Swarthmore College
Report on 2016-2019 Waste Characterization Studies

Prepared by the Swarthmore College Zero Waste Working Group

Patti Braun, Purchasing
Anthony Coschignano, Auxiliary Services
Alex Danovitch, Zero Waste Consultant
Tyrone Dunston, EVS
Andy Feick, Facilities
Chris Kane, Purchasing
Steve Lockard, EVS
Chip Proctor, EVS
Alex Sastre, Communications
Susan Smythe, Facilities
Melissa Tier, Sustainability
Chantal Reyes '22
Tyler White '22
Aurora Winslade, Sustainability

A. Waste Characterization Protocols

Swarthmore College has conducted annual waste characterization studies since 2016. The studies have been led by staff and students of the Office for Sustainability and EVS. In 2019, the effort was spearheaded by PSRF students Chantal Reyes '22 and Tyler White '22. The terms 'waste' and 'discards' are used interchangeably throughout this report to describe any and all disposed materials. We acknowledge that in the future, we want to limit the use of 'waste' to describe incinerated and landfilled materials (the trash stream), in an effort to reconceptualize Zero Waste as a circular system.

Each year, a set of locations is targeted and all discard streams (trash, recycling, and composting) are kept segregated by building for five days prior to the sort. At the sort, the bags are opened, sorted and weighed by both broad categories (recycling, compost, or trash) and in more defined sub-categories such as single use plastics or compostable wares. While the total weight sorted is a small percent of the total discards generated on campus, the study results provide a snapshot of progress. This provides an opportunity to benchmark current recycling and composting efforts and a highly visible opportunity to engage the community in conversations around waste.

The waste composition studies do not include other campus waste, such as yard debris that is composted onsite, construction and demolition waste, or electronic waste. **Charts J and K** show an estimate of these numbers and the impact they have on the total campus diversion rate.

The main goals of collecting the data:

- Determining the percent of recyclable and compostable discards that are *correctly* sorted to the right stream (i.e., the campus **diversion rate**).
- Understanding the overall composition of discards (whether or not they are correctly sorted) and aligning that with access to regional end markets to understand the ***potential* diversion rate**.
- Tracking and documenting progress over multiple years.
- Informing the development of strategies to best meet the College's goals of reducing waste first and then diverting remaining discards away from incineration.

Chart A below summarizes the buildings included in each year's study as well as the total pounds sorted. As different buildings and sorting categories have been used each year, the comparisons are not completely applicable year to year; however, work was done this year to reformat and standardize data collection and analysis in order to provide a framework going forward. In addition, changes to how the College manages waste on campus will result in better data tracking of total weights for each stream. Despite imperfections the data may have, the results suggest general trends on campus and are a starting point in understanding the limitations and opportunities ahead.

Chart A. Historic Data Summary

Study Demographic Overview				
Year of Study	**2016**	**2017**	**2018**	**2019**
Buildings Included (5 days of waste collected)	Sci Center, Willets, Kohlberg, Parish, BCC	Eldridge Commons, Kholberg, Parrish, PPR Apts, Clothier, 101 S. Chester	Eldridge Commons, Sci Center, Kohberg, Parrish, Willets, Fieldhouse, 101 S. Chester	Parrish, Essie Mae's, Sci Center, Field House, PPR Apts
Total Weight Sorted (pounds)	1,679	509	685	794

B. Key Findings from the 2019 Waste Characterization Study

Below are summaries of key findings from the 2019 study in comparison to past years. Please keep in mind that there was some variation in data collection over the years, and that the statements below are generalizing for campus based on the sample data.

- The 2019 net diversion rate (amount of correctly sorted material that is recycled or composted) was 41%, up from 31.5% in 2016 (**Chart B**).

- Compost diversion (the percentage of all discarded materials that was successfully composted) has increased from 11% to 25% since 2016 (**Chart C**). The compost capture rate (the percentage of all compostable items that made it correctly into compost bins) has also increased from 23% to 56% since 2016 (**Chart E**). This reflects the significant work and investment in placing compost containers around campus as well as transitioning to compostable wares.

- While the recycling diversion rate has stagnated around 15-20% (**Chart C**), the stream has become much cleaner with less contamination, which is a critical success in today's marketplace. This shows the value of investing in a uniform system of containers and increasing education and signage.

- 64% of what is currently sent to the incinerator could be diverted to composting and recycling streams (**Chart D**).

- 56% of all compostable materials make it into the compost stream on campus (**Chart E**).

    - 36.6% of food waste is in the trash, instead of composting (**Chart F**).

    - 37.4% of compostable products are mistakenly placed in recycling, contributing to contamination (**Chart F**).

- 47% of all recyclable products on campus make it into the recycling stream (**Chart E**).

    - 54.6% of bottles and cans are in the trash instead of recycling (**Chart F**).

    - 58.5% of recyclable paper is in the trash instead of recycling (**Chart F**).

- 78% of all discards (across all 3 streams) in the study are recyclable or compostable (**Chart G**).

- There were significant marketplace issues globally that created challenges for recycling in 2019. The College is now under a new recycling contract and system that creates more transparency and accountability to ensure that recycling collected on campus is authentically recycled after it leaves campus. With this new contract, the recycling captured on campus is now better aligned with what is accepted at recycling end markets.

- Incorporating emissions calculations helps us see the value of reducing our waste over just diverting it away from incineration. For example: composting food waste rather than incinerating it results in a carbon savings of just .18 $MTCO_2e$, while changing one ton of the food supply to vegetarian results in a carbon savings of 2.9 $MTC0_2e$.

Conclusion:

Much progress has been made in cleaning up recycling and increasing the amount of composting taking place on campus over the last four years. The estimated rate of 41% of discards being diverted from the landfill and sent to recycling or composting is great progress.

The overall diversion rate for the campus, including other diversion streams such as electronics and yard debris, is estimated to be 55% (**Chart J**). Including construction and demolition waste brings the overall diversion to 88% (**Chart K**), given the extraordinary amount of material associated with Singer Hall in 2019. According to a recent survey of 340 schools by the College and University Recycling Council, 87% of schools had a diversion rate under 69%, and 56% of schools surveyed had a diversion rate under 50%. In addition, many of these schools do not take

the extra step to subtract contamination (non-recyclables from the recycling stream or non-compostable materials from the composting stream), as was done in this analysis.

In terms of meeting the 80% zero waste diversion goal, the data from the characterization studies can help inform what strategies should be prioritized. The trend lines detailed in the analysis below indicate that there is likely a segment of the population that does not participate in recycling or composting and/or only diverts certain items. While focusing on recycling and composting are important transitional tools towards zero waste, new strategies to address consumption, purchasing, and participation will need to be implemented to reach the College's zero waste goals.

