

# Waste Characterization: Study & Outreach on Nantucket

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Full project materials are available at: <https://wp.wpi.edu/nantucket/projects/2018-projects/dpw/>.

## Abstract

The Nantucket recycling system is unique given its use of a biodigester and the large fluctuation of waste generated between the summer tourist and winter seasons. This project developed a waste characterization process for the Department of Public Works that was then conducted to collect data about the waste stream. The study data was analyzed to understand how much of the waste stream could be diverted from the landfill through proper recycling, and used in the creation of educational materials for the public and a tutorial guide for the DPW to use for future waste characterization studies. Additional developments from this project included a recycling poster for the community, and recommendations for improving the overall disposal systems on Nantucket.

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# Executive Summary

## Introduction

Nantucket, Massachusetts is a unique, small island community that faces challenges similar to most other places of reducing landfill use and increasing recycling while reducing the wastes mixed with recycling material. Issues involving general waste and recycling management on Nantucket are exacerbated by Nantucket's unique tourism environment; about 50,000 tourists and visitors arrive in the summer while there are only about 12,000 year round residents (Lajoie, 2017). The fluctuating population results in a remarkable increase of waste production. Unfortunately, the year-round waste stream, including the summer months, is often contaminated by recyclable items that could have been diverted from the landfill. To improve upon efforts to reduce, reuse, and recycle across the island, Nantucket has to better educate its residents and visitors on ways to improve adherence to the "3 R's" approach. This requires a better understanding of the waste disposal habits of both the year-round residents and visitors of the island to help better understand the root of the problem.

The Nantucket Department of Public Works (DPW) has a long-standing mandatory recycling program on the island for residents, visitors, and commercial businesses, which focuses



**Figure 1.** *Nantucket's Biodigester*

mainly on the recycling component of "reduce, reuse and recycle." There is the Madaket Mall, where people can leave items such as clothes and books for others to take as a method of reuse. Nantucket also utilizes a special biodigester (Figure 1), that breaks down any compostable material in the waste stream so that it can be repurposed as soil. This feature reduces the use of the landfill.

Because there had never been a waste characterization done on the island, the DPW staff had insufficient data for its website and for use in educational materials to help residents and visitors of Nantucket do a better job with recycling and improve their own waste management practices.

## Mission Statement

Nantucket cannot effectively reduce landfill usage and improve recycling habits without conducting a waste characterization study to determine where and how contamination is occurring in their waste stream. The primary goal of this project was to develop and test a waste characterization process for the Nantucket DPW in order to recommend a repeatable waste characterization method. By repeatedly collecting data on what is going into the waste stream over time, the DPW can develop more focused messaging and outreach materials for the public.

## Methodology

The specific goals, objectives, and tasks of this project were originally developed prior to arriving on the island. Subsequently, they evolved and were completed while working on site. The final list of objectives divided the project into three phases:

- Develop a method for and conduct a waste characterization study on a sample of waste from Nantucket.
- Evaluate and recommend a repeatable method for waste characterization based on research and the data collected during the test waste characterization study.
- Develop public outreach materials to help educate the Nantucket community on proper waste disposal.

To achieve the project objectives, the team applied research conducted on past waste characterization studies from other communities and the findings from a test waste characterization study on Nantucket to create a step-by-step guide detailing a waste characterization process. The data from the test waste characterization study was also analyzed based on the DPW's interests with the intent of developing educational materials for community outreach and knowledge.

## Data Analysis and Findings

Analysis of the data collected during the test waste characterization study on October 30th, 2018 led to several conclusions about Nantucket's waste disposal habits. To start, during October 2018 the DPW collected 702 tons of municipal solid waste. After observing total waste trends across four years, the sample taken on October 29th, 2018 was concluded as representative of the month of October 2018. The sample was used to represent the distribution of waste collected during the entire off-season of 2018, divided into the categories shown in Table 1. As illustrated in Table 2, 119 tons (17%) out of an approximately 702 tons of waste are recyclable monthly. This recyclable waste includes corrugated cardboard, recyclable plastics, textiles, recyclable glass, tin/aluminum, and other metals.

**Table 1: Waste Characterization Results, October 2018**

General Category	Sub-Category	Total Wt (lb)	Wt % of Total	Total Weight Month Oct 2018 (tons)
Paper	Paper and Cardboard	429	24%	169
Paper	Waxed Paper	30	2%	12
Paper	Corrugated Cardboard	79	4%	31
Organics	Compostable Organics	668	37%	263
Organics	Non-Compostable Organics	55	3%	21
Plastic	Non-recyclable plastics	158	9%	62
Plastic	Recyclable plastics	43	2%	17
Plastic	2020-Ban plastics	12	1%	5
Plastic	Films	93	5%	37
Plastic	Styrofoam	22	1%	9
Other Waste	Textiles	49	3%	19
Other Waste	Other materials	-	0%	-
Metal	Tin/aluminum	64	4%	25
Metal	Other metals	14	1%	5
Glass	Bottles/Jars	53	3%	21
Glass	Other Glass	4	0%	2
Electronics	Electronics	11	1%	4
Bulky Materials	Bulky Materials	-	0%	-
<b>Total Samples</b>		<b>1,781</b>	<b>100%</b>	<b>702</b>



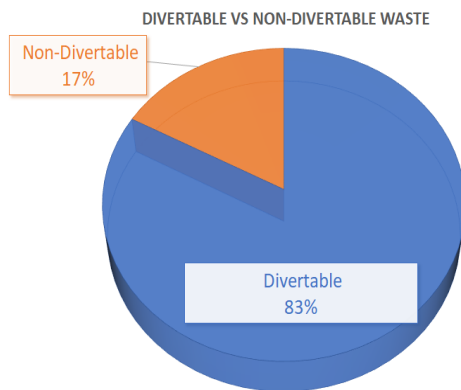
**Table 2:** Categorical Percentage of Total Weight, October 2018

SUB-TOTAL CATEGORIES	Weight(lb)	% Total	Tons in Oct 2018
Compostable	1,175	66%	463
Non-Compostable	606	34%	239
Recyclables	301	17%	119
Non-Recyclables	1,480	83%	584
Paper	538	30%	212
Organics	722	41%	285
Plastic	328	18%	129
Other Waste	49	3%	19
Metals	78	4%	31
Glass	57	3%	22
Electronics	11	1%	4

Because of Nantucket's unique biodigester, it's important to consider the comparison

between compostable materials, paper and food wastes that will break down and be diverted, and non-compostable materials, which will ultimately go to the landfill. As shown in Table 2, the total percentage of compostable materials in the waste sample was 66%, while non-compostable materials made up the remaining 34%.

For Nantucket, recycling, composting, and the Madaket Mall are the only ways of diverting material from the landfill. All recyclable and compostable items make up the "divertable" section,



**Figure 2.** Ratio of Divertable to Non-Divertable Materials by weight

illustrated in Figure 2. According to the data analysis, approximately 83% of the Nantucket waste stream could be diverted. Thus, public outreach materials were made to portray the importance of both recycling and composting on Nantucket.

## Outcomes

### Outcome 1: Recycling Posters for Public Outreach

To help increase knowledge about proper recycling techniques specific to Nantucket, explanatory posters were created. They are tailored to Nantucket's unique system. There is one version of the poster designed for in-home use, and one designed to be displayed for people dropping-off their household waste at the DPW intake facility.

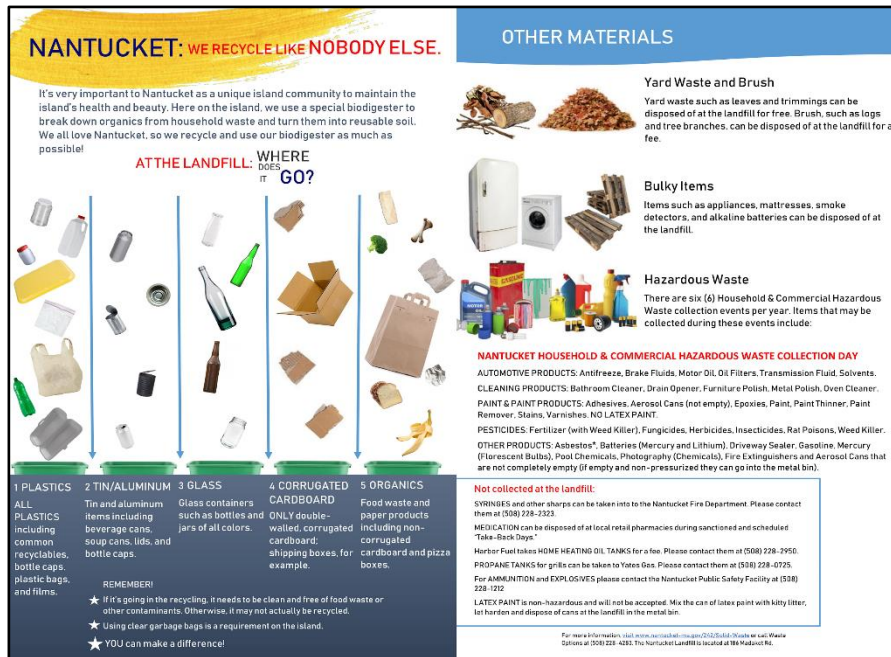


Figure 3. Poster Draft

As shown in Figure 3, the poster drafts include pictured examples of common materials that belong in the various sorting receptacles that the DPW intake facility in Nantucket requires. The reverse side features items that are commonly confusing to dispose of. The posters are meant to act as references for community members who may not be sure how or where to dispose of something. The poster either directly informs the viewer on how to dispose of items (front side of poster, left side of Figure 3), or notes where they can find more information (back side of poster, right side of Figure 3).

