groups are averaged by the control system to drive the blower to aerate the respective zone. All blowers are operated through a variable frequency drive (VFD) to provide continuous modulation of the air flow to precisely maintain process material temperature about a floating set point within the control system.

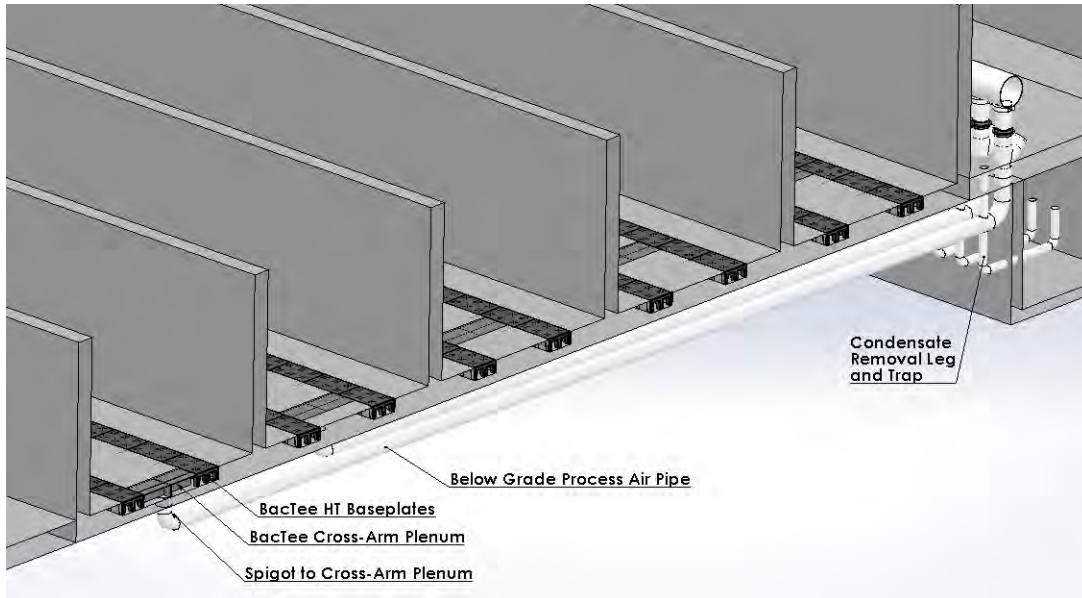


Photo 10: Compost Aeration Floor Components



Photo 11: Temperature probe in wall of empty Bay



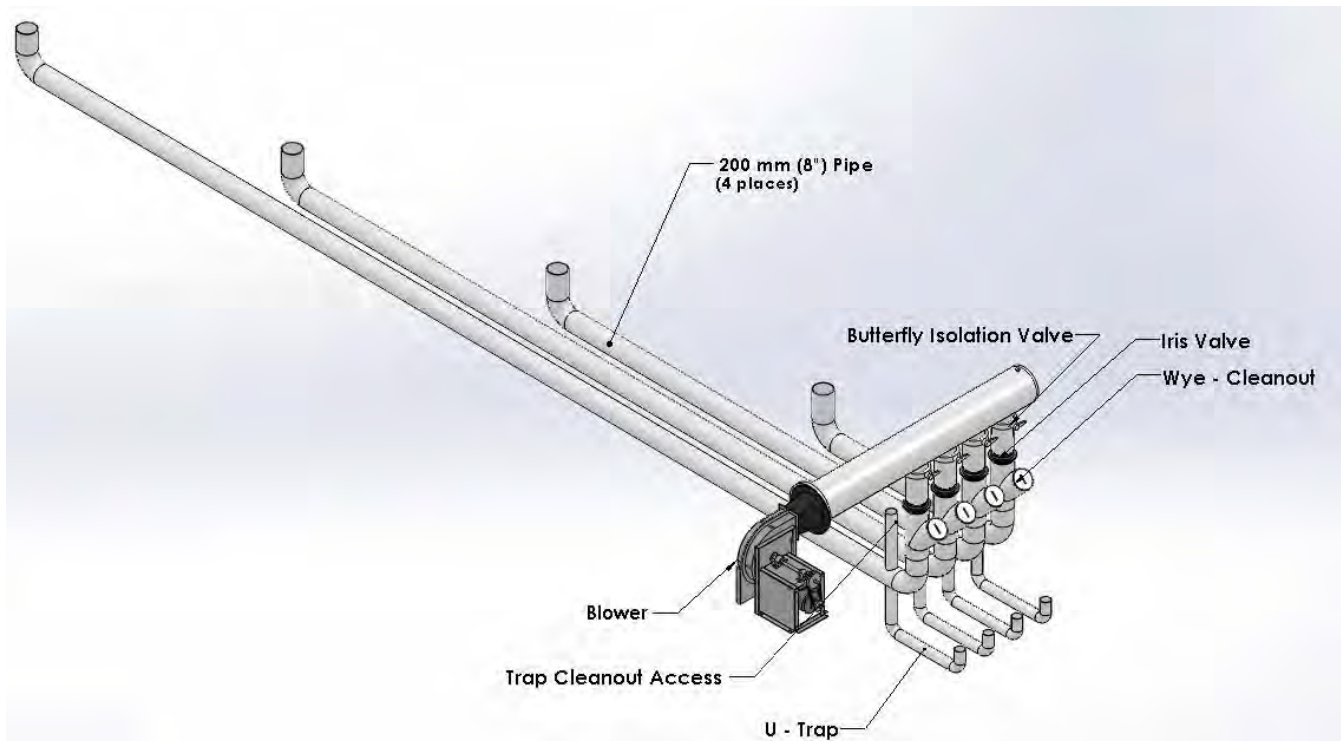


Photo 12: Typical Bay Aeration Piping Arrangement (as shown for 4 bays)

The aeration zones vary in length to provide adequate aeration throughout the composting process. Zones at the beginning of the bay are shorter and provide more airflow to support the higher level of biological activity that produces temperatures that are higher than in those zones nearer the discharge end of the bays. The aeration zones become progressively longer from the fill to the discharge end of the bays. In addition to the aeration zone length varying from the fill to discharge ends of the bays, the air flow rates are decreased. Consequently, blower air flow capacity decreases for the zones nearest the discharge end.

All aeration plenum and manifold units (i.e. pipe) are designed to transport condensate water away from the process bays. The low point of the below-grade aeration manifolds is equipped with a U-trap to prevent short-circuiting of air flow while allowing disposal of water to a below-grade drain manifold. In this case, the drain manifold is also the central process and ventilation exhaust plenum. A collection sump incorporated into the floor of the process area serves as a collection reservoir for the water. The water collected will be discharged to the sewer or recycled for other areas of the facility if permitted.

- ii. **Bay Moisture Addition** – As the compost material progresses down the length of the bays over time it will lose moisture by design. The process air is entrapping the moisture. It becomes blended with the ventilation air and is subsequently transported through the biofilter. In some cases, depending on facility location and feedstock, the compost process begins to suffer due to moisture depletion in the bays. Essentially the compost microbes become starved for water. This tends to occur towards the end of the bays as the compost begins to exceed 60% solids. It is anticipated that the Montgomery County, MD facility could encounter this moisture deficiency during some periods of the year. Therefore, BDP is supplying a moisture addition system to add moisture back into the bays. It uses PVC pipe with spray nozzles nested in the rail that runs along the top of the bay walls as shown in Figure 13. This moisture addition system is controlled by the BDP *AgitatAer*™ SCADA system and usually runs for prescribed time period based on operator experience.

The water supply for the moisture addition should be designed to supply 500 - 1000 gallons/day/bay. The water source does not need to be potable but does need to be free of pathogens. Captured rain water should be appropriate.

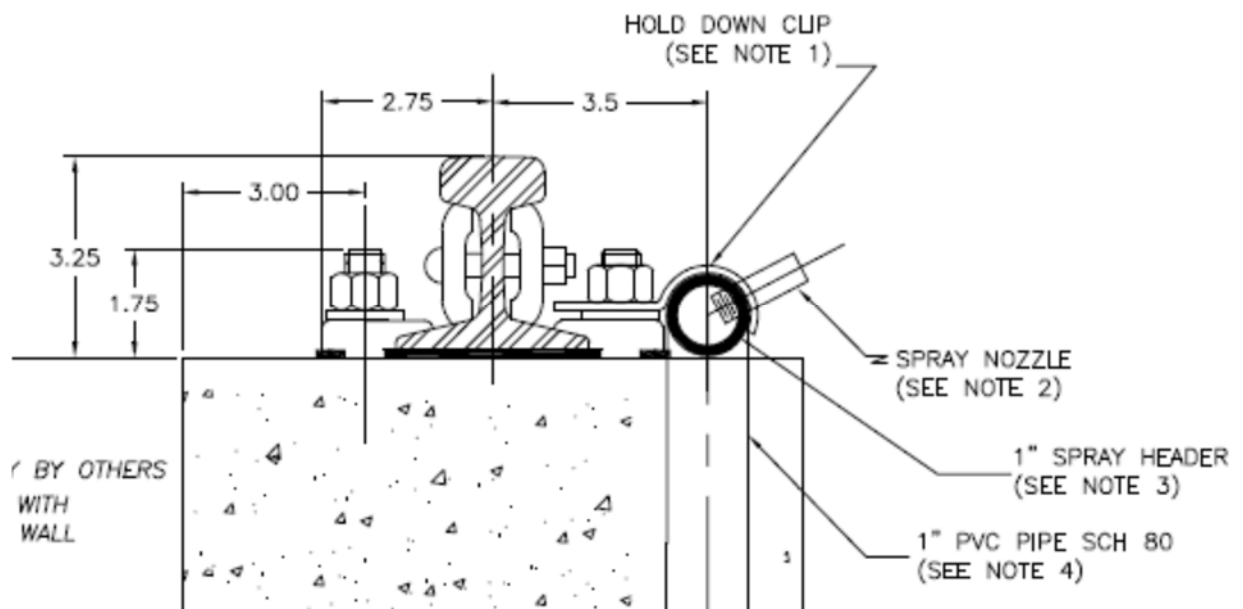


Photo 13: Bay Irrigation System

**iv. *AgitatAeR™ Computer Control*** – The BDP *AgitatAeR™* Process Control System (system) is designed to be the total compost facility control system interfacing with the various fans, blowers, agitators and other miscellaneous equipment.

- i. The primary function of the system is to ensure that the compost material in the bays is subjected to the required USEPA Time/Temperature protocol = 3 continuous days at  $\geq 55^{\circ}\text{C}$  for pathogen destruction (PFRP) and 14 days at  $\geq 45^{\circ}\text{C}$  for Vector Attraction Reduction (VAR). This is done by the system monitoring the (120) bay wall mounted RTD type temperature probes (Photo 9) and correlating that data with the material movement through the bays. The compost temperature at the bay wall should be the coolest spot due to the heat sink effect of the concrete wall.

Each 40 yd<sup>3</sup> “charge” of material that is loaded in the front of the bays is assigned a unique 4-digit Charge Number as shown in Photo 11 below. For the 230 ft length bay, there will be about 17 individual charges per bay. The system also monitors which bays are agitated on a given day. As indicated above, with each agitation the compost pile in a bay is translated about 13 feet towards the end of the bay. Charge movement down the length of the bay is estimated by the system via a site specific charge movement algorithm. With each bay agitation, the computer advances the charges towards the discharge end of that bay. The system correlates the appropriate wall temperature measurement to the charge as it moves.



Photo 14 – Sample Charge Status Screen

The charges are color coded such that the operator can visually tell the status of a charge as it moves thru bay. When the charge is initially loaded into the bay, the charge number is presented in black text. When the charge achieves the time/temp protocol, the charge number text color changes to green indicating the material has met this requirement. If the charge gets within the last 5 segments in the bay, and does not achieve time/temp protocol, the charge number text turns red indicating to the operator corrective action for that charge is required (typically taking hand probe temperature probe measurement). If the charge does not reach time/temp protocol when it is discharged, it will be recycled back to the front of the facility for re-processing.

The system can generate detailed time/temperature reports for compliance proof as shown below.

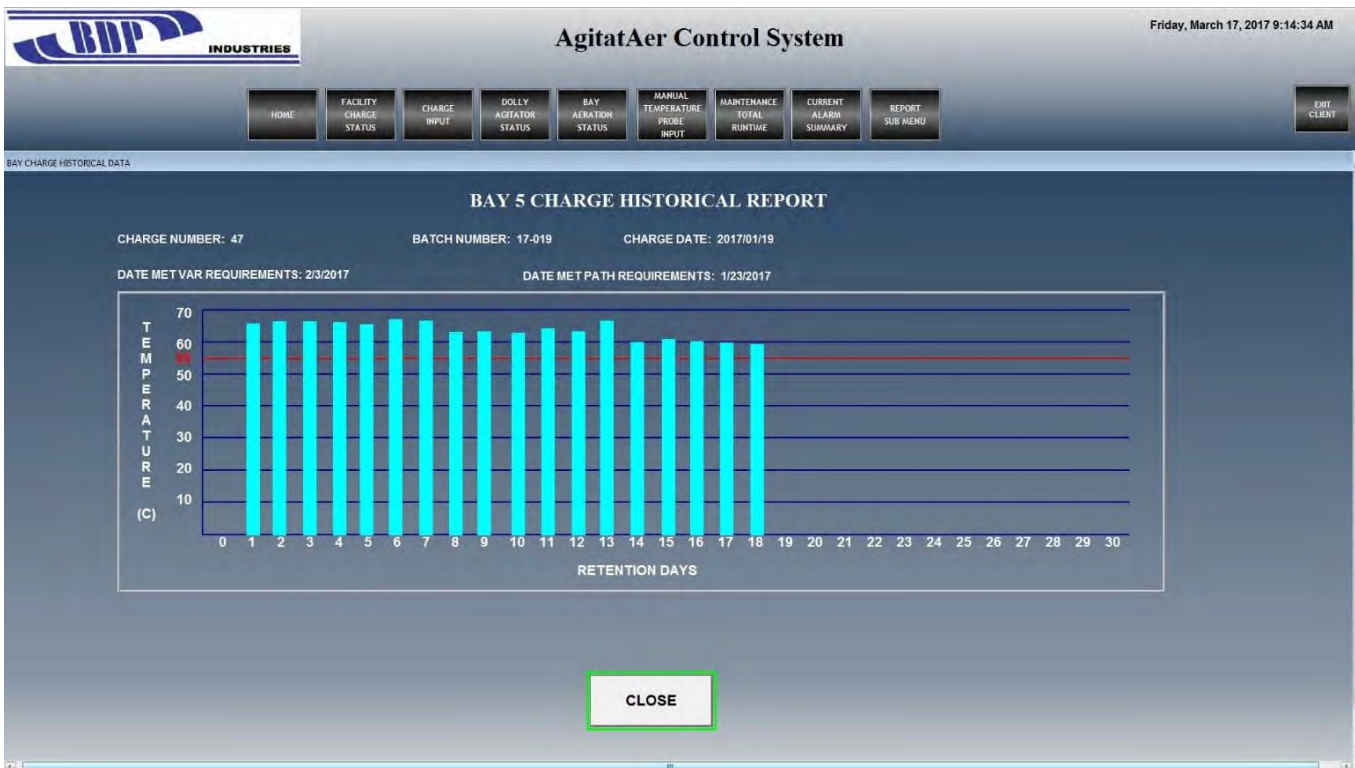


Photo 15 – Sample Charge Historical Report



- ii. The system also is used to automatically control the aeration blowers to optimize compost conditions and to maintain aerobic conditions in the bays. The goal is to discharge a suitably mature compost product from the bays that can be moved outdoors for Curing without significant odor concerns. The system modulates the process blower speed, as needed, to allow the process temperatures to stay within a limited range. The desired range of process temperature is determined by input parameters that may be varied by simple menu-driven changes to the control system if feedstock properties and the objective final material properties change.

Both process control and data acquisition functions are provided within the system. The screen shot below indicates aeration blower control and monitoring for a 5 zone (A – E) bay.



Photo 16 – Sample Blower Control Screen

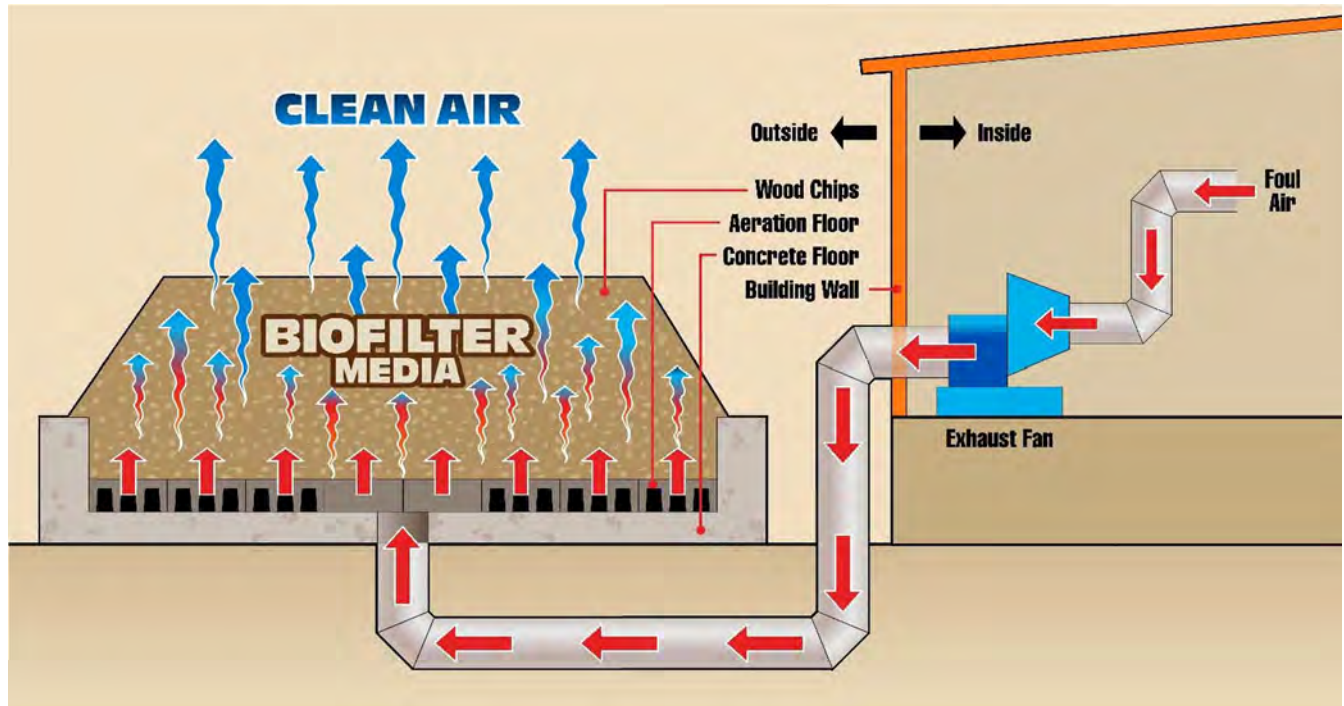
- iii. The system is also used to control the building ventilation fans/blowers VFD drives to control the fans speed to maintain negative pressure conditions within the building for optimal odor containment.
  
- v. **Ventilation** – The fully-enclosed Composting structure is maintained under a slight negative pressure by the (6) 100 HPe Exhaust Fans drawing process air from the building. Fresh air is drawn into the structure through louvered grilles in the sidewalls of the building. The negative pressure maintained within the duct draws air through a series of intakes located in the Feedstock Receiving and Composting areas.

**Step 4 – Composting Material Discharge** – After approximately 20 days in the bays the compost material is moved by the agitator into the final 16 ft discharge zone of the bays. Like the loading Zone at the front of the bays, the discharge zone is a solid concrete floor with no aeration. BDP presumes the compost is removed from the bay by loaders but can also be automated as shown below. At this point the compost is expected to have a solids content in the range of 60% and a density of about 0.4 tons/yd<sup>3</sup>. Approximately 25 yd<sup>3</sup> of material are removed from each bay after each agitation and transferred to the outdoor Curing area.



Photo 17 – Optional Automated Bay Unloading

## Step 6 – Odor Control – Biofiltration



A biofilter odor control system treats all process and ventilation air from the building. Building air is drawn under negative pressure, created by the suction side of the Exhaust Fans, into the main duct. Three 100 HP Exhaust Fans are located at the entrance to each the biofilters to maintain a constant, slightly-negative air pressure within this duct under the control of the AgitatAer™ system. The Exhaust Fans transport the air through the biofilter bays and media.

The biofilters will be equipped with the BacTee biofilter aeration floor components. Due to space constraints, the proposed biofilter media is a synthetic media like that manufactured by Biorem Inc.

Condensate may form in all air manifolds before and within the air passageways of the biofilter. A condensate leg and trap conveys condensate formed in the aeration zone piping and can be removed via a condensate drain to appropriate storage or disposal. In addition, heavy rains may potentially permeate through the biofilter media. Consequently, condensate collection and drain piping is provided to remove water from the biofilter unit for re-use/disposal. Condensate is removed from both the biofilter and duct via ports at low points in the respective plenums.

Sample Biofilter related drawings:



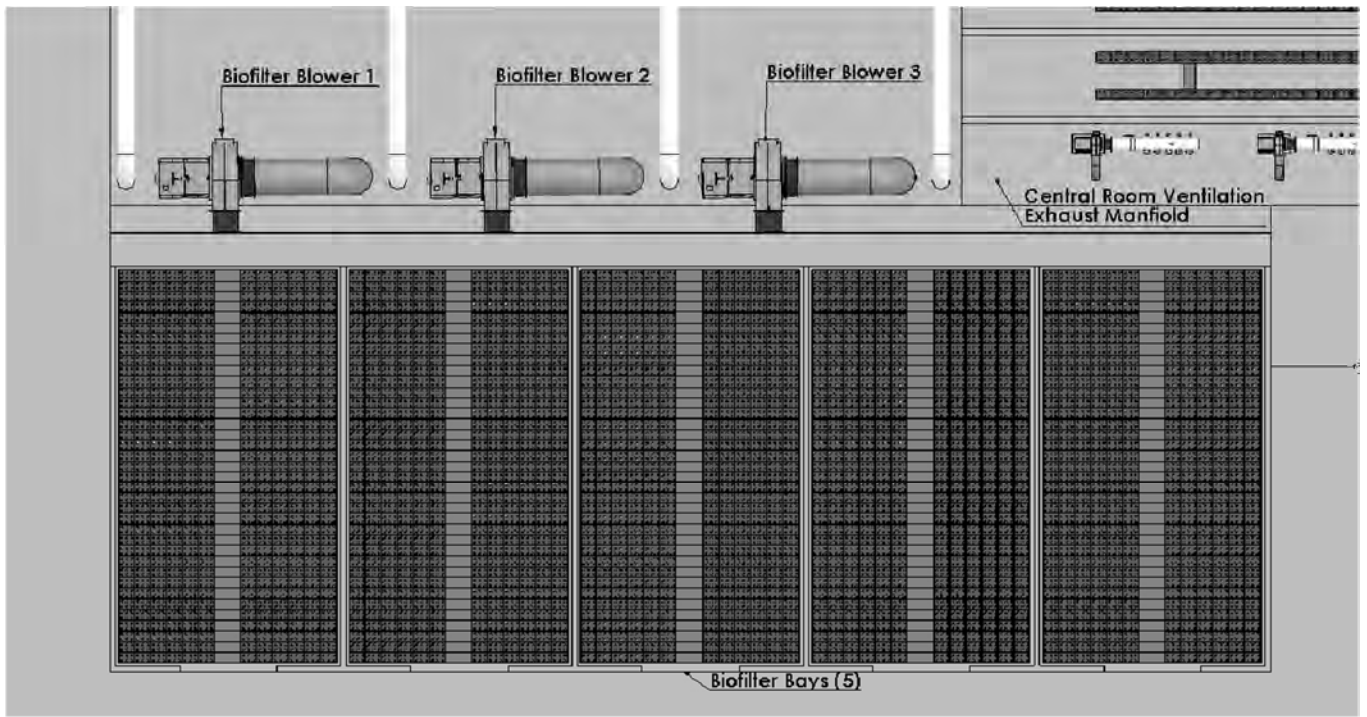


Figure 1: Conceptual Biofilter

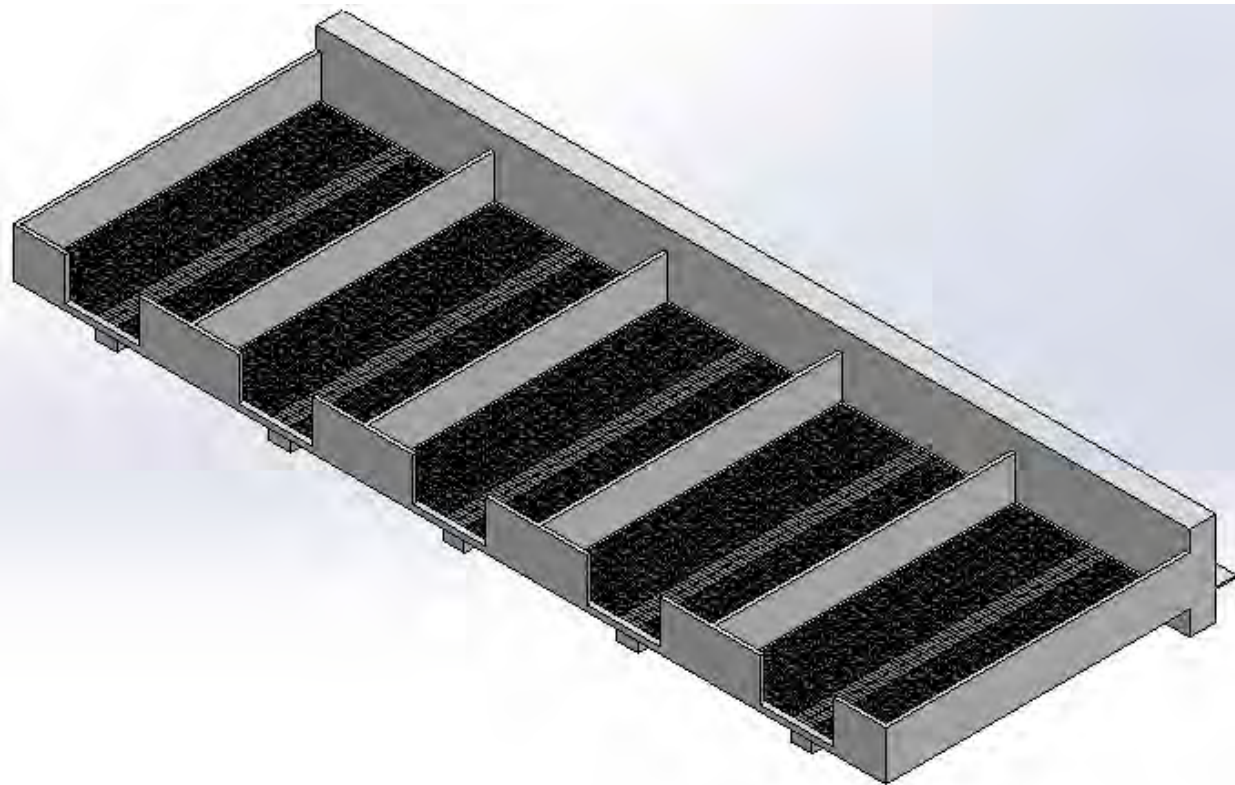


Fig 2: Conceptual Biofilter showing concrete details for media placement access

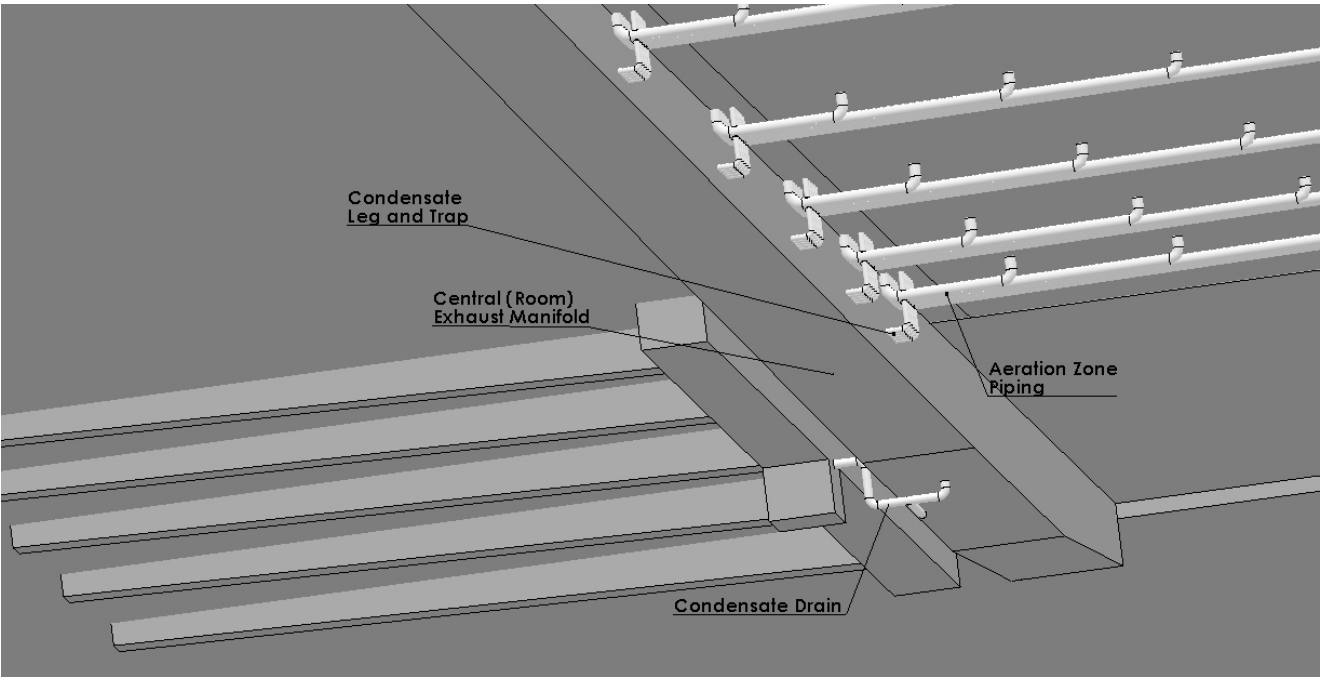
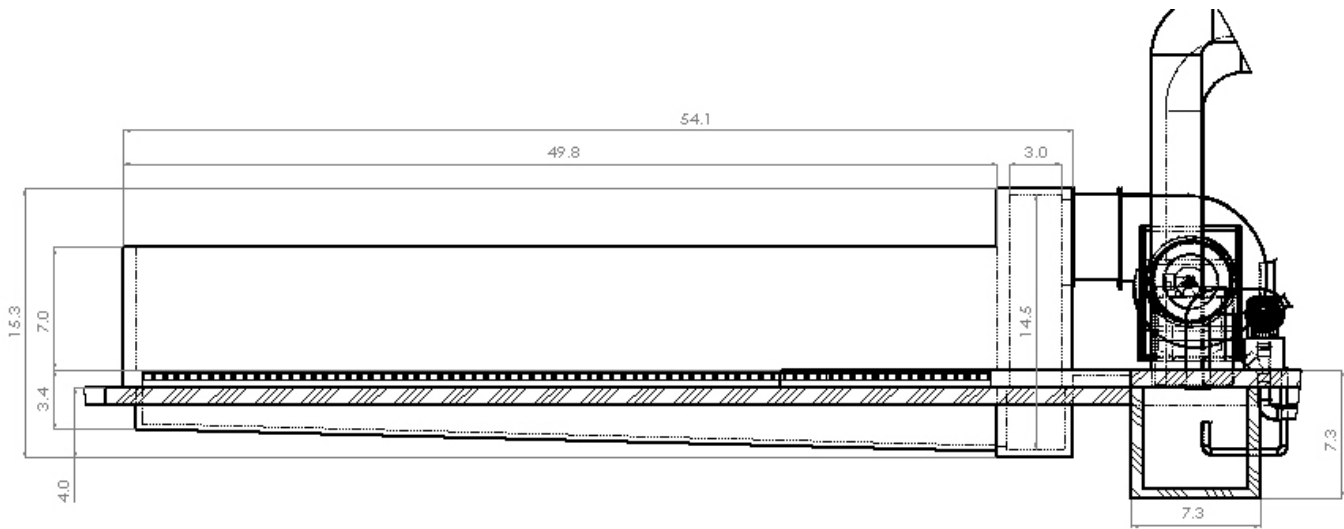


Fig. 3: Biofilter Drain Piping (typical)

Fig 4 – Biofilter Detail



**Commentary**  
**for**  
**Biogas to Hydrogen Conversion**  
for EA Engineering  
August 16, 2023

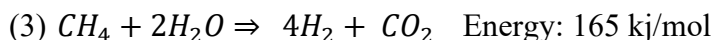
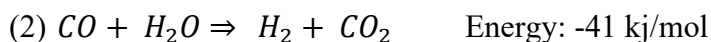
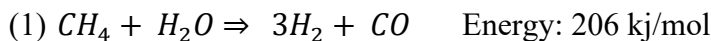
**OBJECTIVE**

Montgomery County, Maryland, is interested in evaluating the feasibility of conversion of biogas produced in anaerobic digesters into hydrogen gas. This hydrogen could be readily stored and used to fuel vehicles and other hydrogen-burning equipment for the county.

This analysis presents a high-level analysis and commentary about the biogas-to-hydrogen conversion with respect to gas mass balance and energy balance. Vendors have been contacted to develop an estimate of CAPEX and OPEX of a conversion system. Currently an estimate of CAPEX for the methane-to-hydrogen equipment only and exclusive of installation and operating costs has been received and will be presented.

**RESULTS**

The process of steam reforming methane (SRM) is a mature technology in the oil and gas industry.<sup>12</sup> In this method, methane that is captured from subsurface hydrocarbon repositories is reacted at high temperatures (700 °C – 1000 °C) and with water. This reaction produces hydrogen gas and carbon monoxide. A further reaction is then performed on the gas which transforms carbon monoxide into carbon dioxide and nets one more molecule of hydrogen. In these reactions, 1 mole of methane is transformed into four moles of hydrogen gas while some energy is consumed. The stoichiometric reactions and the overall reaction are presented in equations 1-3 below.



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<sup>1</sup> Song H. et al. 2022. Energy, environment, and economic analyses on a novel hydrogen production method by electrified steam methane reforming with renewable energy accommodation. Energy Conversion Management, 258

<sup>2</sup> Challiwala M.S. et al. 2017. A combined thermos-kinetic analysis of various methane reforming technologies: Comparison with dry reforming. Journal of CO2 Utilization, 17, 99-111.

As the equations show, the process requires an input of energy. The net energy required for both reactions is 165 kJ/mol of CH<sub>4</sub> converted into methane.

There are other methods such as dry reforming methane (DRM) that produce a similar gas mixture with the goal of producing hydrogen gas from organic precursors.<sup>3</sup>

For this analysis, we considered only SRM for hydrogen formation as it is the most mature and commercially available method. The other methods may be worth investigation if vendor with suitably mature technology could be identified.

Data about system operation was taken from the websites of Linde Engineering and HyGear. The energy requirements reported by HyGear are significantly lower than what is expected from the stoichiometry. It is possible that the HyGear process is able to incorporate efficiencies in their design that lower the net energy cost for conversion using SRM. EA is still working with HyGear to understand the energy balance in their process and those results are not presented here. Several things are apparent from an evaluation of the stoichiometry:

- 1) There is a net gain in energy contained in the hydrogen gas after conversion from methane. The net gain in 1000 SCF of methane gas is approximately 46 KWh.
- 2) There is a net negative balance of energy over the whole reaction. Approximately 8 KWh of energy are required for the conversion of 1,000 SCF of methane to 4,000 SCF of hydrogen.
- 3) The net energy contained in 1000 SCF of methane gas drops from 270 KWh to 79 KWh (316/4).