A focus on informing and inspiring behavior change is needed beyond basic education of what is recyclable or compostable. This is indicated by the fact that some of the most basic recyclable or compostable items (bottles and cans, paper, food waste) are each diverted at roughly a 50% rate. Reduction is also a needed priority, as transitioning non-recyclable items to recyclable or compostable items still results in a large portion being disposed of and a large impact upstream on resource extraction. For example, the compostable service ware that increased composting diversion also resulted in 38% of those items being disposed of in the wrong stream.

Efforts to change behavior should include an emphasis on the positive benefits of reduction and reuse and the detrimental impacts upstream (i.e., for every bag of trash there are 70 more bags created upstream from extraction, manufacturing, and transportation). Research conducted by the 2020 zero waste PSRFs, Chantal Reyes '22 and Tyler White '22, on changing behavior around zero waste through a focus on the environmental justice impacts of consumption and disposal could be a powerful approach. Along with efforts to increase access to recycling and composting across campus and at events, it is critical to increase efforts to reduce consumption and increase reuse. Approaches such as the reusable bento box pilot at Sharples and various clothing exchanges are great examples.

Ultimately, establishing campus wide policies, both in terms of expectations for discards and purchasing, have proven to be the most impactful strategy when it comes to zero waste. Policies set standards, provide funding, and create mechanisms to incentivize participation. For instance, states that have returnable bottle deposits have a 70-90% diversion rate compared to a national average under 30% diversion for states that rely on voluntary recycling participation.

Including reduction, policy, purchasing, and behavior change initiatives with a continued emphasis on education and infrastructure will move the campus towards its meaningful and impactful zero waste goal.

C. Data Analysis

1. Waste Diversion Rate and Contamination

At most buildings on campus, there are three discard options located at each disposal station: composting, recycling, and incinerator (trash). The **waste diversion rate** is defined as the amount of material diverted from the incinerator and instead recycled or composted. Diversion is measured by specific items accepted by the College's recycling (J.P. Mascaro) and composting (Kitchen Harvest) vendors. In an effort to measure impact of what happens to the materials after it leaves campus, diversion rates are measured after removing contamination (non-recyclable/compostable items) from the recycling and compost streams. To date, diversion rates have not included reduction; however, work is being done to benchmark total volumes in an effort to be able to include reduction in future measurements.

Chart B below shows that net waste diversion on campus has increased from 32% in 2016 to 41% in 2019.

Chart B: Waste Diversion Rate, 2016-2019

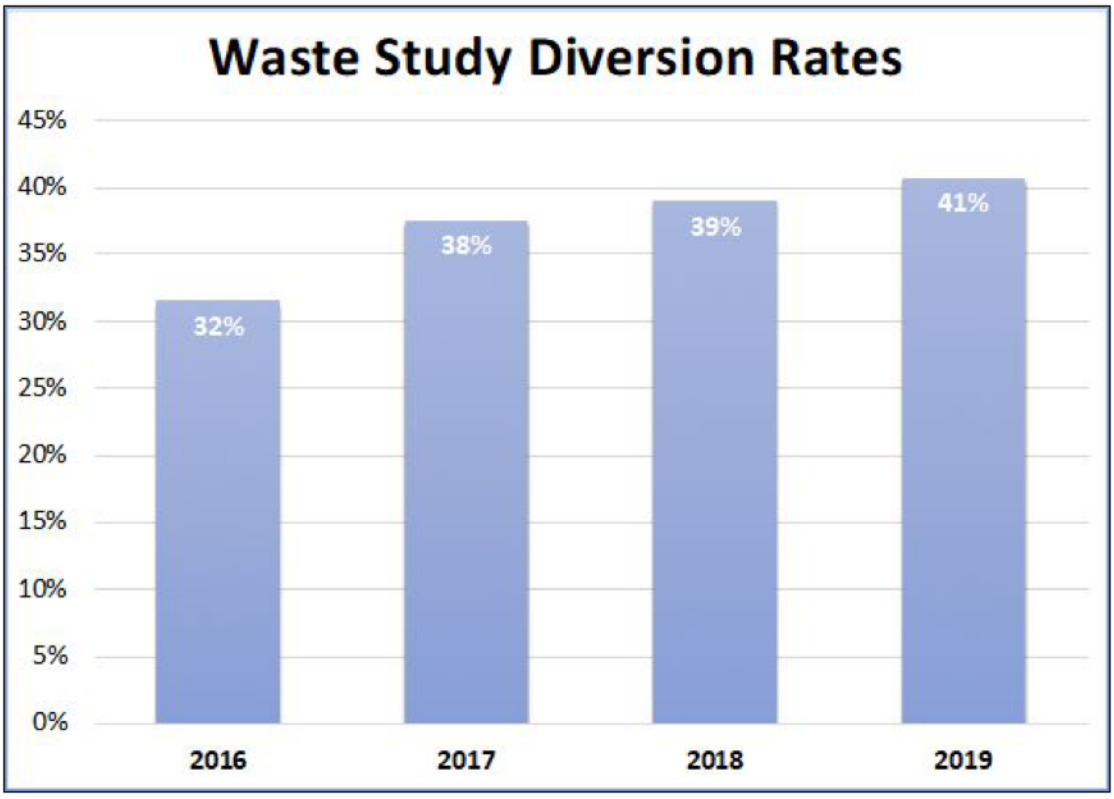
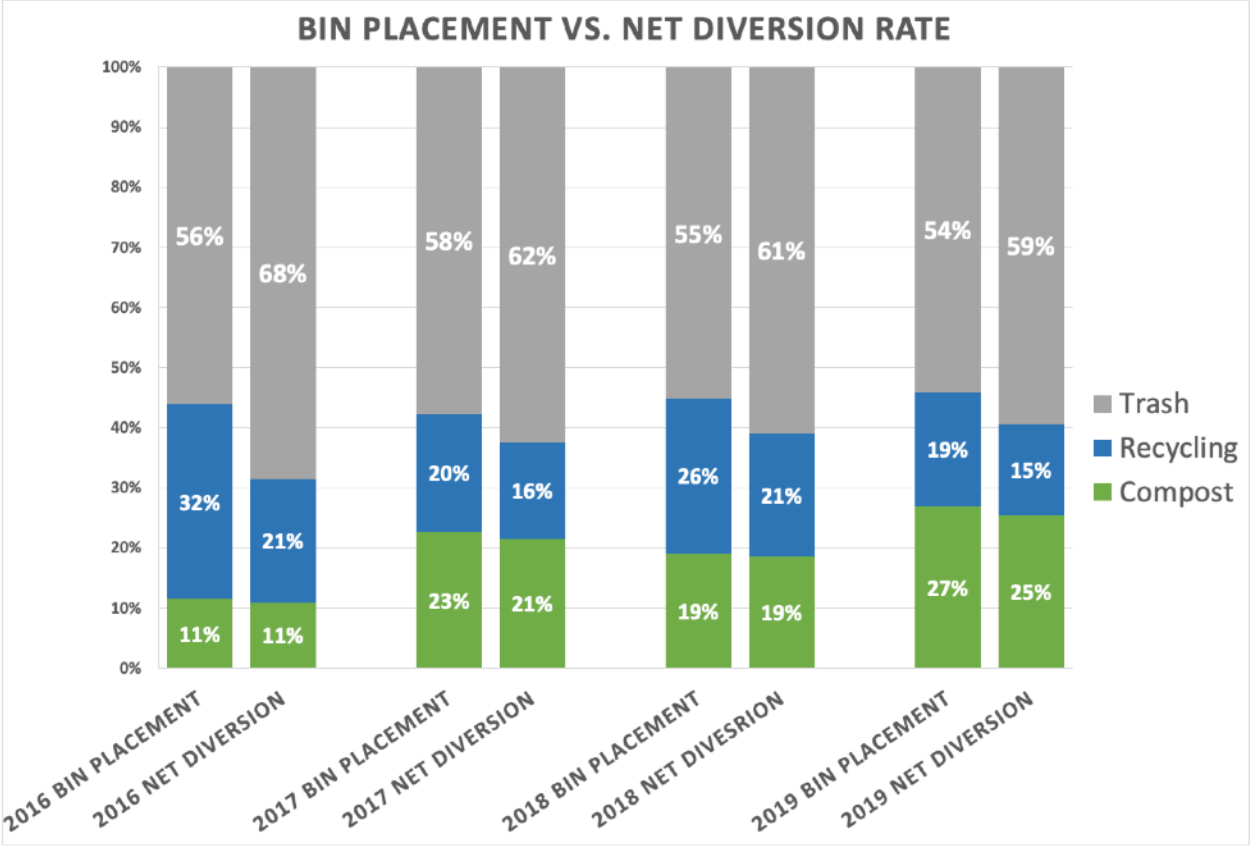