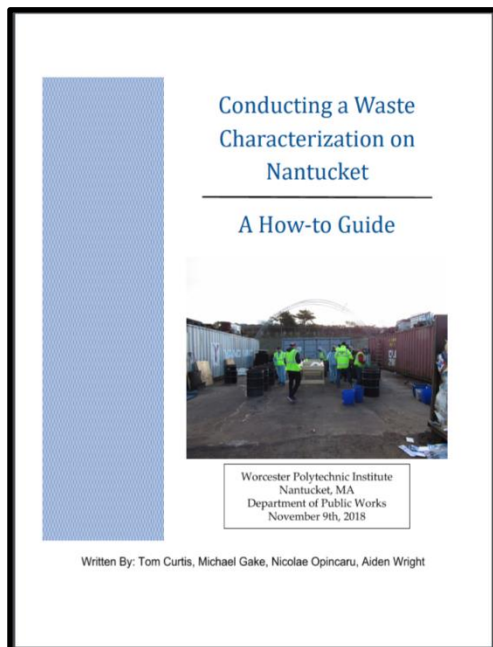


Figure 4. Title page of the guide

## Outcome 2: How-to Guide on Conducting a Waste Characterization Study

To ensure that the Nantucket DPW and other interested parties have a process to follow, a detailed guide for conducting a waste characterization study (Figure 5) was developed. The “How-to” Guide covers the logistics of a waste characterization study, detailing all necessary steps. The guide is divided into the three main sections: the planning phase, the action phase, and the analysis phase. A photo of the action phase is shown in Figure 4. The guide serves as a guideline and is meant to be adapted and changed depending on resources and intent of a sort.

## Chapter 1: Introduction

Nantucket, Massachusetts is a unique, small island community that faces challenges similar to most other cities of reducing landfill use and increasing recycling while reducing the wastes mixed with recycling material. Issues involving general waste and recycling management on Nantucket are exasperated by Nantucket's unique tourism environment; about 50,000 tourists and visitors arrive in the summer while there are only about 12,000 year round residents (Lajoie, 2017). The fluctuating population results in a remarkable increase of waste production. Unfortunately, the year-round waste stream, including the summer months, is often contaminated by items that could have been diverted from the landfill. Namely, it is contaminated with recyclables. To improve upon efforts of reducing, reusing, and recycling across the island, Nantucket has to better educate its residents and visitors on ways to improve adherence to the "3 R's" approach. This requires a better understanding of the waste disposal habits of both the year-round residents and visitors of the island to help better understand the root of the problem.

In an Ipsos Public Affairs Survey from 2011, 45% of people cited recycling wasn't convenient, took up too much time, or that they simply forgot to do it. It is also known that tourists go through behavioral change when on vacation, and in particular often feel a lack of responsibility for recycling and waste disposal in a community they may not consider to be their "home" (Oliver, 2011). This is locally evident, in part, in that there are uniformly-labelled bins placed around multiple public spaces on Nantucket - such as the beaches and the downtown areas that often are filled with contaminants or misplaced products - primarily during the summer-tourist months.

Although the bins help keep the downtown common areas cleaner, most of the Municipal Solid Waste (MSW) comes from commercial, curbside, and residential pickup of waste and recycling material throughout the island. MSW is essentially the official term for "trash," and consists of everyday items, such as product packaging, clothing, bottles, food scraps, and batteries. While there can be a new emphasis placed on the public bins to help remind tourists to dispose of wastes and recycling material properly, efforts also need to be put into studying household and commercial waste disposal on the island.

Nantucket cannot effectively reduce landfill usage and improve recycling habits without conducting a waste characterization study to determine where and how waste and recycling

contamination is occurring where, for the purpose of this report, contamination in the recycling stream is defined as mixed recyclable materials in single streams, such as plastic scraps mixed in to the paper stream, which leaves the paper stream unrecyclable. A waste characterization study involves a community taking a random sample of waste and categorizing the contents to determine what materials have been disposed of improperly (Tomaszeski, 2018).

There were numerous previous studies that provided examples to draw from when developing a waste characterization process tailored specifically to Nantucket and its particular needs. One example is a six step guide provided by the EPA for conducting a waste characterization study. The Director of the Nantucket Department of Public Works (DPW), Robert McNeil, led a waste characterization in Millbury, Massachusetts in 2015. McNeil stated that Millbury has a similar population to Nantucket and found that the study data supported the implementation of a new food scraps disposal system. Similar studies have been conducted in places like Pierce County, Oregon (Pierce County, 2015) and at Worcester Polytechnic Institute (WPI) in Massachusetts (4th Annual, 2014). The waste audit on the WPI campus in particular is conducted by primarily student volunteers once a year. The school takes a random sample of waste, weighs it, sorts out the misplaced trash and contaminants, and then weighs the waste again. These types of efforts help expose what types of waste are being disposed of improperly and to what extent. These efforts also helped in guiding our team as we developed a Nantucket specific waste characterization study.

Despite the Nantucket Department of Public Works' (DPW) recognition of the waste disposal and recycling issues on the island, there were still complications preventing solutions being implemented. The DPW has the responsibility of maintaining the public services across the island (Public Works, 2018). They have a long-standing mandatory recycling program on the island for residential members and commercial businesses, which focuses on only the recycling component of "reduce, reuse and recycle." Because there had never been a waste characterization done on the island before, the DPW staff has not had data needed for its website and in educational materials to be directed towards residents and visitors of Nantucket. Both summer and winter populations on Nantucket will be more aware of Nantucket's disposal procedures when presented with clear, specific data and waste disposal guidelines.

The goal of our project was to address the issue of waste stream contamination by helping the Nantucket DPW develop a repeatable waste characterization process and, in doing

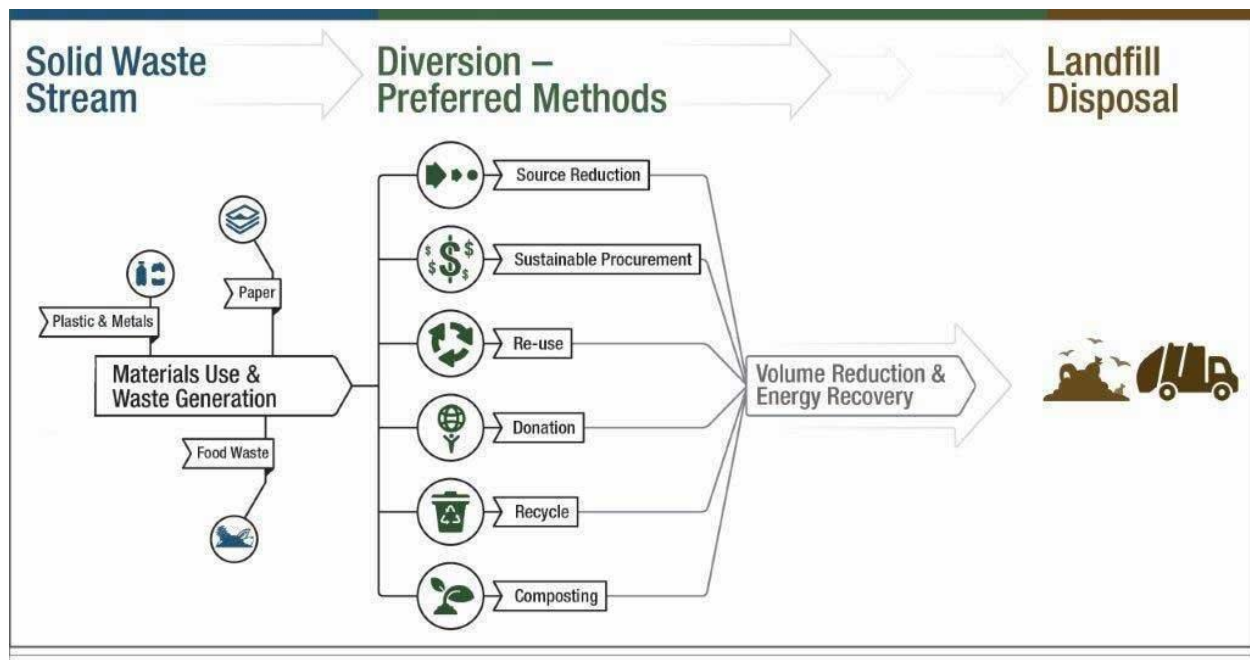
so, collect data that could be used to advance public educational materials across the island. To achieve the project goal, the team applied research conducted on past waste characterization studies from other communities to create a step-by-step guide to conducting Nantucket's study that complied with the DPW's interests and resources. This guide was then used to conduct a waste characterization on a sample of 200 bags of waste from Nantucket. Our team then analyzed the resulting data based on the DPW's interests, working primarily to develop educational materials for the community on how to fully encompass the goals of reduce, reuse, and recycle. An aspect of this educational effort was the creation of two brochures -- one for locals and one for visitors -- that explained the specifics of recycling and waste disposal on Nantucket. Another aspect involved using focus groups to better understand locals' opinions and motivations in regards to recycling.

## Chapter 2: Background

Our background research was conducted with the motivation of understanding community waste disposal systems, how they have been implemented in the past, and what challenges come with their development. The information presented in this background serves the purpose of creating a foundation for understanding and completing our project. In looking at waste disposal and recycling on Nantucket, this chapter presents the history and policies of waste management, the technicalities of a waste characterization, the economic benefits and impacts of recycling, factors that influence recycling behavior, case studies on past recycling programs, specifics on Nantucket's recycling and waste management and its Department of Public Works, and research on creating educational materials about recycling.

### 2.1 History of Recycling and Waste Management

Historically, the development and implementation of waste management systems has presented a wide range of problems. Currently in the United States, waste disposal is typically managed by a local municipality that collects trash door to door and processes it through the appropriate channels, usually by taking recycling to a processing plant and sorting solid waste to either be incinerated or put in a landfill. In figure 1.1 we can see all the different methods of waste diversion. We can see the three R's exemplified in the methods below with source reduction, reuse and recycling. Each of these methods help divert waste from landfills; trying to increase the amount of waste that gets diverted has become a priority for waste managers.