Table 1. Energy balance for conversion of methane to hydrogen.

| Item                            | Unit | per m3 of gas | per 1000 SCF Methane** |
|---------------------------------|------|---------------|------------------------|
| Methane Energy                  | KWh  | 10            | 270                    |
| Hydrogen Energy                 | KWh  | 11.2          | 316                    |
| Energy Consumed (Stoichiometry) | KWh  | 1.9           | 55                     |
| Net Energy Stiochiometry        | KWh  | -0.3          | -8                     |

\*SCF = Standard cubic foot = 1 ft<sup>3</sup> of gas at 1 atm and 15 C

For conversion of methane gas to hydrogen, high purity is required of the initial gas. This will require removal of hydrogen sulfide primarily. Ammonia and other trace impurities such as siloxanes also likely will need to be addressed in systems burning either methane or with conversion to hydrogen. Therefore, there is no difference in cost for the pretreatment of biogas for use as methane or for use after conversion to hydrogen.

There will be a capital expense for the methane conversion equipment. Base equipment cost for the methane-to-hydrogen conversion equipment will be \$2,500,000 for a system capable of converting 180 SCFM of methane to hydrogen. With engineering and installation, the total cost will likely be ~\$7,500,000. Additional costs associated with pressurization equipment, gas storage equipment, gas purification equipment, and finished gas transportation equipment will

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<sup>3</sup> Song et al.



need to be added for a final cost of the system. There will also be operating expenses for conversion equipment. Operating expenses are not known at this time.

With respect to carbon emissions, one carbon dioxide molecule is produced from burning a single molecule of methane. One carbon dioxide molecule is also produced during the conversion of methane to hydrogen. Therefore, there is no reduction in carbon dioxide or carbon emissions when converting methane to hydrogen.

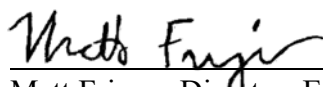
There are some advantages to conversion of methane to hydrogen:

- 1) Convenient storage and unlimited shelf life of hydrogen gas.
- 2) Use of hydrogen in equipment that is designed to burn hydrogen gas.
- 3) No carbon emissions at the point of use of the hydrogen gas.

### **CONCLUSIONS**

1. There is a net gain in energy from conversion of methane to hydrogen of 117%.
2. There is a consumption of energy from conversion of methane to hydrogen due to energy consumed in the reaction. Energy consumption will be >8 KWh/1000 SCF of methane.
3. There is no advantage to conversion of methane to hydrogen with respect to carbon emissions.
4. Both gasses will require similar pretreatment of the raw biogas prior to use.
5. There are costs associated with the purchase and upkeep of methane-to-hydrogen conversion equipment.

Methane-to-hydrogen conversion is a common and cost-effective way of generating hydrogen gas from fossil fuel. There is a relatively small consumption of energy for conversion of methane to hydrogen. Capital cost of installation of a facility that can convert 178 SCFM of methane to hydrogen may make economic sense if use of the hydrogen is paired with equipment that uses hydrogen, not methane, as a fuel source.



August 16, 2023

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Montgomery County Department of Environmental  
Protection

Recycling and Resource Management Division

# **Municipal Solid Waste Management System**

## **Alternatives Analysis**

May 2025

## Municipal Solid Waste Management System Alternatives Analysis

May 2025

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## Contents

|          |                                                                                  |           |
|----------|----------------------------------------------------------------------------------|-----------|
| <b>1</b> | <b>IDENTIFICATION AND COMPARISON OF MSW MANAGEMENT SYSTEM ALTERNATIVES .....</b> | <b>2</b>  |
| 1.1      | Existing MSW Management System .....                                             | 2         |
| 1.2      | Alternative MSW Management Systems .....                                         | 3         |
| <b>2</b> | <b>EVALUATION OF ALTERNATIVE SYSTEMS .....</b>                                   | <b>7</b>  |
| 2.1      | Waste Diversion .....                                                            | 8         |
| 2.2      | Carbon Footprint/Greenhouse Gas (GHG) Emissions .....                            | 9         |
| 2.3      | Cost of Service .....                                                            | 12        |
| 2.4      | Environmental Justice (EJ) Screening .....                                       | 16        |
| 2.5      | Uncertainties and Risks in Analyses .....                                        | 19        |
| <b>3</b> | <b>PROCUREMENT AND SOLICITATION OF QUALIFIED PROJECT DEVELOPERS .....</b>        | <b>20</b> |
| <b>4</b> | <b>CONCLUSIONS .....</b>                                                         | <b>22</b> |
| <b>5</b> | <b>REFERENCES .....</b>                                                          | <b>22</b> |

## Tables

Table 2-1 Summary of Evaluation Model Ranking of Alternatives

Table 2-2 Summary of Waste Diversion from Disposal

Table 2-3 Summary of GHG Emissions

Table 2-4 Summary of Estimated MSW Management System Cost of Service

Table 2-5 Summary of Environmental Justice Screening Analyses for Potential ‘Host Communities’

Table 2-6 Summary of Supplemental Environmental Justice Screening Analyses for Alternate MSWLF Host Communities

## Figures

Figure 1-1 Summary of Alternatives Evaluated

Figure 1-2 Typical MRBT Facility Configuration

Figure 2-1 Summary of Estimated Cost of Service Including Contributions of CAPEX and OPEX Components

## Appendices

Appendix A: Technical Memorandum

Appendix B: Additional Detail on Evaluation Model

Appendix C: Additional Detail on WARM Analysis

Appendix D: Additional Detail on Financial Model

## 1. IDENTIFICATION OF MSW MANAGEMENT SYSTEM ALTERNATIVES

The County continues to implement a combination of source reduction and recycling programs to reduce waste generation and divert materials from future disposal while moving toward a 'zero-waste' model. Even so, approximately 52 percent of materials delivered to the County's waste processing facility and transfer station (TFS) tipping floor are still comprised of either comingled recyclables, recyclable paper, or compostable organics, which represent a significant opportunity for enhanced waste diversion [Ref. 1]. In addition, the County's current municipal solid waste (MSW) management system relies upon a Resource Recovery Facility (RRF) to combust approximately 600,000 tons per year of processible waste materials; and although the facility operates in compliance with its Permit requirements as well as applicable Federal and State regulations, it has been recognized as a significant source of air emissions (primarily carbon dioxide and other compounds).

The County retained Arcadis in November 2023 to evaluate and compare multiple alternative MSW management systems including the following:

- Alternative 1 Materials Recovery and Biological Treatment (MRBT) to enhance recovery of valuable materials from the TFS tipping floor.
- Alternative 2 Long-Haul MSW to an Out-of-County MSW Landfill (MSWLF).
- Baseline for Comparison – Retrofit/Repair and/or Rehabilitation of the County's existing RRF.

Based upon the results of that evaluation, the County's Department of Environmental Protection (DEP) is proposing development of an innovative MRBT facility, which represents a significant opportunity to enhance diversion of MSW and reduce future GHG emissions.

### 1.1 Existing MSW Management System

MSW materials collected from within the County's jurisdictional boundaries are delivered to the TFS located in Derwood, MD. Four (4) compactors at the transfer building load MSW into 40-foot length intermodal containers (ITCs) with a target weight of 27 tons of waste, which are then hauled by a small 'terminal tractor' unit to an adjacent 1.2-mile length access track within the adjacent TFS railyard.

From there, containers are lifted by gantry crane and stacked two-high on special purpose rail cars which are pulled by locomotive engine approximately 18 miles by rail after close of daily TFS operations to the County's existing RRF located in Dickerson, MD. CSX Transportation, Inc. provides rail service.

The RRF, also referred to as a Waste-to-Energy facility, incinerates the MSW and creates high pressure steam which is input to a turbine engine. The turbine generator is capable of producing up to 52 MW of electricity, 24 hours per day, 7 days per week, which is sold and exported to the local power grid. Resulting revenues from the sale of electricity and renewable energy certificates (RECs) are used to offset operating expenses (OPEX) charged to the County from the facility operator.

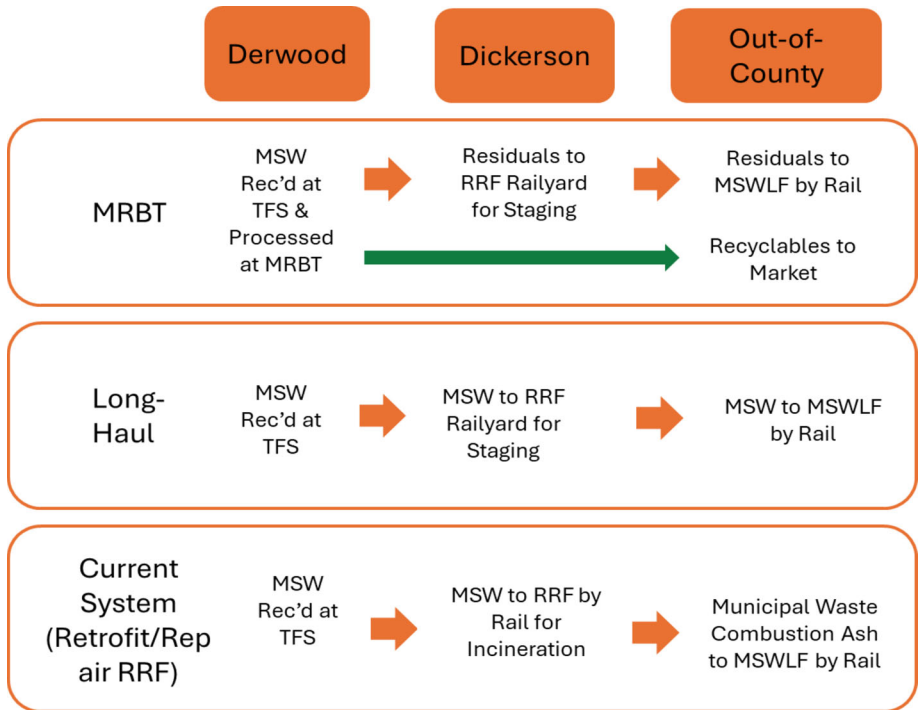
Following incineration, the resulting residual material, sometimes referred to as Municipal Waste Combustion (MWC) Ash, is again loaded into ITCs and onto railcars within the RRF railyard. After staging off-site at a local CSX junction, a length of approximately 120 rail cars is sent by locomotive every 3 days, approximately 160 rail-miles for disposal at the Old Dominion Landfill owned and operated by Republic Services, Inc., located in Henrico County, VA (in proximity to Richmond, VA). Given the relatively large distance, the journey from the RRF to the landfill and back to the RRF requires several days to complete. Republic Services utilizes the MWC Ash as an

Alternate Daily Cover (ADC) pursuant to Virginia Solid Waste Management Regulations, avoids the cost of importing other fill materials for use as daily cover, and receives credit for beneficial re-use.

## 1.2 Alternative MSW Management Systems

Multiple alternative MSW management systems were evaluated and are summarized in **Figure 1-1**.

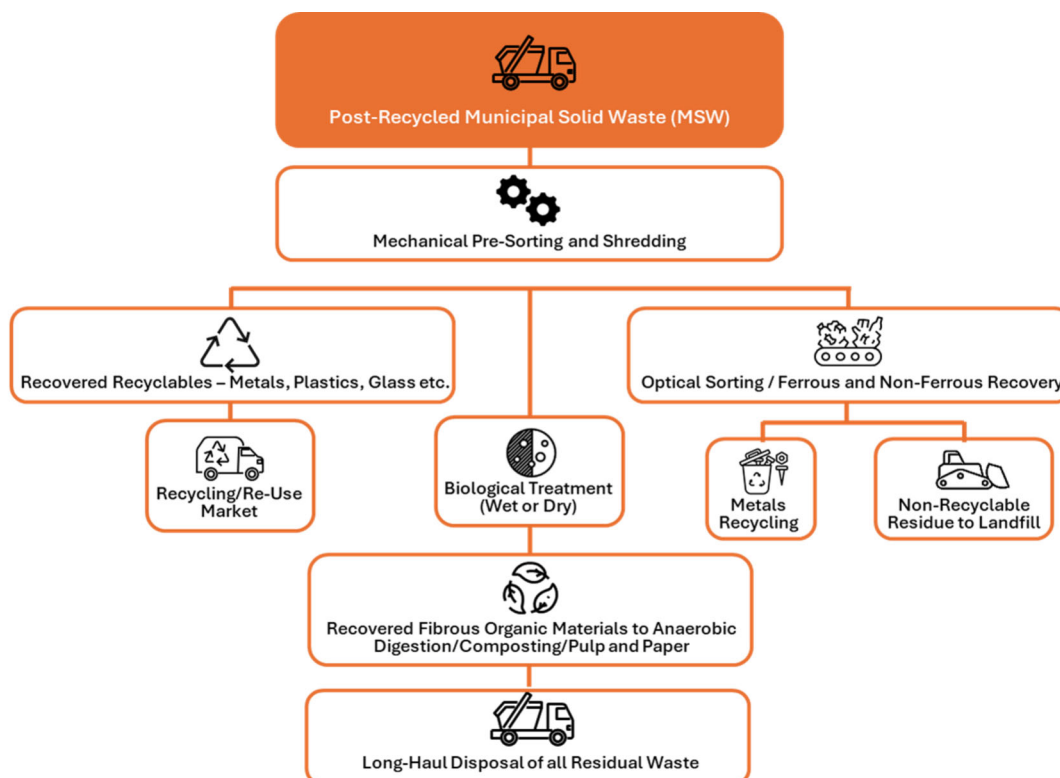
**Figure 1-1: Summary of Alternatives Evaluated**



A more complete discussion of the alternative MSW management technologies can be found in **Appendix A**.

**Alternative 1 - MRBT** - This alternative would adapt the TFS (or other potential site) to accommodate development of a MRBT facility and increase waste diversion. Basic components of an MRBT facility are shown in **Figure 1-2**.

**Figure 1-2: Typical MRBT Facility Configuration**



It is noteworthy that the MRBT facility is intended to supplement (not replace) on-going diversion efforts within the County and would be used to manage materials remaining in the MSW stream which arrive at the TFS tipping floor after recycling and other source reduction efforts.

MRBT utilizes mechanical equipment separation technologies to sort residential or commercial-generated MSW by size, shape, weight, conductivity, or other parameters into recoverable recyclable materials for market sale and recoverable organic waste fractions for possible beneficial use, along with residual waste that require disposal at a RCRA Subtitle D-compliant MSWLF. Recovered recyclable commodities (e.g., plastics, ferrous and non-ferrous metals, cardboard, etc.) will vary in quality and may require a washing process to optimize pricing for market sales. The recoverable organic waste fraction (e.g., food scraps, yard trim, non-recyclable paper) will undergo biological stabilization, most likely through anaerobic digestion (AD) that uses microorganisms to break down organic matter in the absence of oxygen and produce biogas that can be upgraded to an energy source such as renewable natural gas (RNG).

AD facilities produce solid digestate that will require disposal at a permitted landfill or may potentially be used for land application as a soil amendment; as well as liquid digestate which may require both pre-treatment (typically on-site) before final treatment at a wastewater treatment facility prior to discharge.

The MRBT residue would require disposal and would follow a sequence of transfer and hauling processes similar to that described previously for the County's existing MSW management system. Residue would be compacted

within the transfer building into ITCs and transferred at the end of each operating day by CSX rail from the TFS to the RRF railyard for temporary storage and staging. After staging into longer train-lengths, again, as required by CSX, the ITCs would be hauled via rail from the RRF railyard to an Out-of-County MSWLF.

There are no MRBT facilities of the projected size required for management of Montgomery County's MSW stream operating in the United States. However, the City of San Jose, CA relies upon an MRBT facility (Greenwaste) with nameplate capacity of approximately 90 tons/hour (or about 900 tons/day), or approximately one-half the capacity required by Montgomery County. It is our understanding the Greenwaste facility was constructed on behalf of a private sector vendor (Athen's Services) and operated pursuant to an agreement with the City. It sits on a property comprising an approximate 10-acre footprint (which is similar in size to the footprint available at the County's TFS and/or RRF footprint following decommissioning).

With regard to the potential location of the MRBT facility, a formal feasibility study has not been carried out but one of the Offerors deemed responsive to a preceding Request for Expression of Interest (REOI) included a preliminary site plan with their submittal which showed locating the proposed MRBT facility at the TFS. This may require relocation of other activities which are currently co-located with the Transfer Building and future MRBT facility. If the County chooses to proceed with procurement for an MRBT facility, the selected project developer would be required to identify the proposed facility location and plan the facility design and construction to abate or minimize disruption of activities at the TFS (which may include temporary or permanent relocation of some existing supporting activities).

**Alternative 2 - Long Haul of MSW to an Out-of-County MSWLF** - This alternative would transport the entire MSW stream of materials from the TFS tipping floor to an Out-of-County MSWLF. Multiple scenarios (labeled 2A through 2E) were evaluated utilizing either rail or tractor-trailer for hauling MSW. Facility adaptation, rolling stock requirements to transport waste materials, as well as resulting cost of service varied significantly when compared to other alternatives.

The implications of hauling MSW as opposed to MWC Ash relate directly to their physical properties which are changed by the incineration process and have a significant impact on long haul operations and disposal. In each of these scenarios the impact of change from hauling and disposal of MWC Ash to that of hauling and disposal of unsorted MSW has been considered. These included evaluation of public safety, cost (including facility adaptation and rolling stock requirements), potential nuisance impacts on the immediate surrounding community) and other factors such as complexity of operations as well as proximity and availability of disposal capacity from landfills.

More specifically depending upon whether rail or tractor-trailer is used for hauling:

- **Rail Haul** - Long haul via rail would continue to rely upon dedicated rolling stock specifically designed to accommodate between 2 to 4 ITCs per rail car depending upon whether the containers are single- or double-stacked. Two scenarios were evaluated:
  - **2A Long Haul MSW by Rail from the RRF to an Out-of-County MSWLF** – Hauling and disposal of waste materials in this scenario is similar in many ways to the process used for the County's existing MSW management system as well as the previously described MRBT alternative. This alternative includes compaction of waste into ITCs at the transfer building; daily transfer of waste by CSX rail from the TFS to the RRF railyard in Dickerson; temporary storage and staging of waste-filled ITCs on rail cars to enable formation of longer train lengths in accordance with CSX requirements; followed by transport by CSX rail to an Out-of-County MSWLF for final disposal.



- **2B Long Haul by Rail from the TFS to an Out-of-County MSWLF** – Direct hauling of MSW from the TFS railyard omits utilizing the RRF railyard as an intermediate staging area. In other respects, it is similar to Alternative 2A. Although staging of ITCs on railcars is still required to satisfy CSX requirements, these efforts would be performed within the TFS railyard and then transported by CSX rail to an Out-of-County MSWLF for final disposal. There are significant constraints and limitations associated with this alternative, relating to cost of necessary railyard adaptation and rolling stock, regulatory requirements, and potential nuisance impacts on the surrounding community associated with overnight storage of MSW within ITCs.
- **Tractor-Trailer** – MSW transport by tractor-trailer would require utilization of walking-floor trailers in lieu of ITCs. Unlike ITCs, walking-floor trailers cannot be ‘double-stacked’ on railcars. The corresponding reduction in payload has significant implications on the cost of railyard adaptation and rolling stock requirements:
  - **2C Long Haul Tractor-Trailer from the TFS to an Out-of-County MSWLF** – Direct hauling of MSW from the TFS to an Out-of-County MSWLF using tractor-trailer appears to be the simplest operation, however, there are significant constraints and limitations relating to potential public and worker safety as well as potential nuisance impacts (largely traffic related) on the surrounding community.
  - **Hybrid Utilizing both Rail and Tractor-Trailer:**
    - **2D Long Haul by Rail from the RRF (65%) and Long Haul by Tractor -Trailer from the TFS (35%) to an Out-of-County MSWLF** – This represents a ‘hybrid’ approach which attempts to relieve pressure on the TFS facility caused by increased rolling stock and ‘heavy’ tractor-trailer traffic by hauling from both the RRF and TFS locations. To avoid overly complex operations all MSW materials would be compacted into walking floor trailers (no utilization of ITCs). Approximately 65 percent of the MSW would be transported to the RRF railyard and the remaining 35 percent via direct haul from the TFS.

The fraction of MSW managed via the RRF railyard would utilize a process similar to that described previously for Scenario 2A following compaction of waste into walking-floor trailers at the transfer building (including daily transfer of waste by CSX rail from the TFS to the RRF railyard in Dickerson; temporary storage and staging on rail cars to enable formation of longer train lengths in accordance with CSX requirements; followed by transport by CSX rail to an Out-of-County MSWLF for final disposal).

The fraction of MSW managed via the TFS would utilize a process similar to that described previously for Scenario 2C. MSW would be direct hauled from the TFS to an Out-of-County MSWLF. Constraints and limitations relating to potential public and worker safety as well as nuisance impacts (largely traffic related) on the surrounding community would be reduced but not abated.
    - **2E Long Haul by Tractor-Trailer from the RRF (100%) to an Out-of-County MSWLF** – This scenario represents a variation of the previously described ‘hybrid approach’ and was suggested by external stakeholders as a way to expedite transition to another technology and avoid extension of the RRF operations agreement. All MSW arriving at the TFS tipping floor would first be transported by rail to the RRF railyard, similar to the previously described Scenario 2A. and

then subject to additional handling and transferred for long-hauling via tractor-trailer from the RRF to an Out-of-County MSWLF.

Constraints/Limitations and potential impacts on the TFS railyard and rolling stock requirements are unchanged, while potential nuisance impacts on the community surrounding the TFS are shifted to the community surrounding the RRF. In addition, significant potential impacts are associated with adding between 110-115 outbound and 110-115 inbound tractor-trailers daily on local roadways between the RRF and Routes 28 and/or 109 through Beallsville and Barnesville (while heading toward or coming from I-270); as well as potential significant roadway/intersection improvements within both towns. Remedying these potential impacts are anticipated to be costly and time-consuming, which would preclude immediate implementation of this alternative.

Alternative 2E was shown to be the most expensive, least practical, and most time-consuming of the various alternatives and dismissed from further consideration.

Results of the separate evaluation of these various Long Haul to an Out-of-County MSWLF scenarios indicated Alternative 2A Long Haul MSW by Rail from the RRF should be used for comparison to Alternative 1 and the base case because Alternative 2A minimized cost and avoided traffic impacts around the already-busy TFS site.

**Current System for Comparison: Retrofit/Repair and/or Rehabilitation of the County's Existing RRF** - This system is described for comparison purposes only, understanding the County Executive's intent to decommission the RRF following transition to another MSW management system utilizing a different primary technology for MSW processing.

The analysis assumes retrofit/repair and/or rehabilitation of the existing RRF suitable for a 30-year planning horizon. The scope of these efforts is deemed sufficient and necessary to facilitate long-term operations and include significant modifications to the facility's major components. These modifications include full boiler replacement, an upgraded air pollution control system including selective catalytic reduction (SCR) system components, as well as upgrades to the Municipal Waste Combustion (MWC) ash process and handling system and improvements to enhance recovery of ferrous and non-ferrous metals.

## 2. EVALUATION OF ALTERNATIVE SYSTEMS

A multi-variable evaluation model was developed to enable comparison of the alternative MSW management systems defined above. Detailed methodology is provided in **Appendix B**. Technologies were compared on the basis of the following evaluation criteria identified by the County:

- **Waste Diversion (Percent Diversion from Disposal)** – Estimates were made of anticipated diversion using reasonable assumptions based on past performance of similar facilities.
- **Carbon Footprint/Greenhouse Gas (GHG) Emissions (eCO<sub>2</sub>/ton)** - USEPA Waste Reduction Model (WARM) was utilized to estimate resulting emissions based upon waste composition obtained from previous County studies.
- **Cost-of-Service (Net Present Value (\$/Ton))** – The model utilized estimated cost of developing the various technology-based alternative systems using data collected from local, regional and national sources.

Each of the evaluation criteria were equally weighted pursuant to the County's policy objectives. Results of the evaluation using the model and comparison of alternatives are summarized in **Table 2-1**:

- **Alternative 1 MRBT** represents the top-ranked alternative. Highest scores for individual criteria were associated with waste diversion and carbon footprint.
- **Alternative 2A Long Haul of MSW by Rail from the RRF to an Out-of-County MSWLF** was the lowest ranked alternative.
- For comparison purposes the **Current System including Retrofit/Repair and/or Rehabilitation of the County's Existing RRF** was ranked second. It received the highest rank score for cost-of-service.

**Table 2-1: Summary of Evaluation Model Ranking of Alternatives**

| Alternative                                                      | Rank | Diversion | Carbon Footprint | Cost |
|------------------------------------------------------------------|------|-----------|------------------|------|
| 1 – MRBT (with Long-Haul)                                        | 1    |           |                  |      |
| 2 – Long Haul to Out-of-County MSWLF from RRF (Options 2A or 2C) | 3    |           |                  |      |
| Current System for Comparison (Retrofit/Repair RRF)              | 2    |           |                  |      |

**Legend:**

|     |        |     |
|-----|--------|-----|
|     |        |     |
| Top | Middle | Low |

- Notes:**
1. Diversion Reflects Rate of Avoided Disposal off TFS Tipping Floor. Top Rank Equals High Diversion.
  2. Carbon Footprint is the Difference in MTCO2e/Ton MSW Processed when Compared to Current County System. Top Rank Equals Small/Reduced Footprint.
  3. Cost-of-Service includes Preliminary Estimate of Potential Health & Environmental Impacts. Top Rank Equals Low Cost.

In addition, the USEPA Environmental Justice Screening and Mapping Tool (EJ Screen) was utilized to identify and compare socioeconomic, health and environmental data for a range of indices and indicator parameters in an effort to identify the extent to which any community that may host a waste processing facility is already disadvantaged.

## 2.1. Waste Diversion

Waste diversion was evaluated as the percentage of MSW arriving at the TFS tipping floor that could be diverted from disposal. Results of analyses showing estimated percent diversion of waste materials from disposal are summarized in **Table 2-2**.

**Table 2-2: Summary of Waste Diversion from Disposal**

| MSW Management System Alternatives                                          | Est. Percent Diversion from Disposal |
|-----------------------------------------------------------------------------|--------------------------------------|
| 1 – MRBT (with Long-Haul)                                                   | 45                                   |
| 2 – Long Haul MSW to Out-of-County MSWLF by Rail from RRF (Option 2A or 2C) | 0                                    |
| Current System for Comparison (Retrofit/Repair of RRF)                      | 3 to 4                               |

- Notes:**
1. Percent diversion expressed as fraction of MSW delivered to the TFS Tipping Floor and does not include up-front programmatic efforts to prevent recoverable materials such as recyclables or compostable organics from entering the TFS.
  2. Alternative 1 MRBT subject to confirmation by collaborative design with System Developer. A diversion rate of 45% is assumed and reflects average of data provided by two Offerors in response to the County's recent REOI, as well as typical diversion rates independently confirmed with a provider of existing MRBT systems.

Results of these analyses indicate the following:

- **Alternative 1 MRBT** - Development and operation of an MRBT facility may result in approximately 45 percent diversion depending upon the efficiency and effectiveness of the System Developer's proprietary process. The assumed percent diversion was based upon responses to a previous County REOI and conversations with other similar facilities operating or planned in the U.S.
- **Alternative 2A Long Haul of MSW by Rail from the RRF to an Out-of-County MSWLF** – Disposal of MSW at a typical MSWLF obviously results in no supplemental waste diversion.
- **Current System for Comparison Including Retrofit/Repair and/or Rehabilitation of the County's RRF** - For comparison purposes the RRF with upgraded metals recovery from the MWC Ash may be expected to result in approximately 3 to 4 percent diversion of materials from landfill disposal.

While the exact diversion rate that can be accomplished by MRBT would be determined through the facility design process, it is clear MRBT represents the alternative with the greatest potential for waste diversion.

## 2.2. Carbon Footprint/Greenhouse Gas (GHG) Emissions

Modeling was performed using USEPA Waste Reduction Model (WARM), which is a tool for comparing life cycle greenhouse gas emissions for different material management strategies or practices. WARM was used to compare GHG emissions of the various alternatives to a baseline which corresponds with upgrade of the County's RRF. The County's waste composition, as determined by the 2023 waste composition study (previous **Ref.1**), was used to develop WARM inputs.

WARM was first introduced in 1998 and has been periodically updated to incorporate new data and waste management strategies. The current Version 16 was published by USEPA in December 2023 and includes

updates to landfill emissions factors for organic fractions of MSW such as food waste and other wood products. Professional peer review was completed using a team of independent researchers with no conflict of interest who collectively had specialized expertise relating to life cycle assessment modeling, solid waste management modeling, modeling GHG emissions and other environmental impacts, as well as experience in modelling carbon storage (in landfills and other natural environmental systems).

The model treats biogenic carbon sources as carbon neutral since potential GHG emissions from biogenic carbon do not interrupt the natural carbon cycle within the timeframe of the model assumptions. This is consistent with the International Panel on Climate Change (IPCC). As such, WARM makes a distinction between biogenic and non-biogenic carbon sources and how those impact lifecycle emissions:

- **Biogenic Carbon** - If the source of carbon is biogenic, the material in its original condition prior to being disposed would still produce carbon dioxide (CO<sub>2</sub>) if it were to degrade naturally:
  - CO<sub>2</sub> emissions from biogenic carbon sources are considered carbon neutral regardless of the disposal technology. Biogenic CO<sub>2</sub> emissions resulting from any of the MSW management alternatives, which utilize incineration, anaerobic digestion, or landfill disposal as their primary technology, are all considered carbon neutral.
  - Emission of GHGs other than CO<sub>2</sub>, which are anthropogenic in nature and caused and/or influenced by the waste processing technology, and which would otherwise not occur under natural conditions, are not carbon neutral and considered in the analyses.
- **Non-Biogenic Carbon Sources (sometimes referred to as ‘fossil carbon sources’)** – If the source of carbon within the MSW stream of materials is derived from non-biogenic sources, such as plastics (which are anthropogenic in nature given they are derived from extracted fossil-based fuel), WARM will assume that component of the waste stream may result in discharge of GHG emissions, but only to the extent to which the processing technology is able to convert non-biogenic carbon to other gases.

Examples of how the source of carbon (whether it be biogenic or non-biogenic) and waste processing technology affect the formation of CO<sub>2</sub> and other climate-relevant GHGs include the following:

- **Landfill Disposal** results in the decomposition of biogenic carbon and formation of methane (CH<sub>4</sub>), CO<sub>2</sub> and N<sub>2</sub>O during anaerobic decomposition in the presence of methanogens (bacteria) within the waste mass, as well as CO<sub>2</sub> which occurs during aerobic decomposition at the landfill surface either prior to burial of the waste, or as fugitive CH<sub>4</sub> molecules produced within the waste mass migrate to the landfill surface and are oxidized by methanotrophs (which consume the CH<sub>4</sub> as a food source). The CO<sub>2</sub> component is deemed ‘carbon neutral’ inasmuch as it would have formed in absence of the landfill process, whereas the CH<sub>4</sub> which is caused specifically by burial of the carbon source within the landfill waste mass is not. However, it is important to note these compounds are only formed from degradation of biogenic carbon, and not non-biogenic or fossil carbon sources (such as plastics embedded within the MSW). It is also noteworthy that the model appears to over-estimate the collection efficiency of Landfill Gas Collection and Control System (LFGCCS) thus likely under-reporting fugitive emissions of methane.
- **Anaerobic Digestion** (which can be used on the ‘back end’ of an enhanced MRBT facility) creates both methane (CH<sub>4</sub>) and N<sub>2</sub>O from biogenic carbon embedded within the MSW. Although the resulting biogas is ultimately combusted, both compounds are deemed climate-relevant inasmuch as they are caused directly by the waste processing technology which is anthropogenic. It is equally important to note that

Anerobic Digestion is not able to synthesize plastics derived from non-biogenic carbon sources embedded within MSW.

- **Incineration of MSW** on the other hand, can emit CO<sub>2</sub>, as well as other GHGs such as nitrous oxide (N<sub>2</sub>O), oxides of nitrogen (NOX) and ammonia (NH<sub>3</sub>), from both biogenic and non-biogenic carbon sources. Thus, inasmuch as CO<sub>2</sub> derived from biogenic carbon is deemed 'carbon-neutral', the 'climate-relevant' CO<sub>2</sub> emissions from MSW incineration are determined by the proportion of waste whose carbon compounds are assumed to be of 'fossil origin'; and the allocation of percentages of the MSW stream of materials to biogenic or fossil carbon sources has a significant influence on the calculated amounts of climate-relevant CO<sub>2</sub> emissions. It is also noteworthy that WARM does not take credit for carbon offsets associated with recovery of nonferrous metals (such as copper and aluminum) which would have a large impact on calculated net GHG emissions and energy use footprints.

Results of analyses comparing the estimated GHG emissions are summarized in **Table 2-3**.

**Table 2-3: Summary of GHG Emissions Reductions Relative to RRF**

| Alternative <sup>1</sup><br>Systems                                            | GHG Emissions<br>Per Ton MSW<br>(MTCO <sub>2</sub> E/ton) <sup>2</sup> | Annual GHG<br>Emissions<br>(MTCO <sub>2</sub> E) <sup>2</sup> | Annual Avoided<br>Emissions<br>(Passenger Vehicles ) <sup>3</sup> |
|--------------------------------------------------------------------------------|------------------------------------------------------------------------|---------------------------------------------------------------|-------------------------------------------------------------------|
| 1 – MRBT<br>(with Long-Haul)                                                   | (0.70)                                                                 | (418,560)                                                     | 97,524                                                            |
| 2 – Long Haul<br>MSW to Out-of-County<br>MSWLF by Rail from RRF<br>(Option 2A) | (0.03)                                                                 | (20,537)                                                      | 4,785                                                             |

- Notes:**
1. Alternatives were compared to Baseline (MCRRF Upgrade with Long-Haul MWC Ash by Rail to Out-of-County Landfill).
  2. Assumes 600,000 tons MSW per year.
  3. Greenhouse Gas (GHG) Emissions performed by WARM pursuant to USEPA passenger vehicle emissions assumptions. MTCO<sub>2</sub>E refers to metric tonnes of carbon dioxide equivalent.
  4. Alternative 1, MRBT, assumed approximately 45% diversion off of TFS tipping floor.

The Table shows the reduction in GHG emissions for each option relative to continuation of the RRF. Results of these analyses indicate the following:

- **Alternative 1 MRBT** - Development and operation of an MRBT facility represents a potential reduction in GHG emissions equivalent to approximately 0.70 metric tonnes eCO<sub>2</sub> per short ton of MSW processed.
- **Alternative 2A Long Haul of MSW by Rail from the RRF to an Out-of-County MSWLF** – This alternative represents a reduction in GHG emissions equivalent to approximately 0.03 metric tonnes eCO<sub>2</sub> per short ton of MSW processed.

Development and operation of an MRBT facility represents the alternative with the greatest potential for reduction in GHG emissions and associated carbon footprint.



Carbon footprint and GHG emissions are affected by the MSW composition and processing technology. MRBT represents a potential significant reduction in carbon footprint by removing and recycling materials from the waste stream (plastics, paper and other organics) which would otherwise be combusted in the County's RRF (the baseline system used for comparison). This results in both avoided emissions from the RRF and avoided emissions from the use of recycled commodities in making new products. Long Haul of MSW by Rail to an Out-of-County MSWLF reduces the carbon footprint less due to potential 'fugitive' air emissions at the landfill tipping face during early stages of aerobic decomposition, incomplete collection of methane from the facility's Landfill Gas Collection and Control System (LFGCCS) during later anaerobic decomposition, and diesel emissions associated with rail haul operations.

A full explanation of the inputs and results of the WARM analysis are included in **Appendix C**.

### 2.3. Cost of Service

A financial model has been developed to enable estimation of capital and operating expenditures (CAPEX and OPEX, respectively), off-setting revenue and resulting expenditure schedules for the alternatives, including variations of MRBT, Long-Haul of MSW to an Out-of-County MSWLF, and the existing system as a baseline for comparison.