Chart C further compares which stream discards were placed in ("Stream Placement"), and how the composition changes after contamination is removed ("After Contamination"). The "After Contamination" values reflect the amount of correct discards in the correct stream, not including contamination. This is referred to as the **net diversion rate** because it is the actual amount of material used as feedstock for another process, resulting in positive environmental and social impacts. For this analysis, compostable items incorrectly placed in recycling were subtracted and added to the trash (as this is what happens at the recycling facility when it is sorted). Likewise, recyclable items in the compost stream were subtracted and added to the trash (as this is what happens when student Green Advisors daily sort the compost stream).

Chart C shows that based on the above analysis, the number of discards placed in recycling has actually gone down but, because the stream has become much cleaner, this resulted in an increase in the net amount of recycling diverted on campus.

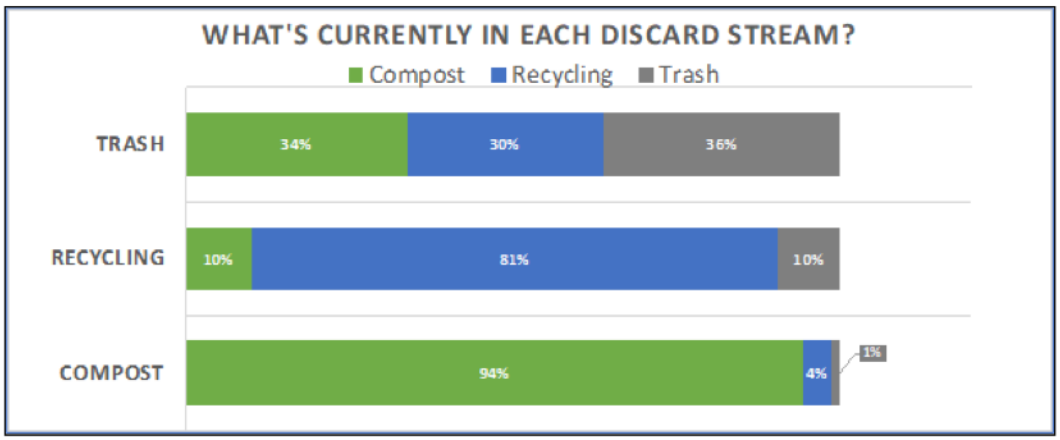
Chart C: Impact of Contamination - Comparison of Actual Stream Placement in Bins and Net Diversion Rate, 2016-2019



2. Waste Stream Composition

Chart D, below, shows what the average composition was of each stream in the 2019 waste characterization study, as placed in the bins by the campus community.

Chart D: 2019 Composition of Each Discard Stream



This chart explores two vital pieces of information. First, it shows that the trash stream includes 34% compostable material and 30% recyclable material. Thus, 64% of the items sent to the incinerator could be diverted to composting and recycling. The final 36% of the trash that is not recyclable or compostable can be addressed by rethinking the products purchased and consumed, and then reducing or replacing them with more sustainable options.

The second trend this chart shows is the impact of contamination. Contamination is a critical issue in the marketplace today and keeping the compost and recycling streams clean helps ensure that the recycling and composting is used as feedstock in new, valuable uses that result in a net decrease in carbon emissions. 20% of the recycling stream currently includes contamination that is not accepted in the recycling program. About half of the contamination is from compostable products that were mistakenly put in the recycling (e.g., compostable cups, service ware, etc.). The other half is from non-recyclable packaging like black plastic, poly-lined cups, Styrofoam, film and bags, and food contaminated items – all of which are not accepted by typical recycling facilities. **Chart C** above shows that the contamination rate for recycling has gone down significantly from 2016. This is likely from the investments in education and uniform waste bins on campus. Approximately 6% of the compost stream was non-compostable contamination. This was made up of mostly non-compostable cups and food serviceware, and shows how having a consistent stream of compostable products is a critical strategy for avoiding contamination. Legislation that standardizes labeling, such as that recently adopted by Washington State, can help reduce confusion about what is compostable or recyclable. Having some cups that are compostable and others that are not is confusing, and having a uniform stream of all recyclable or all compostable items is critical.

It should be noted that waste characterization studies are done prior to compost sorting by the Green Advisors, who would likely remove most of the contamination (at least that is easily identifiable) of the compost stream prior to shipping to be composted at Kitchen Harvest.

3. Capture Rate

As an alternative to looking at overall diversion rate, looking at capture rates can be more helpful in determining specific strategies to reduce waste. **Capture rate** is the measure of what percent of a specific item ends up in the correct stream. **Chart E** below shows that the capture rate for all compostable items on campus that correctly make it into the compost stream has grown from 23% in 2016 to 56% in 2019. The recycling capture rate has stayed relatively flat, actually decreasing in 2019 to 47% from a high of 63% in 2018. This is likely due to variability in waste characterization study protocols across the years. The decrease in recycling capture rate could also be attributed to confusion and overcorrection with understanding what is recyclable, suggesting greater need for clarity through signage, messaging, and education.