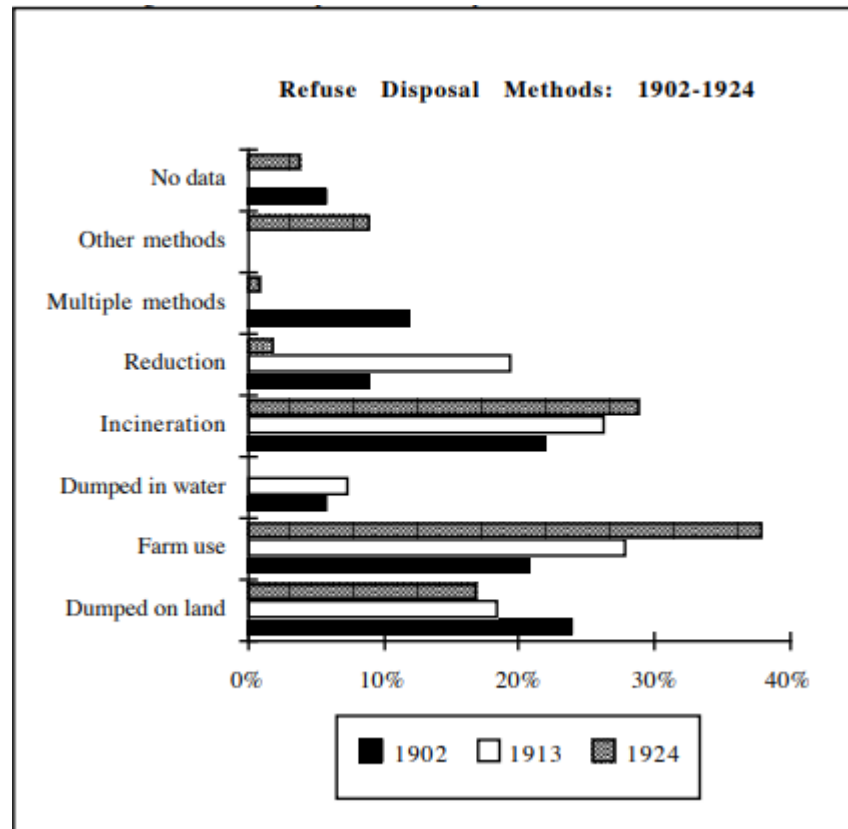


**Figure 1.** Municipal Solid Waste (Flowchart (Department of Defense Environment, 2016))

Before our modern institutions of waste municipalities and organized systems were put in place, solid waste posed a major problem for public health and safety. In the mid to late 19th century, expanding city populations led to an unsustainable amount of waste being disposed of in downtown areas. This waste impeded city traffic and endangered public health, and local governments had to consider solutions to the waste problems, such as hiring private contractors or implementing programs of their own. Hiring private contractors to handle the waste was expensive for the city, and the population expanded faster than their workforces could handle effectively, but some argued that a public waste management service would be prone to corruption. Over time, city governments employed various combinations of public and private methods, and while contracted waste disposal did manage to keep the streets cleaner, the ways that the waste was removed was largely at the cost of the local environment with large portions of waste being dumped on unused lands or in the ocean (Louis, 2004).

Eventually, cities started adopting more organized and environmentally friendly ways of disposing of waste. New York City's implementation of waste management in the 1890s established a system that effectively kept the pavement clear of trash. This system employed organized and scheduled street cleaning crews as well as designated landfill areas for trash. The success of this system led to other cities employing similar methods themselves. As time went on

cities also started to employ more effective methods for diverting trash such as incinerating solid waste and sending food waste to farms for fertilizer and feed (Louis, 2004), as seen in figure 1.2. Dumping in water became an almost non-existent practice in cities by 1924, and land dumping became less frequent as more diversion processes were being employed.



**Figure 2.** Refuse Disposal Methods (Louis, 2004)

By the mid-20th century, waste management processes were highly organized with well defined waste streams, defined as the complete flow of waste from domestic or industrial areas through to final disposal. Unfortunately, with the new development of single-use packaging, waste managers and municipalities started to struggle with increases in trash production. Specifically, prior to World War Two, and especially in the wake of the great depression, the culture of reusing items was common. Bags, jars, cans, and containers of all kinds were kept and saved for future reuse by people who bought them. This was not necessarily an effort to reduce waste but was rather an economic decision by consumers who were saving money by reusing products rather than buying new ones (Waxman, 2016). This culture of saving and reusing started to disappear after the introduction of single-use products like plastic bags and disposable



bottles. It was only after the increase of non-reusable products that the waste systems of the time started to be challenged.

Between 1960 and 1970, waste generation increased by more than a third causing increased harm to the environment (EPA, 2015). In response, President Nixon started the Environmental Protection Agency, a federal agency that was tasked with protecting the nation's environment by regulating hazardous materials. Over time, the EPA took on more responsibilities regarding the problems of solid waste management and it was during this time that the three R's of waste were emphasized: Reduce, Reuse, and Recycle. The hierarchy starts with reduction, trying to generate less waste (Louis, 2004). If a reduction in waste is not possible, reusing materials allows items that would end up in the trash to fulfill a new purpose. Finally, recycling enables materials to be reclaimed from goods that would otherwise end up in landfills. When implemented, these methods have been shown to reduce waste substantially, but it is not enough. In 2015, yearly waste generation reached 262.4 million tons in America, triple the amount from 1960 (EPA, 2015).

Recently, the EPA published a report in which they discuss the breakdown of waste by materials. Having access to this data allows municipalities to better understand the influx of waste and create systems to deal with certain types in a more sustainable fashion. For instance, yard trimmings represented 13.3% of the total waste in 2015 (EPA, 2015). Knowing this, municipalities that wish to reduce their waste and carbon emissions could divert yard trimmings from incineration to farming use or paper production. Of course, local municipalities cannot be entirely sure that the national statistics regarding material breakdowns will be applicable to their situations. These local departments can instead rely on data collected locally by performing a waste characterization study.

### Waste Characterization Studies

Waste characterization is a process in which waste is collected and analyzed in order to provide a more intricate understanding of the different materials coming into the waste stream. The data generated from waste characterizations is valuable to lawmaker and local solid waste management agencies as it allows solid waste planners to accurately target and handle certain waste materials. We will go into more detail about waste characterizations in section 2.2.

### 2.1.1 Waste Management and Recycling Programs in the United States

The United States has the highest waste production rates per person in the world. In a study by the EPA, it was found that the country creates about 250 million tons of solid waste per year, or about 4.6 pounds from each person. Fortunately, positive changes are underway; the recycling rate in the US has increased from 10% to 34% between 1980 and 2010, and disposal into landfills has decreased from 89% to 54% of the waste stream in the same time period (Rogoff, 2014). The recycling rate is obtained by dividing the total amount of municipal solid waste recycled in a given year by the total generated municipal solid waste for that same year.

The recycling industry itself is one that has seen changes over the past 20 years, and will continue to change. There have been advances in the technologies available to countries and cities, largely due to the increase of new recycling programs. In 2010, it was reported that there were around 9000 curbside programs implemented to improve recycling rates and limit the necessity of landfill use in the United States. Furthermore, the construction of waste facilities has paved the way for even greater reduction in the number of landfills. There are roughly 1900 active landfills in the United States, down from about 8000 landfills being used in 1988 (Rogoff, 2014).

#### *California Waste Management*

In 2000, California set an overall waste diversion goal of 50%, which Los Angeles used as a motivator to develop its city-wide recycling program to achieve zero waste by 2025. Their program initially used 14-gallon yellow bins for recyclables and green bins for yard waste and collected these with manual recycling vehicles. This approach has since been changed to 90-gallon wheeled carts for all residential customers; blue carts for recyclables and green carts for yard waste and which are now collected by fully-automated vehicles. Businesses in the city have the option of delivering recyclables directly to drop-off centers or hiring permitted haulers. As of 2010, the residential households were generating 979 tons of recyclables per day and 1783 tons of green waste per day: a rate of 72% residential solid waste being recycled.

San Francisco's Department of the Environment partnered with Recology (SF Environment) to run its waste program. The city's goal was to reach a landfill diversion rate of 75% by 2010 and zero waste total by 2020. To accomplish this goal, the city and Recology set-up a mandatory composting and recycling diversion program, requiring every person in the city

to source-separate their recyclables, compostables, and trash into the corresponding container. The mandatory composting system involves collecting all organic waste, such as food scraps and yard trimmings, and storing it under conditions designed to help it break down naturally. 99% of apartment buildings have a recycling service in-place and 95% have a composting service. Each single-family and multi-family residence can get 32-, 64-, or 96-gallon bins at no cost. Because of their efforts, San Francisco is collecting over 600 tons of organics per day and 160,000 tons annually. Overall, 80% of municipal solid waste is being kept from landfills (Rogoff, 2014).

### *Seattle, Washington Solid Waste Management System*

The Seattle Public Utilities runs the city's solid waste management system with the goal of reaching 70% recycling of municipal solid waste by 2025. Through their program, single-family households receive a 64-gallon recycling bin for single-stream recycling and are required to keep food and yard waste. Both recycling and garbage requirements come with a detailed list of what materials are accepted. As a result of this program, single-family households recycle at a rate of about 71%, or 66 lb/month. For comparison, multi-family households recycle at a rate of about 29%, or 30 lb/month (Rogoff, 2014).

Although only a few examples of recycling programs have been discussed in this section, there are many cases like these that can be researched and learned from.

## 2.2 Waste Characterization

A waste characterization study is a community wide event that aims to reduce the tonnage of municipal solid waste (MSW) landing either into the incinerator or the landfill of the city. The process behind a waste characterization is simply hands-on trash sorting. As stated in an informational guide from Pierce County (Pierce County, 2015), a waste characterization sort starts off with broad waste types and then narrows down the incoming waste into specific waste categories, the amount and specificity of which are up to the discretion of the local waste study project manager. Broader categories of waste are generally based on the source of the incoming waste. Such categories include residential waste streams, commercial waste streams, and industrial waste streams. The waste from each of the broader streams is randomly sampled and further separated into specific categories ranging from food waste and plastic containers to

electronic waste and batteries. (*Tomaszeski, 2018*) The weight is recorded for all incoming trash and then recorded again for each of the specific categories for post-waste sort data studies.