The analysis considers a 30-year planning horizon. Input variables include the following:

- MSW system mass balance and waste stream characteristics including tonnage, anticipated growth rate, and composition. The analysis did not consider implications of potential future waste reduction efforts on the various alternative MSW management systems and focused on existing waste stream characteristics. For instance, if less food waste is included in the MSW stream, the diversion rate from MRBT would likely be reduced, but the overall diversion rate for the County (including diversion from MSW and source-separated composting) would likely still be higher than if food waste was not captured in advance of the TFS tipping floor.
- Waste processing technology efficiency in recovering materials from the TFS tipping floor.
- Cost and revenue inputs including CAPEX, OPEX including but not limited to TFS and railyards; Residue Transport via truck and/or rails as well as MSWLF tipping fees.
- Other project development costs include fees paid to project developers and/or the County's professional services A/E contractor team.
- Financing costs.
- Scheduling details, including project startup and duration of phased build-out and development.

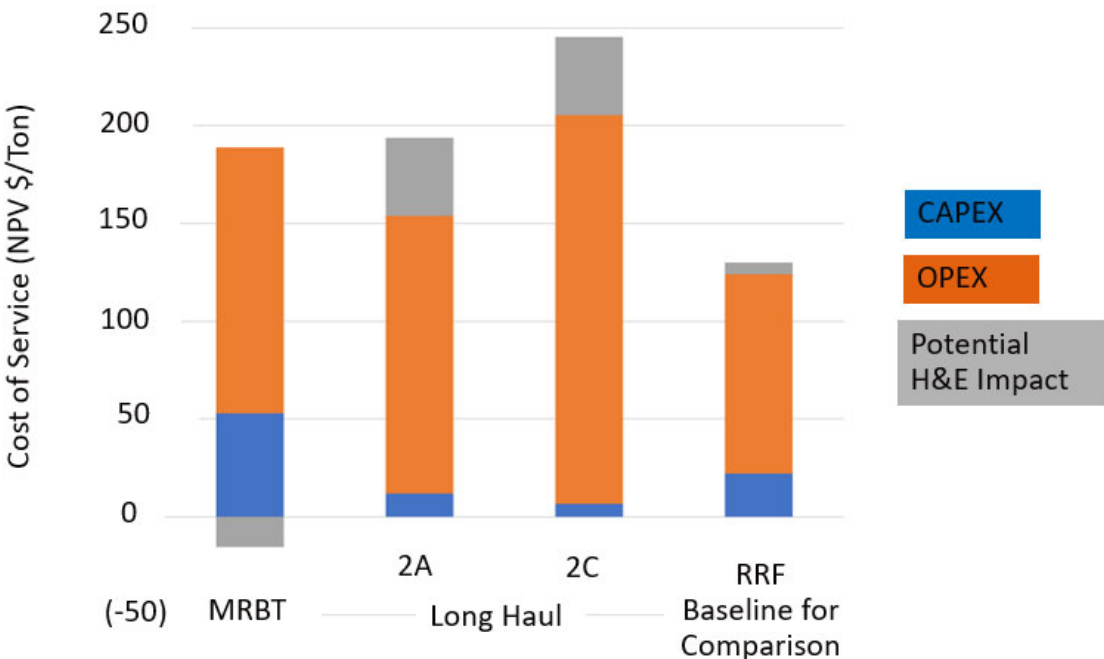
The financial model reports cost of the various alternatives in terms of Net Present Value (NPV). Future CAPEX, OPEX and offsetting revenue line-items are projected forward and backward using assumed inflation and discount rates, respectively, to create a 'net' cost estimate expressed in terms of 2025 dollars on a \$/ton basis over the planning horizon.

Detailed analyses provided by the financial model are included in **Appendix D**.

Results of financial modeling showing the estimated cost of service for the alternative MSW management systems over a 30-year planning horizon are summarized in **Figure 2-1**, including the relative contribution of CAPEX and OPEX. The figure indicates that annual recurring operating expenses have a significantly larger

impact on the resulting lifecycle cost than the up-front capital expenditure required to construct the various facilities and associated infrastructure.

**Figure 2-1: Summary of Estimated Cost of Service Including Contributions of CAPEX and OPEX Components**



OPEX has been shown as a net operating expense and includes the contribution of off-setting revenues for the various alternatives:

- MRBT offsetting revenues may be derived from the sale of recovered recyclable materials and biogas.
- RRF offsetting revenues include the sale of energy as well as recovered ferrous and non-ferrous metals from RRF MWC Ash recycling. Off-setting revenue from potential sales of Renewable Energy Credits (RECs) has been ignored. Pursuant to HB 1035 of 2025, waste-to-energy has been removed from Tier 1 of the State's Renewable Portfolio Standard. The change becomes effective for Montgomery County's RRF on July 1, 2026. After that date the market for RECs from the facility is expected to be eliminated or severely limited.
- Long-Haul of MSW to an Out-of-County MSWLF does not generate any off-setting revenue.

Future decommissioning of the approximate 10-acre RRF footprint in the MRBT or Long-Haul scenarios may allow development of alternative 'secondary' revenue-generating technologies which may or may not result in net revenue generation.

More detailed results of the financial analyses are summarized in **Table 2-4**. The Table indicates the following system costs for each alternative, which do not include estimated monetized cost of potential public health and environment impacts to the surrounding area. Such potential costs are calculated separately and subsequently added to the system cost to estimate the approximate total cost of service:



- **Alternative 1 MRBT** - The estimated cost-of-service for development and operation of an MRBT facility with long-haul of residual wastes by rail is approximately \$189/ton. The unit cost of the alternative may be expected to increase if the County chooses to send residual waste materials to an Out-of-County MSWLF located at greater distance than the Republic Services Old Dominion Landfill located in Henrico County, VA (in proximity to Richmond, VA).
- **Alternative 2A Long Haul of MSW by Rail from the RRF to an Out-of-County MSWLF** - The estimated cost of service for long-haul using the RRF railyard as a staging area is approximately \$154/ton. Again, the unit cost of long-haul may be expected to increase if the County chooses to send MSW to an Out-of-County landfill located at greater distance than the Republic Services Old Dominion Landfill in Henrico County, VA (in proximity to Richmond, VA).
- **Current System for Comparison Including Retrofit/Repair and/or Rehabilitation of the County's RRF** - For comparison purposes, the estimated cost of service for upgrading the RRF is approximately \$124/ton.

Not including upgrade of the RRF (current system for comparison), Alternative 2A Long Haul of MSW by rail from the RRF to an Out-of-County MSWLF represents the lowest system base cost.

**Table 2-4: Summary of Estimated MSW Management System Cost of Service**

| Alternative Systems                                                   | 30-year System Costs (NPV\$ billion) | System Cost (\$/ton) <sup>1</sup> | Health and Environment (H&E) Impact (\$/ton) <sup>2</sup> | Total with H&E (\$/ton) |
|-----------------------------------------------------------------------|--------------------------------------|-----------------------------------|-----------------------------------------------------------|-------------------------|
| 1 – MRBT <sup>3</sup> (with Long-Haul)                                | 3.8                                  | 189                               | -16                                                       | 173                     |
| 2A – Long-Haul MSW to Out-of-County MSWLF by Rail from RRF            | 3.0                                  | 154                               | +40                                                       | 194                     |
| 2C – Long Haul MSW to Out-of-County MSWLF by Tractor-Trailer from TFS | 4.0                                  | 205                               | +40                                                       | 245                     |
| Current System for Comparison (Retrofit/Repair of RRF)                | 2.4                                  | 124                               | +6                                                        | 130                     |

**Notes:**

1. System Cost \$/Ton is the Net Present Value (NPV) for a 30-Year Planning Horizon accounting for future inflation including all anticipated capital/operating expenses and off-setting revenue.
2. Potential H&E Impacts have been assigned a preliminary monetary value based upon Morris et. al., 2013.
3. MRBT assumes 45% recovery rate from TFS tipping floor and corresponds with the average of data provided by two Offerors in response to the County's recent REOI.

An external source [Ref. 2] has estimated the relative monetized cost of potential human health and environmental impacts associated with various MSW processing technologies. For the purpose of comparison, we have included values for the differential monetized cost of potential health and environmental impacts derived from that external technical source. Monetized costs of potential impacts estimated from this source have been

increased to account for simple inflation since the time of its publication (2013). The monetized costs presented are only intended to represent the variance in approximate cost of potential health and environmental impacts relative to the other alternatives. Our independent review of the referenced document, and other references provided by the same author, have been unable to replicate the potential cost of impact for several categories of potential health and environmental impacts. Although more recent cost estimates presented by external stakeholders indicate significantly greater monetized cost of potential impacts, insufficient supporting documentation has been provided to enable review or confirmation of those separate analyses. The 2013 publication was thus used in absence of more detailed data available for technical peer review.

The estimates of monetized cost of potential health and environmental impact include the contribution of the following categories of impacts:

- Climate change – eCO<sub>2</sub>
- Acidification - eSO<sub>2</sub>
- Eutrophication - eNitrogen
- Respiratory PM<sub>2.5</sub> emissions - ePM<sub>2.5</sub>
- Non-Cancer Toxicity - eToluene
- Cancer (Human Disease and Carcinogen) - eBenzene
- Ecosystem Toxicity - e2,4-D

The values for the estimated differential cost of potential health and environmental impacts include the following:

- **Alternative 1 MRBT** - Enhanced diversion and capture of co-mingled recyclables, recyclable paper and compostable organics is estimated to result in an approximate \$16/ton reduction in cost of service when compared to the other alternatives. This represents a preliminary estimate and is subject to confirmation once updated estimates are obtained of potential air emissions associated with the MRBT process, which can be proprietary.
- **Alternative 2A Long Haul of MSW by Rail from the RRF to an Out-of-County MSWLF** – Utilization of a MSWLF with anticipated Landfill Gas to Energy plant is anticipated to result in an approximately \$40/ton increase in cost of service.
- **Current System for Comparison Including Retrofit/Repair and/or Rehabilitation of the County's RRF** – On-going utilization of the RRF is estimated to result in an approximate \$6/ton increase in cost of service.

Adding these potential incremental costs to those indicated in the previously referenced table indicates the following 'total' cost of service including the estimated difference in monetized cost of potential health and environmental impacts:

- **Alternative 1 MRBT** - \$173/ton.
- **Alternative 2A Long Haul of MSW by Rail from the RRF to an Out-of-County MSWLF** - \$194/ton.
- **Current System for Comparison Including Retrofit/Repair and/or Rehabilitation of the County's RRF** – \$130/ton

Not including the current system used for comparison, the estimated cost of service for Alternative 1 represents the low-cost alternative after accounting for the monetized cost of potential health and environmental impacts. However, for comparison purposes the existing system, including retrofit/repair and/or rehabilitation of the County's existing RRF is approximately \$43/ton less cost than MRBT.

#### **2.4. Environmental Justice (EJ) Screening**

EJ Screening was developed for a range of environmental indexes as well as socioeconomic and public health indicators at three communities which may potentially host one of the necessary MSW system components for waste processing (waste processing and transfer (TFS in Derwood, MD), staging of waste prior to transport (RRF railyard in Dickerson, MD) and final disposal at an Out-of-County MSWLF (location to be determined). EJ Screening was not included in the previously described Evaluation Model used for comparison of alternatives because each alternative anticipates some form of waste management activity at the same three (3) previously referenced geographic locations.

Eleven (11) screening criteria were deemed relevant to the analysis associated with locating and development of a waste management processing facility:

- Environmental Indexes:
  - Particulate Matter 2.5
  - Ozone
  - Diesel Particulate Matter
  - Toxic Releases to Air
  - RMP Facility Proximity
- Public Health Indicators:
  - Cancer
  - Asthma
  - Low Life Expectancy
- Socioeconomic Indicators:
  - Low Income
  - People of Color
  - Limited English-Speaking Households

Other factors may also influence the potential health and environmental impacts of the alternatives on host communities, such as the specific waste processing technology used at any given location and its associated air emissions, the type of waste material managed (such as MWC ash, MSW or MRBT residual), as well as the quantity of materials managed at the location.

Results of EJ Screening analyses for various infrastructure host communities are summarized in **Table 2-5**.

**Table 2-5: Summary of Environmental Justice Screening Analyses for Potential Host Communities**

| EJ Screen Indicators                | RRF,<br>Dickerson,<br>MD | TFS,<br>Derwood,<br>MD | Republic Old<br>Dominion, Henrico<br>County, VA |
|-------------------------------------|--------------------------|------------------------|-------------------------------------------------|
| PM 2.5                              |                          |                        | X                                               |
| Ozone                               |                          | X                      |                                                 |
| Diesel Particulate Matter           |                          | X                      | X                                               |
| Toxic Releases to Air               |                          |                        | X                                               |
| RMP Facility Proximity              |                          |                        | X                                               |
| Cancer                              |                          |                        |                                                 |
| Asthma                              |                          |                        | X                                               |
| Low Life Expectancy                 |                          |                        | X                                               |
| Low Income                          |                          |                        | X                                               |
| People of Color                     |                          | X                      | X                                               |
| Limited English-Speaking Households |                          | X                      | X                                               |

**Notes:** 1. X Indicates Surrounding Host Community Area Exceeds National 50<sup>th</sup> percentile.

The community surrounding the Republic Services Old Dominion Landfill in Henrico County, VA, the landfill currently used for MWC ash disposal, exceeds national 50 percentile data for nine (9) of the eleven (11) EJ Screening indicators:

- Particulate Matter 2.5 - 56 percentile
- Diesel Particulate Matter – 82 percentile
- Toxic Releases to Air – 97 percentile
- RMP Facility Proximity – 94 percentile
- Asthma – 91 percentile
- Low Life Expectancy – 64 percentile
- Low Income – 81 percentile
- People of color – 84 percentile
- Limited English-Speaking Households – 58 percentile

Conversely, communities within the County surrounding the TFS and RRF indicate relatively favorable characteristics. The community surrounding the TFS (and TFS Railyard) as well as the potential future MRBT facility exceeds the 50<sup>th</sup> percentile data in four (4) of the eleven (11) criteria:

- Limited English-Speaking Households – 78.1 percentile
- Diesel Particulate Matter – 73.5 percentile
- People of Color – 73.2 percentile
- Ozone – 51.3 percentile

The community surrounding the location of the RRF (and RRF Railyard), the latter of which may be used as a staging area for waste containers prior to shipment to an Out-of-County MSWLF, has no indicator parameters exceeding the national 50 percentile.

Changing the location of the Out-of-County MSWLF for final disposition of waste materials could reduce potential impact on a disadvantaged community. EJ Screening Criteria were identified for communities surrounding ten (9) additional Out-of-County MSWLF located in either Virginia or Pennsylvania:

- Virginia:
  - Waste Management Maplewood Landfill, Jetersville, VA.
  - Shoosmith Sanitary Landfill, Chester, VA.
- Pennsylvania:
  - Republic Services
    - Modern Landfill, York, PA.
    - Imperial Landfill, Imperial PA.
  - Waste Management Inc.:
    - Laurel Highlands Landfill Johnstown, PA.
    - Evergreen Landfill, Blairsville, PA.
    - Mostoller Landfill, Somerset, PA.
  - Noble Environmental (formerly GFL)
    - Sandy Run Landfill, Hopewell, PA
    - Southern Alleghenies Landfill, Davidsville, PA.

These facilities would require confirmation of compatibility with waste by rail (presuming long-haul via tractor-trailer from either the Derwood TFS or Dickerson RRF railyards was not acceptable). Review of screening criteria for these various facilities is summarized in **Table 2-6** and indicates the following:

- Each of the host communities surrounding the referenced MSWLF facilities exceeded the national 50 percentile data for at least two (2) and as many as seven (7) of the screening criteria.
- All of the potential host communities exceeded the national 50 percentile for fewer criteria than the community around the Old Dominion Landfill currently used for disposal of MWC Ash produced from the County's current MSW management system.

Elevated frequency or incidence rate of public health indicators exceeding the national 50 percentile data do not indicate the MSWLF is the cause of increased incidence.

It is noteworthy that the facilities identified in the previously referenced table are not intended as an exhaustive list of alternative MSWLFs. This list was compiled for the purpose of comparing environmental justice screening results for alternative landfills, with the intent of determining whether a change in MSWLF for final disposal of waste materials could potentially reduce the impact of the County's MSW management on disadvantaged or overburdened communities. Other landfill options may exist. The ultimate choice of landfill would be determined by the MRBT developer or long-haul contractor and informed by additional considerations such as cost, distance, rail compatibility, etc. (Changes in OPEX associated with the various potential out-of-County MSWLF were not considered and are not anticipated to change the identification of a preferred alternative given the selection criteria.)

**Table 2-6: Summary of Environmental Justice Screening Analyses for Alternate MSWLF Host Communities**

| EJ Screen Indicators                | Republic Old Dominion, Henrico County, VA | GFLSandy Run, Hopewell PA | GFL Southern Alleghenies Landfill, Davidsville PA | Republic Services Imperial Landfill, Imperial PA | WM Maplewood Landfill, Jetersville VA | WM Laurel Highlands Landfill, Johnstown, PA | WM Evergreen Landfill, Blairsville, PA | WM Mostoller Landfill, Somerset, PA | Shoosmith Sanitary Landfill, Chester, VA | Republic Modern Landfill, York PA |
|-------------------------------------|-------------------------------------------|---------------------------|---------------------------------------------------|--------------------------------------------------|---------------------------------------|---------------------------------------------|----------------------------------------|-------------------------------------|------------------------------------------|-----------------------------------|
| PM 2.5                              | x                                         |                           |                                                   | x                                                |                                       |                                             |                                        |                                     |                                          | x                                 |
| Ozone                               |                                           |                           |                                                   | x                                                |                                       | x                                           | x                                      |                                     |                                          |                                   |
| Diesel Particulate Matter           | x                                         |                           |                                                   |                                                  |                                       |                                             |                                        |                                     |                                          |                                   |
| Toxic Releases to Air               | x                                         | x                         | x                                                 | x                                                |                                       | x                                           | x                                      | x                                   | x                                        | x                                 |
| RMP Facility Proximity              | x                                         |                           |                                                   | x                                                |                                       |                                             |                                        |                                     | x                                        |                                   |
| Cancer                              |                                           | x                         | x                                                 | x                                                | x                                     | x                                           | x                                      | x                                   | x                                        | x                                 |
| Asthma                              | x                                         | x                         | x                                                 | x                                                | x                                     | x                                           | x                                      | x                                   |                                          |                                   |
| Low Life Expectancy                 | x                                         |                           |                                                   |                                                  | x                                     | x                                           |                                        | x                                   | x                                        |                                   |
| Low Income                          | x                                         | x                         |                                                   | x                                                | x                                     |                                             | x                                      | x                                   |                                          |                                   |
| People of Color                     | x                                         |                           |                                                   |                                                  |                                       |                                             |                                        |                                     | x                                        |                                   |
| Limited English-Speaking Households | x                                         |                           |                                                   |                                                  |                                       |                                             |                                        |                                     |                                          |                                   |

**Notes:** 1. X Indicates Surrounding Host Community Area Exceeds National 50<sup>th</sup> percentile.

2. Availability of each alternative landfill would need to be confirmed prior to use. Maplewood and Modern Landfill are the only two known to have current rail access.

7

## 2.5. Uncertainties and Risks in Analyses

It is important to recognize there are several elements of risk and/or uncertainty associated with these various analyses.

One risk is greater-than-anticipated CAPEX and OPEX. All alternatives carry some risk of actual costs exceeding the estimate cost of service. Because there are no domestic examples of MRBT at the scale required for Montgomery County's MSW there may be more significant uncertainty of variance in anticipated CAPEX for MRBT than for the other options. However, this risk would be limited contractually before the County must make the final decision to construct the MRBT. In the phased procurement approach envisioned for MRBT (see Section 3 of this report), a small percentage of the investment would be made during the pre-construction phase. Prior to



deciding to initiate construction, the County would receive a Guaranteed Maximum Price (GMP), which could be incorporated into the contract for construction services, shifting the risk of cost overages to the project developer.

Another risk is reliance on external disposal facilities. All alternatives rely on an Out-of-County MSWLF for disposal of MSW, MRBT residual or MWC Ash. Long-term, there are both financial and operational risks associated with increased tipping fees or reduced availability at Out-of-County MSWLFs. Development of new MSWLFs in the mid-Atlantic is significantly constrained by space, land use, and political factors. Consequently, there is finite capacity in the region and there may be increasing incentives to conserve capacity for locally generated waste materials. The greater an option's reliance on Out-of-County MSWLF the greater the exposure to this element of risk.

Finally, there is some uncertainty about system performance. Across existing MRBT systems, there is some variation and limited transparency of actual diversion rates, which raises a potential risk of lower-than-anticipated system performance. In addition, the MRBT system contemplated in Montgomery County would be the largest of its kind. Although the diversion rate assumed for this analysis was conservative to account for this it still indicated significantly greater diversion and GHG emissions reductions than the other alternatives. Performance risk will also be mitigated through utilization of a phased procurement process. Performance standards can be refined during the design phase and incorporated in the construction contract and any operating contracts to limit risk to the County. Long haul and continuation of the RRF promise less in terms of diversion and greenhouse gas emission avoidance, so there is less risk of mismatch between anticipated and actual performance in these areas. However, because these options fail to address environmental concerns raised with the current MSW management system, they pose their own risk in terms of long-term public acceptance and ability for the County to reach its climate and other commitments.

### 3. PROCUREMENT AND SOLICITATION OF QUALIFIED PROJECT DEVELOPERS

The preceding analysis of alternatives resulted in a top ranking for MRBT. If the County proceeds with developing a MRBT facility, a phased approach would be used to procure a preferred project developer to design, build and operate an MRBT waste processing facility.

The first step in this process was to issue a REOI. This initial phase was completed in parallel with the alternatives analysis presented in this report and results of the REOI informed the analysis. The REOI solicited interest from a range of technology vendors and/or system integrators capable of implementing various waste processing technologies. Recipients of the REOI were required to include information relating to both their qualifications, experience and capabilities to enhance recovery and diversion of materials from the County's MSW stream of materials. Efforts included extensive vendor outreach which resulted in identification of seven (7) Offerors deemed qualified for further consideration and inclusion in a subsequent Request for Proposal (RFP). Those seven (7) offerors included the following:

- Freepoint Ecosystems (with BHS)
- AMP Robotics Corporation
- Juno
- Stadler American

- Machinex
- Republic
- Sparta Manufacturing

The next component of the procurement process is the RFP which is anticipated to utilize a Progressive Design-Build-Operate (PDBO) method of project delivery in order to foster collaboration between the County and the selected project developer.

The RFP itself reflects a phased approach to procurement. The selected project developer would originally be retained to provide Phase 1 Pre-Construction Services (PCS) on a Time and Material basis up to an agreed Not-To-Exceed amount. The County would work in a collaborative manner with the project developer in the design of the MRBT facility through approximately 80 percent completion and lock-in a GMP for the completed project. This enables the County to participate in the conceptual design of the facility while seeking to balance cost-of-service with performance objectives, as well as allowing multiple opportunities to terminate the process if the County is unable to achieve its performance objectives at an agreeable cost.

Once the GMP is agreed upon, the County then has the opportunity to confirm whether or not to award a Phase 2 contract to complete detailed design and build the proposed facility for the agreed upon amount.

Upon completion of Phase 2 services, the County may, in its discretion, award a Phase 3 contract for future operations of the completed facility.

The estimated total cost of Phase 1 PCS is approximately \$36 million and is comprised of the following:

- PCS Developers Fee – this budget-level planning estimate is based on 3% of the estimated up front capital cost of \$701M for the proposed MRBT facility. This results in an estimated cost of approximately \$21.3M over 3 years (FY26-FY28) that will be allocated to the Developer of the proposed MRBT facility to facilitate detailed design and lock-in of a GMP as part of the Phase 1 collaborative design process. Funding will be allocated over multiple project development milestones to manage performance risk to the County. This approach will provide the County with opportunities to review and verify the work of each project development milestone independently for items such as operational capability and effectiveness, risks, costs, and other pertinent factors of performance prior to providing approval to proceed to the next project development milestone. The PCS funding amount will be confirmed during the RFP but will include all of the Developer's resources to complete Phase 1. Project developer personnel and specialty subcontractors may include the following: administrative staff, planners, engineers (architectural, structural, mechanical, electrical, plumbing, fire, safety, site civil), utility experts, business and financial analysts, bonding agents, attorneys, land and property assessment experts, equipment manufacturers (with suppliers and distributors), construction contractors, solid waste management companies and material management facilities, and other entities to support the delivery of the project.
- County Owner's Representative/Agent Professional Fee – this budget-level planning estimate is based on 2% of the estimated up front capital cost of \$701M for the proposed MRBT facility. This results in an estimated cost of approximately \$14.2M over 3 years (FY26-FY28) that will be allocated to the Owner's Representative/Agent to support the County during the Phase 1 collaborative design process. This includes staff of the County Owner's Representative/Agent, their team of technical sub-consultants, and other potential staffing resources such as new dedicated positions in County DEP through completion of the Phase 1 PCS contract.



## 4. CONCLUSIONS

Development of an MRBT facility in lieu of long-term utilization of the County's existing RRF represents a significant opportunity to enhance diversion of MSW from disposal and reduce future GHG emissions. This alternative represents a preferred MSW Management System alternative when compared to long-haul of MSW to an Out-of-County MSWLF, or the retrofit/rehabilitation and/or repair of the County's RRF, when using the evaluation model and criteria identified by the County for this project-specific analysis.

Regardless of which alternative MSW management system is selected for future operations, an acceptable Out-of-County MSWLF capable of receiving MSW or residual MRBT materials will need to be identified. Selecting a landfill other than the Old Dominion Landfill, currently used for MWC ash, could result in shifting landfill-related impacts of the County's MSW management system to a community that is less disadvantaged.

The short-term extension of existing RRF operations is necessary to ensure continuity of service. Utilization of an innovative Progressive Design-Build-Operate (PDBO) project delivery method in the intervening period will help mitigate risk associated with project cost- and level-of-service.

## 5. REFERENCES

1. SCS Engineers, 2022/23 Montgomery County Waste Composition Study, <https://www.montgomerycountymd.gov/DEP/Resources/Files/trash-recycling/waste-composition-study.pdf>, April 2023.
2. Morris, Favoino, Lombardi and Baily, What is the Best Disposal Option for the "Leftovers" on the Way to Zero Waste, [www.ecocycle.org/specialreports/leftovers](http://www.ecocycle.org/specialreports/leftovers), May 2013.

## **Appendix A: Technical Memorandum**

## TECHNICAL MEMORANDUM

To: Kaley Laleker, Montgomery County

Copies: Willie Wainer, Montgomery County  
John Monger, Montgomery County  
Jeff Seltzer, PE, Montgomery County  
Steve Lezinski, PE, B&L

From: Steve R. Nesbitt, Arcadis

Date: May 13, 2025

Arcadis Project No.: 30164537

Subject: Municipal Solid Waste Management System Analysis  
Solid Waste Processing Technology Assessment

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### INTRODUCTION

We have completed our evaluation of commercially available technologies to enhance recovery of resources and/or energy from the County's municipal solid waste (MSW) stream as input to future procurement efforts associated with adaptation and/or re-use of the County's Derwood and Dickerson facilities. A web-based technical literature search confirmed identification of the following short-list of relevant technologies which may be adaptable to Montgomery County:

- Mixed Waste Processing (MWP)
- Material Recovery and Biological Treatment (MRBT)
- Composting
- Anaerobic Digestion (AD)
- Construction & Demolition Debris (CDD) Recycling
- Glass Pulverization

Based upon our previous conversations with the County our review did **not** include technologies characterized as 'emerging' and specifically excluded pyrolysis, gasification, plasma arc or any sort of waste-to-fuels technology. In addition, enhanced materials and/or resource recovery from the County's existing Material Recovery Facility (MRF) was not addressed because it is the subject of other on-going retrofit efforts by the County.

The following information is provided for each of these screened technologies:

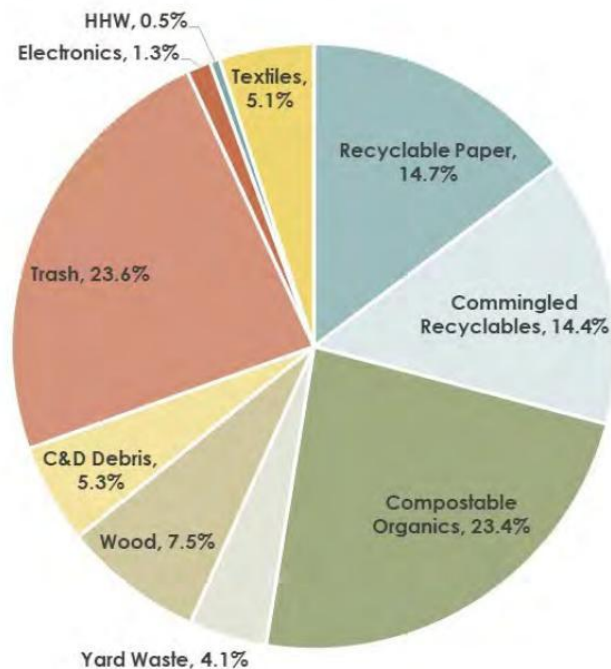
- A general description of the technology.
- Site considerations, including compatibility with Montgomery County Derwood Transfer Station (TFS) and/or Dickerson Resource Recovery Facility (RRF) locations. The TFS can accommodate approximately 15- to 20-acre footprint with some re-location of existing secondary waste management processes; whereas the RRF can accommodate only an approximate 10-acre footprint if and when the facility is demolished and properly decommissioned.
- Rough order of magnitude cost for development and operations.

An annotated bibliography of reference materials used in sourcing information related to these technologies is provided in **Appendix A**.

### MSW COMPOSITION

A process flow diagram for the County's TFS is provided in **Appendix B** (which relies upon 2021 data). Extrapolating for incremental growth in population and waste generation since that time, we estimate approximately 777,000 tons of MSW crossed the TFS tipping floor in 2024 (ranging from approximately 2,000 tons to 3,000 tons per day assuming 6 days per week operations). Results of the County's recent Waste Composition Study [Ref. 1] indicate approximately 23 percent compostable organics, 14.7 percent recyclable paper, and 14.4 percent of comingled recyclables remain with the MSW stream of materials delivered to the TFS tipping floor.

Their combined 52.5 percent equates to approximately 400,000 tons per year of material – and post-consumer food waste (approximately 16.6 percent or about 125,000 tons per year) represents the single-largest component of that waste fraction which is potentially recoverable. To maintain perspective the County's existing MRF processes approximately 37,500 tons per year of co-mingled recyclables. This suggests any supplemental facility to extract the combined quantity of compostable organics, recyclable paper and comingled recyclables from the MSW waste stream, would need to be several times larger than the existing MRF.



## SUMMARY/PRELIMINARY ASSESSMENT

In all cases, adaptation of both the TFS and RRF to accommodate supplemental waste processing technologies to advance waste diversion goals represents significant constraints and limitations.

Adaptation of the TFS represents significant constraints and limitations with regard to potential health, nuisance and/or aesthetic impacts associated with supplemental processing of plastics (and associated fossil carbon) or organic waste materials within its urban setting and limited available footprint while maintaining uninterrupted MSW transfer operations. This includes but is not limited to the following:

- The facility is located within an urban area with already surrounding residential and commercial development, adjacent Metro Station, and future planned residential housing.
- The site itself is already congested with limited available footprint outside of the transfer building unless portions of the existing railyard can also be captured and adapted.
- In the absence of source-separated collection of organics, managing significant quantities of organic materials extracted from the MSW stream represents specific challenges related to both limited available footprint for managing the materials (either within or exterior to the transfer building), interim storage requirements during 'batch' processing, as well as odor and vector control once it is extracted.
- Depending upon the nature of the waste processing system, such as MRBT, potential air emissions including but not limited to potentially harmful Volatile Organic Compounds (VOCs), which may be associated with either thermal hydrolysis and/or anaerobic digestion, must be carefully addressed and managed.
- Neither Aerobic Composting nor Anaerobic Digestion of any organic fraction of the waste extracted from the TFS tipping floor appear compatible with the TFS location.

Facility adaptation must consider on-going MSW transfer operations. This is separate and apart from consideration of interim operations until programs are in place to replace current RRF operations and relate to the logistics of adapting the transfer building while maintaining flow of materials through the TFS. Other interim operations may be necessary while the transfer building is being retrofitted and adapted.

The RRF facility represents an even more limited 10-acre footprint which would only become available after future decommissioning, presumably no sooner than mid-2031, and is not suitable for adaptation to accommodate the alternative primary technologies required to process between 2,000 to 3,000 tons per day of processible MSW. The RRF is better suited for the adaptation of secondary technologies which may be capable of generating offsetting revenue.

Rough Order of Magnitude (ROM) cost estimates provided in the following discussion of alternative technologies reflect 2024-dollar amounts. The cost estimates vary widely based on multiple factors:

- Facility capacity.
- Economies of scale.
- Required land acreage.
- Degree of automation and utilization of low-or high-technology equipment.
- Price of utilities such as energy and water.

- Recovery rate and distance to markets of recovered materials.
- Hours of operation and contract terms.

The estimated cost for each technology is summarized in **Table 1** with supporting details provided in **Appendix C**. Cost details are based on limited available public sources and represent a range of financing options for capital and operating expenses (CAPEX and OPEX).

### 1. Mixed Waste Processing (MWP)

Mixed Waste Processing (MWP) facilities utilize a combination of mechanical and manual systems to receive, separate and process collected MSW to recover materials for recycling or beneficial use. Typical processes include the following:

- Preparation – removal of large items (i.e., metal, concrete, non-recyclable items [carpeting, etc.]).
- Separation into different fractions based on material properties via one or more of the following:
  - Trommels and screens
  - Manual separation
  - Magnetic removal of ferrous metals.
  - Eddy current separation of non-ferrous metals.
  - Wet separation
  - Air trommel to separate heavier (i.e., concrete, glass, ceramics, etc.) and lighter (i.e., cardboard, wood, insulation, etc.) materials.
  - Ballistic separation
  - Optical separation



*Athens Sun Valley MRF located in Sun Valley, CA  
(courtesy Athens Services)*

A 2022 Greenpeace survey [Ref. 2] showed seven (7) MWP facilities operating at the time in the US, which appears to be consistent with recent industry reports (SWANA reported less than 20 in operation as of 2019). Although these facilities can be designed to accept both MSW and recyclables they are better used in combination with source separation of organics and a Material Recovery Facility (MRF) with either single and/or dual stream collection of recyclable materials to enhance recovery of higher value metals and plastics/resins. However, contamination of lower value paper and fiber is often observed within MWP facilities based on collection and processing methods. Organic materials extracted from the waste stream have historically also been observed to be contaminated with fats, oil, grease, and glass with corresponding small residual commercial value.

Reported diversion rates range from approximately 10 to 50 percent [Ref. 3], depending upon the extent of source-separated collection of organics and other recycling efforts. Implementation requires no supplemental consumer participation, education, or sorting behavior.

It is noteworthy that odors and vector control associated with treatment of the organic fraction extracted from the MSW stream are significant issues that, in absence of supplemental biological treatment, must be addressed by careful facility design.

## Siting Considerations/Compatibility

MWP facilities are trending to larger footprint to accommodate complicated automated sorting equipment and typically situated upon land parcels ranging in size from 20 to 60 acres. However, footprint requirements are much smaller if co-located with other MSW management facilities/activities. Retrofit of the TFS is not ruled out but complicated by previously described site constraints/limitations.

## Costs

Development and operation of MWP facilities are both capital and labor intensive. Recently completed facilities across the country range in capital cost of construction from approximately \$50 to \$140 Million for facilities with operating capacity ranging from only

| Source           | Project Year | Capacity (tons/yr) | Rough Order of Magnitude Adjusted Inflation @3% |
|------------------|--------------|--------------------|-------------------------------------------------|
| Monro County, IN | 2018         | 130,000            | \$ 47,507,452                                   |
| San Leandro, CA  | 2020         | 150,000            | \$ 133,046,145                                  |
| Sant Barbara, CA | 2021         | 180,000            | \$ 139,259,250                                  |

130,000 to 180,000 tons per year [Ref. 4], whereas the County's TFS processes about 3 to 4 times that quantity. On a unit cost basis, CAPEX and OPEX range from approximately \$15 to \$45 per ton [Ref. 5 and 6] and \$90 to \$210 per ton, respectively [Ref. 7 and 8]. The OPEX is similar to those of MRFs due to similar operations and the wide range is dependent on the number of shifts per day. Total combined CAPEX and OPEX, not including other lifecycle costs, ranges from approximately \$105 to \$255 per ton of waste processed. Anticipated revenue from sale of recovered materials should be discounted given the recovered product quality is typically less than similar material recovered from the County's MRF which relies upon dual-stream collection (incremental diversion with limited off-setting revenue).