Chart E: Compost & Recycling Capture Rates, 2016-2019

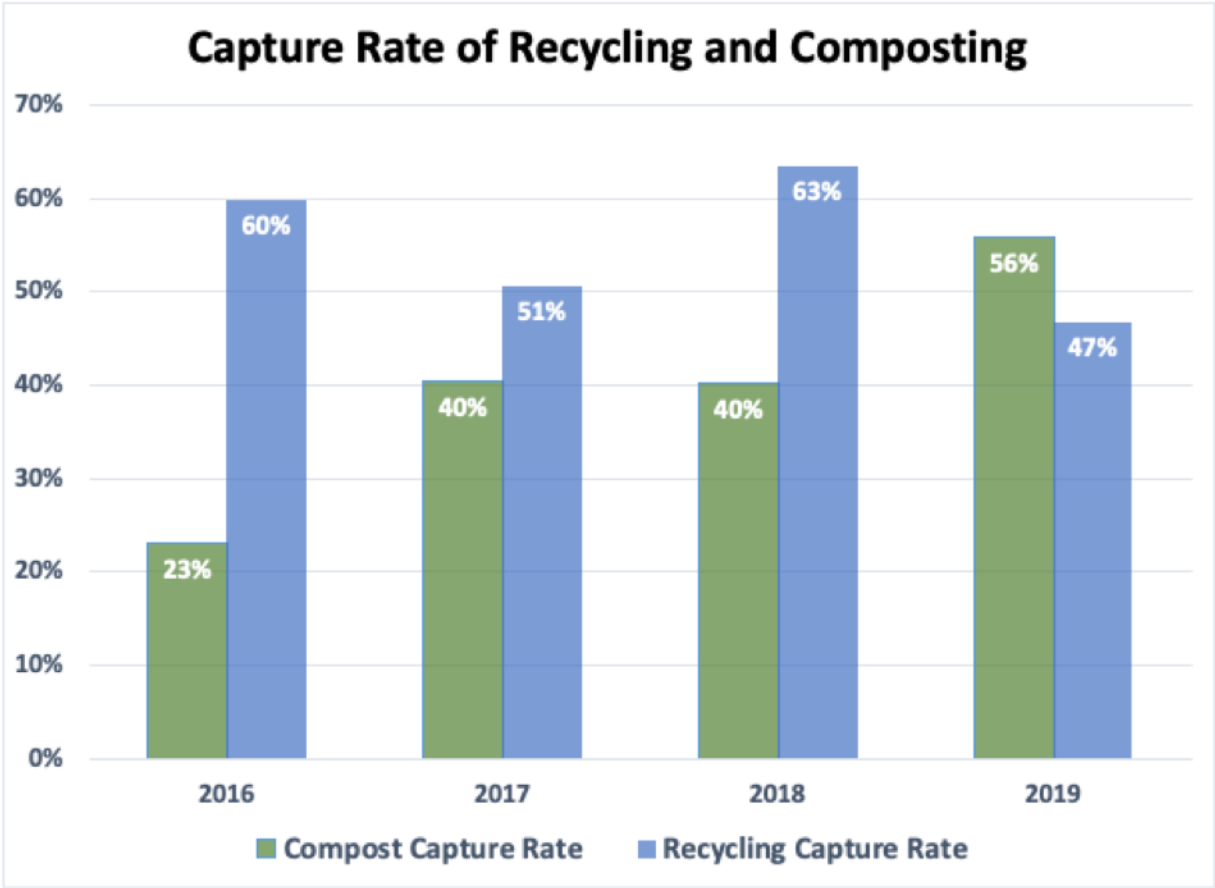
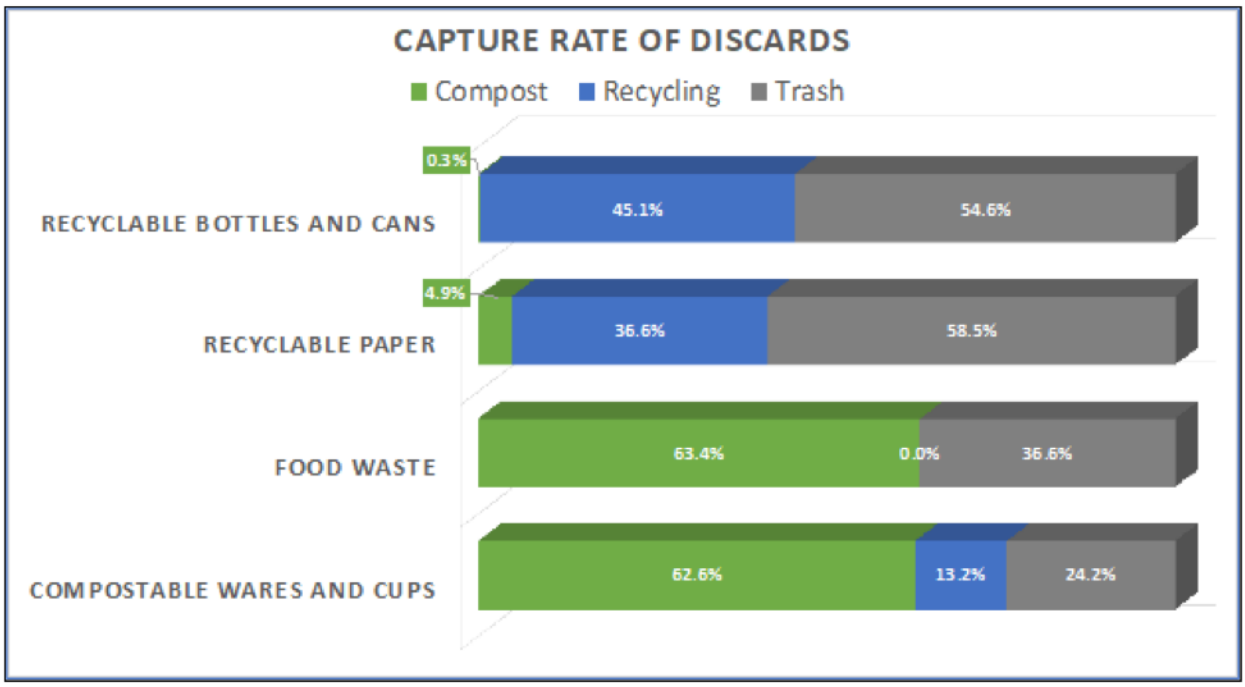


Chart F below shows the 2019 capture rate for more defined sub-categories of items within the overall streams. These numbers show that over half of even the most basic recyclable items are still not being recycled, while 35-38% of the most basic compostable items are still ending up in the wrong stream.

- 54.6% of bottles and cans are in the trash instead of recycling.
- 58.5% of recyclable paper is in the trash instead of recycling.
- 36.6% of food waste is in the trash, instead of composting.
- 37.4% of compostable products are not composted and contribute to contamination in the recycling stream where they are mistakenly placed.