The logistics behind a waste characterization and the amount of time planning one is surprising to some due to the desired thoroughness of a waste study and the volume of solid waste sampled. According to a guide provided by the EPA on conducting a waste characterization, there are six steps to a successful waste characterization:

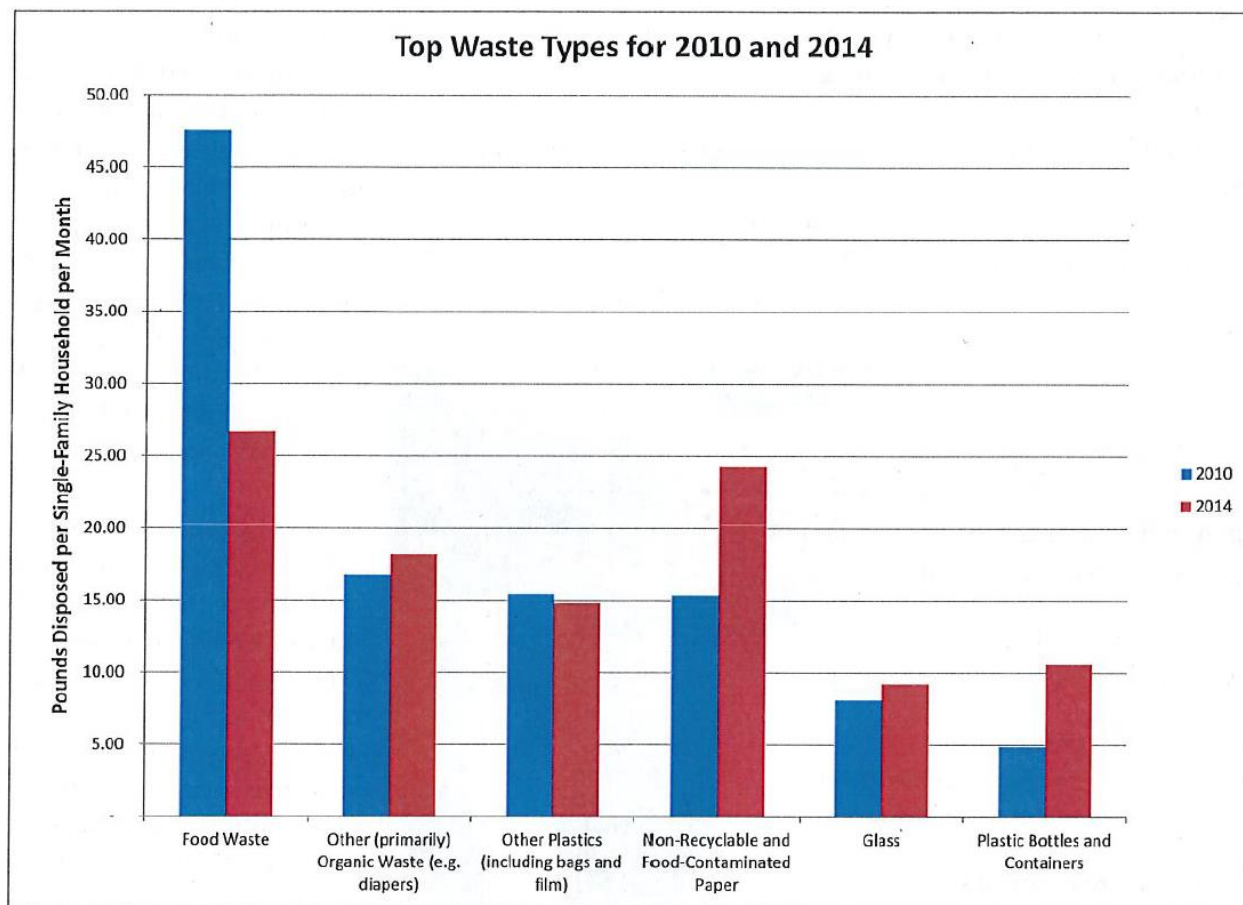
1. Develop Goals and Target Waste Sample
2. Complete Pre-Assessment Process Questionnaire
3. Plan Assessment Process
4. Coordinate Logistics
5. Conduct Waste Sort
6. Collect and Review Data

Targeting the correct waste samples is the most important step of the waste characterization process. Carefully selecting the waste samples is necessary to collect data that is representative of the waste stream. For example, Coyote Valley is a 78 acre reservation of Native American Pomo people located in Redwood Valley, California. The reservation is home to a gym, casino, police station and 35 homes and is currently expanding, and there were concerns about solid waste generation on the reservation with the upcoming expansion projects. Their waste hauler targeted two waste samples: residential and casino waste and had them separated before the beginning of the sort. With the help of the EPA the Native American Pomo people followed exactly the 6 steps outlined above to conduct their waste characterization. Steps 2-4 involve the logistical planning of the sort: outlining the area to be used, the plan of hauling the waste, determining the purpose of this waste characterization and the goal of the community. These steps are not described as in-depth due to the specificity of waste characterization cases, the location of the sort and the transport of waste is up to each individual characterization and the restriction of the location it takes place in.

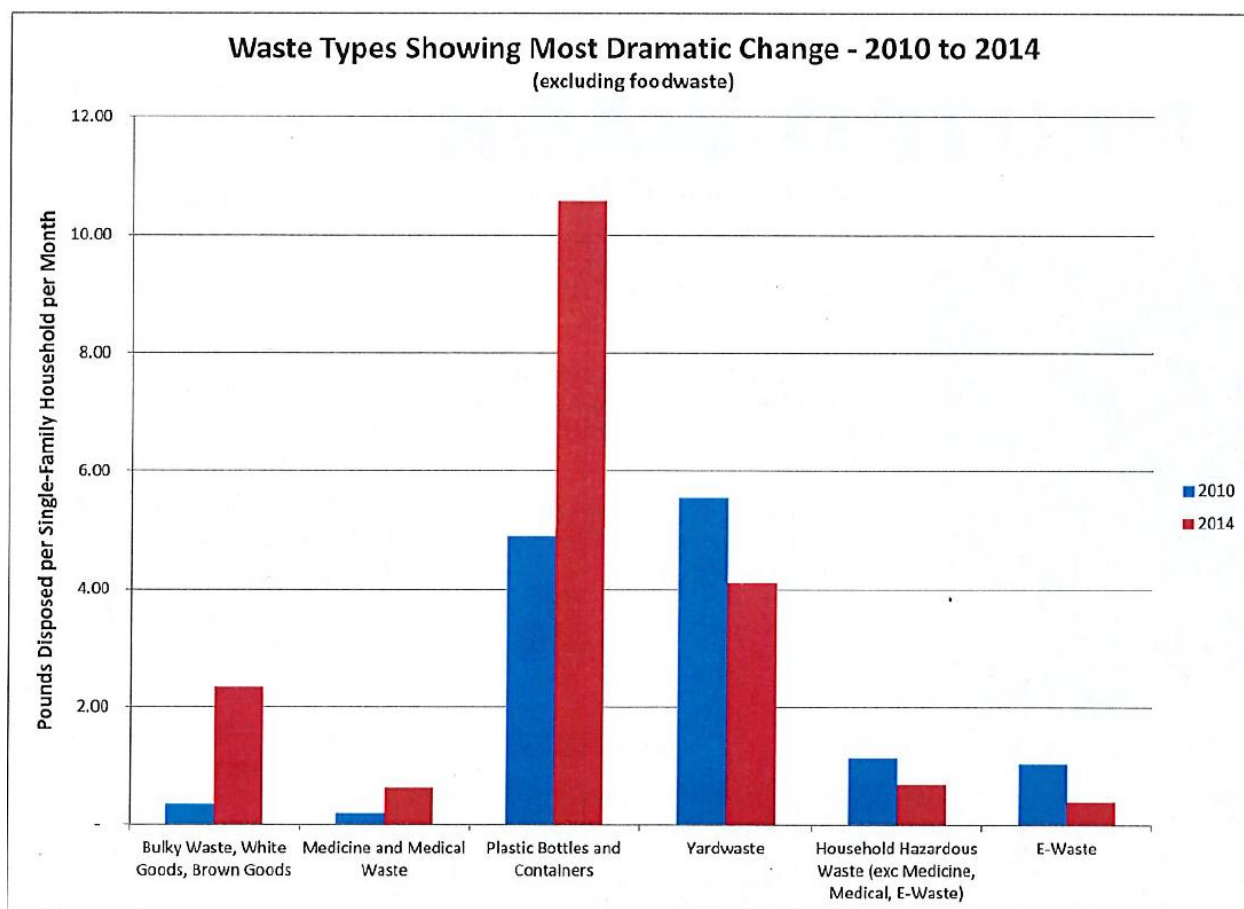
Step 5-6 are simple but have a few caveats: items like household hazardous waste and bio/medical waste are ambiguous in their categories and oftentimes a health hazard to the workers, such waste needs a protocol and specific bins assigned before the sort. Then all the waste from the different streams are separated in appropriately labeled bins and weighed. In Coyote Valley, the data collected from the two streams highlighted the waste management issue

on the reservation: while the number was unspecified, the waste characterization study results indicated that Styrofoam represented a large volume of casino waste, but not the residential waste. With this information casinos changed from Styrofoam containers and replaced them with greener containers. The amount of liquids and food waste in the casino waste also spurred discussion on ways of addressing those wastes outside the waste stream. The waste generated by the households on the reservation had more textiles than expected, prompting the deployment of Textile Recycling bins across the reservation. There were less recyclables mixed in with the waste than expected, showing that the previous education efforts were effective. The feedback from the community after the characterization asked for future changes to the process by providing more adaptable tooling for sorting through the trash such as tongs for sifting through bags with a lot of liquid and food waste and thicker rubber gloves.

Following are some example data results from a waste characterization conducted in 2010 and 2014 in Beaverton, Pierce County.



**Figure 3.** Waste Types in Beaverton, APWA Reporter, 2014



**Figure 4.** Changes in Waste in Beaverton, APWA Reporter, 2014

### *Millbury Waste Characterization Study*

Nantucket DPW director Robert McNeil previously held the position as director of the DPW of Millbury, Massachusetts and has overlooked a waste characterization study conducted in Millbury, as well as obtained 6 years worth of data on trash and recycling tonnage that helps highlight the waste stream and the situation that Millbury is in. These data highlight the purpose of the waste characterization study: to realize faults in the waste disposal system. For example, after Millbury conducted a waste characterization study of 60 bags equivalent of “trash” were sorted by volunteer staff into 5 separate barrels: plastic, paper, metal, food scraps and trash. The original 60 bags of “trash” were destined for the incinerator, but after the characterization study around 20 bags of “trash” were found to be appropriately intended for incineration, while the rest of the waste was recyclables.

Based on the data generated from their waste sorting exercise, seen in Figure 5, trash tonnage, and Figure 6, recycling tonnage, below, the town of Millbury adopted new barrels to

separate the largest tonnage of these recyclables and food scraps, from the rest of the waste to decrease the amount of food scraps reaching the incinerator (*Millbury Public Access PSA*). The purpose of the waste characterization was fulfilled in Millbury; the town learned its biggest source of incinerator-bound tonnage and reacted appropriately by labeling bins as specifically “food-scrap” to further increase the rebates of the town and to reduce the cost and volume of waste requiring incineration.