## 2. Mechanical Biological Treatment (MBT) and/or Material Recovery and Biological Treatment (MRBT)

These facilities range in capacity from approximately 55,000 to 336,000 tons per year (again, significantly less than the quantity of MSW passing across the Derwood Transfer Station tipping floor) and are typically designed to operate for 15 to 25 years. Although there are more than 300 MBT and/or MRBT facilities operating in Europe there are only a few here in the United States.

MRBT facilities integrate mechanical processes found in either a Materials Recovery Facility (MRF) or Mixed Waste Processing (MWP) facility with supplemental capture and processing of organic material via various biological processes. Some modern facilities incorporate thermal hydrolysis at the front end of the facility to enhance recovery of the organic fraction of waste (OFW) and accelerate its decomposition, as well as improve separation from components of the waste stream, decrease contamination, and increase effective diversion. The goal of such facilities is to augment, not replace, source separated removal and recycling, capture remaining recyclables as well as stabilize the residual organic fraction to minimize potential greenhouse gas emissions.

Biological treatment of the organic waste fraction can take place prior to or after mechanical sorting of the waste to achieve different objectives depending upon the nature of the waste stream.

It is noteworthy that the same constraints and limitations which relate to the quality of lower value recyclables described for MWP applies to MRBT facilities as well. Unless supplemental efforts are performed, recyclables are typically of a lesser quality than those derived from a separate household recycling collection system, and contamination of lower value paper and fiber cannot be undone.



Consequently, many MRBT facilities only recover high value metals or plastics/resins and, although low value materials (such as glass, plastics, and paper) can be recovered, their cost of recovery is high, and the materials have limited residual value and utility.

With regard to the organic fraction of MSW passing through the facilities, depending on facility design basis, the biological treatment of mechanically separated organics produces either partially/fully stabilized compost-like outputs (CLO) or partially stabilized digestate material:

- CLO is produced by facilities that employ an aerobic process such as bio-drying, in-vessel composting, and agitated bed.
- Digestate material is produced from anaerobic digestion.

Again, these materials are often contaminated with little residual commercial value and typically require extensive post-treatment processing. The goal is not so much as to create a saleable product as much as it is to stabilize the remaining organic fraction and reduce potential future greenhouse gas emissions.

Odor, vector, and noise control is required and are important design considerations. Mitigation/abatement of potential health and environmental impacts associated with potential discharge of compounds associated with air discharge (if any) must be carefully considered and managed.

#### Siting Considerations/Compatibility

Site location and footprint requirements depend on their individual design basis and performance requirements, but most operational facilities range in size from 7 to 40 acres. Again, similar to expressed concerns of siting an MWP facility, these facilities are trending to larger footprint requirements but are much smaller if co-located with other MSW management facilities/activities. Retrofit of the TFS is not ruled out but again, is complicated by previously described site constraints/limitations. Re-use of the RRF footprint following future potential demolition and decommissioning of the site does not appear viable given the limited footprint.



*Veolia Southwark MBT Facility, Southwark, England  
(photo courtesy Veolia Southwark)*



## Costs

MRBT facilities are both capital and labor intensive:

- Aerobic Facilities - Capital as well as O&M costs were found to range from approximately 65 to 490 \$/ton/year processing capacity and \$40 to \$150 per ton, respectively [Ref. 9 and 10].
- Anaerobic Facilities – Capital as well as O&M costs were found to range from approximately 370 to 1,570 \$/ton/year processing capacity and \$132 to 175 per ton, respectively [Ref. 9 and 10 and other data sources].

Revenue from the sale of recovered materials (and electricity if so equipped) may help offset some of the costs but are highly dependent upon localized markets.

## Case Studies

Here is a brief sample of US facilities:

### **GreenWaste San Jose Material Recovery Facility San Jose, CA**

The facility was developed by Bulk Handling Systems (BHS) on behalf of Athens Services and is a high diversion organic waste processing facility designed to maximize recovery of compostable and other recyclable materials. It operates at approximately 75 to 90 tons per hour and recovers approximately 75 percent of the material processed.

<https://www.greenwaste.com/facilities/greenwaste-san-jose-material-recovery-facility/><https://bulkhandlingsystems.com/solutions/municipal-solid-waste-msw/>

### **Renovare Environmental Berkeley County Martinsburg, WV**

Approximately 100,000 ton per year facility opened in 2019 and suspended operations in 2023:

<https://www.wastedive.com/news/renovare-traqiq-aerobic-digester-entsorga/640053/>  
<https://www.wastedive.com/news/entsorga-west-virginia-renovare-us-bank-apple-valley/652083/>

There are some reports that the facility never truly exited start-up testing and may have failed prematurely due to financial stability of the private sector owner/operator.

## 3. Composting

Methods presented are considered suitable for composting food and/or horticultural waste considering the volume of material expected to be received, available land area and level of operational difficulty. Most stakeholders recognize the constraints/limitations and potential health effects associated with conventional active windrow composting. Concerns include but are not limited to airborne dispersion of *Aspergillus Fumigatus* (recognized health hazard), large pad area, extensive equipment, and labor-intensive methods with associated investment in equipment as well as operations and maintenance.

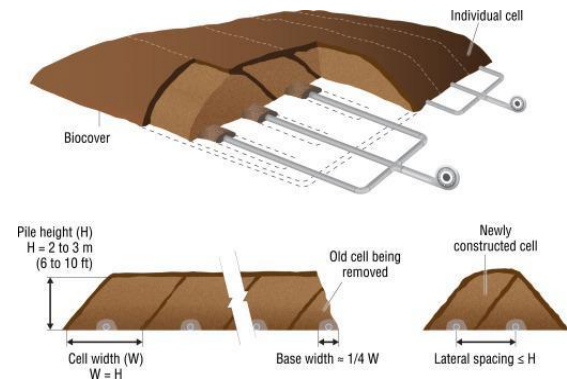
### Open Methods with Forced Aeration

Forced aeration uses a blower to introduce and control the flow of air through a pile of organic waste, providing a constant supply of oxygen while removing heat, moisture, and carbon dioxide. This reduces the need for both mechanical turning of the pile (windrows) along with corresponding reduction in overall site footprint and fugitive airborne emissions (particularly if air supply is via negative pressure). Forced air can be supplied via either positive or negative pressure.

- Aerated Static Pile (ASP) – Organic waste formed into freestanding piles approximately 6 to 12-feet high are aerated using blowers providing negative (or positive) air pressure through perforated pipes. During initial pile construction a ‘biocover’, typically consisting of compost or wood chips, is added to protect from drying, reduce heat loss and vector attraction; as well as filter odors, ammonia and other compounds which may be released.

It is noteworthy this technology is:

- Well proven and reliable
  - Requires smaller footprint than windrow composting
  - Scalable to large capacity
  - Susceptible to operational difficulties (over-drying of piles and difficult to add water)
  - Suitable for feedstock mixes that require documented pathogen and vector reduction (i.e., food waste, manure, etc.)
  - Can be outdoors or enclosed in a building but are usually built on a concrete pad.
  - Efficient with regard to processing of material – hot compost is generally produced in 4 to 8 weeks, which is then cured for another 4 to 8 weeks to produce finished compost.
- Aerated Static Pile with Microporous Cover – Essentially the same operation as ASP described above but replaces the ‘biocover’ with a semipermeable microporous fabric membrane which discourages birds and other vectors that may be attracted to feedstocks like food waste.



*Aerated Static Pile Diagram (courtesy Compost Research & Education Foundation)*



*Aerated Static Pile with Microporous Cover (courtesy Prince George's County, MD)*

### In-Vessel Composting - Rotating Drums

These systems use a slightly inclined horizontal steel cylinder to agitate, aerate, and move compost through to the discharge end of the cylinder. Feedstocks are loaded on one end through a hopper or infeed conveyor. The drum is slowly rotated on bearings typically by a simple electric motor-driven gear system with minimal moving parts. A fan or the hopper opening provides continuous air to the cylinder, while warmer air exits the end, allowing for some measure of temperature control while maintaining aerobic conditions. These systems are designed to handle virtually any materials, including animal

mortalities, and the decomposition process occurs rapidly (typical retention time is 3 to 5 days). Once processed through the rotating drum, compost is moved to windrows for another 30 to 60 days of curing and stabilization.



*Rotaposter® Rotating Drum Composter – (courtesy Rotary Composters, LLC)*

The following is noteworthy:

- Commercially engineered systems are available for direct purchase.
- Batch system – not continuous feed, although initial retention time is short (3-5 days), followed by a second stage of composting, limits application for continuous feedstock. Would require purchase of multiple 'train' to accommodate lag in batch mode and require additional footprint.
- Works well for highly degradable feedstocks (i.e., food waste, meats, etc.) and quickly converts organic feedstock which would otherwise attract pets/vectors into a compostable material.
- Built-in materials handling and aeration.
- Closed vessel aerobic process reduces odor, prevents pests, reduces heat loss with added ability to operate in enclosed building or open environment.

### Agitated Bed

This method uses forced aeration like ASP and in vessel composting. Organic material is placed in a large bed that is mechanically turned every 1 to 3 days to allow an even aeration of the waste. As an auger moves down the pile of organic waste in the bed, stable compost is discharged onto the bed floor or conveyor for further processing. This opens up space for new material to be loaded by front end loaders upstream. The active composting phase is typically 3 to 4 weeks and the total processing time to produce compost is 2 to 4 months [Ref. 11].

The following is noteworthy:

- This process is highly automated and has high capital costs.
- Suitable for food scraps and yard trim material.
- Typical facility sizes range from 50,000 to 100,000 tons per year capacity.
- Land requirement is low compared to other open composting methods.
- Odor is better controlled and can be implemented in buildings.

#### Siting Considerations/Compatibility

The siting requirements for composting operations vary depending on their design and technology selection:

- No conflict with Dickerson facility and relatively remote location, distant from residential and commercial neighbors, schools, hospitals, and sensitive populations.
- Not suitable for adaptation of the Derwood Transfer Station due to previously described site constraints/limitations:
  - Batch System – Not continuous feed. Although initial retention time is short (3 to 5 days) there is a necessary 2<sup>nd</sup> stage of composting/curing which limits applications for continuous feedstock. Alternatively, would require purchase of multiple treatment ‘trains’ at cost of added capital, O&M, and footprint.
  - Applicability is limited to processing capacity – in vessel systems in particular typically manage only a few tons per day and do not compare well with the volume of organic material which may be extracted from the County’s MSW stream.

#### Costs

Cost data was not uniformly available for each of the various types of composting processes. Composting facilities are generally not as capital and labor intensive as other solid waste management systems, but their capital and operating costs vary depending on the site design, capacity, and technology selected. Based on nationwide average data, larger ASP, CASP, or in-vessel composting facilities that can process up to 40,000 tons per year are expected to cost \$5 to \$9 million in up-front capital and \$17 to \$28 per incoming ton to operate based on national averages [Ref. 12]. Revenue from the sale of finished compost helps to offset some of the costs.



#### 4. Anaerobic Digestion (AD)

Anaerobic digestion is a process through which bacteria decompose (digest) organic matter (i.e., animal manure, wastewater biosolids, food wastes, etc.) in the absence of oxygen within a sealed reactor vessel.

The digestion process produces biogas (primarily methane) that can be flared or recovered for energy production, solid digestate that can be land applied as a soil amendment, and liquid digestate that can be used for fertilizer. The digestate can also be bio-stabilized when processed in combination with other aerobic composting efforts. A 2021 EPA report addressing 209 AD facilities shows the top feedstock sources as Fats, Oils and Greases (FOG), as well as some digesters designed to process specific types of organic waste found in MSW [Ref. 13].



*BTS anaerobic digestion system at the Maryland Food Center in Jessup, Maryland. – (courtesy BioCycle)*

There are a few basic approaches that may be used depending upon the nature of the organic feedstock:

- Wet low solids for dilute feedstock with very little to no contamination and is not compatible with MSW. These are typically large tank-based systems with mixing used at Wastewater Treatment Plants and used in co-digestion systems which process both biosolids and other dilute putrescible materials.
- Wet high solids for thick but pumpable materials that contain some contamination. These systems use a plug flow or similar process, which does not include mixing. The system can be configured in either vertical or horizontal orientations. Materials advance through the digester when new feedstock is added.

Anaerobic digestion of MSW requires 'organic' feedstock (food and yard waste) be collected separately, mixed with water to form a wet 'slurry' and then conveyed via conveyors, pumps, and mechanized agitation to a digester. Insoluble inorganics (glass, plastics, and metals otherwise not recovered from the waste stream) are discharged for separate processing or disposal. The remaining slurry stream is processed by a series of sealed chambers/digesters designed to remain at the optimum conditions for anaerobic digestion by specific bacteria for a determined residence time to optimize the production of biogas, which is composed primarily of methane, carbon dioxide, hydrogen sulfide, and water vapor.

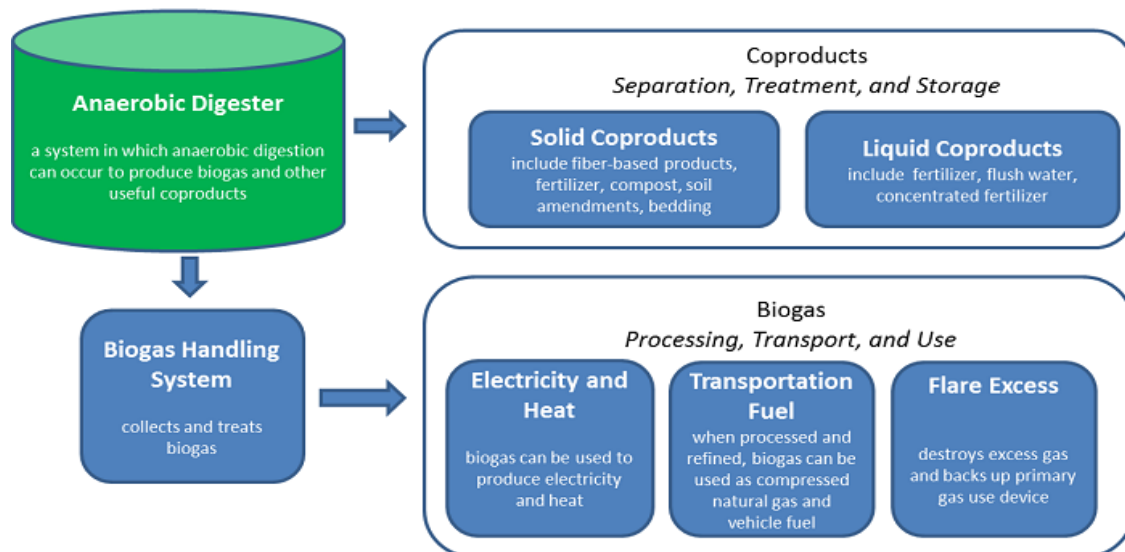
The resulting biogas can be used for one of the following purposes:

- Electricity generation via reciprocating internal combustion and conversion to electrical energy for sale to a host generator.
- Further refined to remove contaminants (hydrogen sulfide, particulates, moisture, etc.), carbon dioxide, oxygen, and/or nitrogen to produce renewable natural gas (RNG) for sale to a local

natural gas utility or other end-user as transportation fuel or capture as Renewable Energy Credit (REC) tax credits.

Anaerobic digesters have been increasingly used to combat the emissions issue of food waste or other residuals by diverting organic carbon from landfills, where it decomposes and creates methane, a greenhouse gas with significantly greater global warming potential than carbon dioxide. Biogas production can also create additional income and can reduce the overall costs of operating waste handling facilities, particularly if organics can be presorted and separated from MSW (source separated organics).

The figure below depicts a United States Environmental Protection Agency (USEPA) process diagram of anaerobic digestion [Ref. 14]. The organic feedstock becomes processed and creates the two co-products of solid compost and a liquid concentrate fertilizer which may be sold for agricultural purposes. It is critical that the presorting is efficient at removing non-organic waste to prevent contamination and ensure quality co-products that can be sold.



*Anaerobic Digestion Process Flow Diagram (courtesy USEPA)*

It is noteworthy that AD plants capture most emissions primarily related to combustion of resulting biogas via either baghouses for particulates, scrubbers for SO<sub>2</sub>, oxidation catalysts and/or selective catalytic reduction for various other air pollutants. A flare may also be required to burn any excess produced biogas. In addition, because the AD process is biologically driven, time is required for microorganisms to start up and complete the digestion process. Consequently, AD facilities require relatively large storage and processing vessels with corresponding capital investment and land area.

Other significant technical constraints and limitations relate to contamination of the organic feedstock from inorganic and/or hazardous materials, which if not prevented from entering the organic feedstock, can have a significant detrimental inhibition on the digestion process or biogas production. Rigorous source separation is critical.

### Siting Considerations

According to the American Biogas Council there are currently 473 anaerobic digesters on farms, 1,269 water resource recovery facilities using an anaerobic digester, and 102 stand-alone systems that digest food waste, which are operating in the United States.

The site characteristics for anaerobic digestion vary depending on the facility design and capacity. Locating AD is compatible with the Dickerson facility but not Derwood due to previously expressed concerns regarding limited available footprint and aesthetic/nuisance impacts (largely odor related).

### Costs

Capital costs for facilities with capacity between 25,000 to 100,000 tons per year range from approximately \$15 to \$30 per ton, and O&M costs average around \$40 per ton [Ref. 15]. Total combined capital plus O&M costs, not including other lifecycle cost costs, can be expected to range from approximately \$55 to \$70 per ton of waste processed.

## 5. Construction & Demolition Debris Recycling

Processing of CDD waste is typically performed using mechanical and manual sorting systems. Smaller materials may be handled using systems not too dissimilar to those found in a Material Recovery Facility. The size, equipment, labor needs and layout depend on its complexity and capacity.

There are two waste CDD waste streams to consider:

- Type 1 - soil, broken asphalt and concrete, stone, brick, and block from road and structure demolition projects that may also have large pieces of pipe and other heavy materials, often mixed with soil and fines.
- Type 2 - mixed construction materials which may include drywall, dimensioned lumber, metal pipe, electrical wire, and a range of other materials found in buildings during demolition such as different flooring materials, insulation, and lighting and plumbing fixtures.

For heavy Type 1 materials, separation of bulky oversize items and then screening enables the soils and finer grained materials to be shipped out as clean fill material. To the extent loads can be sorted while coming in based on origin and purity of materials, separate piles of broken concrete, broken asphalt, and other inert materials can be established to make them more suitable for reuse or further processing.

For Type 2 mixed construction and demolition materials, conveyor systems are often used with the following processes:

- Initial sorting – removal of large items (metal, concrete, non-recyclable items [carpeting, etc.]) This is usually done on a tip floor or concrete pad prior to loading other materials onto conveyors.
- Shredding
- Separation of materials into basic sizes (>5", <5")
- Magnetic removal of ferrous metals, eddy current separation of non-ferrous metals.
- Trommel screening to further separate materials by size and remove fines.
- Air trommel to separate heavier (concrete, glass, ceramics, etc.) and lighter (cardboard, wood, insulation, etc.) materials.
- Manual sorting to remove plastics, non-recyclables, and other materials.
- Bunker storage of sorted materials.

Many materials are recovered and either reused or recycled into other products such as:

- Crushed concrete and brick used in road construction, drainage projects.
- Concrete, block, masonry, and other clean debris used as clean fill.
- Reusable building supplies such as lumber and whole bricks.
- Remanufacture of wood chips into engineered wood.
- Wood fuels used in co-generation plants and industrial boilers.
- Horticultural mulches made from natural woody material.
- Dyed, decorative mulches made from construction debris wood.
- Wood chips used as a bulking agent in biosolids, compost, and animal bedding.
- Planks and other dimensional lumber sawn from whole trees.
- Corrugated cardboard containers.
- Metals (steel, aluminum other non-ferrous)
- Recovered screened material (RSM) for soil amendments and other approved uses.
- Processed CDD used as daily landfill cover material.

It is noteworthy that CDD recycling facilities, depending on their design and operation, can divert up to 70 percent or more of the materials they receive [Ref. 16] and can be designed to process between approximately 500 to 1,200 tpd, exceeding any short- and/or long-term demands by the County.

### Siting Considerations

The size, equipment, labor needs and layout of a CDD recycling facility depends on its complexity and capacity. Most facilities only require an area of approximately 5 to 10 acres, but they generate high levels of noise, dust, and traffic. This technology is not suitable for Derwood given the previously described site constraints and limitations.

### Costs

Depending on the layout and complexity, capital costs for CDD recycling facilities range from \$13 to \$16 million, and annual O&M costs are generally in the range of \$2.2 to \$ 2.7 million for a 135,000 to 160,000 tons per year capacity facility [Ref. 17].

## 6. Glass Pulverization

Glass is a particularly difficult material for the recycling industry, as its bulk weight makes it expensive to transport. In addition, glass 'remelt' facilities are usually not locally available, and broken glass contaminates cardboard and other recyclables, presents hazards to workers, and causes significant wear and tear on sorting and processing equipment. For these reasons, many communities simply crush collected glass and use it as landfill road or cover material.



One way to move glass toward a more circular economy is to pulverize the material and create both glass sand and glass gravel, which can then be used as fill material, pipe bedding, cement additives, beach renourishment, or other potential uses. Glass pulverizers use hammermills to reduce the glass to a set size gradation, and remove bottle caps, labels, and other contaminants during the process.

Readily available commercial glass pulverizer systems can process up to 20 tons of glass per hour. Larger capacity pulverizers can be custom designed and fabricated to meet the specific glass processing demands of a municipality.



*Figure 6. Glass Crushed to Sand (Courtesy Aqua Tools)*

Many municipalities around the country have begun investigating glass pulverizing operations in recent years, mostly as a measure to reduce glass hauling and disposal costs. Most notably, as of March 1, 2023, Walt Disney World in Orlando, Florida was conducting a pilot program to pulverize collected glass and use it to fill holes on roads and trails.

### Siting Considerations

The size, equipment, labor needs and layout of a glass pulverizing facility depends on its complexity and capacity. Most facilities are co-located with MRFs, transfer stations, or other solid waste facilities, and usually occupy less than an acre of area. However, they generate high levels of noise. Glass pulverizer facilities should have good truck access with short travel times to major roads, and electrical utilities available at the property.

### Costs

Capital as well as O&M costs for commercial scale pulverizers vary by capacity and throughput but are generally not cost-intensive operations. Estimated capital costs derived from multiple sources ranged from approximately \$10 to \$13 per ton, and O&M costs were found to range from approximately \$10 to \$15 per ton [Ref. 18]. Resulting total costs typically range from approximately \$20 to \$28 per ton of processed material.

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<https://wasteadvantagemag.com/waste-conversion-mechanical-biological-treatment-mbt-concept-for-material-and-energy-recovery-from-mixed-msw/>
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18. WIH Resource Group, City of Walla Walla, Washington, Glass Recycling Alternatives Analysis Report, October 2022.

## TABLES



Municipal Solid Waste Management System Alternatives Analysis

Table 1

Summary of CAPEX and OPEX for MSW Processing Technologies

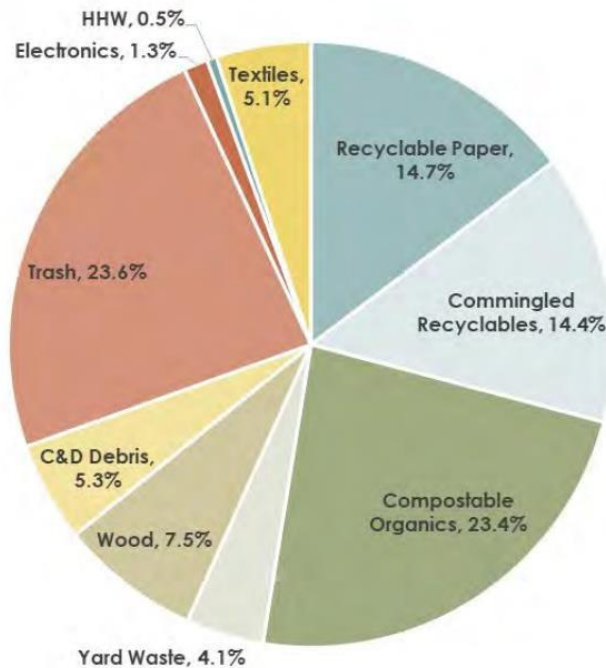
| Technology                                       | Cost Component                         |      |       |      |                                                                                                                                                 |      |     |      |
|--------------------------------------------------|----------------------------------------|------|-------|------|-------------------------------------------------------------------------------------------------------------------------------------------------|------|-----|------|
|                                                  | Capital (\$/Ton or \$/Ton/Year (MRBT)) |      | O & M |      | Total                                                                                                                                           |      |     |      |
|                                                  | Low                                    | High | Low   | High | Low                                                                                                                                             | High | Low | High |
| Mixed Waste Processing                           | 15                                     | 45   | 90    | 210  | 105                                                                                                                                             |      |     | 255  |
| MRBT - Aerobic                                   | 65                                     | 490  | 40    | 150  | Not Available - Capital Cost Varies per \$/Ton/Year and Financing Scenarios. Information is mostly proprietary. See Tables 2 and 3 for Details. |      |     |      |
| MRBT Anaerobic                                   | 370                                    | 1570 | 50    | 175  |                                                                                                                                                 |      |     |      |
| Composting                                       | 6                                      | 11   | 17    | 28   | 23                                                                                                                                              |      |     | 39   |
| Anaerobic Digestion of Source Separated Organics | 15                                     | 30   | 40    |      |                                                                                                                                                 |      | 55  | 70   |
| Construction & Demolition Debris Recycling       | 4                                      | 5    | 15    | 18   | 19                                                                                                                                              |      |     | 23   |
| Glass Pulverization                              | 10                                     | 13   | 10    | 15   | 20                                                                                                                                              |      |     | 28   |

## APPENDIX A



**1. SCS Engineers, 2022/23 Montgomery County Waste Composition Study, Ref. No. 0222013.0000, April 18, 2023.**

SCS Engineers conducted a waste composition study for the waste received at the Montgomery County Transfer Station for the period between Spring 2022 to Winter 2023. Some of the key results are:



- The pie chart above shows the weighted overall waste composition by material. It indicates approximately 23 percent combined compostable organics and approximately 14 percent of comingled recyclables remain with the MSW stream.
- Overall, the three largest subcomponents by weight of the waste stream are Food Waste (16.6 percent), Film Plastic - Other (7.3 percent), and Non-Recyclable Paper (6.9 percent).
  - The three largest recyclable subcomponents are Corrugated Cardboard (4.9 percent), Other Recyclable Paper (3.3 percent), and Paperboard (2.1 percent).
- Waste Composition of Single-Family Subdistrict A waste stream are Food Waste (19.3 percent), Non-Recyclable Paper (7.7 percent), and Film Plastic - Other (7.4 percent).
  - The three largest recyclable subcomponents are Other Recyclable Paper (3.3 percent), Corrugated Cardboard (2.5 percent), and Other Plastic Containers/Tubs (2.1 percent).
- Waste Composition of Single-Family Municipal waste stream are Food Waste (16.4 percent), Non-Recyclable Paper (8.1 percent), and Miscellaneous Organics (7.8 percent).
  - The three largest recyclable subcomponents are Corrugated Cardboard (3.4 percent), Other Recyclable Paper (2.7 percent), and Other Plastic Container/Tubs (2.3 percent)
- Waste Composition of Multi-Family waste stream are Food Waste (15.9 percent), Non-Recyclable Paper (7.5 percent), and Film Plastic - Other (7.3 percent).
  - The three largest recyclable subcomponents are Corrugated Cardboard (4.3 percent), Other Recyclable Mixed Paper (3.9 percent), and Office Paper (1.9 percent).
- Waste Composition of Non-Residential waste stream are Food Waste (14.8 percent), Film Plastic - Other (7.4 percent), and Non-Recyclable Paper (6.1 percent).

- The three largest recyclable subcomponents are Corrugated Cardboard (6.7 percent), Other Recyclable Paper (3.4 percent), and Paperboard (2.5 percent).
- Materials such as yard waste and wood were more prevalent in the Spring, Summer, and Fall seasons.

**2. Greenpeace 2022 US MRF Survey.** <https://www.greenpeace.org/usa/wp-content/uploads/2022/10/2022-MRF-Survey-August-15-2022-Final.pdf>

Presents a summary table of the results of the survey of U.S. Residential Material Recovery Facilities - Acceptance of Post-Consumer Plastic Products published on August 15, 2022.

Five out of 7 of the active MWP Facilities in the US that process all trash are located in California as listed below:

- Advance Disposal Hesperia located in Hesperia, CA.
- Athens Services Sun Valley MRF located in Sun Valley, CA.
- LA County Sanitation: Puente Hills MRF located in Whittier, CA
- Nortech Waste MRF located in Roseville, CA.
- South Tahoe Refuse and Recycling Services located in South Tahoe, CA.

The other two active MWP Facilities in the US are operated by RePower:

- RePower South Montgomery, AL
- RePower South Berkeley County, SC

**3. Long Term Disposal Alternatives Analysis for Cumberland County, NC Department of Solid Waste, HDR, Jan 2022**

HDR provided a summary of the technical viability and commercial readiness of waste reduction technologies to Cumberland County. A summary of Mixed Waste Processing findings include:

- Traditional dirty MRFs (Mixed Waste Processing Facility (MWPF)) typically recover from 10 to 25 percent of the recyclable waste stream.
- Some advanced MWPF can achieve up to 50 percent recovery rate if the owner diverts both recyclable and other organic from the waste stream prior to reaching the facility.
- Typical capacity is between 200 tons per day (TPD) and 1,500 TPD.
- Useful operating life of 20 to 30 years with proper maintenance.
- Job creation of approximately 20 to 60 permanent jobs.
- A 1,500 TPD MWPF has an estimated capital cost of \$50 million or approximately \$33,000 per ton of daily design capacity.
  - Capital cost per ton over an assumed lifetime of 20 years is \$5/ton
- Average processing cost (O&M only) is approximately \$112/ton
- Average processing cost (O&M only) for recyclables via MRF is approximately \$60/ton
- Total cost (not including source separated organics) is approximately \$177/ton
- MWPF Revenue is approximately \$42/ton
- Source separated MRF revenue is approximately \$53/ton
- Total revenue is approximately \$95/ton
- Net cost is approximately \$82/ton

#### **4. King County Government, Re+ Action Overview, Mixed Waste Processing of Municipal Solid Waste**

King County Seattle reviewed the feasibility of Mixed Waste Processing Facility as one of the ways to achieve their diversion goals set by the Re+ programs.

- MWP operations can divert up to 75 percent of municipal waste.
- Priority materials for recovery may include fiber for paper production, organics for anaerobic digestion and/or composting, metals and high-quality plastics for recycling, and various low-value materials for energy production.
- MWP facilities work best in communities with effective curbside recycling programs.
- Cost ranges from \$120 million to 130 million for a MWP processing capacity of 150,000 tpy to 180,000 tpy respectively.
  - Cost per ton over an assumed lifetime of 20 years ranges from \$36/ton to \$40/ton.
- Existing MWPs in California have capacity ranging from 120,000 tpy to 180,000 tpy
- Implementation of MWP may impact and change hauler routes.
- MWPs are relatively easy to integrate and requires no behavior change from residents or workers.
- Employees in a MWP facility are sorting mixed waste, so they are exposed to typical dangers associated with working around municipal solid waste.

#### **5. Details on WM's \$75 million MRF in South Florida, Resource Recycling, <https://resource-recycling.com/recycling/2023/03/20/the-details-on-wms-75-million-mrf-in-south-florida/>**

Article summarizing details of the new Waste Management's MRF in South Florida. Details include:

- Facility located in Pembroke Pines, Broward County, Florida.
- Facility can process between 750 to 825 tons per day.
- Capital Cost: \$75 million
- Land footprint: 127,000 square feet
- Projected to recover up to 95% material.
- Under the contract, the tipping fee for County material is \$143.99 per ton.

#### **6. Details on Oregon's \$150 million trash-sorting MRF, Resource Recycling, <https://resource-recycling.com/recycling/2024/02/06/details-on-oregons-150m-trash-sorting-mrf/>**

Article summarizing details of the new Waste Management's MRF in Lane County, Oregon. Details include:

- Facility capacity: 160,000 tpy
- Projected to boost County diversion by 20% more.
- Recycling system supplied by Bulk Handling Systems and included an anaerobic digester.
- Capital cost: \$150 million.
- Targeted start of operation is 2025.
- Facility will be constructed on a 26-acre site.

#### **7. Northeast Recycling Council (NERC) Recycling Market Report, September 2023**



NERC publishes quarterly reports starting in April 2019 aimed at assessing regional market trends to inform decisions of recyclers, MRFS and municipalities. The most recent report was published in September 2023 and covers the periods between April to September 2023.

The blended market value of commodities recovered from a MRF for the last two quarters are reported in the table below.

| All Reporting MRFs | Blended Value<br>April - June 2023 | Percentage Change from<br>Previous Quarter |
|--------------------|------------------------------------|--------------------------------------------|
| Without residuals  | \$85.63                            | 10%                                        |
| With residuals     | \$76.99                            | 13%                                        |

| All Reporting MRFs | Blended Value<br>July - September 2023 | Percentage Change from<br>Previous Quarter |
|--------------------|----------------------------------------|--------------------------------------------|
| Without residuals  | \$72.77                                | -15%                                       |
| With residuals     | \$63.95                                | -17%                                       |

The average processing cost per was \$87.54/ton and \$87.78/ton, respectively.

**8. Material Recovery Facility Evaluation, Isabelle County, Michigan, January 2023. Recycle.com**

Recycle.com (RRS) assessed Isabella County recycling program, operation, staffing, costs and improvements. Details on MRF capital and O&M costs include:

- Capital costs (includes building, processing line and system infrastructure) is approximately \$12 million to \$19 million for a 7tph and 10 tph facility respectively.
- O&M costs include sorting, equipment O&M, admin, staff, utilities, hauling and disposal.
- Gross O&M cost per ton ranges from approximately \$178 to \$205 per ton for a 10tph and 7 tph facility respectively.
- Net O&M cost per ton ranges from approximately \$142 to \$169 per ton for a 10 tph and 7 tph facility respectively. Net cost includes potential revenue from disposal.

**9. Mechanical Biological Treatment of Municipal Solid Waste. UK Department for Environment, Food and Rural Affairs, February 2013.**

Provides an overview of Mechanical Biological Treatment (MBT) of MSW as a reference for decision makers.

- Different mechanical separation technologies use varying properties of the materials such as shape, size, weight, conductivity to separate the MSW and are listed in the report.
- Biological treatment can take place before or after mechanical separation. There are three main ways to biologically treat the waste that include Aerobic- Bio drying, Aerobic in Vessel Composting and Anaerobic Digestion.
- Segregating glass would require material specific sorting technique for high value products.
- Textiles, paper and plastics are unlikely to receive an income.
- A common product of the MBT process is compost like outputs and can be used to improve low quality soil, restore brown field sites and landfill cap restoration.
- There are over 330 MBT facilities in operation throughout Europe.
- Capital costs for MBT facilities are relatively high. Recent example estimates and actual costs for the construction of MBT plants fall in the range of (2013 dollars):

- £50m (\$64m) – £125m (\$159m) for MBT facilities in the capacity range 80,000 – 225,000 tpy.
- Footprint required varies on type of facility but can range from 7.4 acres to 42 acres for a 110,000 tpy to 305,000 tpy capacity plant.