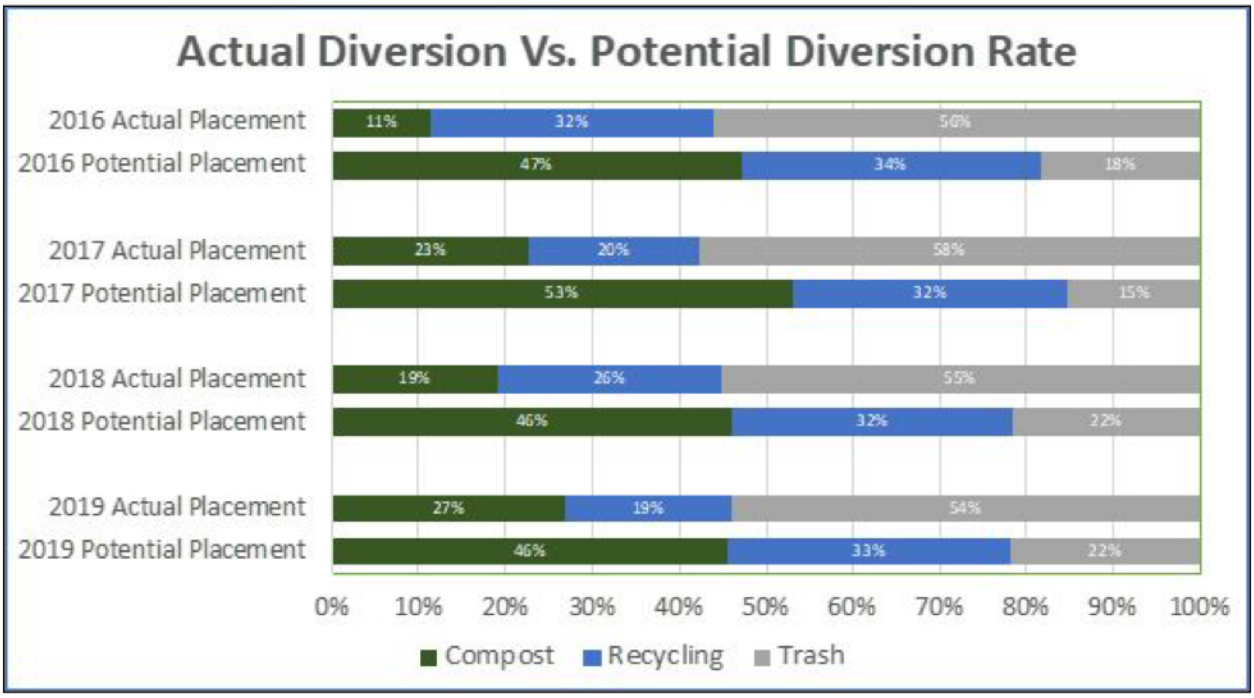
Chart F: 2019 Sub-Category Capture Rates



4. Potential Diversion Rate

Chart G shows the potential opportunity to divert discards to the recycling and/or compost streams. The rows listed as "potential placement" show the optimal levels possible if recycling and/or composting everything possible. While the actual placement in bins has changed towards increasing diversion rates over the years, the potential placement has remained relatively consistent. The overall mix of items consumed on campus in terms of potential for recycling and/or composting has been consistent. In 2016, 18% of all discards had no option for recycling and/or composting, increasing slightly to 22% in 2019. If the College reached this optimal 100% capture rate of all compostable and recyclable items, a 78% diversion rate would have been achievable in 2019.

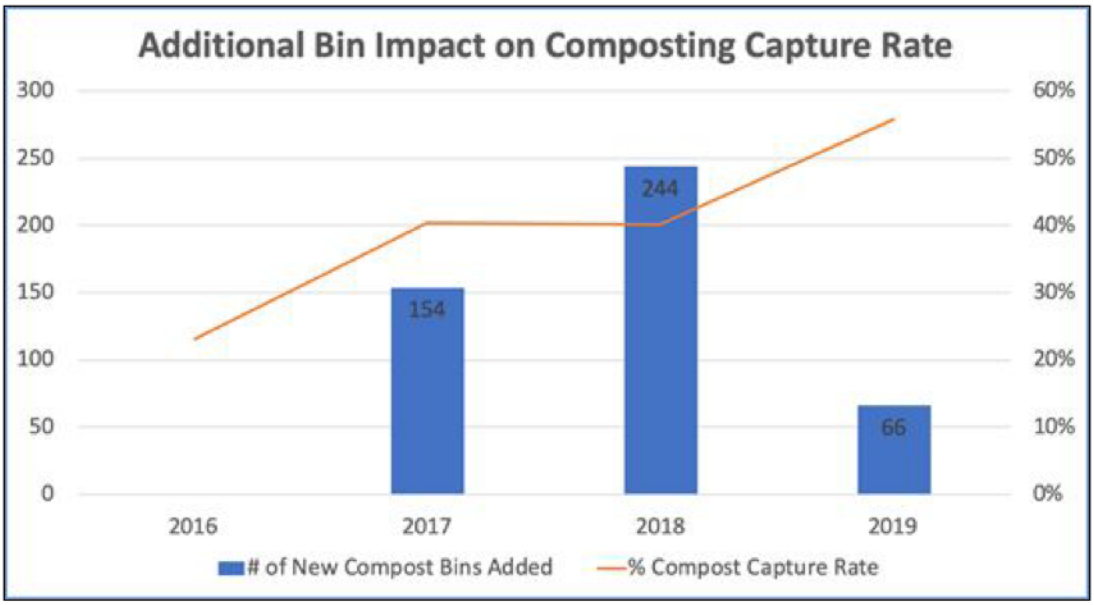
Chart G: Comparison of Actual and Potential Discard Placements, 2016-2019



5. New Infrastructure and Analysis

Chart H shows how the addition of new bins has correlated with the increase in the capture rate of compost. Between 2017-2019, 464 "waste stations" (each including a compost, recycling, and trash bin) were added across campus. In 2020, 53 more bins were added, resulting in a station with compost, recycling, and trash being located at almost every building hallway on campus. With the option to compost available in most locations, the amount of potentially compostable items captured in the proper composting bins rose from 23% in 2016 to 56% in 2019.