Fiscal Year	Transfer Station - Trash Tonnage							
	2010	2011	2012	2013	2014	2015	2016	1-yr trend
July	241.46	272.40	269.82	211.91	204.77	170.27	166.81	-2%
August	253.68	224.49	244.22	238.17	196.66	170.44	149.28	-12%
September	244.01	256.16	236.74	232.30	192.79	144.82	139.16	-4%
October	239.69	247.38	243.32	234.70	184.43	147.23	180.13	22%
November	223.76	201.85	239.54	277.59	176.13	161.54	128.67	-20%
December	264.66	259.11	270.66	219.17	184.46	172.28	155.64	-10%
January	202.52	205.39	219.96	198.41	162.31	157.44	149.43	-5%
February	203.45	188.44	207.41	193.46	153.22	119.82	143.12	19%
March	203.63	238.00	233.10	213.67	143.27	139.63	131.14	-6%
April	249.90	275.74	238.50	209.34	166.71	159.17	153.99	-3%
May	256.70	257.09	248.01	229.12	175.67	169.03		-100%
June	262.03	283.39	276.46	223.22	155.55	149.13		-100%
Total	2,845	2,909	2,928	2,681	2,096	1,861	1,497	-20%
% CHANGE	N/A	2%	1%	-8%	-22%	-11%	-20%	

**Figure 5. Millbury Trash Transfer Station Data, Millbury DPW**

	Fiscal	Transfer Station - Recycling Tonnage							
	Year	2010	2011	2012*	2013	2014	2015	2016	1-yr trend
J	July	42.42	44.98	5.76	24.90	49.96	66.07	70.24	6%
A	August	41.13	34.88	41.81	25.67	51.17	65.69	63.49	-3%
S	September	30.85	40.16	34.32	24.18	51.35	60.98	66.45	9%
O	October	35.91	35.46	31.07	27.06	48.60	67.86	69.13	2%
N	November	38.49	30.42	35.59	27.50	51.29	65.45	71.83	10%
D	December	40.45	39.36	37.44	27.17	71.97	82.41	77.63	-6%
J	January	43.88	46.12	33.93	37.98	50.37	65.43	67.00	2%
F	February	35.98	32.06	24.76	30.92	49.46	59.52	64.22	8%
M	March	33.00	35.01	24.96	36.90	46.24	60.42	58.29	-4%
A	April	43.00	37.90	27.74	51.95	63.55	63.26	67.75	7%
M	May	37.79	39.41	25.61	43.41	56.75	69.02		-100%
J	June	37.49	41.66	27.66	52.85	57.27	73.09		-100%
	Total	460	457	351	410	648	799	676	-15%
	% CHANGE	N/A	-1%	-23%	17%	58%	23%	-15%	
*Note: Abitibi Paper collection bins helped reduce the overall recycling tonnage reported between 12/12 and 12/13.									

**Figure 6. Millbury Recycling Transfer Station Data, Millbury DPW**

Following along this process we could create our own step 7, where as a team we utilize the gathered data to produce educational material similar to the video posted by the Millbury DPW. The root cause of waste issues is misinformation and education is the greatest weapon to use against misinformation and lack of knowledge. The most important step in the waste characterization process is the use of the data collected to better the understanding of the community, to bring them closer together on a common issue of sustainability and preservation of the environment.

## 2.3 Economic Benefits and Impacts of Recycling

One of the core tenants of recycling is that one can reclaim value from what would otherwise be considered waste. Whether it be from scrapping items for raw materials, or fixing up old items and using them like new, recycling benefits everyone by removing waste from landfills and giving it a new purpose. The fact that trash is being filled with items that people are deeming obsolete before their use has run out, has led to a new treasure trove of goods to be discovered by up and coming industries.

Recycling stimulates the economy in regards to the capital the recycled products return. If we view the system of waste in our culture, we can see that the main issue is that things have more intrinsic value than their lifetime use will allow. Aluminum cans, plastic bottles, and paper are examples of items that after being used once, serve no value to the user, but have value as raw materials. Unfortunately, processing these raw materials currently requires a good deal of labor. The EPA estimates that 1 worker is required for every 637 tons of recyclable material (Recycling Economic Information). In 2015, the US saw 3,140,000 tons of plastic recycled which would require nearly 4,930 sorting jobs, just for plastics. What's more, as recycling rates increase, the total number of possible jobs also increases. 2015 saw a total number of 34,500,000 tons of plastic waste generated (EPA, 2015). If 100% of that waste was recycled, it would have led to the creation of over 50,000 jobs. If the culture of recycling expanded, it could turn into a major industry and help curb unemployment (Forstater, 2006).

## 2.4 Recycling Influences and Effects



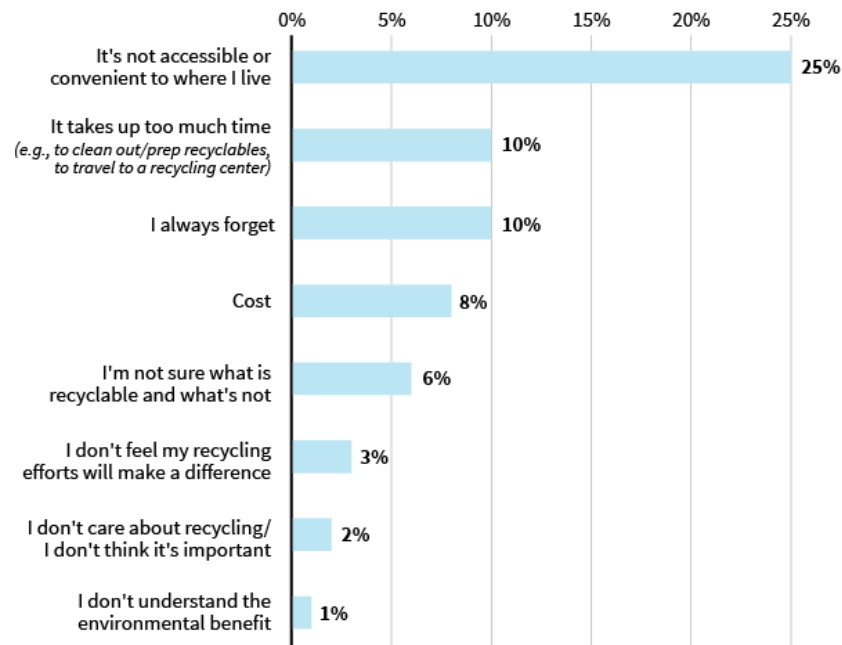
There are many factors that influence recycling rates. The perceived importance of recycling often depends on the way it is discussed and taught. In a national survey, it was found that 87% of residents in the United States say they recycle the majority of the time. In the same survey, 72% of those residents said they recycle mainly at home (Flagg, 2016). As a country, the United States has pushed for a more widespread effort in reducing waste. With over 9,000 curbside recycling programs made available to residents, there is an evident effort to push for a more sustainable society (Flagg, 2016).

The psychology of recycling directly affects the outcome of recycling efforts. This is because the nature of recycling, a voluntary act, is such that recycling rates rely on the participation of the community member; every disposal is a conscious decision on how and where waste is disposed of. Is there a difference in recycling rates in places where the community experiences the ease of curbside pickup as opposed to places where they do not? What are the most effective ways to stimulate efficient waste disposal behaviors? Answers to questions like these will lay the groundwork for the development of methods to increase the effectiveness of recycling programs.

An important consideration when it comes to recycling is that the human mind does not do well associating things that are not immediately accessible to it. The effects of recycling, such as a reduction of the rate of waste entering landfills and a reduction of the production of new non-compostable materials like plastics, are neither immediate nor visible to the public. This disconnect can be defined more comprehensively by the most common reasons that prevented people from recycling more in a 2011 Ipsos Public Affairs Survey: “it’s not accessible or convenient to where I live”, “it takes up too much time”, “I always forget”, “I’m not sure what is recyclable and what’s not”, “I don’t feel my recycling efforts will make a difference”, “I don’t care about recycling”, and “I don’t understand the environmental benefit” (Sizelove). Percentages of these answers may be found in Figure 7.

## Why People Don't Recycle

Which of the following, if any, prevents you from recycling more?



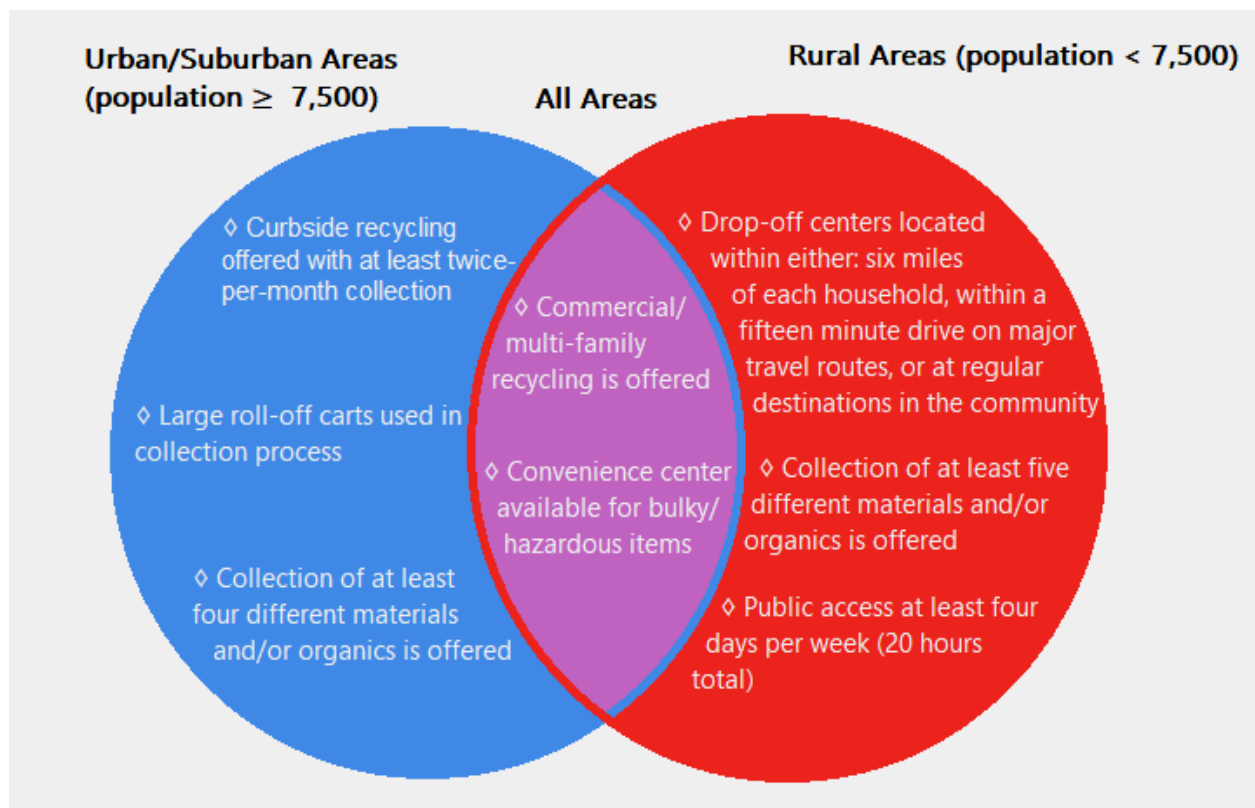
**Figure 7.** Common Reasons People Don't Recycle More (Sizelove, 2011)