#### **10. Waste Conversion Mechanical Biological Treatment (MBT) Concept for Material and Energy Recovery from Mixed MSW. Waste Advantage Magazine, April 2015**

<https://wasteadvantagemag.com/waste-conversion-mechanical-biological-treatment-mbt-concept-for-material-and-energy-recovery-from-mixed-msw/>

- According to the USEPA food waste comprises up to 21 percent of the MSW currently landfilled in the U.S.
- The growing demand for high-grade refuse derived fuel (RDF) around Europe additionally motivated the development of the MBT plants as one major by-product of these plants is RDF (~40 percent by weight).
- The leading MBT markets in Europe are Germany, Austria, Italy and Spain.
- The MBT plants accept for processing the mixed MSW as collected after source separation of recyclables and organics has been completed.
- The MBT plants with major landfilling fraction have a landfill diversion rate of around 60 percent, and the MBT plants dedicated to RDF production reduce the amount of waste being landfilled to 90 percent.
- Actual costs for the construction of MBT plants in the UK fall in the range of \$150 per annual ton of capacity of MBT plant with aerobic composting (2015 dollars).
- Operational costs at the German MBT plants have been reported in the range of \$45 to \$103 per ton of MSW processed (2015 dollars).
- One of the issues these plants are facing is the quality of the recovered recyclables and the produced compost.

#### **11. Organics Management Plan, Montgomery County, Maryland. EA 2023.**

This organics siting study plan evaluates the siting, technology, and capacity planning for a County-owned organics processing facility in Montgomery County to meet the food scrap, non-recyclable paper, and yard trim diversion needs of the County for the next 20 years. Includes costs for different aerobic and anaerobic processing technologies.

| <b>Technology</b>                                                | <b>Capital Cost</b> | <b>O&amp;M Cost</b> |
|------------------------------------------------------------------|---------------------|---------------------|
| Aerated Static Pile                                              | \$31,325,000        | \$11,050,000        |
| In-Vessel Tunnel Reactor                                         | \$62,811,000        | \$13,770,000        |
| Agitated Bed                                                     | \$89,632,000        | \$12,260,000        |
| Dry fermentation Anaerobic Digestion w/tunnel reactor composting | \$139,460,000       | \$17,950,000        |
| Dry fermentation Anaerobic Digestion                             | \$105,041,000       | \$15,450,000        |

The alternatives presented considered a phased processing facility development, with adequate capacity to process up to 97,400 tons (273,500 CY) of yard trim and food scrap in Phase I, and to meet the future processing capacity needs identified in the mandatory program and some high capture scenarios in Phase II.

**12. ReFed.com at <https://insights-engine.refed.org/solution-database/centralized-composting>**

Summarizes the financial cost and benefits of composting and impacts to relevant stakeholders.

- In rural areas, windrow composting is more common, while aerated static pile composting is found in urban areas.
- There are over 5,000 composting facilities nationwide, with only 500 facilities accepting food scraps.
- Larger facilities that can process up to 40,000 tons per year are expected to cost \$5 to \$9 million in upfront capital and \$17 to \$28 per incoming ton to operate.
- National average of processing capacity of the facilities is approximately 5,000 tons per year.
- Can achieve up to 16.2 M tons nationwide of annual food waste diversion.
- Results in an annual emission reduction of 8.75 M MTCO<sub>2e</sub> or (0.54 MTCO<sub>2e</sub>)

**13. Anaerobic Digestion Facilities Processing Food Waste in the United States (2017 & 2018). USEPA Survey Results, January 2021.**

EPA surveyed 209 AD facilities that accept food waste to identify the facilities, learn about their operations and develop a database. A summary of the major findings are listed:

- California has the greatest number of operating digesters (23) followed by Wisconsin (10). Ohio and New York both have nine digesters, Massachusetts has eight digesters and Pennsylvania has six digesters.
- Top Five feedstock sources for ADs in 2019: Food/beverage processors, restaurants, grocery stores, industrial sources, biodiesel production.
- Top five feedstocks accepted by ADs in 2019: Fats, oils and greases, food processing industry waste, beverage processing industry waste, fruit/vegetative waste and food service waste.
- Top uses of biogas were to produce electricity and fuel boiler and furnaces.
- Top uses of solid and liquid digestate include land applications, animal bedding, reusable and sellable product.

**14. United States Environmental Protection Agency at <https://www.epa.gov/agstar/anaerobic-system-design-and-technology>**

- Depending on the type of feedstock and the type of digester, pretreatment may be required.
- Digested solids may be used as animal bedding, as a soil amendment, a primary constituent in potting soils, or bio-based products (e.g., bioplastics).
- The liquid effluent from a digester can be used as a fertilizer, reducing the purchase of commercial fertilizers.

**15. National Renewable Energy Laboratory (NREL) Comparison of Select Food Waste Utilization Options (2021).**

NREL conducted a study to compare different food waste utilization options including landfill gas capture, anaerobic digestion and composting. Costs (in 2020 \$) related to anaerobic digestion include:

| Capacity (tpy) | Capital Cost (million USD) | O&M Cost (thousand USD) |
|----------------|----------------------------|-------------------------|
| 2,500          | 3.0                        | 85                      |
| 5,000          | 4.7                        | 171                     |
| 25,000         | 12.3                       | 854                     |
| 50,000         | 18.6                       | 1,707                   |
| 100,000        | 28.2                       | 3,415                   |
| 200,000        | 42.7                       | 6,830                   |

Net GHG emissions (MTCO<sub>2</sub>e/ton) based on different final product applications:

- Dry AD with digestate curing: -0.04
- Dry AD with direct land application: -0.10
- Wet AD with digestate curing: -0.06
- Wet AD with direct land application: -0.14

Land area required: 3 to 6 acres

#### 16. Zanker Material Processing Facility (ZMPF) Advanced C&D Processing System - Protocol Evaluation Report. Recycling Certification Institute, June 2020.

Presents the results of an evaluation of the process train for the Advanced C&D Recycling System operated at the Zanker Materials Processing Facility.

- In 2018 this operation processed 185,000 tons of material with a 70% diversion rate, approximately 41,000 tons more than its design capacity.
- The Advanced C&D Processing System is planned to operate 6 days per week and process an average of 500 tons per day, or 155,000 tons per year. Based on a preliminary acceptance test the operation achieved an 84.95% diversion rate with alternative daily cover (ADC) and a 64.68% diversion rate without ADC.
- *The following residue is disposed by:*
  - **ADC** is sent to landfill
  - **Concrete** is made into Base Rock
  - **Metal** (Tin, Steel, Aluminum, Copper) is delivered to a recycler for metal products.
  - **Plastic (Beverage Containers, PET, HDPE)** is delivered to other facilities for recycling.
  - **Wood** is processed into Biomass Fuel, Mulch, and Soil Amendments.
  - **Trash** is delivered to other landfills for disposal or disposed at the onsite landfill.
- Employee training should include hazardous materials recognition and screening and heavy equipment, operations, with emphasis on safety, health, environmental controls, and emergency procedures.

#### 17. Consulting Services in Support of Resource Recovery Planning and Implementation, City of Dallas Sanitation Services, May 2014.

City of Dallas conducted a study on their Resource Recovery Planning and Implementation in an effort to meet their zero waste goals. The study provides an alternatives analysis of available technologies including C&D facilities. Cost information include:

- Capital cost range from \$10 to \$12 million in total.
  - Building and site construction - \$7 to \$8 million;
  - Processing equipment - \$2 to \$2.5 million; and
  - Rolling stock - \$1 to \$1.5 million.
- O&M costs range from \$1.7 to \$2.1 million annually.
  - Personnel - \$1.3 to \$1.5 million;
  - Rolling stock O&M - \$175,000 to \$250,000;
  - Processing equipment O&M - \$80,000 to \$90,000; and
  - Other operating expenses (utilities, fuel, supplies, training, etc.) - \$225,000 to \$260,000.
- The conceptual facility was sized to process 135,000 tons of C&D debris (including residuals) and increasing to 160,000 tons over ten years. Other assumptions include a debt issuance of 20 years for the facility/site development and a 5.0 percent interest rate on debt.

#### **18. WIH Resource Group, City of Walla Walla, Washington, Glass Recycling Alternatives Analysis Report, October 2022.**

The WIH Resource Group conducted a study for the City of Walla Walla in 2022 to analyze available alternative for glass recycling.

- Recycled glass can substitute for up to 95% of raw materials and extend manufacturing equipment's life.
- The estimated additional cost to collect and recycle glass from residential customers is \$0.89 per month (2022 dollars).
- Because the glass will be source separated by the customers at the time of collection, SMI will pay the City of Walla Walla \$15 per ton for the clean glass material stream.
- In 2018, 39.6% of beer and soft drink bottles were recovered for recycling, according to the U.S. EPA - 39.8% of wine and liquor bottles and 15.0% of food and other glass jars were recycled. In total, 33.1% of all glass food and beverage containers were recycled. Energy costs drop about 2-3% for every 10% cullet used in the manufacturing process.
- States with container deposit legislation have an average glass container recycling rate of just over 63%, while non-deposit states only reach about 24%, according to the Container Recycling Institute.
- Refillable bottles can be used about 25 times. Sterilizing and refilling a bottle use about 93% less energy and 47% to 82% less water than making a new bottle.
- The cost of the machine plus the setup costs is \$277,000. It has an expected ten-year life and has a run cost of \$2.96 per ton.
- Glass storage cost is \$85,000. If this cost is depreciated over a ten-year life, the annual \$8,500 cost has a monthly rate impact to each recycle customer of \$0.07 (\$8,500 / 10,335 customers/ 12 months).
- Reusing wine bottles has the highest net GHG impact compared to landfilling by reducing emissions by 5129 MT CO<sub>2</sub> e throughout its lifetime assuming it is reused 25 times before landfilling.
- Added glass collection routes and transport lead to an increase in GHG emissions by +255.61 MT CO<sub>2</sub> e.
- Pulverize glass can reduce GHG emissions by 61 MT CO<sub>2</sub> e.
- Andela glass pulverization system unit annual cost of operating ranges from \$36 to \$56 per ton.
- Cost per ton of glass depot (way to collect glass) is \$0.64 per ton.

## APPENDIX B



Mass Balance Status: OK

Waste Generation

746,498 tons

Collection

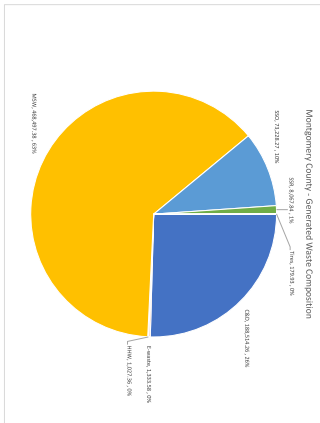
746,498 tons

Processing & Transport

746,498 tons

Disposal and Dispatch

746,498 tons



| Source       | Material     | Tons        |
|--------------|--------------|-------------|
| MSW          | MSW          | 500,743,472 |
| Construction | Construction | 184,444,148 |
| Other        | Other        | 19,311,878  |
| Recycling    | Recycling    | 1,000,000   |
| Landfill     | Landfill     | 1,000,000   |
| Other        | Other        | 1,000,000   |

| Material     | Tons        |
|--------------|-------------|
| MSW          | 500,743,472 |
| Construction | 184,444,148 |
| Other        | 19,311,878  |
| Recycling    | 1,000,000   |
| Landfill     | 1,000,000   |
| Other        | 1,000,000   |

| Material     | Tons        |
|--------------|-------------|
| MSW          | 500,743,472 |
| Construction | 184,444,148 |
| Other        | 19,311,878  |
| Recycling    | 1,000,000   |
| Landfill     | 1,000,000   |
| Other        | 1,000,000   |

| Material     | Transport    | Destination  | Tons        |
|--------------|--------------|--------------|-------------|
| MSW          | MSW          | MSW          | 500,743,472 |
| Construction | Construction | Construction | 184,444,148 |
| Other        | Other        | Other        | 19,311,878  |
| Recycling    | Recycling    | Recycling    | 1,000,000   |
| Landfill     | Landfill     | Landfill     | 1,000,000   |
| Other        | Other        | Other        | 1,000,000   |

| Material     | Tons        |
|--------------|-------------|
| MSW          | 500,743,472 |
| Construction | 184,444,148 |
| Other        | 19,311,878  |
| Recycling    | 1,000,000   |
| Landfill     | 1,000,000   |
| Other        | 1,000,000   |

| Material     | Destination  | Tons        |
|--------------|--------------|-------------|
| MSW          | MSW          | 500,743,472 |
| Construction | Construction | 184,444,148 |
| Other        | Other        | 19,311,878  |
| Recycling    | Recycling    | 1,000,000   |
| Landfill     | Landfill     | 1,000,000   |
| Other        | Other        | 1,000,000   |

| Material     | Destination  | Tons        |
|--------------|--------------|-------------|
| MSW          | MSW          | 500,743,472 |
| Construction | Construction | 184,444,148 |
| Other        | Other        | 19,311,878  |
| Recycling    | Recycling    | 1,000,000   |
| Landfill     | Landfill     | 1,000,000   |
| Other        | Other        | 1,000,000   |

## APPENDIX C





Mixed Waste Processing Facility Cost Detail

| Sources                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Facility Name and Location                                                   | Capacity (tpy)  | Capital        | Capital dollars in year | ENR CCI % Time Adjustment Factor | Capital (\$ 2024) adjusted for location | Capital Costs (\$/tpy) 2024 | O&M           | O&M Year in dollars | ENR CCI % Time Adjustment Factor2 | O&M costs (\$/ton) | Notes                                                                                             |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------|-----------------|----------------|-------------------------|----------------------------------|-----------------------------------------|-----------------------------|---------------|---------------------|-----------------------------------|--------------------|---------------------------------------------------------------------------------------------------|
| <a href="https://nec.org/documents/conferences/Spring%202015%20Conference/Eileen%20Berenyi_Mixed%20Waste%20Processing_The%20Good%20the%20Bad,%20and%20the%20Ugly.pdf">https://nec.org/documents/conferences/Spring%202015%20Conference/Eileen%20Berenyi_Mixed%20Waste%20Processing_The%20Good%20the%20Bad,%20and%20the%20Ugly.pdf</a><br><a href="https://sunnyvaleca.legistar.com/LegislationDetail.aspx?ID=1820584&amp;GUID=E6A6F02A-3988-477E-8FDC-C26246DD22E3&amp;FullText=1">https://sunnyvaleca.legistar.com/LegislationDetail.aspx?ID=1820584&amp;GUID=E6A6F02A-3988-477E-8FDC-C26246DD22E3&amp;FullText=1</a> | Sunnyvale Materials Recovery and Transfer Station (SMaRT)                    | 142,780         | \$ 23,600,000  | \$ 1,993                | 1.53                             | \$ 45,261,595                           | \$ 418                      | \$ 17,662,000 | \$ 2,023            | 0.00                              | \$ 94              | \$59.29 per ton<br>OPEX \$17,662,000 in 2023<br>OPEX \$21,300,000 in 2013<br>(offset by revenues) |
| City of Dallas - Consulting services in support of resource recovery planning and implementation (May 2014)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | N/A                                                                          | 250,000         | \$ 36,955,000  | \$ 2,014                | 0.52                             | N/A                                     | \$ 224                      | \$ 7,427,580  | \$ 2,014            | 0.52                              | \$ 45              | 2 nine hour shifts, 5 days a week                                                                 |
| Broward Report (Arcadis)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | N/A                                                                          | 60tph (~600tpd) | \$ 193,200,000 | \$ 2,020                | 0.03                             | N/A                                     | N/A                         | N/A           | N/A                 | N/A                               | N/A                | Assumes 1 shift and 7 operating lines.                                                            |
| MRF Yearbook (2016-17)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Vieste, Glendale, AZ (6, 19)                                                 | 22,500          | \$ 6,500,000   | \$ 1,999                | 1.31                             | \$ 19,937,470                           | \$ 668                      | \$ 1,764,461  | \$ 2,014            | 0.52                              | \$ 157.90          | Single stream.<br>4 day operation, 1 shift per day.<br>260 days per year.                         |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Placer County/Western Regional Materials Recovery Facility, Lincoln, CA (19) | 205,283         | \$ 22,000,000  | \$ 1,994                | 1.51                             | \$ 41,919,694                           | \$ 269                      | \$ 11,418,618 | \$ 2,014            | 0.52                              | \$ 64.01           | Dual stream.<br>5 day operation, 1 shift per day.<br>260 days per year.                           |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Monterey Regional Waste Management District, Marina, CA (10, 19)             | 100,000         | \$ 21,000,000  | \$ 2,015                | 0.52                             | \$ 24,239,867                           | \$ 320                      | N/A           | N/A                 | N/A                               | N/A                | Dual stream.<br>5 day operation, 1 shift per day.<br>260 days per year.                           |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Newby Island Recyclery, Milpitas, CA (9, 19)                                 | 208,000         | \$ 4,500,000   | \$ 1,994                | 1.51                             | \$ 8,574,483                            | \$ 54                       | N/A           | N/A                 | N/A                               | N/A                | Dual stream.<br>5 day operation, 1 shift per day.<br>260 days per year.                           |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Athens Services Sun Valley MRF and Transfer Station, Sun Valley, CA (6, 19)  | 216,000         | \$ 50,000,000  | \$ 2,013                | 0.52                             | \$ 57,678,561                           | \$ 352                      | N/A           | N/A                 | N/A                               | N/A                | Single stream.<br>5 day operation, 1.5 shift per day.<br>260 days per year.                       |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Eastern Regional MRF, Truckee, CA (19)                                       | 53,000          | \$ 4,500,000   | \$ 1,994                | 1.51                             | \$ 8,574,483                            | \$ 213                      | N/A           | N/A                 | N/A                               | N/A                | Dual stream.<br>5 day operation, 1 shift per day.<br>260 days per year.                           |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Michiana Recycling and Disposal, Niles, MI (19)                              | 28,050          | \$ 4,500,000   | \$ 2,007                | 0.95                             | \$ 7,775,677                            | \$ 312                      | N/A           | N/A                 | N/A                               | N/A                | Single Stream.<br>5 day operation, 2 shift per day.<br>260 days per year.                         |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Recycle City - Central Materials Processing Facility, St. Peters, MO (19)    | 57,116          | \$ 4,500,000   | \$ 1,995                | 1.44                             | \$ 9,941,863                            | \$ 192                      | \$ 1,902,082  | \$ 2,015            | 0.52                              | \$ 45.91           | Dual stream.<br>5 day operation, 1 shift per day.<br>260 days per year.                           |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Van der Linde Recycling, Troy VA (19)                                        | 156,000         | \$ 11,000,000  | \$ 2,009                | 0.79                             | \$ 19,647,765                           | \$ 126                      | N/A           | N/A                 | N/A                               | N/A                | Single stream.<br>6 day operation, 1 shift per day.                                               |

\*tpy to tpd conversion factor = 364 (from MWPF Assumptions tab)

Summary of Analysis

| Capital Costs (\$/tpy) 2024 |    |     |  | O&M costs (\$/ton)      |    |     |  |
|-----------------------------|----|-----|--|-------------------------|----|-----|--|
| Low                         | \$ | 54  |  | Low                     | \$ | 46  |  |
| Average                     | \$ | 292 |  | Average                 | \$ | 91  |  |
| Average (excluding Low)     | \$ | 319 |  | Average (excluding Low) | \$ | 105 |  |
| High                        | \$ | 668 |  | High                    | \$ | 158 |  |

MRRT Facility Cost Detail

| Sources                                                                                                                                                                                                                                                                                                                                                         | Facility Name and Location                                    | Capacity (tpy) | Capital        | Year in dollars | ENR CCI % change | Capital \$2024 | Capital Costs (\$/tpy) 2024 | O&M (\$/year)  | O&M (\$/ton) 2024 | Total                                                                  | Notes                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------|----------------|----------------|-----------------|------------------|----------------|-----------------------------|----------------|-------------------|------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <a href="https://zerowasteurope.eu/press-release/new-report-proves-cost-competitiveness-of-material-recovery-and-biological-treatment-based-approaches-for-mixed-waste-treatment/">https://zerowasteurope.eu/press-release/new-report-proves-cost-competitiveness-of-material-recovery-and-biological-treatment-based-approaches-for-mixed-waste-treatment/</a> | Index Value/ Not facility Specific Value*                     | 100,000        | \$ 37,050,000  | 2023            | 0.4%             | \$ 37,211,946  | \$ 372                      | \$ 10,197,500  | \$ 102            | E37-123 per ton<br>\$106-135 per ton                                   | E236-377 per tpy<br>\$326-415 per tpy                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| <a href="https://zerowasteurope.eu/press-release/new-report-proves-cost-competitiveness-of-material-recovery-and-biological-treatment-based-approaches-for-mixed-waste-treatment/">https://zerowasteurope.eu/press-release/new-report-proves-cost-competitiveness-of-material-recovery-and-biological-treatment-based-approaches-for-mixed-waste-treatment/</a> | Index Value/ Not facility Specific Value*                     | 200,000        | \$ 280,000,000 | 2023            | 0.4%             | \$ 281,223,885 | \$ 1,406                    | \$ 4,800,000   | \$ 24             | E76-96 per ton<br>\$83-105 per ton                                     | E232-304 per tpy<br>\$226-334 per tpy                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| Mechanical Biological Treatment of Municipal Solid Waste, UK Department for Environment, Food and Rural Affairs, February 2013.                                                                                                                                                                                                                                 | Index Value/ Not facility Specific Value*                     | 80,000         | \$ 78,550,000  | 2012            | 53.6%            | \$ 125,346,566 | \$ 1,567                    | N/A            | N/A               | N/A                                                                    | N/A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| Mechanical Biological Treatment of Municipal Solid Waste, UK Department for Environment, Food and Rural Affairs, February 2013.                                                                                                                                                                                                                                 | Index Value/ Not facility Specific Value*                     | 225,000        | \$ 196,375,000 | 2012            | 59.6%            | \$ 313,366,415 | \$ 1,393                    | N/A            | N/A               | N/A                                                                    | N/A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| <a href="https://resource-recycling.com/recycling/2017/04/18/ir-exclusive-waste-management-builds-trash-sorting-and-rear-cake-hand/">https://resource-recycling.com/recycling/2017/04/18/ir-exclusive-waste-management-builds-trash-sorting-and-rear-cake-hand/</a>                                                                                             | WM "O-MRF" San Leandro, California                            | 150,000        | \$ 120,000,000 | 2017            | 34.3%            | \$ 161,113,258 | \$ 1,074                    | None available | N/A               | 2017 dollars, Davis Street Transfer Station in San Leandro, California | 100 tpy                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| King County Re+ Plan                                                                                                                                                                                                                                                                                                                                            | Tajiguas Resource Recovery Project, Santa Barbara, California | 250,000        | \$ 140,600,000 | 2021            | 6.2%             | \$ 149,344,583 | \$ 597                      | N/A            | N/A               | N/A                                                                    | In FY 2018/19 a CDP for \$149 million was issued to finance the Tajiguas Resource Recovery Project.<br>The MRF is started in three 8-hour shifts: with primary processing occurring during the early morning and late afternoon shifts and only maintenance and cleaning occurring during the third evening shift. The ADF operates continuously and is started during daytime hours but is un-manned at night.<br><a href="https://www.fws.gov/sites/default/files/documents/Tajiguas%20Draft%20HCP_040722.pdf">https://www.fws.gov/sites/default/files/documents/Tajiguas%20Draft%20HCP_040722.pdf</a> |

\*Reported estimates from industry experts not referencing a particular facility

Summary of Analysis

| US Facilities (Excludes Europe)                                   |  | Low \$                   | 597               | None Available           |     |
|-------------------------------------------------------------------|--|--------------------------|-------------------|--------------------------|-----|
|                                                                   |  | Average \$               | 868               |                          |     |
|                                                                   |  | High \$                  | 1,074             |                          |     |
|                                                                   |  |                          |                   |                          |     |
| All Facilities (Includes Europe)                                  |  | Low \$                   | 372               | Low \$                   | 24  |
|                                                                   |  | Average \$               | 1,068             | Average \$               | 63  |
|                                                                   |  | Average Excluding Low \$ | 1,068             | Average Excluding Low \$ | 102 |
|                                                                   |  | High \$                  | 1,567             | High \$                  | 102 |
|                                                                   |  |                          |                   |                          |     |
| In absence of significant US operation data use US Based MMP + AD |  |                          | MMP x 1.25 \$ 132 |                          |     |
|                                                                   |  |                          | AD \$ 43          |                          |     |
|                                                                   |  |                          | MMP + AD \$ 175   |                          |     |

Anaerobic Digestion Facility Cost Detail

| Sources                                                   | Technology                                                                              | Capacity (tpy) | Capital       | Year in dollars | ENR CCI % change | Capital (\$ 2024) | Capital Costs (\$/tpy) 2024 | O&M (\$/year) | O&M Costs (\$/ton) 2024 | Total         | Notes                                                                                                            | Notes2                                                                      | Notes3               |
|-----------------------------------------------------------|-----------------------------------------------------------------------------------------|----------------|---------------|-----------------|------------------|-------------------|-----------------------------|---------------|-------------------------|---------------|------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------|----------------------|
| City of Tucson Zero waste road map (HDR, May 2023)        | Anaerobic Digestion                                                                     | 70600          | \$ 50,100,000 | 2030            | -20.1%           | \$ 40,053,130     | \$ 567                      | \$ 4,100,000  | \$ 46                   | \$ 7,800,000  | Assumes 23,300 tons of food waste, 42,400 tons of yard waste, 5,000 tons of industrial food waste. Low Estimate. | Annualized capital cost (4%, 20 years) 3,700,000. Total cost is annualized. | \$110/ ton processed |
| City of Tucson Zero waste road map (HDR, May 2023)        | Anaerobic Digestion                                                                     | 70600          | \$ 69,600,000 | 2030            | -20.1%           | \$ 55,642,671     | \$ 788                      | \$ 5,700,000  | \$ 65                   | \$ 10,800,000 | High estimate                                                                                                    | Annualized capital cost (4%, 20 years) 5,100,000. Total cost is annualized  | \$153/ton processed  |
| HDR - Harford WTE Facility Reuse study - Nov 2012         | Anaerobic Digestion                                                                     |                | \$ 11,000,000 | 2019            | 18.7%            | \$ 13,058,644     |                             |               |                         |               | Low cost estimate assuming source separated manure and bedding and food waste.                                   |                                                                             |                      |
| HDR - Harford WTE Facility Reuse study - Nov 2012         | Anaerobic Digestion                                                                     |                | \$ 31,000,000 | 2019            | 18.7%            | \$ 36,801,634     |                             |               |                         |               | Facility receives MSW in addition to source separated organic material.                                          |                                                                             |                      |
| EA Organics Study - Montgomery County 2023                | Dry fermentation Anaerobic Digestion w/ product finishing via tunnel reactor composting | 97,400         | \$ 73,089,000 | 2023            | 0.4%             | \$ 73,408,473     | \$ 754                      | \$ 6,310,000  | \$ 65                   |               | Includes 30% contingency                                                                                         |                                                                             |                      |
| EA Organics Study - Montgomery County 2023                | Dry fermentation Anaerobic Digestion w/ product finishing                               | 97,400         | \$ 56,348,000 | 2023            | 0.4%             | \$ 56,594,298     | \$ 581                      | \$ 5,270,000  | \$ 54                   |               | Includes 30% contingency                                                                                         |                                                                             |                      |
| NREL- Comparison of select food waste utilization options | Anaerobic Digestion w/biogas                                                            | 2,500          | \$ 3,000,000  | 2020            | 15.3%            | \$ 3,457,758      | \$ 1,383                    | \$ 85,000     | \$ 39                   |               |                                                                                                                  |                                                                             |                      |
| NREL- Comparison of select food waste utilization options | Anaerobic Digestion w/biogas                                                            | 5,000          | \$ 4,700,000  | 2020            | 15.3%            | \$ 5,417,154      | \$ 1,083                    | \$ 171,000    | \$ 39                   |               |                                                                                                                  |                                                                             |                      |
| NREL- Comparison of select food waste utilization options | Anaerobic Digestion w/biogas                                                            | 25,000         | \$ 12,300,000 | 2020            | 15.3%            | \$ 14,176,807     | \$ 567                      | \$ 854,000    | \$ 39                   |               |                                                                                                                  |                                                                             |                      |
| NREL- Comparison of select food waste utilization options | Anaerobic Digestion w/biogas                                                            | 50,000         | \$ 18,600,000 | 2020            | 15.3%            | \$ 21,438,098     | \$ 429                      | \$ 1,707,000  | \$ 39                   |               |                                                                                                                  |                                                                             |                      |
| NREL- Comparison of select food waste utilization options | Anaerobic Digestion w/biogas                                                            | 100,000        | \$ 28,200,000 | 2020            | 15.3%            | \$ 32,502,923     | \$ 325                      | \$ 3,415,000  | \$ 39                   |               |                                                                                                                  |                                                                             |                      |
| NREL- Comparison of select food waste utilization options | Anaerobic Digestion w/biogas                                                            | 200,000        | \$ 42,700,000 | 2020            | 15.3%            | \$ 49,215,418     | \$ 246                      | \$ 6,830,000  | \$ 39                   |               |                                                                                                                  |                                                                             |                      |

\* All facilities in this table are based on industry expert reports

Summary of Analyses

| Capital Costs (\$/tpy) 2024    |             | O&M Costs (\$/ton) 2024        |          |
|--------------------------------|-------------|--------------------------------|----------|
| Low                            | \$ 246.08   | Low                            | \$ 39.19 |
| Average                        | \$ 673.62   | Average                        | \$ 43.38 |
| Average Excluding High Outlier | \$ 572.26   | Average Excluding High Outlier | \$ 40.35 |
| High                           | \$ 1,383.10 | High                           | \$ 65.07 |



Construction & Demolition Debris Recycling Facility Cost Detail

| Sources                                                                                                     | Capacity (tpy)  | Capital       | Year in dollars | ENR CCI % change | Capital (\$ 2024) | Capital Costs (\$/tpy) 2024 | O&M (\$/year) | O&M Costs (\$/ton) 2024 | Total (annual cost) | Notes                                                                                      | Notes2                                                                                                | Notes3                                                            | Notes4                                 |
|-------------------------------------------------------------------------------------------------------------|-----------------|---------------|-----------------|------------------|-------------------|-----------------------------|---------------|-------------------------|---------------------|--------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------|----------------------------------------|
| City of Tucson Zero waste road map (HDR, May 2023)                                                          | 33,600          | \$ 1,300,000  | 2030            | -20.1%           | \$ 1,039,303      | \$ 31                       | \$ 800,000    | \$ 19                   | \$ 900,000          | C&D Low tech - includes pad and bunkers Low estimate                                       |                                                                                                       | \$27-37/ton processed                                             | Capital cost annualized (4%, 20 years) |
|                                                                                                             | 33,600          | \$ 1,900,000  | 2030            | -20.1%           | \$ 1,518,981      | \$ 45                       | \$ 1,100,000  | \$ 26                   | \$ 1,200,000        | High estimate                                                                              |                                                                                                       | \$27-37/ton processed                                             | Capital cost annualized (4%, 20 years) |
|                                                                                                             | 47,000          | \$ 4,800,000  | 2030            | -20.1%           | \$ 3,837,426      | \$ 82                       | \$ 1,500,000  | \$ 26                   | \$ 1,800,000        | C&D Medium tech - recycling system sort line Low estimate                                  |                                                                                                       | \$39-55/ton processed                                             | Capital cost annualized (4%, 20 years) |
|                                                                                                             | 47,000          | \$ 6,700,000  | 2030            | -20.1%           | \$ 5,356,407      | \$ 114                      | \$ 2,100,000  | \$ 36                   | \$ 2,600,000        | High estimate                                                                              |                                                                                                       | \$39-55/ton processed                                             | Capital cost annualized (4%, 20 years) |
|                                                                                                             | 67,100          | \$ 27,400,000 | 2030            | -20.1%           | \$ 21,905,304     | \$ 326                      | \$ 3,100,000  | \$ 37                   | \$ 5,100,000        | C&D High tech MRF Low Estimate                                                             | 26 tph /line/shift                                                                                    | \$76-106/ton processed                                            | Capital cost annualized (4%, 20 years) |
|                                                                                                             | 67,100          | \$ 38,100,000 | 2030            | -20.1%           | \$ 30,459,566     | \$ 454                      | \$ 4,300,000  | \$ 51                   | \$ 7,100,000        | High estimate                                                                              | 26 tph /line/shift                                                                                    | \$76-106/ton processed                                            | Capital cost annualized (4%, 20 years) |
| City of Dallas - Consulting services in support of resource recovery planning and implementation (May 2014) | 135000 - 160000 | \$ 11,000,000 | 2009            | 78.6%            | \$ 19,647,765     | \$ 133                      | \$ 1,900,000  | \$ 23                   |                     | Capital cost includes building and site construction, processing equipment, rolling stock. | \$1.7 -2.1 million. O&M costs includes personnel, equipment O&M, utilities, supplies, training, misc. | Includes debt issuance for 20 years and 5% interest rate on debt. | \$10-12 million                        |

Summary of Analysis

| Capital Costs (\$/tpy) 2024 |        | O&M Costs (\$/ton) 2024 |       |
|-----------------------------|--------|-------------------------|-------|
| Low                         | \$ 31  | Low                     | \$ 19 |
| Average                     | \$ 169 | Average                 | \$ 31 |
| High                        | \$ 454 | High                    | \$ 51 |