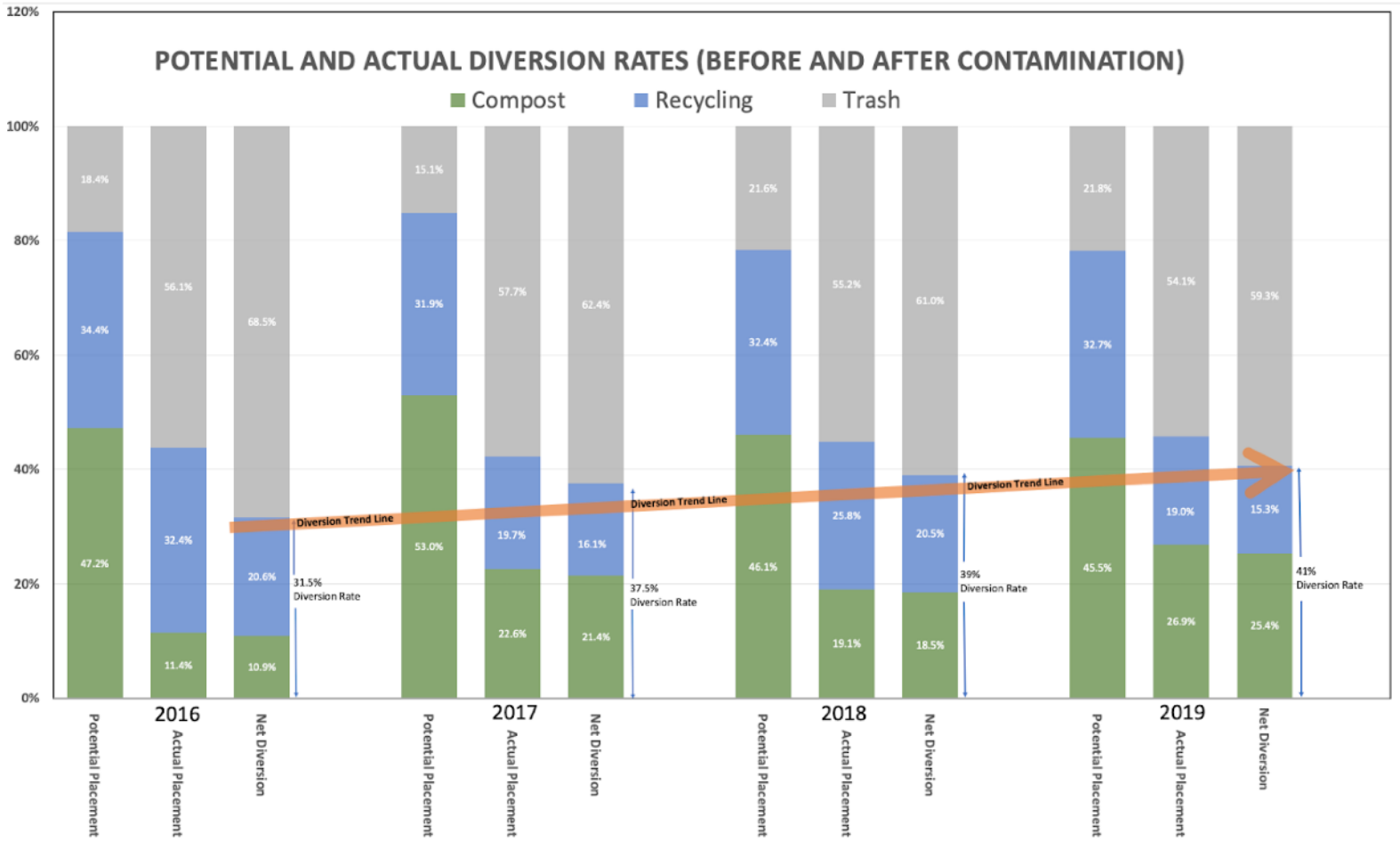
Chart H: Impact of Additional Composting Bins on Compost Capture Rate



6. Waste Characterization Study Results Analysis

Chart I summarizes the key elements to focus on in the waste sort, including overall composition of the college's discard stream, diversion rate trend line, contamination impact and net diversion rate.

Chart I: Key Elements in Understanding Diversion Over Time



The following columns are shown over time, from 2016-2019 waste characterization studies.

- **Potential Placement:** This shows what the optimal recovery rate could theoretically be based on the composition of all 3 discard streams (compost, recycling, and trash).
- **Actual Placement:** This reflects where people placed discards, whether it was in the right container or not. This includes correctly discarded materials as well as contamination that was placed in the wrong bin.
- **After Contamination is Removed:** This reflects the correct discard in the correct bin, after contamination was removed. This is referred to as the "net diversion rate" as it is the true amount of material resulting in environmental and social impacts. For this analysis,

compostable items incorrectly placed in recycling were subtracted and added to the trash (as this is what happens at the recycling facility when it's sorted). Likewise, recyclable items in the compost stream where subtracted and added to the trash (as this is what happens when student Green Advisors daily sort the compost stream).

- The green, blue, and gray bars show the percentage of composting, recycling, and trash in each column.

Chart I shows that while the College's net diversion rate (after contamination is removed) is gradually increasing over time, the two biggest factors in achieving the diversion rate have been an increase in compost bins and less contamination in the recycling stream.

- The orange **Diversion Trend Line** shows the net diversion rate after subtracting contamination (non-recyclable/compostable items put in the wrong container): The diversion rate has gradually increased from 31.5% in 2016, to 41% in 2019. This growth is due largely to the increase in access to composting.

- The green bars show composting rates.

    - This shows compost had the most growth and that increasing both compostable serviceware options and access to composting containers has been responsible for most of the growth in net diversion. However, compostable serviceware also contributes to contamination in the recycling stream (**Chart F**).

- The blue bars show recycling rates:

    - In 2016-2017, when much of the diversion focus was on recycling and with limited options for composting, we saw a decrease in the number of items that were placed in recycling, reflecting a better job of the community keeping non-recyclable items out of the recycling.

    - Reducing contamination is a huge environmental benefit but isn't reflected in the metrics of diversion rate. Having a cleaner recycling stream actually decreases the overall diversion rate since this contamination would typically be removed at the recycling facility and counted as diversion when it leaves campus. This is an example of why focusing on diversion alone is dangerous.

    - The recycling rate stayed fairly flat through 2018. This reflects that behavior was not changing, either due to people not participating in recycling at all, or not recycling certain types of recyclable products.

    - In 2019 there was a decrease in the recycling rate. This could be due to the community's distrust in the recycling industry (as reflected in the media) or just an anomaly of the small sample size.

7. Overall Campus Discards

To date, the waste characterization study has focused on only discards generated in the day to day actions of the campus community. This has not included materials such as electronic waste (e-waste), scrap metal, yard waste, and construction and demolition (C&D). A rough estimate of these discards streams was included in **Charts J and K** to show that this brings the overall campus diversion rate up to 55.4% without construction and demolition waste, and 87.7% if you include construction waste sent to a C&D recycler. It should be noted that 2019 numbers include above-average C&D waste (67.6%) due to the deconstruction associated with Singer Hall.

Chart J: Estimating Total Campus Discard Stream in 2019 (not including construction and demolition waste).