These reasons for not recycling can be classified as either accessibility or knowledge-related issues. If a person does not have convenient enough access to recycling methods, the benefits of the program are not outweighed by the costs: transportation to materials recovery facilities, also known as MRF's, time spent organizing recyclables, or money spent on related fees. A person who does not have sufficient knowledge about the importance or process of recycling will not understand the benefits of the program and thus will not even have a basis against which to evaluate the costs. Knowledge-related shortcomings and misunderstandings take the form of not knowing what to recycle, not understanding the environmental benefits, or not believing their efforts will make a difference. Both accessibility of and public knowledge about recycling programs are responsibilities of local governments and agencies.

### 2.4.1 Accessibility

Accessibility of recycling services is commonly credited as one of the most important factors affecting recycling participation rates. It's important to establish a definition of "accessible." According to Carl Smith, president and CEO of Call2Recycle, accessibility can be

assessed by considering whether “a site is open to the public, whether the hours of operation are robust and flexible, and the proximity of sites to [community members].” People are far more likely to place their recyclables in the proper receptacles if the means to do so are close and readily available for them. In general, the US pales in comparison to Europe, and specifically Northern Europe, when it comes to its recycling rates - and a leading cause of America’s inadequacy is that as of 2008, only 50% of American households had access to curbside recyclable collection programs (Smith). Research specific to accessibility has led certain organizations, such as the Northeast Michigan Council of Governments, to formulate definitive requirements for the statistically successful recycling programs. These requirements have been organized into the following venn diagram.



**Figure 8.** *Optimal Recycling Program Service*

*Provisions (Northeast Michigan Council of Governments)*

## Nantucket Accessibility

Nantucket is a unique location in that its population fluctuates seasonally, placing it well into the “urban/suburban area” classification during the summer months and closer to the “rural area” classification during the rest of the year. Thus, all of these considerations are technically

applicable to the community of Nantucket. Nantucket has one materials recovery facility with deposit areas for all separated recyclables and even bulky items. It services the entire island and is open to the public for seven hours a day Monday through Friday and four hours a day on weekends.



**Figure 9.** Nantucket community members using the materials recovery facility (Alison Fader-Brock, *livemom.com*)

#### 2.4.2 Public Knowledge

There are several propositions regarding the relationship between the public's recycling-related knowledge and their recycling participation by different researchers that are worth considering. According to research from Jacobs et al., information-only-based education systems are ineffective in changing behavior. Contrarily, Ester and Winett argue that if information is sufficiently "specific and is delivered creatively and intrusively, the dissemination of information alone can lead to high levels of participation" (Reams, 1994). In 1997, Vining and Ebreo studied 197 Illinois households and found that the most important difference in knowledge between recycling and non-recycling households has to do with collectable materials; which materials are

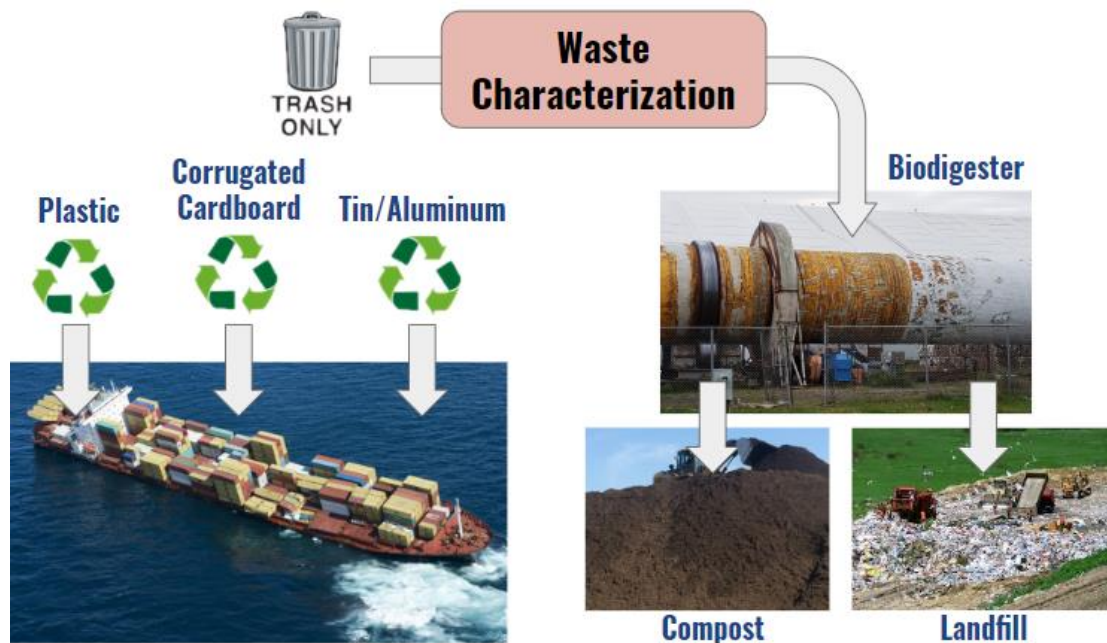
recyclable versus which are not (Schultz, 1995). P.W. Schultz et al. concludes that in general, a community member with more knowledge about the recycling process itself, which materials are recyclable, and where they are collected is more likely to recycle. This could be especially important when considering community-specific protocols that community members may be aware of, such as paper belonging in the regular trash on Nantucket.

There are many methods of sharing educational recycling information with the public. In general, knowledge tends to be distributed through a method called prompting, in which “information (e.g. about the relevance of recycling to alleviating solid waste problems, or about the community’s recycling program) is presented to potential participants” in an effort to increase potential participants’ understanding of their local programs and inspire them to participate them (Schultz, 1995). Occasionally, prompting can also involve a call to action, or a direct request for participation. Prompting can be in the form of, for example, indirect information sharing such as a publicly posted informational flyer or poster, direct information sharing such as mail delivered to homes, or the securing of pledges. The implementation of a waste characterization study will provide an excellent basis for data to be provided to the community on Nantucket to help educate them about exactly what happens to the things they dispose of, and how they can do better.

## 2.5 Nantucket-Specific Considerations to Recycling and Waste Management

The island of Nantucket, Massachusetts implemented a mandatory recycling program in July of 1996. The Material Recovery Facility on the island provides all residential and commercial property owners with a single drop-off area for all source-separated recyclables and households waste. The only curbside pickup available from the DPW is from municipal recycling cans located around the island. Commercial haulers are responsible for residential curbside pickup. Large loads of waste from commercial haulers are given a separate place in the Material Recovery Facility to dump their loads. These loads when en route to the landfill must be covered or a fine will be issued (Public Works, 2018). Waste previously organized into recycling

containers is separated from the rest of the waste and shipped off-island. The remaining material is then fed into a large-scale biodigester by a conveyor belt.



**Figure 10.** Nantucket waste system diagram.

The Nantucket biodigester is a single rotary drum reactor that uses bacteria to break down biodegradable material contained in the waste in order to catalyze the composting process and reduce the amount of space that waste occupies in the landfill. It is important to note that on Nantucket, all packaging used by any vendor or commercial establishment must be “biodegradable,” meaning anything capable of being decomposed by bacteria or living organisms. This produces more waste that can be processed by the biodigester. After this process, materials including films and plastics, which are not biodegradable, are mixed with compost and placed in the landfill. The plastics mixed in with the compost were either not recyclable in the first place, or simply were not recycled. During the waste characterization study, we will be sampling the municipal solid waste after the material already labeled as “recyclable” (i.e. the recyclables that people put into recycling bins) is removed. This will provide a clear image of how much recyclable material is making it into the landfill.

## 2.6 Nantucket DPW: Project Sponsor

The Nantucket Department of Public Works (DPW) holds the responsibility of maintaining public facilities and infrastructure on Nantucket. On its website, the DPW states that its leadership must: “ensure that all the functions of the Department are carried out completely and efficiently.” The department is lead by the Public Works Director, the Town Engineer, the Facilities Manager, and its Office Administrators. Altogether, the DPW staff includes 33 employees throughout 6 divisions. These divisions include Public Works, Administration, Engineering, Highway, Facilities, and Solid Waste. Their organization hopes to: “provide public safety and to provide and maintain public services necessary for the economy, growth, and quality of life for the citizens and visitors to Nantucket.” (Public Works, 2018)

There are several functions the Nantucket DPW is responsible for conducting in the Nantucket community. Some of their main functions center around maintaining coherence and order. These include ensuring their staff is properly trained, their operations adhere to federal, state, and local laws and regulations, and their departments and the town board are coordinating with state and federal agencies and municipalities on public works projects. Furthermore, they must handle complaints from citizens relating to public works. Many of their other functions relate to the financial upkeep of all departments. They are responsible for the annual operating budget, as well as overseeing spending and processing the payrolls, invoices, and purchase orders for the other departments. They must also continuously work on the long term Capital Plan for all divisions. (Public Works, 2018)

Along with its functions within the department, the DPW also heads several projects throughout the Nantucket community. It is underway in the planning and development of a new facility for the department, as a whole. The current facility is lacking in many areas, which impacts the operations of the department. The upgraded building will be much larger, consisting of employee facilities, vehicle and equipment storage, and trade shops, all of which serving both present and future needs of the department. The department is also in charge of pothole and general road repair, streetlamps, waste disposal and recycling regulations, and beach maintenance among other things.