Composting Facility Cost Detail

| Sources                                                                  | Technology                          | Capacity (tpy) | Capital       | Year in dollars | EMR CCI % change | Capital (\$ 2024) | Capital Costs (\$/tpd) 2024 | Capital Costs (\$/tpy) 2024 | O&M (\$/year) | O&M Costs (\$/ton) 2024 | Total     | Notes                                                                                                                                                                                                                                                                                                                                                      | Notes2                       | Notes3                                                |
|--------------------------------------------------------------------------|-------------------------------------|----------------|---------------|-----------------|------------------|-------------------|-----------------------------|-----------------------------|---------------|-------------------------|-----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|-------------------------------------------------------|
| City of Tucson Zero waste road map (HDR, May 2023)                       | Composting - ASP                    | 150,600        | \$ 30,000,000 | 2030            | -20.05%          | \$ 23,983,910     | \$ 57,969                   | \$ 159                      | \$ 2,700,000  | \$ 14                   |           | Assumes 127,300 tons of yard waste and 23,300 tons of food waste. Capital costs include site preparation, utilities, equipment and construction. It includes contingency, engineering and design, QA/QC and permitting costs. O&M costs include labor, utilities, maintenance, repairs, fuel, ongoing consulting services, insurance, compost lab testing. | Total<br>\$327/ton processed | Annualized capital cost (4%, 20 years)<br>\$2,200,000 |
|                                                                          |                                     |                |               |                 |                  |                   |                             |                             |               |                         |           |                                                                                                                                                                                                                                                                                                                                                            |                              |                                                       |
| City of Tucson Zero waste road map (HDR, May 2023)                       | Composting - ASP                    | 150,600        | \$ 41,600,000 | 2030            | -20.05%          | \$ 33,257,688     | \$ 80,384                   | \$ 221                      | \$ 3,700,000  | \$ 20                   |           | Assumes 127,300 tons of yard waste and 23,300 tons of food waste. Capital costs include site preparation, utilities, equipment and construction. It includes contingency, engineering and design, QA/QC and permitting costs. O&M costs include labor, utilities, maintenance, repairs, fuel, ongoing consulting services, insurance, compost lab testing. | Total<br>\$457/ton processed | Annualized capital cost (4%, 20 years)<br>\$3,100,000 |
|                                                                          |                                     |                |               |                 |                  |                   |                             |                             |               |                         |           |                                                                                                                                                                                                                                                                                                                                                            |                              |                                                       |
| City of Tucson Zero waste road map (HDR, May 2023)                       | Composting - Windrow                | 132,000        | \$ 12,900,000 | 2030            | -20.05%          | \$ 10,313,081     | \$ 28,439                   | \$ 78                       | \$ 1,900,000  | \$ 12                   |           | Assumes 4,700 tons of food waste and 127,300 tons of yard waste.                                                                                                                                                                                                                                                                                           | Total<br>\$211/ton processed | Annualized capital cost (4%, 20 years)<br>\$900,000   |
| City of Tucson Zero waste road map (HDR, May 2023)                       | Composting - Windrow                | 132,000        | \$ 17,900,000 | 2030            | -20.05%          | \$ 14,310,400     | \$ 39,462                   | \$ 108                      | \$ 2,600,000  | \$ 16                   |           | Assumes 4,700 tons of food waste and 127,300 tons of yard waste.                                                                                                                                                                                                                                                                                           | Total<br>\$307/ton processed | Annualized capital cost (4%, 20 years)<br>\$1,300,000 |
| EA Organics Study - Montgomery County 2023                               | Composting - ASP                    | 97,400         | \$ 16,318,000 | 2023            | 0.44%            | \$ 16,389,326     | \$ 61,250                   | \$ 168                      | \$ 3,470,000  | \$ 36                   |           | Includes 30% contingency                                                                                                                                                                                                                                                                                                                                   |                              |                                                       |
| EA Organics Study - Montgomery County 2023                               | In vessel tunnel reactor composting | 97,400         | \$ 42,315,000 | 2023            | 0.44%            | \$ 42,499,960     | \$ 158,829                  | \$ 436                      | \$ 4,640,000  | \$ 48                   |           | Includes 30% contingency                                                                                                                                                                                                                                                                                                                                   |                              |                                                       |
| EA Organics Study - Montgomery County 2023                               | Agitated Bed Composting             | 97,400         | \$ 71,315,000 | 2023            | 0.44%            | \$ 71,626,719     | \$ 267,681                  | \$ 735                      | \$ 3,830,000  | \$ 39                   |           | Includes 30% contingency                                                                                                                                                                                                                                                                                                                                   |                              |                                                       |
| https://insights-engineered.org/solution-database/centralized-composting | All                                 | 40,000         | \$5-9 million | 2023            | 0.44%            |                   |                             |                             | \$ 900,000    | \$ 23                   | \$203/ton | \$17-28/ton                                                                                                                                                                                                                                                                                                                                                |                              |                                                       |
|                                                                          | Composting - ASP                    | 1,800          | \$ 1,700,000  | 2020            | 15.26%           | \$ 1,959,396      | \$ 396,233                  | \$ 1,089                    | \$ 247,000    | \$ 158                  |           |                                                                                                                                                                                                                                                                                                                                                            |                              |                                                       |
| NREL: Comparison of select food waste utilization options                | Composting - ASP                    | 40,000         | \$ 8,900,000  | 2020            | 15.26%           | \$ 10,256,015     | \$ 93,348                   | \$ 256                      | \$ 1,000,000  | \$ 29                   |           |                                                                                                                                                                                                                                                                                                                                                            |                              |                                                       |
|                                                                          | Composting - ASP                    | 180,000        | \$ 25,000,000 | 2020            | 15.26%           | \$ 28,814,648     | \$ 58,270                   | \$ 160                      |               |                         |           |                                                                                                                                                                                                                                                                                                                                                            |                              |                                                       |
|                                                                          | Composting - Windrow                | 30,000         | \$ 4,300,000  | 2020            | 15.26%           | \$ 4,956,119      | \$ 60,134                   | \$ 165                      | \$ 601,000    | \$ 23                   |           | \$457,000-765,000                                                                                                                                                                                                                                                                                                                                          |                              |                                                       |
|                                                                          | Composting - Windrow                | 25,000         |               | 2020            | 15.26%           |                   |                             |                             | \$ 362,000    | \$ 17                   |           |                                                                                                                                                                                                                                                                                                                                                            |                              |                                                       |

Summary of Analysis

Organics Composting Expansion (Static Aerated Windrow w Membrane Cover)

| Capital Costs (\$/tpy) 2024 |                                |        | O&M Costs (\$/ton) 2024 |                                |       |
|-----------------------------|--------------------------------|--------|-------------------------|--------------------------------|-------|
|                             | Low                            | \$ 160 |                         | Low                            | \$ 20 |
|                             | Average                        | \$ 379 |                         | Average                        | \$ 61 |
|                             | Average Excluding High Outlier | \$ 201 |                         | Average Excluding High Outlier | \$ 28 |
|                             | High                           | \$ 256 |                         | High                           | \$ 36 |

## **Appendix B: Additional Detail on Evaluation Model**

## Montgomery County MSW Management System Alternatives Analysis

### Summary of Ranked Alternatives

| Alternative                                                                   | Rank | Points | Cost-of-Service |              | Carbon Footprint | Diversion |
|-------------------------------------------------------------------------------|------|--------|-----------------|--------------|------------------|-----------|
|                                                                               |      |        | NPV (\$/Ton)    | CAPEX (\$MM) |                  |           |
| Alternative 1B MRBT-Medium                                                    | 1    | 91.6   | 189             | 810          | -0.72            | 45        |
| Alternative 2A Long Haul MSW to Out-of-County MSWLF from RRF                  | 3    | 59.9   | 154             | 216          | -0.03            | 0         |
| Baseline for Comparison - Retrofit/Repair and/or Rehabilitation of County RRF | 2    | 63.5   | 124             | 356          | 0.00             | 4         |

#### NOTES:

1. NPV (\$/Ton) Includes Preliminary Estimated Cost of Potential Health & Environmental Impacts which are Subject to On-Going E
2. Carbon Footprint Expressed as Difference in MTCO2e/Ton MSW Processed when Compared to Baseline
3. Diversion of Waste from Disposal is Represented as Percentage of Tipping Floor and/or MSW Delivered to RRF.

# Montgomery County Municipal Solid Waste Management System Alternatives Analysis

Evaluation Model  
Updated Weighted Ranking Differential **10%**

## Legend

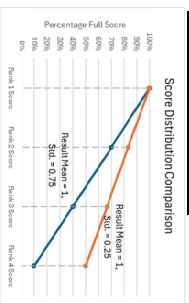
|                          |
|--------------------------|
| Copied from Data Results |
| Input Parameter          |
| Model Output             |

| Evaluation Criteria |                                                                                        |                                                                  | Performance Metric                             |                         |                              | MSW Management System Alternatives |               |                             |      |       |        |      |       |                                                              |      |       |        |      |       |                                                                               |  |  |  |  |  |
|---------------------|----------------------------------------------------------------------------------------|------------------------------------------------------------------|------------------------------------------------|-------------------------|------------------------------|------------------------------------|---------------|-----------------------------|------|-------|--------|------|-------|--------------------------------------------------------------|------|-------|--------|------|-------|-------------------------------------------------------------------------------|--|--|--|--|--|
| No.                 | Description                                                                            | Measurement                                                      | Rank                                           | Unit                    | Threshold Score per Criteria | Weighting Criteria                 | Maximum Score | Alternative 1B MRBT- Medium |      |       |        |      |       | Alternative 2A Long Haul MSW to Out-of-County MSWLF from RRF |      |       |        |      |       | Baseline for Comparison - Retrofit/Repair and/or Rehabilitation of County RRF |  |  |  |  |  |
|                     |                                                                                        |                                                                  |                                                |                         |                              |                                    |               | Result                      | Rank | Score | Result | Rank | Score | Result                                                       | Rank | Score | Result | Rank | Score |                                                                               |  |  |  |  |  |
| 1                   | Lifecycle Cost of Service (30 Years) Including Monetized Cost of Potential H&E Impacts | Net Present Value                                                | 1 (Least Expensive)<br>2<br>3 (Most Expensive) | \$/Ton of MSW Processed | 33<br>29<br>25               | 0.33                               | 33            | 189                         | 3    | 25    | 154    | 2    | 29    | 124                                                          | 1    | 33    |        |      |       |                                                                               |  |  |  |  |  |
| 2                   | Waste Diversion                                                                        | Diversion of MSW from Disposal                                   | 1 (Most Diversion)<br>2<br>3 (Least Diversion) | Percentage              | 33<br>21<br>9                | 0.33                               | 33            | 45                          | 1    | 33    | 0      | 3    | 9     | 4                                                            | 2    | 21    |        |      |       |                                                                               |  |  |  |  |  |
| 3                   | GHG Emissions                                                                          | Difference in MTCO2e/Ton MSW Processed when Compared to Baseline | 1 (Least Emission)<br>2<br>3 (Most Emission)   | MTCO2e/Ton              | 34<br>22<br>9                | 0.34                               | 34            | -0.72                       | 1    | 34    | -0.03  | 2    | 22    | 0                                                            | 3    | 9     |        |      |       |                                                                               |  |  |  |  |  |
|                     |                                                                                        |                                                                  |                                                |                         | Total Points                 |                                    | 100           |                             |      | 91.6  |        |      | 59.9  |                                                              |      | 63.5  |        |      |       |                                                                               |  |  |  |  |  |
|                     |                                                                                        |                                                                  |                                                |                         |                              |                                    | Rank          | 1                           |      |       |        | 3    |       |                                                              |      | 2     |        |      |       |                                                                               |  |  |  |  |  |

## NOTES:

1. Lifecycle Cost of Service: How expensive is this technology? Does the cost change based on contract terms? What drives the cost of the technology?
2. Waste Diversion: How does this technology contribute to Montgomery County's Zero Waste Goals? Diversion is calculated as total tonnage divertable based on the technology added to the current diversion of the County.
3. GHG Emissions: How does this technology contribute to Montgomery County's GHG emission reduction goals? The County has a stated commitment to reducing GHG emissions with a goal of reducing GHG emissions by 80 percent by 2027 and 100 percent by 2035. The EPA WARM Tool is suggested to calculation the Metric Ton of CO<sub>2</sub> Equivalency per Ton of MSW Processed.

## Threshold Score per Criteria



For each criterion, the threshold score distribution aligns with the result distribution (as shown in Column K).

The spacing of score intervals depends on the spread of the results:

Wider result distributions (e.g., results with a larger standard deviation) lead to larger score intervals. This is illustrated in the graphic: the blue line, representing results with a larger standard deviation, has wider score intervals.

Key scoring principles:

The top-ranked proposal always receives the maximum score.

Proposals with results significantly below the average receive a score of 0.

The score distribution method employed here ensures that both the ranking and the quality of the results are accurately and fairly represented in the final scores.

When the proposals are of relatively similar quality, this is reflected by closer scores across the board, creating a relatively even playing field. Conversely, when there is greater variability in the quality of the proposals, the score distribution reflects this by assigning wider gaps between scores. This method provides a balanced approach to scoring, rewarding both relative performance and absolute quality.

## Results Differential (Cell D7)

The differential in Cell D7 represents the percentage difference between proposals' results that the ranking model considers acceptable. Proposal results that differ by less than the differential are treated as similar.

The formula evaluates the original results by comparing them against one another.

For proposals with similar original results (i.e., differences below the differential threshold), the formula assigns the average of the two results to both proposals. This effectively gives them the same rank, ensuring that minor differences in results do not disproportionately impact the rankings.

This approach promotes fairness by recognizing and grouping proposals with comparable performance.

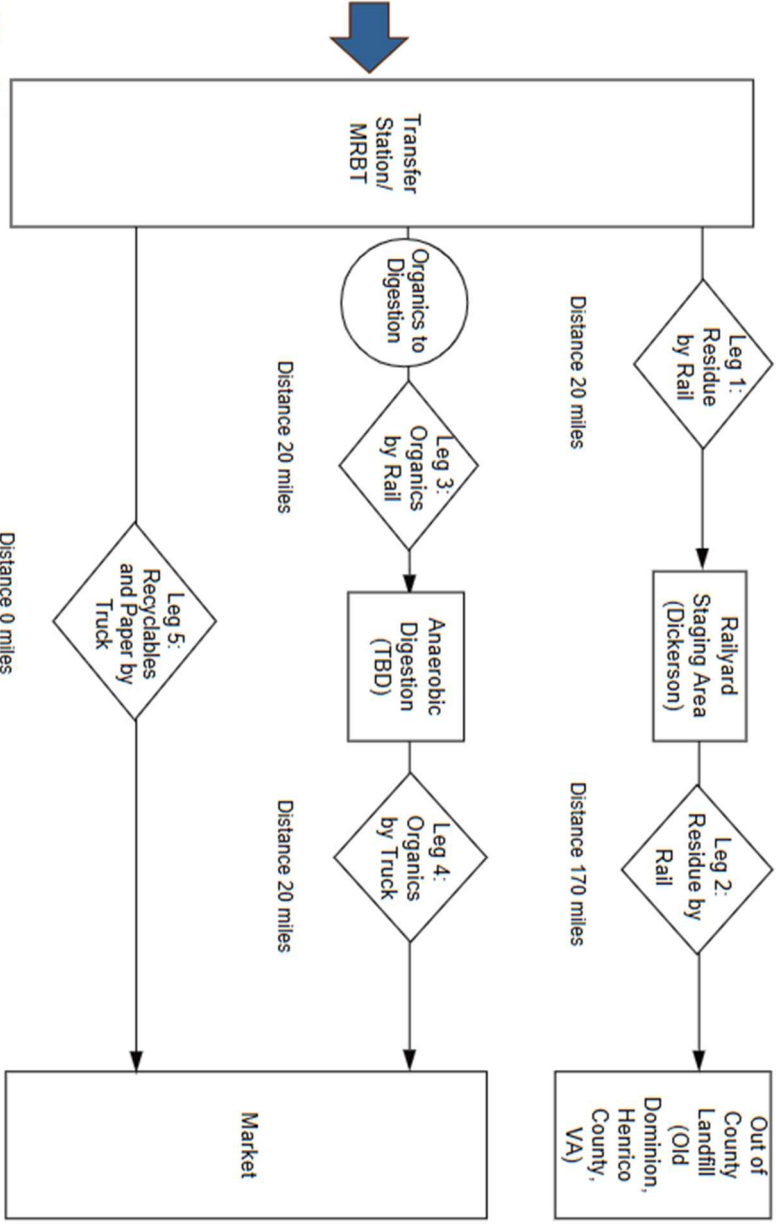


## **Appendix C: Additional Detail on WARM Analysis**

| Alternative <sup>1</sup>                                    | GHG Emissions per Ton MSW<br>(MTCO <sub>2</sub> E/ton) <sup>2</sup> | Annual GHG Emissions<br>(MTCO <sub>2</sub> E) <sup>2</sup> | Annual Avoided Emissions,<br>Passenger Vehicles Eliminated <sup>3</sup> |
|-------------------------------------------------------------|---------------------------------------------------------------------|------------------------------------------------------------|-------------------------------------------------------------------------|
| Alternative 1 (Original) - MRBT 52% Diversion <sup>4</sup>  | (0.78)                                                              | (469,389)                                                  | 109,368                                                                 |
| Alternative 1A - 30% Diversion <sup>4</sup>                 | (0.49)                                                              | (294,037)                                                  | 68,511                                                                  |
| Alternative 1B - 60% Diversion <sup>4</sup>                 | (0.92)                                                              | (550,851)                                                  | 128,348                                                                 |
| Alternative 1C - 45% Diversion <sup>4</sup>                 | (0.70)                                                              | (418,560)                                                  | 97,524                                                                  |
| Alternative - 2A/B Long-Haul by Rail                        | (0.03)                                                              | (15,027)                                                   | 3,501                                                                   |
| Alternative 2C - Long-Haul Tractor-Trailer                  | (0.005)                                                             | (3,273)                                                    | 763                                                                     |
| Alternative 2D - Hybrid Transportation (65% Rail/35% Truck) | (0.02)                                                              | (10,953)                                                   | 2,552                                                                   |

1. Alternatives were compared to Alternative 1 (MCRRF Upgrade Long Haul MWC Ash by Rail to Out-of County Landfill) in WARM.
2. Assumes 600,000 tons MSW per year.
3. This calculation is performed by WARM according to USEPA passenger vehicle emissions assumptions (<https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator#results> (Accessed February 2025)).
4. Assumes that anaerobic digestate is cured and used for land application.
5. Alternative 1C (MRBT 45% Diversion) was interpolated from a curve fit using the 30%, 52%, and 60% scenarios.

Figure 1. Calculation of the effective WARM mileage to account for rail transport was performed for Legs 1 and 2 (underlined in red). This example is for Alternative 1C - MRBT with 45% Diversion, though other alternatives used the same approach.



**Notes and Abbreviations**  
D = Distance (miles)  
T = Tonnage  
NA = Not Applicable  
VTM = Vehicle Ton-Mile  
MSW = Municipal Solid Waste  
CF = Transportation Emissions Factor (Rail or Truck): 0.13524 for rail, 1 for diesel truck

### Accounting for Rail Transportation in WARM: Corrected Mileage Methodology

WARM allows users to enter transport distances for different waste management endpoints. However, WARM assumes that all transportation is conducted via diesel trucking. Because the alternatives described above utilize a combination of diesel trucking and rail to transport MSW, a correction factor approach was used to account for the different emissions between these two hauling approaches. The correction factor was calculated by comparing the ratio of the average GHG emissions per vehicle type (e.g. diesel truck and rail) per ton per mile from several academic, industry, and government emissions studies. This factor was multiplied by the distance to the MSW or residual waste endpoint to calculate a representative effective rail mileage which was input into WARM.

Ratios of rail to truck emissions were determined from US DOT and Texas A&M studies (see attached email). The ratios were averaged to create a single correction factor for rail using the following process:

$$\frac{MT\ GHG\ Emissions\ per\ rail\ ton - mile}{MT\ GHG\ Emissions\ per\ truck\ ton - mile} = 0.13524$$

This correction factor was used to adjust the mileage for shipments taken by rail. The mileage used for input into the WARM model is as follows:

- *Landfill: 190 miles by rail × 0.13524 = 25.70 miles*
- *Anaerobic Digestion: (20 miles by rail × 0.13524) + (20 miles by truck) = 22.70 miles*
- *Recyclables = 0 miles*

**Interpolation for Scenario 1C (45%) using 1A (30%) and 1B (60%) and  
Original (52%)**

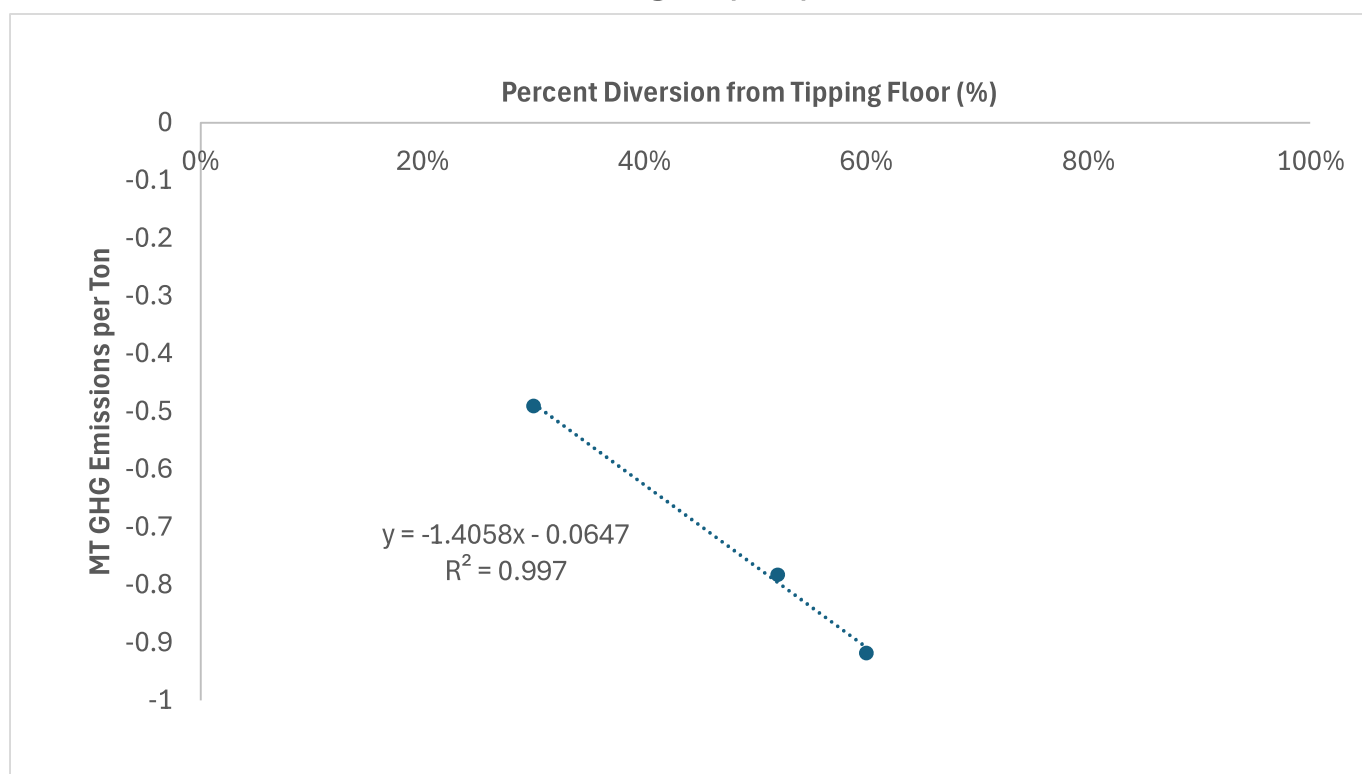


Table 1  
U.S. EPA WARM Model Results  
Comparison of LCA GHG Emissions Between RRF and MRBT Alternatives - 52% Diversion  
Municipal Solid Waste Management System Alternatives Analysis  
Montgomery County, Maryland

GHG Emissions Analysis -- Summary Report

Version 16

GHG Emissions Waste Management Analysis for

Prepared By: Arcadis

Project Period for this Analysis: 01/00/00 to 01/00/00

Note: If you wish to save these results, rename this file (e.g., WARM-AMT) and save it. Then the "Analysis Inputs" sheet of the "WARM" file will be blank when you are ready to make another model run.

GHG Emissions from Baseline Waste Management (MTCO<sub>2</sub>E):

0.01

| Material                            | Tons Recycled* | Tons Landfilled | Tons Combusted | Tons Composted | Tons Anaerobically Digested | Total MTCO <sub>2</sub> E |
|-------------------------------------|----------------|-----------------|----------------|----------------|-----------------------------|---------------------------|
| Corrugated Containers               | -              | -               | 0.05           | NA             | NA                          | (0.02)                    |
| Magnetizable-class mail             | -              | -               | 0.01           | NA             | NA                          | (0.00)                    |
| Office Paper                        | -              | -               | 0.02           | NA             | NA                          | (0.01)                    |
| Mixed Paper (general)               | -              | -               | 0.11           | NA             | NA                          | (0.05)                    |
| Mixed Paper (primarily residential) | -              | -               | 0.03           | NA             | NA                          | (0.01)                    |
| Food Waste                          | NA             | -               | 0.17           | -              | -                           | (0.02)                    |
| Grass                               | NA             | -               | 0.02           | -              | -                           | (0.00)                    |
| Leaves                              | NA             | -               | 0.02           | -              | -                           | (0.00)                    |
| HDPE                                | -              | -               | 0.01           | NA             | NA                          | 0.01                      |
| LDPE                                | NA             | -               | 0.08           | NA             | NA                          | 0.10                      |
| PET                                 | -              | -               | 0.02           | NA             | NA                          | 0.03                      |
| PS                                  | NA             | -               | 0.01           | NA             | NA                          | 0.02                      |
| Mixed Plastics                      | -              | -               | 0.06           | NA             | NA                          | 0.07                      |
| Aluminum Cans                       | -              | -               | 0.02           | NA             | NA                          | 0.01                      |
| Aluminum Cans                       | -              | -               | 0.00           | NA             | NA                          | 0.00                      |
| Aluminum Ingot                      | -              | -               | 0.01           | NA             | NA                          | (0.00)                    |
| Steel Cans                          | -              | -               | 0.02           | NA             | NA                          | (0.03)                    |
| Glass                               | -              | -               | 0.03           | NA             | NA                          | 0.00                      |
| Carpet                              | -              | 0.03            | -              | NA             | NA                          | 0.00                      |
| Concrete                            | -              | 0.01            | -              | NA             | NA                          | 0.00                      |
| Dimensional Lumber*                 | -              | -               | 0.07           | NA             | NA                          | (0.04)                    |
| Drywall                             | -              | 0.01            | -              | NA             | NA                          | (0.00)                    |
| Tires                               | -              | -               | 0.00           | NA             | NA                          | 0.00                      |
| Mixed Recyclables                   | -              | -               | 0.03           | NA             | NA                          | (0.01)                    |
| Mixed Organics                      | NA             | -               | 0.17           | -              | -                           | (0.02)                    |
|                                     |                |                 |                |                |                             | 0                         |

GHG Emissions from Alternative Waste Management Scenario (MTCO<sub>2</sub>E):

(0.77)

| Material                            | Tons Source Reduced | Tons Recycled* | Tons Landfilled | Tons Combusted | Tons Composted | Tons Anaerobically Digested | Total MTCO <sub>2</sub> E |
|-------------------------------------|---------------------|----------------|-----------------|----------------|----------------|-----------------------------|---------------------------|
| Corrugated Containers               | -                   | 0.03           | 0.01            | -              | NA             | NA                          | (0.11)                    |
| Magnetizable-class mail             | -                   | 0.00           | 0.00            | -              | NA             | NA                          | (0.00)                    |
| Office Paper                        | -                   | 0.01           | 0.01            | -              | NA             | NA                          | (0.02)                    |
| Mixed Paper (general)               | -                   | 0.08           | 0.03            | -              | NA             | NA                          | (0.29)                    |
| Mixed Paper (primarily residential) | -                   | 0.02           | 0.01            | -              | NA             | NA                          | (0.07)                    |
| Food Waste                          | -                   | NA             | 0.05            | -              | -              | 0.12                        | 0.02                      |
| Grass                               | NA                  | NA             | 0.01            | -              | -              | 0.00                        | 0.00                      |
| Leaves                              | NA                  | NA             | 0.01            | -              | -              | 0.01                        | 0.00                      |
| HDPE                                | -                   | 0.01           | 0.00            | -              | NA             | NA                          | (0.00)                    |
| LDPE                                | -                   | NA             | 0.08            | -              | NA             | NA                          | 0.00                      |
| PET                                 | -                   | 0.02           | 0.01            | -              | NA             | NA                          | (0.02)                    |
| PS                                  | -                   | NA             | 0.01            | -              | NA             | NA                          | 0.00                      |
| Mixed Plastics                      | -                   | 0.04           | 0.02            | -              | NA             | NA                          | (0.04)                    |
| Aluminum Cans                       | -                   | -              | 0.02            | -              | NA             | NA                          | (0.01)                    |
| Aluminum Cans                       | -                   | -              | 0.00            | -              | NA             | NA                          | (0.02)                    |
| Aluminum Ingot                      | -                   | 0.00           | 0.00            | -              | NA             | NA                          | (0.03)                    |
| Steel Cans                          | -                   | 0.02           | 0.00            | -              | NA             | NA                          | (0.03)                    |
| Glass                               | -                   | -              | 0.03            | -              | NA             | NA                          | (0.00)                    |
| Carpet                              | -                   | -              | 0.03            | -              | NA             | NA                          | 0.00                      |
| Concrete                            | NA                  | -              | 0.01            | -              | NA             | NA                          | 0.00                      |
| Dimensional Lumber*                 | -                   | -              | 0.07            | -              | NA             | NA                          | (0.06)                    |
| Drywall                             | -                   | -              | 0.01            | NA             | NA             | NA                          | (0.00)                    |
| Tires                               | -                   | -              | 0.00            | -              | NA             | NA                          | 0.00                      |
| Mixed Recyclables                   | NA                  | 0.02           | 0.01            | -              | NA             | NA                          | (0.06)                    |
| Mixed Organics                      | NA                  | NA             | 0.05            | -              | -              | 0.12                        | (0.00)                    |
|                                     |                     |                |                 |                |                |                             | 0                         |

| Change (Alt. - Base) MTCO <sub>2</sub> E |
|------------------------------------------|
| (0.08)                                   |
| (0.01)                                   |
| (0.02)                                   |
| (0.24)                                   |
| (0.06)                                   |
| 0.04                                     |
| 0.00                                     |
| (0.00)                                   |
| (0.02)                                   |
| (0.10)                                   |
| (0.05)                                   |
| (0.02)                                   |
| 0.00                                     |
| (0.03)                                   |
| 0.00                                     |
| (0.00)                                   |
| (0.05)                                   |
| 0.02                                     |
| 0.00                                     |

**Table 1**  
**U.S. EPA WARM Model Results**  
**Comparison of LCA GHG Emissions Between RRF and MRBT Alternatives - 52% Diversion**  
**Municipal Solid Waste Management System Alternatives Analysis**  
**Montgomery County, Maryland**

| GHG Emissions from Baseline Waste Management (MTCO <sub>2</sub> E):                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                |                 |                |                |                                |                           | 0.01 | GHG Emissions from Alternative Waste Management Scenario (MTCO <sub>2</sub> E): |                     |                |                 |                |                |                                | (0.77)                    | Change<br>(Δ) Baseline<br>MTCO <sub>2</sub> E |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|-----------------|----------------|----------------|--------------------------------|---------------------------|------|---------------------------------------------------------------------------------|---------------------|----------------|-----------------|----------------|----------------|--------------------------------|---------------------------|-----------------------------------------------|
| Material                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Tons Recycled* | Tons Landfilled | Tons Combusted | Tons Composted | Tons Anaerobically<br>Digested | Total MTCO <sub>2</sub> E |      | Material                                                                        | Tons Source Reduced | Tons Recycled* | Tons Landfilled | Tons Combusted | Tons Composted | Tons Anaerobically<br>Digested | Total MTCO <sub>2</sub> E |                                               |
| Total Change in GHG Emissions (MTCO <sub>2</sub> E):                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                |                 |                |                |                                |                           |      |                                                                                 |                     |                |                 |                |                |                                |                           | (0.78)                                        |
| <p><i>Note: a negative value (i.e., a value in parentheses) indicates an emission reduction; a positive value indicates an emission increase.</i></p> <p>*Wood Flooring and Dimensional Lumber model reuse under the recycling management pathway.</p> <p>a) For explanation of methodology, see the EPA WARM Documentation:<br/><a href="#">Documentation Chapters for Greenhouse Gas Emission and Energy Factors Used in the Waste Reduction Model (WARM)</a><br/>-- available on the Internet at <a href="https://www.epa.gov/warm/documentation-chapters-greenhouse-gas-emission-and-energy-factors-used-waste-reduction-model">https://www.epa.gov/warm/documentation-chapters-greenhouse-gas-emission-and-energy-factors-used-waste-reduction-model</a></p> <p>b) Emissions estimates provided by this model are intended to support voluntary GHG measurement and reporting initiatives.</p> <p>c) The GHG emissions results estimated in WARM indicate the full life-cycle benefits waste management alternatives. Due to the timing of the GHG emissions from the waste management pathways, (e.g., avoided landfilling and increased recycling), the actual GHG implications may accrue over the long-term. Therefore, one should not interpret the GHG emissions implications as occurring all in one year, but rather through time.</p> |                |                 |                |                |                                |                           |      |                                                                                 |                     |                |                 |                |                |                                |                           |                                               |
| <p>This is equivalent to...</p> <p>Removing annual emissions from</p> <p>0 Passenger Vehicles</p> <p>88 Gallons of Gasoline</p> <p>33 Cylinders of Propane Used for Home Barbeques</p> <p>0.000000% Annual CO<sub>2</sub> emissions from the U.S. transportation sector</p> <p>0.000000% Annual CO<sub>2</sub> emissions from the U.S. electricity sector</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                |                 |                |                |                                |                           |      |                                                                                 |                     |                |                 |                |                |                                |                           |                                               |

Table 1  
U.S. EPA WARM Model Results  
Comparison of LCA GHG Emissions Between RRF and MRBT Alternatives - 1A 30% Diversion  
Municipal Solid Waste Management System Alternatives Analysis  
Montgomery County, Maryland

GHG Emissions Analysis -- Summary Report

Version 16

GHG Emissions Waste Management Analysis for

Prepared By: Arcadis

Project Period for this Analysis: 01/00/00 to 01/00/00

Note: If you wish to save these results, rename this file (e.g., WARM-AMT) and save it. Then the "Analysis Inputs" sheet of the "WARM" file will be blank when you are ready to make another model run.