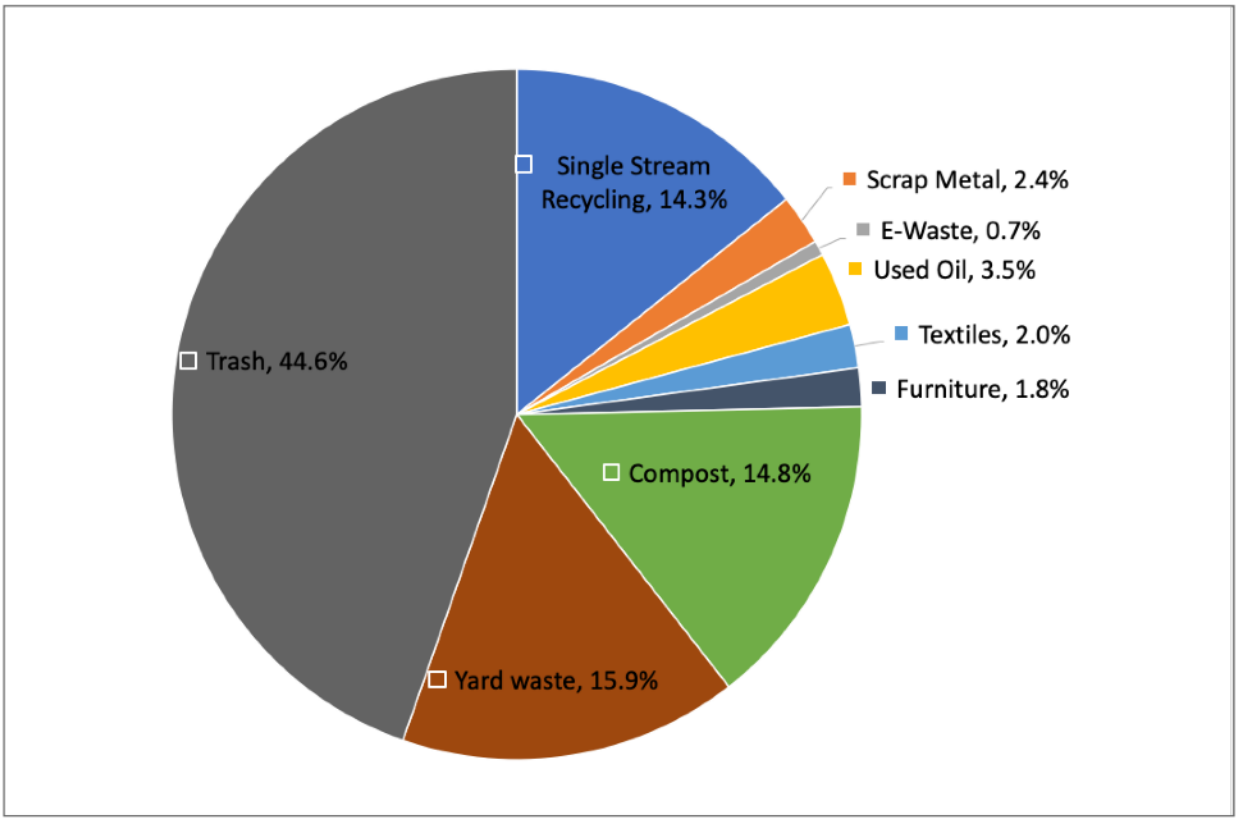
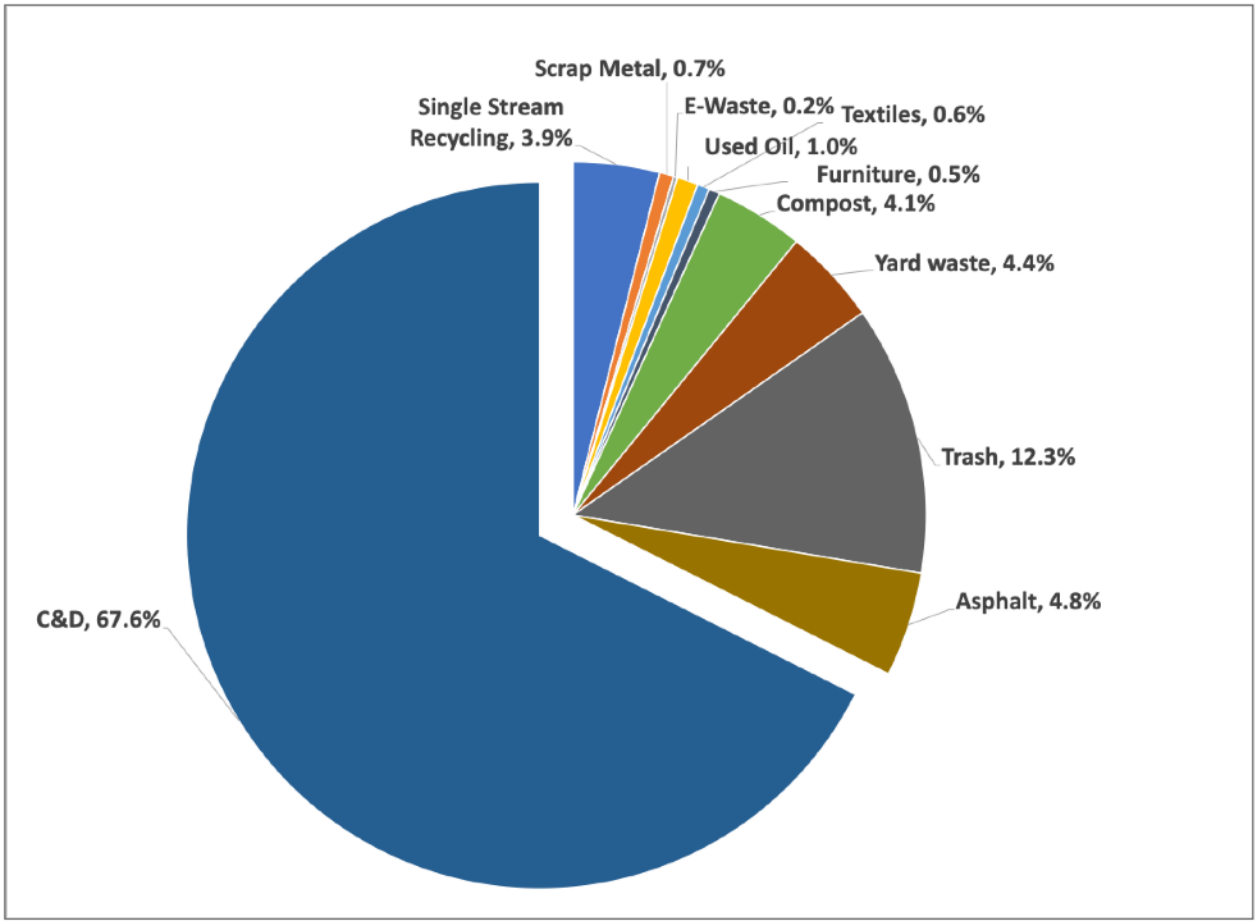


Chart K: Estimating Total Campus Discard Stream in 2019 (including construction and demolition waste).



8. Carbon Costs of Materials Management

The purpose of this section is to explore the embedded carbon in Swarthmore College's materials management system. Currently, the only institutionalized tool which integrates waste data is the College's greenhouse gas inventory, reported annually to Second Nature. Notably, waste is an optional category in the inventory; the Office of Sustainability chooses to include it, using a software tool called SIMAP to calculate the carbon emissions associated with our waste disposal and processing practices. These emissions factor into our Scope 3 emissions under the College's carbon neutrality commitment. However, established greenhouse gas reporting protocols only consider the emissions associated with the end-of-life disposal process (incineration versus landfilling) of discarded materials. Within this model, our incinerated waste is considered a net reduction in the College's emissions due to the waste-to-energy configuration of the Covanta Incinerator. To provide a more holistic picture of the "true cost" of the College's waste, and how this embedded carbon could and should influence strategic thinking around the College's sustainability and environmental justice goals, several other approaches can be used. In this section, the Environmental Protection Agency's Waste Reduction Model (WARM) was employed to provide a broader, systems-based approach to evaluating the emissions reductions associated with the College's diversion and reduction efforts.