In sponsoring a waste characterization project, the DPW is hoping to create a process that is both beneficial for gathering data, but also a scalable and repeatable event. Due to the seasonal

differences in their population during the off-season and the summer, there is a large change in their waste stream. They are looking for a characterization process that can be repeated in both seasons, which is tailored directly to the island. Their main questions revolve around how they can decrease the amount of recyclables entering the waste stream and lower the use of landfills, as well as how to educate year-round residents, summer residents, and tourists on Nantucket on what data was found, what it means, and how they, as individuals and as a community, can work to improve their recycling and waste disposal efforts.

## 2.7 Creating Public Education Materials for Recycling

Before creating public education materials for the Nantucket DPW, research must be conducted to determine the most effective ways of conveying information about waste disposal and recycling. This research involved studying many different examples of both websites and pamphlets of varying cities, states, and companies across the United States.

In conducting research of websites dedicated to recycling and waste disposal, several key components of successful websites became evident. One major element was the ease of use of the website itself. Sites that presented information on their main page and limited the number of subpages were more effective. This also meant presenting visuals when possible, allowing the user to quickly look and understand, rather than to have to read through lines of text. The idea of visuals also ties to the aesthetics of the websites. Sites with well-developed and clear icons and guides, a cohesive color scheme, and accessible pages were much more effective for their user. Another key component was being informative. Recycling sites should aim to make it easy for the user to find what they were looking for and provide it readily and clearly. This may include providing video explanations that show processes in-action. The last key feature of a successful website was how well it tied into its community. This meant sharing links to community events, providing images of local people and places, demonstrating local processes, and expressing a passion for maintaining the community.

The researched websites included:

- Recycle Smart Massachusetts (<https://recyclesmartma.org/>)
- Boston Public Works (<https://www.boston.gov/departments/public-works>)
- Environmental Protection Agency (<https://www.epa.gov/recycle>)



- Recycle Connecticut (<http://www.recyclect.com/>)
- Salt Lake City Recycling (<https://www.slc.gov/sustainability/waste-management/>).

Successful waste disposal and recycling pamphlets also consistently contained features which improved their effectiveness. Like the websites, the more visually-pleasing pamphlets helped the quality. A pamphlet with clearly-labelled diagrams and visuals that look well-developed and clean demonstrate a level of effort. A successful pamphlet should also be location specific. This means that it discusses the specifics of the location and its programs. For example, Nantucket composts its paper, so all paper should be thrown in the trash. This should be conveyed on its pamphlet. Given a pamphlet has less space than a website, its information should be as brief as possible, while maintaining clarity. This could mean providing links to further reading that will further explain the items the pamphlet discusses.

The researched pamphlets and brochures included:

- Casella Recycling (<https://www.casella.com/services/recycling/zero-sort-recycling>)
- WM Waste Management (<https://www.wm.com/us>)
- Cape Cod, Massachusetts  
(<https://www.capecodextension.org/hazardouswaste/wastereduction/>)
- San Francisco, California  
(<https://www.recology.com/recology-san-francisco/your-three-carts/>)
- Concord, New Hampshire (<https://www.concordnh.gov/536/Trash-Recycling>).

## Chapter 3: Methodology

The primary goal of this project was to develop and test a waste characterization process for the Nantucket DPW in order to recommend a repeatable waste characterization method. The data collected from a test of the waste characterization process was then analyzed and used to advance public knowledge on waste disposal and recycling across the island through the development of a comprehensive waste characterization guide, an informational brochure, and a list of recommendations for their website and processes.

The project was divided into the following objectives:

1. Develop and conduct a waste characterization method on a sample of waste from Nantucket.
  - Research waste characterization methods.
  - Collect data on the Nantucket waste collection and disposal system during a test waste characterization audit.
  - Analyze the collected waste sample data.
  - Write a detailed report on findings.
2. Evaluate and recommend a repeatable method for waste characterization based on research and the data collected during the test waste characterization study.
  - Create forms and processes that can be used in future waste characterization studies.
  - Develop a guide for performing future waste characterization studies that also includes recommendations for using the study data to increase landfill longevity and other factors.
3. Develop public outreach materials to help educate the Nantucket community on proper waste disposal.
  - Research educational materials being used by other organizations and communities, including websites and recycling pamphlets.
  - Develop educational materials based on findings from the waste characterization. Materials to be developed were proposed to include: 1:30 minute video time lapse of the waste characterization with important information as narration, educational leaflets detailing hard-to-sort items and Nantucket-specific procedures.

- Conduct focus groups to better understand the best way to communicate goals and proper disposal methods with the community, both based on stakeholder ideas for the messaging and the community's needs.

### 3.1 Develop and Conduct a Waste Characterization

In preparation for this project, we researched past waste characterization studies to develop the best methods to use on Nantucket. This research and analysis is detailed in Appendix A. These methods were developed from the EPA's 6 step recommendations for conducting a waste characterization study (2.2) and through discussions with project sponsors from the DPW.

For the waste characterization, the goal was to perform a waste characterization on 100 bags of waste from two samples, waste that was dropped off at the DPW intake facility and waste that was picked up by commercial haulers. These two sources compose the majority of what enters the landfill. We went to the site where the DPW had been told to bring the garbage and set up a sorting area. This area consisted of 2 tables for the trash to be sorted through on with 24 barrels lined around them in a semicircle. These barrels were then labeled with categories that had been defined beforehand. The trash was taken from a pile near the sorting area and put onto the table a few bags at a time. They were opened and had each of their contents sorted into the barrels of the corresponding category. As each barrel was filled their contents were weighed and recorded before being put into a dumpster so the barrel could be used again. The barrels were weighed a final time when 100 bags of the first sample were sorted, and the process was repeated again with the second sample.

Having conducted the first waste characterization study, a repeatable process to the DPW could be recommended. The "How-to Guide" for replicating the process in the future (3.2) was created based off of the mistakes and successes of the first sort. These findings are detailed in section 4.1.

## 3.2 Evaluate and Recommend a Repeatable Waste Characterization Process

This objective was addressed once the team was on Nantucket and completed a waste characterization study on samples of Nantucket's waste. The possible recommendations focused on its scalability and repeatability.

This evaluation was based on the idea that enough material for the next waste characterization study on Nantucket should be left on the island to require little or no external resources. This entailed using research, insights, and findings from planning, putting into action, and analyzing a waste characterization study to create materials for the Nantucket DPW. It resulted in the development of a guide for the DPW that details how to conduct a waste characterization study (3.2.2).

### 3.2.1 Creating Forms for Future Waste Characterization Studies

To carry out the waste characterization more efficiently forms were created for the purpose of making data collection and analysis easier. The collection forms were created for the purpose of being printed and filled out on the day of the sort by one of our group members. These forms were simple, containing essentially labeled tables with blank areas to be filled in with weight results. Part of the form was meant to allow for a frequency analysis. Each category was given a large blank cell to be filled in with tick marks for each bag of trash that contained at least 1 item from that category. The frequency data helped determine whether certain categories were being inflated by unusual samples. For example if one person threw out a whole bag of batteries, the relatively low frequency compared to the weight of the battery sub-category would allow the data to be explained as an outlier.

The analysis forms were Excel spreadsheet skeletons that could be filled in with data from future sorts to allow for the same analyses that was performed already to happen automatically for the new data. This will cut down the time spent managing the data for future waste characterizations, and should be useful for the purpose of creating and comparing spreadsheets with data from multiple years of characterizations.

### 3.2.2 Creating a How-to Guide on Conducting a Waste Characterization Study

The main deliverable of this project project was a how-to guide detailed the process that was developed to conduct waste characterization study in Nantucket. It synthesizes the details

learned and experienced while conducting the waste characterization study, and presents them in an accessible way. Before the study was conducted, careful notes were kept on the research and creation of appropriate forms for data recording (3.2.1), as well as how the specific details of the sort were decided on. During the study, we took pictures and video to document the entire process from start to finish; this media is used in the guide to help exemplify the processes visually. The purpose of the guide is to provide direct, accessible, and thorough instructions to the DPW that can be used when they conducted another waste characterization study at a future date. Section 4.2 includes an explanation of the different sections of the guide, as well as a link to an online PDF of the guide in full.

### 3.3 Developing Public Outreach Strategies

This objective will rely on our research, recommendations, experience, and data analysis after the waste characterization. Our public outreach materials and strategies will target the community of Nantucket including year-round residents, business owners, and even tourists. The purpose of these materials will be to raise awareness about waste processes on Nantucket, and educate the public about ways they can improve waste disposal efforts and recycling rates. In addition, the materials emphasize the Nantucket-specific considerations like the limited landfill space and single-source water supply.

#### 3.3.1 Creating Informational Posters

By utilizing our knowledge of the DPW from our research (2.7) and waste characterization study, multiple posters were created to instruct people how to dispose of their waste on the island. The poster mimics successful properties of similar materials that other communities have created, while implementing original ideas to better explain Nantucket specific considerations. Our posters were tailored specifically to follow Nantucket's unique waste management systems, using information learned during this time on Nantucket about specific recycling streams and the items that should be represented in each of them. The reasoning behind having multiple posters was to provide the DPW with options as they produce more sources for islanders and tourists to refer to when managing waste. This education aims to reduce miscategorized waste and prevent recyclable materials from ending up in the municipal solid waste.

### 3.3.2 Focus Group

In order to determine the best ways to educate and bring awareness to people about the recycling system on Nantucket, we conducted a focus group of town members. This focus group allowed us to widen our understanding of the public of Nantucket on the subjects of public awareness.

#### **Methodology (Krueger, 2002)**

1. Gathering participants:
  - a. Email and ask multiple carefully selected town councilman/community leaders about the focus group and ask them if they will be willing to participate and when they would be available to do so.
  - b. Once we get responses from 6 members who agree to participate, set up a meeting at a time, date, and place that works for everyone. At most, 8 people will be chosen to participate.
  - c. Members must sign a consent form confirming that they may be quoted or recorded. (Not sure if recording is a good idea or not but figured we could put it in)
2. Design the parameters:
  - a. Establish the goals of what the focus group hopes to achieve. In this case we will be looking for different perspectives and ideas for the recycling public information campaign.
  - b. After the goals of the focus group are firmly established, design a list of 8-10 questions to be used by the moderator throughout the session.
  - c. Establish ground rules for the discussions.
    - i. There are no wrong answers or stupid questions. Feel free to speak your mind, but respect everyone else's right to speak as well.
    - ii. One person may speak at a time.
    - iii. Please turn off all phones for the duration of this discussion.
  - d. The duration of the meeting will be between 45-60 minutes.
3. Conducting the focus group:
  - a. Introduce ourselves, where we are from, why we are here, and ask the opening question.
  - b. Maintain an open and thoughtful environment to create a good dialogue.
  - c. Keep notes on the discussion.
    - i. Write down any notable quotes.
  - d. Watch the time as a marker for when to change topics or questions.
  - e. When time is close to up, ask everyone an ending question that will allow for people to reflect on the discussion so far and put into words what they've taken away from it.