GHG Emissions from Baseline Waste Management (MTCO<sub>2</sub>E):

0.01

| Material                            | Tons Recycled* | Tons Landfilled | Tons Combusted | Tons Composted | Tons Anaerobically Digested | Total MTCO <sub>2</sub> E |
|-------------------------------------|----------------|-----------------|----------------|----------------|-----------------------------|---------------------------|
| Corrugated Containers               | -              | -               | 0.05           | NA             | NA                          | (0.02)                    |
| Magnetizable-class mail             | -              | -               | 0.01           | NA             | NA                          | (0.00)                    |
| Office Paper                        | -              | -               | 0.02           | NA             | NA                          | (0.01)                    |
| Mixed Paper (general)               | -              | -               | 0.11           | NA             | NA                          | (0.05)                    |
| Mixed Paper (primarily residential) | -              | -               | 0.03           | NA             | NA                          | (0.01)                    |
| Food Waste                          | NA             | -               | 0.17           | -              | -                           | (0.02)                    |
| Grass                               | NA             | -               | 0.02           | -              | -                           | (0.00)                    |
| Leaves                              | NA             | -               | 0.02           | -              | -                           | (0.00)                    |
| HDPE                                | -              | -               | 0.01           | NA             | NA                          | 0.01                      |
| LDPE                                | NA             | -               | 0.08           | NA             | NA                          | 0.10                      |
| PET                                 | -              | -               | 0.02           | NA             | NA                          | 0.03                      |
| PS                                  | NA             | -               | 0.01           | NA             | NA                          | 0.02                      |
| Mixed Plastics                      | -              | -               | 0.06           | NA             | NA                          | 0.07                      |
| Aluminum Cans                       | -              | -               | 0.02           | NA             | NA                          | 0.01                      |
| Aluminum Cans                       | -              | -               | 0.00           | NA             | NA                          | 0.00                      |
| Aluminum Ingot                      | -              | -               | 0.01           | NA             | NA                          | (0.00)                    |
| Steel Cans                          | -              | -               | 0.02           | NA             | NA                          | (0.03)                    |
| Glass                               | -              | -               | 0.03           | NA             | NA                          | 0.00                      |
| Carpet                              | -              | 0.03            | -              | NA             | NA                          | 0.00                      |
| Concrete                            | -              | 0.01            | -              | NA             | NA                          | 0.00                      |
| Dimensional Lumber*                 | -              | -               | 0.07           | NA             | NA                          | (0.04)                    |
| Drywall                             | -              | 0.01            | -              | NA             | NA                          | (0.00)                    |
| Tires                               | -              | -               | 0.00           | NA             | NA                          | 0.00                      |
| Mixed Recyclables                   | -              | -               | 0.03           | NA             | NA                          | (0.01)                    |
| Mixed Organics                      | NA             | -               | 0.17           | -              | -                           | (0.02)                    |
|                                     |                |                 |                |                |                             | 0                         |

GHG Emissions from Alternative Waste Management Scenario (MTCO<sub>2</sub>E):

(0.48)

| Material                            | Tons Source Reduced | Tons Recycled* | Tons Landfilled | Tons Combusted | Tons Composted | Tons Anaerobically Digested | Total MTCO <sub>2</sub> E |
|-------------------------------------|---------------------|----------------|-----------------|----------------|----------------|-----------------------------|---------------------------|
| Corrugated Containers               | -                   | 0.02           | 0.03            | -              | NA             | NA                          | (0.05)                    |
| Magnetizable-class mail             | -                   | 0.00           | 0.00            | -              | NA             | NA                          | (0.01)                    |
| Office Paper                        | -                   | 0.01           | 0.01            | -              | NA             | NA                          | (0.01)                    |
| Mixed Paper (general)               | -                   | 0.05           | 0.07            | -              | NA             | NA                          | (0.17)                    |
| Mixed Paper (primarily residential) | -                   | 0.01           | 0.02            | -              | NA             | NA                          | (0.04)                    |
| Food Waste                          | -                   | NA             | 0.10            | -              | -              | 0.07                        | 0.04                      |
| Grass                               | NA                  | NA             | 0.01            | -              | -              | 0.01                        | 0.00                      |
| Leaves                              | NA                  | NA             | 0.01            | -              | -              | 0.01                        | (0.01)                    |
| HDPE                                | -                   | 0.00           | 0.01            | -              | NA             | NA                          | (0.00)                    |
| LDPE                                | -                   | NA             | 0.08            | -              | NA             | NA                          | 0.00                      |
| PET                                 | -                   | 0.01           | 0.01            | -              | NA             | NA                          | (0.04)                    |
| PS                                  | -                   | NA             | 0.01            | -              | NA             | NA                          | 0.00                      |
| Mixed Plastics                      | -                   | 0.02           | 0.03            | -              | NA             | NA                          | (0.02)                    |
| Aluminum Cans                       | -                   | -              | 0.02            | -              | NA             | NA                          | (0.01)                    |
| Aluminum Cans                       | -                   | 0.00           | 0.00            | -              | NA             | NA                          | (0.02)                    |
| Aluminum Ingot                      | -                   | 0.00           | 0.00            | -              | NA             | NA                          | (0.03)                    |
| Steel Cans                          | -                   | 0.02           | 0.00            | -              | NA             | NA                          | (0.03)                    |
| Glass                               | -                   | -              | 0.03            | -              | NA             | NA                          | (0.00)                    |
| Carpet                              | -                   | -              | 0.03            | -              | NA             | NA                          | 0.00                      |
| Concrete                            | NA                  | -              | 0.01            | -              | NA             | NA                          | 0.00                      |
| Dimensional Lumber*                 | -                   | -              | 0.07            | -              | NA             | NA                          | (0.05)                    |
| Drywall                             | -                   | -              | 0.01            | NA             | NA             | NA                          | 0.00                      |
| Tires                               | -                   | -              | 0.00            | -              | NA             | NA                          | (0.00)                    |
| Mixed Recyclables                   | NA                  | 0.01           | 0.02            | -              | NA             | NA                          | (0.04)                    |
| Mixed Organics                      | NA                  | NA             | 0.10            | -              | -              | 0.07                        | 0.01                      |
|                                     |                     |                |                 |                |                |                             | 0                         |

| Change (Alt. - Base) MTCO <sub>2</sub> E |
|------------------------------------------|
| (0.04)                                   |
| (0.01)                                   |
| (0.00)                                   |
| (0.12)                                   |
| (0.03)                                   |
| 0.06                                     |
| 0.00                                     |
| (0.01)                                   |
| (0.00)                                   |
| (0.10)                                   |
| (0.04)                                   |
| (0.02)                                   |
| (0.01)                                   |
| (0.02)                                   |
| (0.03)                                   |
| (0.03)                                   |
| (0.00)                                   |
| (0.00)                                   |
| 0.00                                     |
| 0.00                                     |
| (0.05)                                   |
| 0.00                                     |
| (0.00)                                   |
| (0.00)                                   |
| (0.03)                                   |
| 0.00                                     |



**Table 1**  
**U.S. EPA WARM Model Results**  
**Comparison of LCA GHG Emissions Between RRF and MRBT Alternatives - 1A 30% Diversion**  
**Municipal Solid Waste Management System Alternatives Analysis**  
**Montgomery County, Maryland**

| GHG Emissions from Baseline Waste Management (MTCO <sub>2</sub> E):                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                |                 |                |                |                                |                           | 0.01 | GHG Emissions from Alternative Waste Management Scenario (MTCO <sub>2</sub> E): |                     |                |                 |                |                |                                | (0.48)                    | Change<br>(Addition)<br>MTCO <sub>2</sub> E |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|-----------------|----------------|----------------|--------------------------------|---------------------------|------|---------------------------------------------------------------------------------|---------------------|----------------|-----------------|----------------|----------------|--------------------------------|---------------------------|---------------------------------------------|
| Material                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Tons Recycled* | Tons Landfilled | Tons Combusted | Tons Composted | Tons Anaerobically<br>Digested | Total MTCO <sub>2</sub> E |      | Material                                                                        | Tons Source Reduced | Tons Recycled* | Tons Landfilled | Tons Combusted | Tons Composted | Tons Anaerobically<br>Digested | Total MTCO <sub>2</sub> E |                                             |
| Total Change in GHG Emissions (MTCO <sub>2</sub> E):                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                |                 |                |                |                                |                           |      |                                                                                 |                     |                |                 |                |                |                                |                           | (0.49)                                      |
| <p><i>Note: a negative value (i.e., a value in parentheses) indicates an emission reduction; a positive value indicates an emission increase.</i></p> <p>Wood Flooring and Dimensional Lumber model reuse under the recycling management pathway.</p> <p>a) For explanation of methodology, see the EPA WARM Documentation:<br/><a href="#">Documentation Chapters for Greenhouse Gas Emission and Energy Factors Used in the Waste Reduction Model (WARM)</a><br/>-- available on the Internet at <a href="https://www.epa.gov/warm/documentation-chapters-greenhouse-gas-emission-and-energy-factors-used-waste-reduction-model">https://www.epa.gov/warm/documentation-chapters-greenhouse-gas-emission-and-energy-factors-used-waste-reduction-model</a></p> <p>b) Emissions estimates provided by this model are intended to support voluntary GHG measurement and reporting initiatives.</p> <p>c) The GHG emissions results estimated in WARM indicate the full life-cycle benefits waste management alternatives. Due to the timing of the GHG emissions from the waste management pathways, (e.g., avoided landfilling and increased recycling), the actual GHG implications may accrue over the long-term. Therefore, one should not interpret the GHG emissions implications as occurring all in one year, but rather through time.</p> |                |                 |                |                |                                |                           |      |                                                                                 |                     |                |                 |                |                |                                |                           |                                             |
| <p>This is equivalent to...</p> <p>Removing annual emissions from</p> <p>0 Passenger Vehicles</p> <p>Conserving 55 Gallons of Gasoline</p> <p>Conserving 20 Cylinders of Propane Used for Home Barbeques</p> <p>0.000000% Annual CO<sub>2</sub> emissions from the U.S. transportation sector</p> <p>0.000000% Annual CO<sub>2</sub> emissions from the U.S. electricity sector</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                |                 |                |                |                                |                           |      |                                                                                 |                     |                |                 |                |                |                                |                           |                                             |

Table 1  
U.S. EPA WARM Model Results  
Comparison of LCA GHG Emissions Between RRP and MRBT Alternatives - 1B 60% Diversion  
Municipal Solid Waste Management System Alternatives Analysis  
Montgomery County, Maryland

GHG Emissions Analysis -- Summary Report

Version 1b

GHG Emissions Waste Management Analysis for

Prepared By: Arcadis

Project Period for this Analysis: 01/00/00 to 01/00/00

Note: If you wish to save these results, rename this file (e.g., WARM-AMV) and save it. Then the "Analysis Inputs" sheet of this "WARM" file will be blank when you are ready to make another model run.

GHG Emissions from Baseline Waste Management (MTCO<sub>2</sub>E):

0.01

| Material                            | Tons Recycled* | Tons Landfilled | Tons Combusted | Tons Composted | Tons Anaerobically Digested | Total MTCO <sub>2</sub> E |
|-------------------------------------|----------------|-----------------|----------------|----------------|-----------------------------|---------------------------|
| Corrugated Containers               | -              | -               | 0.05           | NA             | NA                          | (0.02)                    |
| Magazines/hic-class mail            | -              | -               | 0.01           | NA             | NA                          | (0.00)                    |
| Office Paper                        | -              | -               | 0.02           | NA             | NA                          | (0.01)                    |
| Mixed Paper (general)               | -              | -               | 0.11           | NA             | NA                          | (0.05)                    |
| Mixed Paper (primarily residential) | -              | -               | 0.03           | NA             | NA                          | (0.01)                    |
| Food Waste                          | NA             | -               | 0.17           | -              | -                           | (0.02)                    |
| Grass                               | NA             | -               | 0.02           | -              | -                           | (0.00)                    |
| Leaves                              | NA             | -               | 0.02           | -              | -                           | (0.00)                    |
| HDPE                                | -              | 0.01            | NA             | NA             | NA                          | 0.01                      |
| LDPE                                | NA             | -               | 0.08           | NA             | NA                          | 0.10                      |
| PET                                 | -              | 0.02            | NA             | NA             | NA                          | 0.03                      |
| PS                                  | NA             | -               | 0.01           | NA             | NA                          | 0.02                      |
| Mixed Plastics                      | -              | -               | 0.06           | NA             | NA                          | 0.07                      |
| Aluminum Cans                       | -              | -               | 0.02           | NA             | NA                          | 0.01                      |
| Aluminum Cans                       | -              | -               | 0.00           | NA             | NA                          | 0.00                      |
| Aluminum Ingot                      | -              | -               | 0.01           | NA             | NA                          | (0.05)                    |
| Steel Cans                          | -              | -               | 0.02           | NA             | NA                          | (0.03)                    |
| Glass                               | -              | -               | 0.03           | NA             | NA                          | 0.00                      |
| Carpet                              | -              | 0.03            | -              | NA             | NA                          | 0.00                      |
| Concrete                            | -              | 0.01            | NA             | NA             | NA                          | 0.03                      |
| Dimensional Lumber*                 | -              | -               | 0.07           | NA             | NA                          | (0.04)                    |
| Drywall                             | -              | 0.01            | NA             | NA             | NA                          | (0.00)                    |
| Tires                               | -              | -               | 0.00           | NA             | NA                          | 0.00                      |
| Mixed Recyclables                   | -              | -               | 0.03           | NA             | NA                          | (0.01)                    |
| Mixed Organics                      | NA             | -               | 0.17           | -              | -                           | (0.02)                    |
|                                     |                |                 |                |                |                             | 0                         |

GHG Emissions from Alternative Waste Management Scenario (MTCO<sub>2</sub>E):

(0.91)

| Material                            | Tons Source Reduced | Tons Recycled* | Tons Landfilled | Tons Combusted | Tons Composted | Tons Anaerobically Digested | Total MTCO <sub>2</sub> E |
|-------------------------------------|---------------------|----------------|-----------------|----------------|----------------|-----------------------------|---------------------------|
| Corrugated Containers               | -                   | 0.04           | 0.01            | -              | NA             | NA                          | (0.12)                    |
| Magazines/hic-class mail            | -                   | 0.01           | 0.00            | -              | NA             | NA                          | (0.02)                    |
| Office Paper                        | -                   | 0.01           | 0.00            | -              | NA             | NA                          | (0.04)                    |
| Mixed Paper (general)               | -                   | 0.09           | 0.02            | -              | NA             | NA                          | (0.33)                    |
| Mixed Paper (primarily residential) | -                   | 0.02           | 0.01            | -              | NA             | NA                          | (0.06)                    |
| Food Waste                          | -                   | NA             | 0.03            | -              | -              | 0.13                        | 0.11                      |
| Grass                               | NA                  | 0.00           | -               | -              | -              | -                           | 0.00                      |
| Leaves                              | NA                  | 0.00           | -               | -              | -              | 0.02                        | (0.00)                    |
| HDPE                                | -                   | 0.01           | 0.00            | -              | NA             | NA                          | (0.01)                    |
| LDPE                                | -                   | NA             | 0.08            | -              | NA             | NA                          | 0.00                      |
| PET                                 | -                   | 0.02           | 0.00            | -              | NA             | NA                          | (0.02)                    |
| PS                                  | -                   | NA             | 0.01            | -              | NA             | NA                          | 0.00                      |
| Mixed Plastics                      | -                   | 0.05           | 0.01            | -              | NA             | NA                          | (0.04)                    |
| Aluminum Cans                       | -                   | -              | 0.02            | -              | NA             | NA                          | 0.00                      |
| Aluminum Cans                       | -                   | 0.00           | 0.00            | -              | NA             | NA                          | (0.03)                    |
| Aluminum Ingot                      | -                   | 0.01           | 0.00            | -              | NA             | NA                          | (0.05)                    |
| Steel Cans                          | -                   | 0.02           | 0.00            | -              | NA             | NA                          | (0.03)                    |
| Glass                               | -                   | -              | 0.03            | -              | NA             | NA                          | (0.00)                    |
| Carpet                              | -                   | -              | 0.03            | -              | NA             | NA                          | 0.00                      |
| Concrete                            | NA                  | -              | 0.01            | NA             | NA             | NA                          | 0.00                      |
| Dimensional Lumber*                 | -                   | -              | 0.07            | -              | NA             | NA                          | (0.06)                    |
| Drywall                             | -                   | -              | 0.01            | NA             | NA             | NA                          | (0.00)                    |
| Tires                               | -                   | -              | 0.00            | -              | NA             | NA                          | 0.00                      |
| Mixed Recyclables                   | NA                  | 0.03           | 0.01            | -              | NA             | NA                          | (0.07)                    |
| Mixed Organics                      | NA                  | NA             | 0.03            | -              | -              | 0.14                        | (0.01)                    |
|                                     |                     |                |                 |                |                |                             | 0                         |

| Change (Alt. - Base) MTCO <sub>2</sub> E |
|------------------------------------------|
| (0.10)                                   |
| (0.02)                                   |
| (0.05)                                   |
| (0.28)                                   |
| (0.07)                                   |
| 0.03                                     |
| 0.00                                     |
| (0.00)                                   |
| (0.02)                                   |
| (0.10)                                   |
| (0.05)                                   |
| (0.02)                                   |
| (0.12)                                   |
| (0.01)                                   |
| (0.03)                                   |
| (0.05)                                   |
| (0.00)                                   |
| (0.00)                                   |
| (0.00)                                   |
| 0.00                                     |
| 0.00                                     |
| (0.03)                                   |
| (0.00)                                   |
| 0.00                                     |
| (0.00)                                   |
| (0.06)                                   |
| 0.02                                     |
| 0.00                                     |

**Table 1**  
**U.S. EPA WARM Model Results**  
**Comparison of LCA GHG Emissions Between RRF and MRGBT Alternatives - 1B 60% Diversion**  
**Municipal Solid Waste Management System Alternatives Analysis**  
**Montgomery County, Maryland**

| GHG Emissions from Baseline Waste Management (MTCO <sub>2</sub> E):                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                |                 |                |                |                                |                           | 0.01 | GHG Emissions from Alternative Waste Management Scenario (MTCO <sub>2</sub> E): |                     |                |                 |                |                |                                | (0.91)                    | Change<br>(Alt. - Base)<br>MTCO <sub>2</sub> E |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|-----------------|----------------|----------------|--------------------------------|---------------------------|------|---------------------------------------------------------------------------------|---------------------|----------------|-----------------|----------------|----------------|--------------------------------|---------------------------|------------------------------------------------|
| Material                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Tons Recycled* | Tons Landfilled | Tons Combusted | Tons Composted | Tons Anaerobically<br>Digested | Total MTCO <sub>2</sub> E |      | Material                                                                        | Tons Source Reduced | Tons Recycled* | Tons Landfilled | Tons Combusted | Tons Composted | Tons Anaerobically<br>Digested | Total MTCO <sub>2</sub> E |                                                |
| <p><i>Note: a negative value (i.e., a value in parentheses) indicates an emission reduction; a positive value indicates an emission increase.</i></p> <p>*Wood Flooring and Dimensional Lumber model reuse under the recycling management pathway.</p> <p>a) For explanation of methodology, see the EPA WARM Documentation:<br/><a href="#">Documentation Chapters for Greenhouse Gas Emission and Energy Factors Used in the Waste Reduction Model (WARM)</a><br/>-- available on the Internet at <a href="https://www.epa.gov/warm/documentation-chapters-greenhouse-gas-emission-and-energy-factors-used-waste-reduction-model">https://www.epa.gov/warm/documentation-chapters-greenhouse-gas-emission-and-energy-factors-used-waste-reduction-model</a></p> <p>b) Emissions estimates provided by this model are intended to support voluntary GHG measurement and reporting initiatives.</p> <p>c) The GHG emissions results estimated in WARM indicate the full life-cycle benefits waste management alternatives. Due to the timing of the GHG emissions from the waste management pathways (e.g., avoided landfilling and increased recycling), the actual GHG implications may accrue over the long-term. Therefore, one should not interpret the GHG emissions implications as occurring all in one year, but rather through time.</p> |                |                 |                |                |                                |                           |      |                                                                                 |                     |                |                 |                |                |                                |                           |                                                |
| <p><b>Total Change in GHG Emissions (MTCO<sub>2</sub>E):</b> (0.92)</p> <div><p>This is equivalent to...<br/>Removing annual emissions from</p><p>0 Passenger Vehicles</p><p>Conserving 103 Gallons of Gasoline</p><p>Conserving 38 Cylinders of Propane Used for Home Barbeques</p><p>0.000000% Annual CO<sub>2</sub> emissions from the U.S. transportation sector</p><p>0.000000% Annual CO<sub>2</sub> emissions from the U.S. electricity sector</p></div>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                |                 |                |                |                                |                           |      |                                                                                 |                     |                |                 |                |                |                                |                           |                                                |

U.S. EPA WARM Model Results  
Comparison of GHG Emissions between Baseline RRF and Alternatives 2A and 2B - Long Hau Rail by Rail  
Municipal Solid Waste Management System Alternatives Analysis  
Montgomery County, Maryland

GHG Emissions Analysis -- Summary Report

Version 16

GHG Emissions Waste Management Analysis for

Prepared by:

Project Period for this Analysis: 01/00/00 to 01/00/00

Note: If you wish to save these results, rename this file (e.g. WARM-AMT) and save it. Then the "Analysis Input" sheet of the "WARM" file will be blank when you are ready to make another model run.

GHG Emissions from Baseline Waste Management (MTCO<sub>2</sub>E):

0.01

| Material                            | Tons Recycled* | Tons Landfilled | Tons Combusted | Tons Composted | Tons Anaerobically Digested | Total MTCO <sub>2</sub> E |
|-------------------------------------|----------------|-----------------|----------------|----------------|-----------------------------|---------------------------|
| Corrugated Containers               | -              | -               | 0.05           | NA             | NA                          | (0.02)                    |
| Magazines/hird-class mail           | -              | -               | 0.01           | NA             | NA                          | (0.00)                    |
| Office Paper                        | -              | -               | 0.02           | NA             | NA                          | (0.01)                    |
| Mixed Paper (general)               | -              | -               | 0.11           | NA             | NA                          | (0.05)                    |
| Mixed Paper (primarily residential) | -              | -               | 0.03           | NA             | NA                          | (0.01)                    |
| Food Waste                          | NA             | -               | 0.17           | -              | -                           | (0.02)                    |
| Grass                               | NA             | -               | 0.02           | -              | -                           | (0.00)                    |
| Leaves                              | NA             | -               | 0.02           | -              | -                           | (0.00)                    |
| HDPE                                | -              | -               | 0.01           | NA             | NA                          | 0.01                      |
| LDPE                                | NA             | -               | 0.08           | NA             | NA                          | 0.10                      |
| PET                                 | -              | -               | 0.02           | NA             | NA                          | 0.03                      |
| PS                                  | NA             | -               | 0.01           | NA             | NA                          | 0.02                      |
| Mixed Plastics                      | -              | -               | 0.06           | NA             | NA                          | 0.07                      |
| Mixed Electronics                   | -              | -               | 0.02           | NA             | NA                          | 0.01                      |
| Aluminum Cans                       | -              | -               | 0.00           | NA             | NA                          | 0.00                      |
| Aluminum Ingot                      | -              | -               | 0.01           | NA             | NA                          | 0.00                      |
| Steel Cans                          | -              | -               | 0.02           | NA             | NA                          | (0.03)                    |
| Glass                               | -              | -               | 0.03           | NA             | NA                          | 0.00                      |
| Carpet                              | -              | 0.03            | -              | NA             | NA                          | 0.00                      |
| Concrete                            | -              | 0.01            | NA             | NA             | NA                          | 0.00                      |
| Dimensional Lumber*                 | -              | -               | 0.07           | NA             | NA                          | (0.04)                    |
| Drywall                             | -              | 0.01            | NA             | NA             | NA                          | (0.00)                    |
| Tires                               | -              | -               | 0.00           | NA             | NA                          | 0.00                      |
| Mixed Recyclables                   | -              | -               | 0.03           | NA             | NA                          | (0.01)                    |
| Mixed Organics                      | NA             | -               | 0.17           | -              | -                           | (0.02)                    |

GHG Emissions from Alternative Waste Management Scenario (MTCO<sub>2</sub>E):

(0.02)

| Material                            | Tons Source Reduced | Tons Recycled* | Tons Landfilled | Tons Combusted | Tons Composted | Tons Anaerobically Digested | Total MTCO <sub>2</sub> E | Change (Alt - Base) MTCO <sub>2</sub> E |
|-------------------------------------|---------------------|----------------|-----------------|----------------|----------------|-----------------------------|---------------------------|-----------------------------------------|
| Corrugated Containers               | -                   | 0.03           | 0.01            | -              | NA             | NA                          | (0.11)                    | (0.08)                                  |
| Magazines/hird-class mail           | -                   | 0.00           | 0.00            | -              | NA             | NA                          | (0.02)                    | (0.01)                                  |
| Office Paper                        | -                   | 0.01           | 0.01            | -              | NA             | NA                          | (0.03)                    | (0.02)                                  |
| Mixed Paper (general)               | -                   | 0.08           | 0.03            | -              | NA             | NA                          | (0.24)                    | (0.06)                                  |
| Mixed Paper (primarily residential) | -                   | 0.02           | 0.01            | -              | NA             | NA                          | (0.07)                    | (0.06)                                  |
| Food Waste                          | -                   | NA             | 0.05            | -              | -              | 0.12                        | 0.01                      | 0.03                                    |
| Grass                               | NA                  | NA             | 0.01            | -              | -              | 0.01                        | (0.00)                    | 0.00                                    |
| Leaves                              | NA                  | NA             | 0.01            | -              | -              | 0.01                        | (0.01)                    | (0.01)                                  |
| HDPE                                | -                   | 0.01           | 0.00            | -              | NA             | NA                          | (0.00)                    | (0.02)                                  |
| LDPE                                | -                   | NA             | 0.08            | -              | NA             | NA                          | 0.00                      | (0.10)                                  |
| PET                                 | -                   | 0.02           | 0.01            | -              | NA             | NA                          | (0.02)                    | (0.02)                                  |
| PS                                  | -                   | NA             | 0.01            | -              | NA             | NA                          | 0.00                      | (0.05)                                  |
| Mixed Plastics                      | -                   | 0.04           | 0.02            | -              | NA             | NA                          | (0.04)                    | (0.11)                                  |
| Mixed Electronics                   | -                   | -              | 0.02            | -              | NA             | NA                          | 0.00                      | (0.01)                                  |
| Aluminum Cans                       | -                   | 0.00           | 0.00            | -              | NA             | NA                          | (0.02)                    | (0.02)                                  |
| Aluminum Ingot                      | -                   | 0.00           | 0.00            | -              | NA             | NA                          | (0.03)                    | (0.03)                                  |
| Steel Cans                          | -                   | 0.02           | 0.00            | -              | NA             | NA                          | (0.03)                    | (0.00)                                  |
| Glass                               | -                   | -              | 0.03            | -              | NA             | NA                          | 0.00                      | (0.00)                                  |
| Carpet                              | -                   | -              | 0.03            | -              | NA             | NA                          | 0.00                      | 0.00                                    |
| Concrete                            | NA                  | -              | 0.01            | NA             | NA             | NA                          | 0.00                      | 0.00                                    |
| Dimensional Lumber*                 | -                   | -              | 0.07            | -              | NA             | NA                          | (0.08)                    | (0.03)                                  |
| Drywall                             | -                   | -              | 0.01            | NA             | NA             | NA                          | (0.00)                    | 0.00                                    |
| Tires                               | -                   | -              | 0.00            | -              | NA             | NA                          | 0.00                      | 0.00                                    |
| Mixed Recyclables                   | NA                  | 0.02           | 0.01            | -              | NA             | NA                          | (0.06)                    | (0.05)                                  |
| Mixed Organics                      | NA                  | NA             | 0.05            | -              | -              | 0.12                        | (0.02)                    | 0.00                                    |

Total Change in GHG Emissions (MTCO<sub>2</sub>E):

(0.03)

U.S. EPA WARM Model Results  
Comparison of GHG Emissions between Baseline RRF and Alternatives 2A and 2B - Long Hau Rail by Rail  
Municipal Solid Waste Management System Alternatives Analysis  
Montgomery County, Maryland

GHG Emissions Analysis -- Summary Report

Version 16

GHG Emissions Waste Management Analysis for

Prepared by:

Project Period for this Analysis: 01/00/00 to 01/00/00

Note: If you wish to save these results, rename this file (e.g., WARM-AMN1) and save it. Then the "Analysis Inputs" sheet of the "WARM" file will be blank when you are ready to make another model run.

Note: a negative value (i.e., a value in parentheses) indicates an emission reduction; a positive value indicates an emission increase.

\*Wood Flooring and Dimensional Lumber model reuse under the recycling management pathway.

a) For explanation of methodology, see the EPA WARM Documentation:

[Documentation Chapters for Greenhouse Gas Emission and Energy Factors Used in the Waste Reduction Model \(WARM\)](#)

-- available on the Internet at <https://www.epa.gov/warm/documentation-chapters-greenhouse-gas-emission-and-energy-factors-used-waste-reduction-model>

b) Emissions estimates provided by this model are intended to support voluntary GHG measurement and reporting initiatives.

c) The GHG emissions results estimated in WARM indicate the full life-cycle benefits waste management alternatives. Due to the timing of the GHG emissions from the waste management pathways, (e.g., avoided landfilling and increased recycling), the actual GHG implications may accrue over the long-term. Therefore, one should not interpret the GHG emissions implications as occurring all in one year, but rather through time.

This is equivalent to...

|                                |           |                                                                      |
|--------------------------------|-----------|----------------------------------------------------------------------|
| Removing annual emissions from | 0         | Passenger Vehicles                                                   |
| Conserving                     | 3         | Gallons of Gasoline                                                  |
| Conserving                     | 1         | Cylinders of Propane Used for Home Barbeques                         |
|                                | 0.000000% | Annual CO <sub>2</sub> emissions from the U.S. transportation sector |
|                                | 0.000000% | Annual CO <sub>2</sub> emissions from the U.S. electricity sector    |

U.S. EPA WARM Model Results  
Comparison of GHG Emissions between Baseline RRF and Alternative 2C - Long Haul Tractor-Trailer from TFS  
Municipal Solid Waste Management System Alternatives Analysis  
Montgomery County, Maryland

GHG Emissions Analysis -- Summary Report

Version 16

GHG Emissions Waste Management Analysis for

Prepared by:

Project Period for this Analysis: 01/00/00 to 01/00/00

Note: If you wish to save these results, rename this file (e.g., WARM-AM1) and save it. Then the "Analysis Input" sheet of the "WARM" file will be blank when you are ready to make another model run.

GHG Emissions from Baseline Waste Management (MTCO<sub>2</sub>E):

0.01

| Material                            | Tons Recycled* | Tons Landfilled | Tons Combusted | Tons Composted | Tons Anaerobically Digested | Total MTCO <sub>2</sub> E |
|-------------------------------------|----------------|-----------------|----------------|----------------|-----------------------------|---------------------------|
| Corrugated Containers               | -              | -               | 0.05           | NA             | NA                          | (0.02)                    |
| Magazines/hird-class mail           | -              | -               | 0.01           | NA             | NA                          | (0.00)                    |
| Office Paper                        | -              | -               | 0.02           | NA             | NA                          | (0.01)                    |
| Mixed Paper (general)               | -              | -               | 0.11           | NA             | NA                          | (0.05)                    |
| Mixed Paper (primarily residential) | -              | -               | 0.03           | NA             | NA                          | (0.01)                    |
| Food Waste                          | NA             | -               | 0.17           | -              | -                           | (0.02)                    |
| Grass                               | NA             | -               | 0.02           | -              | -                           | (0.00)                    |
| Leaves                              | NA             | -               | 0.02           | -              | -                           | (0.00)                    |
| HDPE                                | -              | -               | 0.01           | NA             | NA                          | 0.01                      |
| LDPE                                | NA             | -               | 0.08           | NA             | NA                          | 0.10                      |
| PET                                 | -              | -               | 0.02           | NA             | NA                          | 0.03                      |
| PS                                  | NA             | -               | 0.01           | NA             | NA                          | 0.02                      |
| Mixed Plastics                      | -              | -               | 0.06           | NA             | NA                          | 0.07                      |
| Mixed Electronics                   | -              | -               | 0.02           | NA             | NA                          | 0.01                      |
| Aluminum Cans                       | -              | -               | 0.00           | NA             | NA                          | 0.00                      |
| Aluminum Ingot                      | -              | -               | 0.01           | NA             | NA                          | 0.00                      |
| Steel Cans                          | -              | -               | 0.02           | NA             | NA                          | (0.03)                    |
| Glass                               | -              | -               | 0.03           | NA             | NA                          | 0.00                      |
| Carpet                              | -              | 0.03            | -              | NA             | NA                          | 0.00                      |
| Concrete                            | -              | 0.01            | NA             | NA             | NA                          | 0.00                      |
| Dimensional Lumber*                 | -              | -               | 0.07           | NA             | NA                          | (0.04)                    |
| Drywall                             | -              | 0.01            | NA             | NA             | NA                          | (0.00)                    |
| Tires                               | -              | -               | 0.00           | NA             | NA                          | 0.00                      |
| Mixed Recyclables                   | -              | -               | 0.03           | NA             | NA                          | (0.01)                    |
| Mixed Organics                      | NA             | -               | 0.17           | -              | -                           | (0.02)                    |

GHG Emissions from Alternative Waste Management Scenario (MTCO<sub>2</sub>E):

0.00

| Material                            | Tons Source Reduced | Tons Recycled* | Tons Landfilled | Tons Combusted | Tons Composted | Tons Anaerobically Digested | Total MTCO <sub>2</sub> E | Change (Alt - Base) MTCO <sub>2</sub> E |
|-------------------------------------|---------------------|----------------|-----------------|----------------|----------------|-----------------------------|---------------------------|-----------------------------------------|
| Corrugated Containers               | -                   | 0.03           | 0.01            | -              | NA             | NA                          | (0.11)                    | (0.08)                                  |
| Magazines/hird-class mail           | -                   | 0.00           | 0.00            | -              | NA             | NA                          | (0.02)                    | (0.01)                                  |
| Office Paper                        | -                   | 0.01           | 0.01            | -              | NA             | NA                          | (0.03)                    | (0.02)                                  |
| Mixed Paper (general)               | -                   | 0.08           | 0.03            | -              | NA             | NA                          | (0.24)                    | (0.06)                                  |
| Mixed Paper (primarily residential) | -                   | 0.02           | 0.01            | -              | NA             | NA                          | (0.07)                    | (0.06)                                  |
| Food Waste                          | -                   | NA             | 0.05            | -              | -              | 0.12                        | 0.01                      | 0.03                                    |
| Grass                               | NA                  | NA             | 0.01            | -              | -              | 0.01                        | (0.00)                    | 0.00                                    |
| Leaves                              | NA                  | NA             | 0.01            | -              | -              | 0.01                        | (0.01)                    | (0.01)                                  |
| HDPE                                | -                   | 0.01           | 0.00            | -              | NA             | NA                          | (0.00)                    | (0.02)                                  |
| LDPE                                | -                   | NA             | 0.08            | -              | NA             | NA                          | 0.00                      | (0.10)                                  |
| PET                                 | -                   | 0.02           | 0.01            | -              | NA             | NA                          | (0.02)                    | (0.02)                                  |
| PS                                  | -                   | NA             | 0.01            | -              | NA             | NA                          | 0.00                      | (0.05)                                  |
| Mixed Plastics                      | -                   | 0.04           | 0.02            | -              | NA             | NA                          | (0.04)                    | (0.11)                                  |
| Mixed Electronics                   | -                   | -              | 0.02            | -              | NA             | NA                          | 0.00                      | (0.01)                                  |
| Aluminum Cans                       | -                   | 0.00           | 0.00            | -              | NA             | NA                          | (0.02)                    | (0.02)                                  |
| Aluminum Ingot                      | -                   | 0.00           | 0.00            | -              | NA             | NA                          | (0.03)                    | (0.03)                                  |
| Steel Cans                          | -                   | 0.02           | 0.00            | -              | NA             | NA                          | (0.03)                    | (0.00)                                  |
| Glass                               | -                   | -              | 0.03            | -              | NA             | NA                          | 0.00                      | (0.00)                                  |
| Carpet                              | -                   | -              | 0.03            | -              | NA             | NA                          | 0.00                      | 0.00                                    |
| Concrete                            | NA                  | -              | 0.01            | NA             | NA             | NA                          | 0.00                      | 0.00                                    |
| Dimensional Lumber*                 | -                   | -              | 0.07            | -              | NA             | NA                          | (0.08)                    | (0.03)                                  |
| Drywall                             | -                   | -              | 0.01            | NA             | NA             | NA                          | (0.00)                    | 0.00                                    |
| Tires                               | -                   | -              | 0.00            | -              | NA             | NA                          | 0.00                      | 0.00                                    |
| Mixed Recyclables                   | NA                  | 0.02           | 0.01            | -              | NA             | NA                          | (0.06)                    | (0.05)                                  |
| Mixed Organics                      | NA                  | NA             | 0.05            | -              | -              | 0.12                        | (0.02)                    | 0.00                                    |

Total Change in GHG Emissions (MTCO<sub>2</sub>E):

(0.01)

GHG Emissions Analysis -- Summary Report

Version 16

GHG Emissions Waste Management Analysis for

Prepared by:

Project Period for this Analysis: 01/00/00 to 01/00/00

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Note: a negative value (i.e., a value in parentheses) indicates an emission reduction; a positive value indicates an emission increase.

\*Wood Flooring and Dimensional Lumber model reuse under the recycling management pathway.

a) For explanation of methodology, see the EPA WARM Documentation:

[Documentation Chapters for Greenhouse Gas Emission and Energy Factors Used in the Waste Reduction Model \(WARM\)](#)

-- available on the Internet at <https://www.epa.gov/warm/documentation-chapters-greenhouse-gas-emission-and-energy-factors-used-waste-reduction-model>

b) Emissions estimates provided by this model are intended to support voluntary GHG measurement and reporting initiatives.

c) The GHG emissions results estimated in WARM indicate the full life-cycle benefits waste management alternatives. Due to the timing of the GHG emissions from the waste management pathways, (e.g., avoided landfilling and increased recycling), the actual GHG implications may accrue over the long-term. Therefore, one should not interpret the GHG emissions implications as occurring all in one year, but rather through time.

This is equivalent to...

|                                |           |                                                                      |
|--------------------------------|-----------|----------------------------------------------------------------------|
| Removing annual emissions from | 0         | Passenger Vehicles                                                   |
| Conserving                     | 1         | Gallons of Gasoline                                                  |
| Conserving                     | 0         | Cylinders of Propane Used for Home Barbeques                         |
|                                | 0.000000% | Annual CO <sub>2</sub> emissions from the U.S. transportation sector |
|                                | 0.000000% | Annual CO <sub>2</sub> emissions from the U.S. electricity sector    |

U.S. EPA WARM Model Results  
Comparison of GHG Emissions between Baseline RfF and Alternative 2D - Hybrid Transportation (65% Rail and 35% Truck)  
Municipal Solid Waste Management System Alternatives Analysis  
Montgomery County, Maryland

GHG Emissions Analysis -- Summary Report

Version 16

GHG Emissions Waste Management Analysis for

Prepared by:

Project Period for this Analysis: 01/00/00 to 01/00/00

Note: If you wish to save these results, rename this file (e.g., WARM-AMT) and save it. Then the "Analysis Input" sheet of the "WARM" file will be blank when you are ready to make another model run.