WARM is a waste management planning tool that cuts across traditional sectors used in GHG inventories (e.g., categorical separation of waste from energy), thereby capturing emissions factors and reductions from a material's complete lifecycle. Emissions from the material's production, transportation, use, disposal, and end-of-life processing etc. are all considered.[1] The systems-based approach used by WARM allows us to identify institutional processes and opportunities for emissions reductions within the College's materials management system, such as the relative impacts of discards reduction versus stream diversion, impacts of stream contamination, specific discards categories, etc.

Chart L shows the calculated projections of annual lifecycle emissions reductions based on Swarthmore's current total discards volume, relative to incineration. The graph demonstrates that the College's current rate of 41% diversion to recycling and compost achieves reductions in greenhouse gas emissions of 475.2 metric tons of CO2e (MTCO2e). If a 20% reduction[2] in total discards volume is additionally applied to this scenario, the reductions in emissions doubles to 965.9 MTCO2e. This demonstrates that reducing the total volume of discards has a significant impact on emissions reductions compared to discard diversion from incineration. **Chart L** also projects that at a 79% diversion rate - the highest possible diversion rate currently reflected by our discard streams[3] - the College would reduce emissions by over 1,006.7 MTCO2e. If a 20%

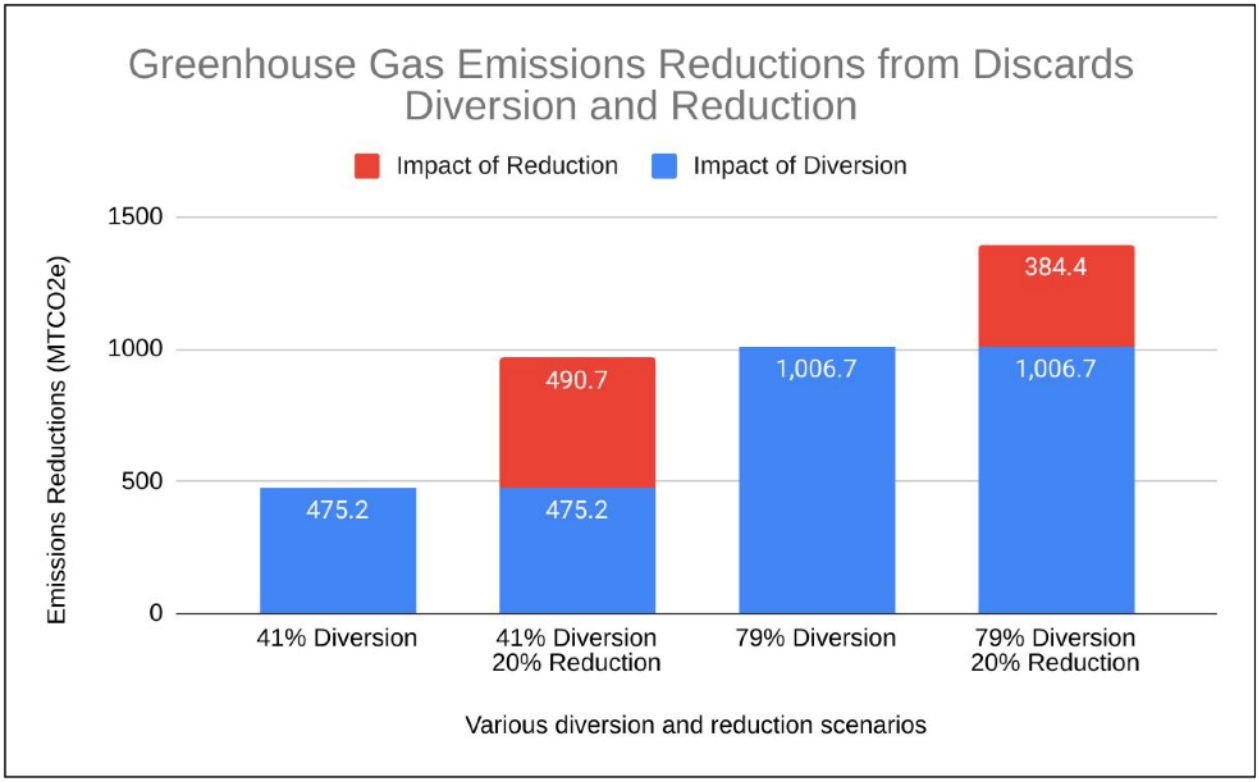
[1] Life-Cycle GHG Accounting Versus GHG Emissions Inventories, Environmental Protection Agency

[2] 20% reduction was chosen as an achievable but impactful goal for reducing discards volume, given Waste Characterization Study results. Note that the Zero Waste Working Group is working on confirming a specific reduction target.

[3] Based on Waste Characterization Study results, not taking into account other waste streams (i.e., construction & demolition).

reduction in total waste volume is additionally applied to this scenario, the reduction in emissions rises to 1,391.1 MTCO2e.

Chart L: Projected greenhouse gas reductions of various waste diversion and reduction scenarios, based on current waste volume and relative to 100% incineration.



There are future opportunities to use the Waste Characterization Study data to calculate net carbon impacts for different waste categories, and then prioritize the reduction, diversion, or replacement of specific materials that have the largest potential for emissions reductions.

For example, recycling one ton of paper and cardboard results in 2.7 $MTCO_2e$ in emissions reductions. For bottles and cans, the impact is 5.81 $MTCO_2e$ per metric ton recycled. Notably, the impact of reducing one ton of either paper/cardboard or bottles/cans results in a reduction of over 7 $MTCO_2e$, illustrating that the institutional policies targeting purchasing decisions are often even more impactful than diversion. As another example, composting food waste rather than incinerating it results in a carbon savings of .18 $MTCO_2e$; however, changing one ton of the food supply to vegetarian results in a carbon savings of 2.9 $MTC0_2e$. Clearly, reducing the amount of meat purchased (and displacing it with a vegetarian option) will result in a significantly higher carbon savings than any action taken at the point of discard.

Finally, it is important to acknowledge that while considering the carbon impacts of the College's materials management is critical from an emissions perspective, there are many other motivations (such as air pollution minimization, improved health and safety, and eradication of environmental racism) that are not directly captured by this focus. There is future work that can

be done to measure and assess the impacts of Swarthmore College's materials management from these different perspectives, which is further explored in the forthcoming 2020 Swarthmore Zero Waste Plan.

Acknowledgements

Special thanks to Alex Danovitch of Nothing Left to Waste for his contributions to this report.