GHG Emissions from Baseline Waste Management (MTCO<sub>2</sub>E):

0.01

| Material                            | Tons Recycled* | Tons Landfilled | Tons Combusted | Tons Composted | Tons Anaerobically Digested | Total MTCO <sub>2</sub> E |
|-------------------------------------|----------------|-----------------|----------------|----------------|-----------------------------|---------------------------|
| Corrugated Containers               | -              | -               | 0.05           | NA             | NA                          | (0.02)                    |
| Magazines/hybrid-class mail         | -              | -               | 0.01           | NA             | NA                          | (0.00)                    |
| Office Paper                        | -              | -               | 0.02           | NA             | NA                          | (0.01)                    |
| Mixed Paper (general)               | -              | -               | 0.11           | NA             | NA                          | (0.05)                    |
| Mixed Paper (primarily residential) | -              | -               | 0.03           | NA             | NA                          | (0.01)                    |
| Food Waste                          | NA             | -               | 0.17           | -              | -                           | (0.02)                    |
| Grass                               | NA             | -               | 0.02           | -              | -                           | (0.00)                    |
| Leaves                              | NA             | -               | 0.02           | -              | -                           | (0.00)                    |
| HDPE                                | -              | -               | 0.01           | NA             | NA                          | 0.01                      |
| LDPE                                | NA             | -               | 0.08           | NA             | NA                          | 0.10                      |
| PET                                 | -              | -               | 0.02           | NA             | NA                          | 0.03                      |
| PS                                  | NA             | -               | 0.01           | NA             | NA                          | 0.02                      |
| Mixed Plastics                      | -              | -               | 0.06           | NA             | NA                          | 0.07                      |
| Mixed Electronics                   | -              | -               | 0.02           | NA             | NA                          | 0.01                      |
| Aluminum Cans                       | -              | -               | 0.00           | NA             | NA                          | 0.00                      |
| Aluminum Ingot                      | -              | -               | 0.01           | NA             | NA                          | 0.00                      |
| Steel Cans                          | -              | -               | 0.02           | NA             | NA                          | (0.03)                    |
| Glass                               | -              | -               | 0.03           | NA             | NA                          | 0.00                      |
| Carpet                              | -              | 0.03            | -              | NA             | NA                          | 0.00                      |
| Concrete                            | -              | 0.01            | NA             | NA             | NA                          | 0.00                      |
| Dimensional Lumber*                 | -              | -               | 0.07           | NA             | NA                          | (0.04)                    |
| Drywall                             | -              | 0.01            | NA             | NA             | NA                          | (0.00)                    |
| Tires                               | -              | -               | 0.00           | NA             | NA                          | 0.00                      |
| Mixed Recyclables                   | -              | -               | 0.03           | NA             | NA                          | (0.01)                    |
| Mixed Organics                      | NA             | -               | 0.17           | -              | -                           | (0.02)                    |

GHG Emissions from Alternative Waste Management Scenario (MTCO<sub>2</sub>E):

(0.01)

| Material                            | Tons Source Reduced | Tons Recycled* | Tons Landfilled | Tons Combusted | Tons Composted | Tons Anaerobically Digested | Total MTCO <sub>2</sub> E |
|-------------------------------------|---------------------|----------------|-----------------|----------------|----------------|-----------------------------|---------------------------|
| Corrugated Containers               | -                   | 0.03           | 0.01            | -              | NA             | NA                          | (0.11)                    |
| Magazines/hybrid-class mail         | -                   | 0.00           | 0.00            | -              | NA             | NA                          | (0.02)                    |
| Office Paper                        | -                   | 0.01           | 0.01            | -              | NA             | NA                          | (0.03)                    |
| Mixed Paper (general)               | -                   | 0.08           | 0.03            | -              | NA             | NA                          | (0.24)                    |
| Mixed Paper (primarily residential) | -                   | 0.02           | 0.01            | -              | NA             | NA                          | (0.07)                    |
| Food Waste                          | -                   | NA             | 0.05            | -              | -              | 0.12                        | 0.01                      |
| Grass                               | NA                  | NA             | 0.01            | -              | -              | 0.01                        | (0.00)                    |
| Leaves                              | NA                  | NA             | 0.01            | -              | -              | 0.01                        | (0.01)                    |
| HDPE                                | -                   | 0.01           | 0.00            | -              | NA             | NA                          | (0.00)                    |
| LDPE                                | -                   | NA             | 0.08            | -              | NA             | NA                          | 0.00                      |
| PET                                 | -                   | 0.02           | 0.01            | -              | NA             | NA                          | (0.02)                    |
| PS                                  | -                   | NA             | 0.01            | -              | NA             | NA                          | 0.00                      |
| Mixed Plastics                      | -                   | 0.04           | 0.02            | -              | NA             | NA                          | (0.04)                    |
| Mixed Electronics                   | -                   | -              | 0.02            | -              | NA             | NA                          | 0.00                      |
| Aluminum Cans                       | -                   | 0.00           | 0.00            | -              | NA             | NA                          | (0.02)                    |
| Aluminum Ingot                      | -                   | 0.00           | 0.00            | -              | NA             | NA                          | (0.03)                    |
| Steel Cans                          | -                   | 0.02           | 0.00            | -              | NA             | NA                          | (0.03)                    |
| Glass                               | -                   | -              | 0.03            | -              | NA             | NA                          | 0.00                      |
| Carpet                              | -                   | -              | 0.03            | -              | NA             | NA                          | 0.00                      |
| Concrete                            | NA                  | -              | 0.01            | NA             | NA             | NA                          | 0.00                      |
| Dimensional Lumber*                 | -                   | -              | 0.07            | -              | NA             | NA                          | (0.03)                    |
| Drywall                             | -                   | -              | 0.01            | NA             | NA             | NA                          | (0.00)                    |
| Tires                               | -                   | -              | 0.00            | -              | NA             | NA                          | 0.00                      |
| Mixed Recyclables                   | NA                  | 0.02           | 0.01            | -              | NA             | NA                          | (0.06)                    |
| Mixed Organics                      | NA                  | NA             | 0.05            | -              | -              | 0.12                        | (0.02)                    |

Total Change in GHG Emissions (MTCO<sub>2</sub>E):

(0.02)

| Change (Alt - Base) MTCO <sub>2</sub> E |
|-----------------------------------------|
| (0.08)                                  |
| (0.01)                                  |
| (0.02)                                  |
| (0.24)                                  |
| (0.06)                                  |
| 0.03                                    |
| 0.00                                    |
| (0.01)                                  |
| (0.02)                                  |
| (0.10)                                  |
| (0.02)                                  |
| (0.05)                                  |
| (0.11)                                  |
| (0.02)                                  |
| (0.03)                                  |
| (0.00)                                  |
| 0.00                                    |
| 0.00                                    |
| (0.03)                                  |
| 0.00                                    |
| (0.05)                                  |
| 0.00                                    |



GHG Emissions Analysis -- Summary Report

Version 16

GHG Emissions Waste Management Analysis for

Prepared by:

Project Period for this Analysis: 01/00/00 to 01/00/00

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Note: a negative value (i.e., a value in parentheses) indicates an emission reduction; a positive value indicates an emission increase.

\*Wood Flooring and Dimensional Lumber model reuse under the recycling management pathway.

a) For explanation of methodology, see the EPA WARM Documentation:

[Documentation Chapters for Greenhouse Gas Emission and Energy Factors Used in the Waste Reduction Model \(WARM\)](#)

-- available on the Internet at <https://www.epa.gov/warm/documentation-chapters-greenhouse-gas-emission-and-energy-factors-used-waste-reduction-model>

b) Emissions estimates provided by this model are intended to support voluntary GHG measurement and reporting initiatives.

c) The GHG emissions results estimated in WARM indicate the full life-cycle benefits waste management alternatives. Due to the timing of the GHG emissions from the waste management pathways, (e.g., avoided landfilling and increased recycling), the actual GHG implications may accrue over the long-term. Therefore, one should not interpret the GHG emissions implications as occurring all in one year, but rather through time.

This is equivalent to...

|                                |           |                                                                      |
|--------------------------------|-----------|----------------------------------------------------------------------|
| Removing annual emissions from | 0         | Passenger Vehicles                                                   |
| Conserving                     | 2         | Gallons of Gasoline                                                  |
| Conserving                     | 1         | Cylinders of Propane Used for Home Barbeques                         |
|                                | 0.000000% | Annual CO <sub>2</sub> emissions from the U.S. transportation sector |
|                                | 0.000000% | Annual CO <sub>2</sub> emissions from the U.S. electricity sector    |

## **Appendix D: Additional Detail on Financial Model**

Montgomery County, MD  
Department of Environmental Protection



Municipal Solid Waste Management System Alternatives Analysis  
Summary of Waste Processing System Costs - Base Cost

|                                                     |                                                                                                                                             |                                |                                                                   |                |                  | Planning Horizon (Years) |                  |           |            |            |
|-----------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------|-------------------------------------------------------------------|----------------|------------------|--------------------------|------------------|-----------|------------|------------|
|                                                     |                                                                                                                                             |                                |                                                                   |                |                  | 1                        | 5                | 10        | 20         | 30         |
| Cumulative Tons MSW Processed Over Planning Horizon |                                                                                                                                             |                                |                                                                   |                |                  | 589,793                  | 2,990,541        | 6,087,226 | 12,614,233 | 19,612,795 |
| Alternative No.                                     | Waste Processing System                                                                                                                     | Cost of Service NPV \$/Ton     | Approximate Lifecycle Expenditures (NPV \$)                       |                |                  |                          |                  |           |            |            |
| 1A                                                  | MRBT-Low (30% Tipping Floor Recovery Rate) & Long Haul of Residuals by Rail Out of Dickerson (2A)                                           | \$ 203                         | \$ 119,524,055                                                    | \$ 606,045,732 | \$ 1,233,602,114 | \$ 2,556,327,871         | \$ 3,974,616,157 |           |            |            |
| 1B                                                  | MRBT-Medium (45% Tipping Floor Recovery Rate) & Long Haul of Residuals by Rail Out of Dickerson (2A)                                        | \$ 189                         | \$ 111,356,257                                                    | \$ 564,630,980 | \$ 1,149,302,657 | \$ 2,381,638,602         | \$ 3,703,006,714 |           |            |            |
| 1C                                                  | MRBT-High (60% Tipping Floor Recovery Rate) & Long Haul of Residuals by Rail Out of Dickerson (2A)                                          | \$ 175                         | \$ 103,188,459                                                    | \$ 523,216,228 | \$ 1,065,003,201 | \$ 2,206,949,334         | \$ 3,431,397,272 |           |            |            |
| 2A                                                  | Long Haul Rail from RRF                                                                                                                     | \$ 154                         | \$ 90,684,179                                                     | \$ 459,813,379 | \$ 935,947,117   | \$ 1,939,513,296         | \$ 3,015,583,788 |           |            |            |
| 2B                                                  | Long Haul Rail from TFS                                                                                                                     | \$ 167                         | \$ 98,220,526                                                     | \$ 498,026,365 | \$ 1,013,729,400 | \$ 2,100,697,373         | \$ 3,266,195,160 |           |            |            |
| 2C                                                  | Long Haul Tractor-Trailer from TFS                                                                                                          | \$ 201                         | \$ 118,558,397                                                    | \$ 601,149,372 | \$ 1,223,635,605 | \$ 2,535,674,806         | \$ 3,942,504,468 |           |            |            |
| 2D                                                  | Long-Haul Rail from RRF (65%) & Long-Haul Tractor Trailer from TFS (35%)                                                                    | \$ 175                         | \$ 103,463,353                                                    | \$ 524,610,076 | \$ 1,067,840,368 | \$ 2,212,828,646         | \$ 3,440,538,512 |           |            |            |
| 2E                                                  | Long Haul Tractor Trailer from RRF                                                                                                          | \$ 197                         | \$ 116,074,661                                                    | \$ 588,555,608 | \$ 1,198,001,081 | \$ 2,482,553,748         | \$ 3,859,911,067 |           |            |            |
| Baseline for Comparison                             | Resource Recovery Facility Upgrades with Long Haul of MWC Ash by Rail Out of Dickerson                                                      | \$ 124                         | \$ 73,210,163                                                     | \$ 371,211,525 | \$ 755,598,624   | \$ 1,565,786,731         | \$ 2,434,508,230 |           |            |            |
| Alternative No.                                     | Waste Processing System                                                                                                                     | Differential Cost (NPV \$/Ton) | Incremental Lifecycle Expenditure Exceeding RRF Upgrades (NPV \$) |                |                  |                          |                  |           |            |            |
| 1A                                                  | Materials Recycling and Biological Treatment Facility and Long Haul of Residuals by Rail Out of Dickerson (30% Tipping Floor Recovery Rate) | \$ 79                          | \$ 46,313,892                                                     | \$ 234,834,208 | \$ 478,003,490   | \$ 990,541,140           | \$ 1,540,107,927 |           |            |            |
| 1B                                                  | MRBT-Medium (45% Tipping Floor Recovery Rate) & Long Haul of Residuals by Rail Out of Dickerson (2A)                                        | \$ 65                          | \$ 38,146,094                                                     | \$ 193,419,456 | \$ 393,704,033   | \$ 815,851,871           | \$ 1,268,498,485 |           |            |            |
| 1C                                                  | Materials Recycling and Biological Treatment Facility and Long Haul of Residuals by Rail Out of Dickerson (60% Tipping Floor Recovery Rate) | \$ 51                          | \$ 29,978,296                                                     | \$ 152,004,703 | \$ 309,404,577   | \$ 641,162,603           | \$ 996,889,042   |           |            |            |
| 2A                                                  | Long Haul MSW By Rail from RRF                                                                                                              | \$ 30                          | \$ 17,474,016                                                     | \$ 88,601,854  | \$ 180,348,494   | \$ 373,726,565           | \$ 581,075,558   |           |            |            |
| 2B                                                  | Long Haul MSW By Rail from TFS                                                                                                              | \$ 42                          | \$ 25,010,363                                                     | \$ 126,814,841 | \$ 258,130,777   | \$ 534,910,642           | \$ 831,686,930   |           |            |            |
| 2C                                                  | Long Haul Tractor-Trailer from TFS                                                                                                          | \$ 77                          | \$ 45,448,235                                                     | \$ 229,937,848 | \$ 468,036,981   | \$ 969,888,075           | \$ 1,507,996,238 |           |            |            |
| 2D                                                  | Long-Haul Rail from RRF (65%) & Long-Haul Tractor Trailer from TFS (35%)                                                                    | \$ 51                          | \$ 30,253,190                                                     | \$ 153,398,551 | \$ 312,241,745   | \$ 647,041,915           | \$ 1,006,030,282 |           |            |            |
| 2E                                                  | Long Haul Tractor Trailer from RRF                                                                                                          | \$ 73                          | \$ 42,864,498                                                     | \$ 217,344,084 | \$ 442,402,457   | \$ 916,767,017           | \$ 1,425,402,837 |           |            |            |
| Baseline for Comparison                             | Resource Recovery Facility Upgrades with Long Haul of MWC Ash by Rail Out of Dickerson                                                      | \$ -                           | \$ -                                                              | \$ -           | \$ -             | \$ -                     | \$ -             |           |            |            |

Montgomery County, MD  
Department of Environmental Protection  
Municipal Solid Waste Management System Alternatives Analysis  
Summary of Waste Processing System Costs - Base + HEI Cost



|                                                     |  | Planning Horizon (Years) |           |           |            |            |
|-----------------------------------------------------|--|--------------------------|-----------|-----------|------------|------------|
|                                                     |  | 1                        | 5         | 10        | 20         | 30         |
| Cumulative Tons MSW Processed Over Planning Horizon |  | 589,793                  | 2,990,541 | 6,087,226 | 12,614,233 | 19,612,795 |

| Alternative No.         | Waste Processing System                                                                                                                     | Cost of Service NPV \$/Ton | Approximate Lifecycle Expenditures (NPV \$) |                |                  |                  |                  |
|-------------------------|---------------------------------------------------------------------------------------------------------------------------------------------|----------------------------|---------------------------------------------|----------------|------------------|------------------|------------------|
| 1A                      | Materials Recycling and Biological Treatment Facility and Long Haul of Residuals by Rail Out of Dickerson (30% Tipping Floor Recovery Rate) | \$ 192                     | \$ 119,524,055                              | \$ 606,045,732 | \$ 1,233,602,114 | \$ 2,556,327,871 | \$ 3,974,616,157 |
| 1B                      | Materials Recycling and Biological Treatment Facility and Long Haul of Residuals by Rail Out of Dickerson (45% Tipping Floor Recovery Rate) | \$ 173                     | \$ 111,356,257                              | \$ 564,630,980 | \$ 1,149,302,657 | \$ 2,381,638,602 | \$ 3,703,006,714 |
| 1C                      | Materials Recycling and Biological Treatment Facility and Long Haul of Residuals by Rail Out of Dickerson (60% Tipping Floor Recovery Rate) | \$ 155                     |                                             |                |                  |                  |                  |
| 2A                      | Long Haul Rail from RRF                                                                                                                     | \$ 194                     | \$ 114,275,899                              | \$ 579,435,000 | \$ 1,179,436,142 | \$ 2,444,082,616 | \$ 3,800,095,585 |
| 2B                      | Long Haul Rail from TFS                                                                                                                     | \$ 207                     | \$ 121,812,246                              | \$ 617,647,986 | \$ 1,257,218,425 | \$ 2,605,266,693 | \$ 4,050,706,957 |
| 2C                      | Long Haul Tractor-Trailer from TFS                                                                                                          | \$ 241                     | \$ 142,150,117                              | \$ 720,770,993 | \$ 1,467,124,630 | \$ 3,040,244,126 | \$ 4,727,016,265 |
| 2D                      | Long-Haul Rail from RRF (65%) & Long-Haul Tractor Trailer from TFS (35%)                                                                    | \$ 215                     | \$ 127,055,073                              | \$ 644,231,696 | \$ 1,311,329,393 | \$ 2,717,397,966 | \$ 4,225,050,309 |
| 2E                      | Long Haul Tractor Trailer from RRF                                                                                                          | \$ 237                     | \$ 139,666,381                              | \$ 708,177,229 | \$ 1,441,490,106 | \$ 2,987,123,069 | \$ 4,644,422,664 |
| Baseline for Comparison | Resource Recovery Facility Upgrades with Long Haul of MMC Ash by Rail Out of Dickerson                                                      | \$ 130                     | \$ 73,210,163                               | \$ 371,211,525 | \$ 755,598,624   | \$ 1,565,786,731 | \$ 2,434,508,230 |

| Alternative No.         | Waste Processing System                                                                                                                     | Differential Cost (NPV \$/Ton) | Incremental Lifecycle Expenditure Exceeding RRF Upgrades (NPV \$) |                |                |                  |                  |
|-------------------------|---------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------|-------------------------------------------------------------------|----------------|----------------|------------------|------------------|
| 1A                      | Materials Recycling and Biological Treatment Facility and Long Haul of Residuals by Rail Out of Dickerson (30% Tipping Floor Recovery Rate) | \$ 62                          | \$ 36,287,411                                                     | \$ 183,995,019 | \$ 374,520,654 | \$ 776,099,178   | \$ 1,206,690,413 |
| 1B                      | Materials Recycling and Biological Treatment Facility and Long Haul of Residuals by Rail Out of Dickerson (60% Tipping Floor Recovery Rate) | \$ 43                          | \$ 25,170,648                                                     | \$ 127,627,564 | \$ 259,785,070 | \$ 538,338,745   | \$ 837,016,996   |
| 2A                      | Long Haul MSW By Rail from RRF                                                                                                              | \$ 64                          | \$ 37,526,978                                                     | \$ 190,280,232 | \$ 387,314,165 | \$ 802,610,487   | \$ 1,247,910,586 |
| 2B                      | Long Haul MSW By Rail from TFS                                                                                                              | \$ 76                          | \$ 45,063,325                                                     | \$ 228,493,218 | \$ 465,096,448 | \$ 963,794,564   | \$ 1,498,521,958 |
| 2C                      | Long Haul Tractor-Trailer from TFS                                                                                                          | \$ 111                         | \$ 65,401,197                                                     | \$ 331,616,225 | \$ 675,002,652 | \$ 1,398,771,997 | \$ 2,174,831,266 |
| 2D                      | Long-Haul Rail from RRF (65%) & Long-Haul Tractor Trailer from TFS (35%)                                                                    | \$ 85                          | \$ 50,306,152                                                     | \$ 255,076,929 | \$ 519,207,416 | \$ 1,075,925,837 | \$ 1,672,865,310 |
| 2E                      | Long Haul Tractor Trailer from RRF                                                                                                          | \$ 107                         | \$ 62,917,460                                                     | \$ 319,022,461 | \$ 649,368,128 | \$ 1,345,650,940 | \$ 2,092,237,865 |
| Baseline for Comparison | Resource Recovery Facility Upgrades with Long Haul of MMC Ash by Rail Out of Dickerson                                                      | \$ -                           | \$ -                                                              | \$ -           | \$ -           | \$ -             | \$ -             |

Montgomery County, MD  
Department of Environmental Protection  
Municipal Solid Waste Management System Alternatives Analysis  
Summary of Waste Processing System Costs - Condensed Summary A



| MSW Management System   |                                                                                | Cost of Service |                  |                     |
|-------------------------|--------------------------------------------------------------------------------|-----------------|------------------|---------------------|
|                         |                                                                                | NPV \$/Ton      | CAPEX NPV \$/Ton | Net OPEX NPV \$/Ton |
| Baseline for Comparison | RRE Upgrades with Long Haul of MWC Ash by Rail Out of Dickerson                | \$ 124          | \$ 22            | \$ 102              |
| Alternative 1           | 1A MRBT - Low ( 30% Tipping Floor Recovery) & Residue by Rail from Dickerson   | \$ 203          | \$ 53            | \$ 150              |
|                         | 1B MRBT - Medium (45% Tipping Floor Recovery) & Residue by Rail from Dickerson | \$ 189          | \$ 53            | \$ 136              |
|                         | 1C MRBT - High (60% Tipping Floor Recovery) & Residue by Rail from Dickerson   | \$ 175          | \$ 53            | \$ 122              |
| Alternative 2           | 2A MSW Long Haul by Rail Derwood/Dickerson                                     | \$ 154          | \$ 12            | \$ 142              |
|                         | 2B MSW Long Haul by Rail Derwood                                               | \$ 167          | \$ 21            | \$ 146              |
|                         | 2C MSW Long Haul by Truck Derwood                                              | \$ 201          | \$ 2             | \$ 199              |
|                         | 2D MSW Long Haul Hybrid Rail and Truck                                         | \$ 175          | \$ 8             | \$ 167              |
|                         | 2E MSW Long Haul Hybrid Truck from Dickerson                                   | \$ 197          | \$ 30            | \$ 167              |

| Cost Component      | System Cost (NPV \$/Ton)                                                 |                                                                             |                                                                           |                                         |                                |                                                                 |
|---------------------|--------------------------------------------------------------------------|-----------------------------------------------------------------------------|---------------------------------------------------------------------------|-----------------------------------------|--------------------------------|-----------------------------------------------------------------|
|                     | 1A                                                                       | 1B                                                                          | 1C                                                                        | 2A                                      | 2C                             | Baseline for Comparison                                         |
|                     | MRBT - Low (30% Tipping Floor Recovery) & Residue by Rail from Dickerson | MRBT - Medium (45% Tipping Floor Recovery) & Residue by Rail from Dickerson | MRBT - High (60% Tipping Floor Recovery) & Residue by Rail from Dickerson | MSW Long Haul by Rail Derwood/Dickerson | MSW Long Haul by Truck Derwood | RRE Upgrades with Long Haul of MWC Ash by Rail Out of Dickerson |
| CAPEX               | \$ 53                                                                    | \$ 53                                                                       | \$ 53                                                                     | \$ 12                                   | \$ 2                           | \$ 22                                                           |
| Net OPEX            | \$ 150                                                                   | \$ 136                                                                      | \$ 122                                                                    | \$ 142                                  | \$ 199                         | \$ 102                                                          |
| Sub-Total Base Cost | \$ 203                                                                   | \$ 189                                                                      | \$ 175                                                                    | \$ 154                                  | \$ 201                         | \$ 124                                                          |
| H&E Impact          | \$ (11)                                                                  | \$ (16)                                                                     | \$ (20)                                                                   | \$ 40                                   | \$ 40                          | \$ 6                                                            |
| Total               | \$ 192                                                                   | \$ 173                                                                      | \$ 155                                                                    | \$ 194                                  | \$ 241                         | \$ 130                                                          |

**NOTES:**

1. Net OPEX includes offsetting revenues

Montgomery County, MD  
Department of Environmental Protection  
Municipal Solid Waste Management Systems Alternatives Analysis  
Input Parameters

| Category | Parameter | Unit              | Waste Processing Technologies & Location                        |                                                                          |                                                                             |                                                                           |                                         |                               |                                |                                     |
|----------|-----------|-------------------|-----------------------------------------------------------------|--------------------------------------------------------------------------|-----------------------------------------------------------------------------|---------------------------------------------------------------------------|-----------------------------------------|-------------------------------|--------------------------------|-------------------------------------|
|          |           |                   | Baseline for Comparison                                         | 1A                                                                       | 1B                                                                          | 1C                                                                        | 2A                                      | 2B                            | 2C                             | 2D                                  |
|          |           |                   | RRF Upgrades with Long Haul of MWC Ash by Rail Out of Dickerson | MRBT - Low (30% Tipping Floor Recovery) & Residue by Rail from Dickerson | MRBT - Medium (45% Tipping Floor Recovery) & Residue by Rail from Dickerson | MRBT - High (60% Tipping Floor Recovery) & Residue by Rail from Dickerson | MSW Long Haul by Rail Derwood/Dickerson | MSW Long Haul by Rail Derwood | MSW Long Haul by Truck Derwood | MSW Long Haul Hybrid Rail and Truck |
|          | Dickerson | Derwood/Dickerson | Derwood/Dickerson                                               | Derwood/Dickerson                                                        | Derwood/Dickerson                                                           | Derwood                                                                   | Derwood                                 | Derwood/Dickerson             |                                |                                     |

| Mass Balance/MSW Waste Stream Metrics (2024) | 2024 Annual Average Quantity of Waste Processed | tpy | 589,793 | 589,793 | 589,793 | 589,793 | 589,793 | 589,793 | 589,793 | 589,793 |
|----------------------------------------------|-------------------------------------------------|-----|---------|---------|---------|---------|---------|---------|---------|---------|
|                                              | 2024 Daily Average Quantity of Waste Processed  | tpd | 1,966   | 1,966   | 1,966   | 1,966   | 1,966   | 1,966   | 1,966   | 1,966   |
|                                              | 2024 Residue or Byproduct Produced for Disposal | tpy | 176,938 | 412,855 | 324,386 | 235,917 | N/A     | N/A     | N/A     | N/A     |

| Tipping Floor Tonnage | Starting Tonnage (2024)                                                                                                | tons/year | 589,793 | 589,793 | 589,793 | 589,793 | 589,793 | 589,793 | 589,793 | 589,793 |
|-----------------------|------------------------------------------------------------------------------------------------------------------------|-----------|---------|---------|---------|---------|---------|---------|---------|---------|
|                       | Change in Per Capita Waste Generation Rate (%/yr)                                                                      | %/year    | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       |
|                       | Population Growth Rate                                                                                                 | %/year    | 0.7%    | 0.7%    | 0.7%    | 0.7%    | 0.7%    | 0.7%    | 0.7%    | 0.7%    |
|                       | Technology Efficiency (Capture of Recyclables and Organics from MSW for MRBT; Reduction of Raw MSW to MWC Ash for RRF) | % Mass    | 70%     | 57.1%   | 85.7%   | 114.3%  | 0%      | 0%      | 0%      | 0%      |

| Category | Parameter | Unit | Waste Processing Technologies & Location                        |                                                                          |                                                                             |                                                                           |                                         |                               |                                |                                     |
|----------|-----------|------|-----------------------------------------------------------------|--------------------------------------------------------------------------|-----------------------------------------------------------------------------|---------------------------------------------------------------------------|-----------------------------------------|-------------------------------|--------------------------------|-------------------------------------|
|          |           |      | Baseline for Comparison                                         | 1A                                                                       | 1B                                                                          | 1C                                                                        | 2A                                      | 2B                            | 2C                             | 2D                                  |
|          |           |      | RRF Upgrades with Long Haul of MWC Ash by Rail Out of Dickerson | MRBT - Low (30% Tipping Floor Recovery) & Residue by Rail from Dickerson | MRBT - Medium (45% Tipping Floor Recovery) & Residue by Rail from Dickerson | MRBT - High (60% Tipping Floor Recovery) & Residue by Rail from Dickerson | MSW Long Haul by Rail Derwood/Dickerson | MSW Long Haul by Rail Derwood | MSW Long Haul by Truck Derwood | MSW Long Haul Hybrid Rail and Truck |
|          |           |      | Dickerson                                                       | Derwood/Dickerson                                                        | Derwood/Dickerson                                                           | Derwood/Dickerson                                                         | Derwood/Dickerson                       | Derwood                       | Derwood                        | Derwood/Dickerson                   |

|                                           |                                                                                                                                      |                            |           |           |           |           |           |           |           |           |
|-------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------|----------------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| Cost and Revenue Inputs<br>Current 2024\$ | Technology CAPEX - Unit Based Not Including Contingency, EPC Fee or Offsetting County Tip Fee & Tax Credit                           | \$/ton processing capacity | N/A       | \$ 868.25 | \$ 868.25 | \$ 868.25 | N/A       | N/A       | N/A       | N/A       |
|                                           | OPEX - Annual Unit Includes Contingency but does NOT include Transport/Disposal of Residuals or Offsetting Revenue from Sale of RECS | \$/ton Processable MSW     | \$ 53.75  | \$ 82.54  | \$ 82.54  | \$ 82.54  | \$ 15.36  | \$ 15.36  | \$ 15.36  | \$ 15.36  |
|                                           | Transfer Station Operating Costs (Does NOT include upper tier)                                                                       | \$/ton Processable MSW     | \$ 15.36  | \$ 6.14   | \$ 6.14   | \$ 6.14   | \$ -      | \$ -      | \$ -      | \$ -      |
|                                           | Railyard Operating Cost (MRBT is Derwood & Dickerson; RRF is Dickerson Only; Long Haul is Derwood & Dickerson)                       | \$/ton Processable MSW     | \$ -      | \$ -      | \$ -      | \$ -      | \$ -      | \$ -      | \$ -      | \$ -      |
|                                           | Residue Transport Hauling by Rail - Unit Based                                                                                       | \$/ton MRBT Residue        | N/A       | \$ 25.00  | \$ 25.00  | \$ 25.00  | N/A       | N/A       | N/A       | N/A       |
|                                           | MWC Ash Transport Hauling by Rail - Unit Based                                                                                       | \$/ton MWC Ash             | \$ 23.44  | N/A       | N/A       | N/A       | N/A       | N/A       | N/A       | N/A       |
|                                           | MSW Transport Hauling by Rail - Unit Based                                                                                           | \$/ton MSW                 | N/A       | \$ -      | \$ -      | \$ -      | \$ 76.34  | \$ 76.34  | N/A       | \$ 76.34  |
|                                           | MSW Transport by Truck - Unit Based                                                                                                  | \$/ton MSW                 | N/A       | N/A       | N/A       | N/A       | N/A       | N/A       | \$ 123.64 | \$ 123.64 |
|                                           | Residue Disposal (Tipping Fee) MRBT is MSWLF; RRF is MWC Ash to Herrioco County; Long Haul is MSW to MSWLF - Unit Based              | \$/ton residue             | \$ 35.12  | \$ 50.00  | \$ 50.00  | \$ 50.00  | \$ 50.00  | \$ 50.00  | \$ 50.00  | \$ 50.00  |
|                                           | Sub-Total OPEX including processing facility, railyard, hauling and disposal of residue, ash or MSW                                  | \$/ton                     | \$ 127.67 | \$ 163.68 | \$ 163.68 | \$ 163.68 | \$ 141.70 | \$ 141.70 | \$ 189.00 | \$ 266.34 |
|                                           | Revenue - Unit Based                                                                                                                 | \$/ton recovered materials | \$ -      | \$ 60.00  | \$ 60.00  | \$ 60.00  | \$ -      | \$ -      | \$ -      | \$ -      |
|                                           | Biogas Revenue /Ton Organics/Year                                                                                                    | \$/year/ton MSW            | N/A       | 6.49      | 6.49      | 6.49      | N/A       | N/A       | N/A       | N/A       |



| Category | Parameter | Unit              | Waste Processing Technologies & Location                        |                                                                          |                                                                             |                                                                           |                                         |                               |                                |                                     |
|----------|-----------|-------------------|-----------------------------------------------------------------|--------------------------------------------------------------------------|-----------------------------------------------------------------------------|---------------------------------------------------------------------------|-----------------------------------------|-------------------------------|--------------------------------|-------------------------------------|
|          |           |                   | Baseline for Comparison                                         | 1A                                                                       | 1B                                                                          | 1C                                                                        | 2A                                      | 2B                            | 2C                             | 2D                                  |
|          |           |                   | RPF Upgrades with Long Haul of MWC Ash by Rail Out of Dickerson | MRBT - Low (30% Tipping Floor Recovery) & Residue by Rail from Dickerson | MRBT - Medium (45% Tipping Floor Recovery) & Residue by Rail from Dickerson | MRBT - High (60% Tipping Floor Recovery) & Residue by Rail from Dickerson | MSW Long Haul by Rail Derwood/Dickerson | MSW Long Haul by Rail Derwood | MSW Long Haul by Truck Derwood | MSW Long Haul Hybrid Rail and Truck |
|          | Dickerson | Derwood/Dickerson | Derwood/Dickerson                                               | Derwood/Dickerson                                                        | Derwood/Dickerson                                                           | Derwood                                                                   | Derwood                                 | Derwood/Dickerson             |                                |                                     |

| Other Project Costs | EPC Professional Fees         | Percent (%) Capital Cost of Construction | 2.0% | 2.0% | 2.0% | 2.0% | 2.0% |      |      | 2.0% |
|---------------------|-------------------------------|------------------------------------------|------|------|------|------|------|------|------|------|
|                     | PCS Contract (Developers Fee) |                                          | 3.0% | 3.0% | 3.0% | 3.0% | 3.0% | 0.0% | 0.0% | 3.0% |
|                     | Permitting Fees               |                                          | 10%  |      |      |      | 10%  | 10%  | 10%  | 10%  |
|                     | Contingencies                 |                                          | 15%  | 15%  | 15%  | 15%  | 0.0% | 0.0% | 0.0% | 0.0% |

| Bond Financing | Bonding               | Percent (%) Capital Cost of Construction | 1.0% | 1.0% | 1.0% | 1.0% | 1.0% | 1.0% | 1.0% | 1.0% |
|----------------|-----------------------|------------------------------------------|------|------|------|------|------|------|------|------|
|                | Finance Rate          | Percent (%)                              | 5.0% | 5.0% | 5.0% | 5.0% | 5.0% | 5.0% | 5.0% | 5.0% |
|                | Module 1 Finance Term | Years                                    | 30   | 30   | 30   | 30   | 30   | 30   | 30   | 30   |
|                | Module 2 Finance Term | Years                                    | N/A  | 20   | 20   | 20   | 30   | 30   | 30   | 30   |
|                | Module 3 Finance Term | Years                                    | N/A  | 10   | 10   | 10   | N/A  | N/A  | N/A  | N/A  |

| Schedule | Award PCS Contract (MRBT) & Start Design (Others) |  | Fiscal Year | 2026  | 2026 | 2026 | 2026 | 2027 | 2027 | 2027 |
|----------|---------------------------------------------------|--|-------------|-------|------|------|------|------|------|------|
|          | Start Permitting                                  |  |             | 2029  | 2029 | 2029 | 2029 | 2029 | 2029 | 2029 |
|          | Start Construction                                |  |             | 2029  | 2029 | 2029 | 2029 | 2029 | 2029 | 2029 |
|          | Start Commercial Operation                        |  |             | 2032  | 2032 | 2032 | 2031 | 2031 | 2031 | 2031 |
|          | Number of Payment Installments                    |  |             | 1     | 1    | 1    | 1    | 1    | 1    | 1    |
|          | Time Between Build Phases                         |  |             | Years | N/A  | 10   | 10   | 10   | N/A  | N/A  |