#### 4. Reporting on findings:

- a. After the group ends discuss with ourselves themes and notable trends.
- b. Review the notes and evaluate quotes. Determine what the major viewpoints of each members were on a given question, how they differed, how they were similar, and how they changed as a result of the discussion.
- c. Take any ideas that were suggested and analyze their value and feasibility. Take these ideas into account when working on future parts of the project.
- d. Reassess the methods we had initially instated for the other parts of our public campaign. What parts did the group show a predilection towards? What parts did they oppose?

### 3.3.3 Recommending Improvements to the DPW Website

Given the research conducted on various recycling and waste disposal websites (2.7), a list of recommendations was drafted to be given to the DPW. The list of recommendations was comprised with the mindset of making the DPW website more accessible to the general public. There are many specific methods to how Nantucket conducts its waste disposal and recycling that a visitor may not know about or understand upon first coming to the island. The list of suggested improvements was intended to encourage the implementation of web-based features that will allow a user to quickly find the information they are looking for. The process of creating a recommendation list involved taking screenshots from other websites of both good and bad examples of implemented features. An explanation of each example was provided, which detailed why the example would be effective or ineffective, and how it could be tailored in a way that fits Nantucket.

## Summary

The main goal of this project was to use the data found in the waste characterization to conduct to help the Nantucket Department of Public Works better understand the waste stream on the island. Through research conducted on past waste characterizations, we developed a plan for implementing a study in Nantucket. The waste characterization study was conducted and provided both data and a better understanding of the process. With the data, an educational brochure was created to be shared with the Nantucket community and the DPW's website was

updated and improved with relevant information. We also created a how-to guide for repeating the waste characterization process in an effective and scalable manner.



## Chapter 4: Outcomes and Findings

This section details the major outcomes and findings resulting from seven weeks on the island, working with the DPW. Most outcomes came as a result of the waste characterization study conducted in the second week on island. The chapter begins by outlining the data collected as a result of the waste characterization study (4.1). In addition to the data analysis, multiple material deliverables were created to aid the island of Nantucket: a “How-to Guide” for repeating the waste characterization process (4.2), a recycling poster to educate the public (4.3), and a focus group analysis (4.4).

### 4.1 Waste Characterization Study Data

The waste characterization study provided a better understanding of Nantucket’s waste disposal and recycling processes. The following section will give an overview of Nantucket’s waste system as a preface to the analysis of the waste characterization data. These analyses include:

- A seasonal explanation of waste on Nantucket
- Explanations of the different waste stream components
- Breakdown of waste intakes by month
- Lists of material categories and examples
- Divertable waste expectations and maximums
- Data breakdowns for categories of waste materials

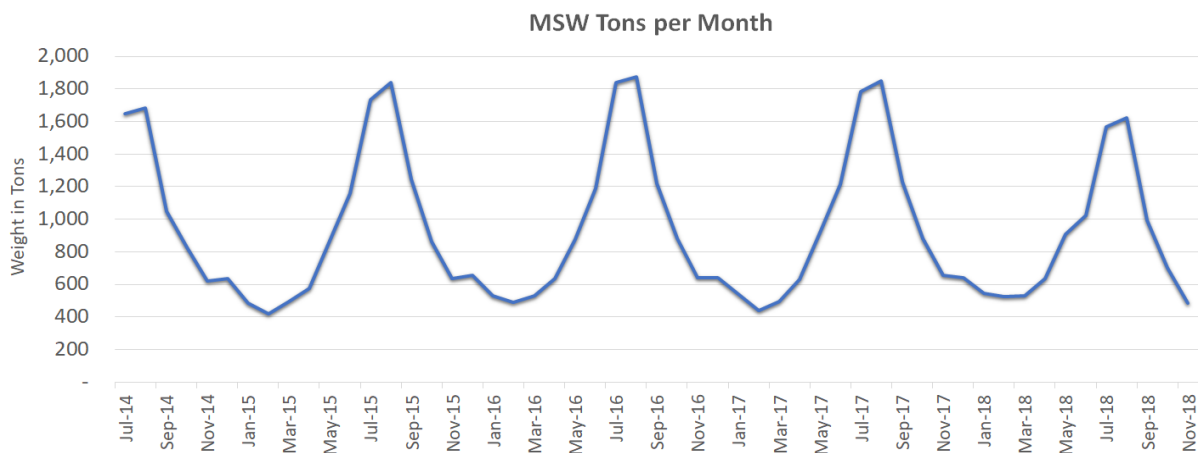
#### 4.1.1 An Overview of Nantucket Waste

Before delving into an analysis of Nantucket’s waste stream, it is important to establish definitions for key terms, systems, and features of Nantucket’s processes. There exists a gap between the DPW and the community in this area, as multiple terms are often used to mean the same or similar things. This confusion will hinder public outreach and educational materials. To avoid misunderstandings in the findings, a glossary of definitions has been created for the purpose of this report.

## Glossary of Definitions:

- Municipal Solid Waste (MSW): components of the waste stream that consists of everyday items that are “thrown out,” excluding recyclables. Commonly referred to as “trash” or “food and paper” by the Town of Nantucket. **This is a non-standard definition, in that the commonly accepted definition includes recyclables and other waste types.**
- Waste Stream: the entire flow of waste from where it is collected to the final disposal
- Recyclables: substances or objects that can be recycled
- Recycling Facility: facility at the DPW intake site responsible for processing all recyclables by sorting them into their correct categories, baling them and preparing them for shipping (or reuse, in the case of glass)
- Compost: decomposed and decayed organic material
- Biodigester: a single rotary drum reactor that uses bacteria to break down biodegradable material contained in the waste in order to catalyze the process of organic material becoming composted
- Bulky Waste: section of the DPW intake facility that deals with large, composite items like appliances and mattresses that cannot fall into single categories
- Household Hazardous Waste: dangerous waste that cannot be processed by the DPW intake facility normally, and is only handled on special HHW drop-off days
- Yard Waste: a processing area for waste generated from landscape work, such as tree branches, leaves, hedge clipping
- Landfill: plot of land where MSW goes into long-term storage
- Shipped off-island: materials are shipped off-island and sold
- Diverted as compost: organics that go through the biodigester break down into compost, and the compost is stored and given out to residents that want it for landscaping

A crucial component to understand about Nantucket’s waste system is the effect of the island’s seasonal population fluctuation. Every year since July 2014, there have been consistent peaks in the municipal solid waste during the summer. Peaks in the “on-season” or summer season occur in August at approximately 1600-1900 tons. Intake slows down during the “off-season,” which was defined as roughly between October through April. The lowest point of MSW intake occurs every year in February at about 500-600 tons. Just as is projected for the population of Nantucket, the MSW monthly intake can triple during the summer months, as illustrated in Figure 11.



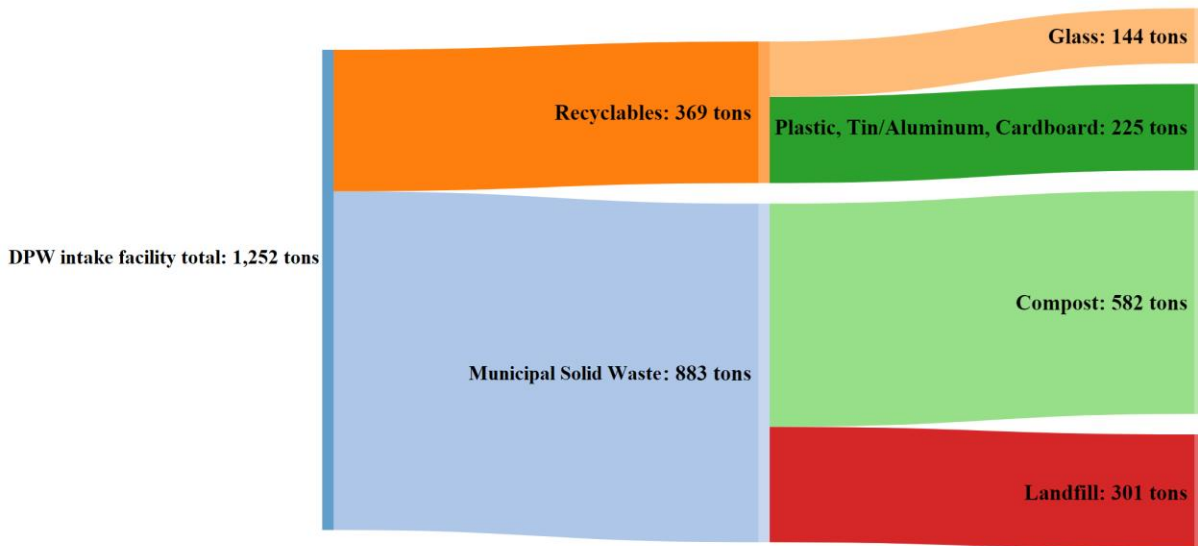
**Figure 11.** Municipal solid waste intake July 2014 through November 2018.

The total MSW tonnage of each month from October 2017 to October 2018 is compiled in Table 1, showing the fluctuation throughout. For example, February 2018 had the lowest total weight at 526 tons, while August 2018 had the highest total weight in this span at 1622 tons.

**Table 1.** Total MSW Tonnage Monthly from October 2017 to October 2018.

Month	Weight (tons)
Oct-17	883
Nov-17	658
Dec-17	639
Jan-18	546
Feb-18	526
Mar-18	530
Apr-18	637
May-18	907
Jun-18	1022
Jul-18	1568
Aug-18	1622
Sep-18	991
Oct-18	702

As discussed in Section 2.5, the system on Nantucket is comprised of a recycling stream and a municipal solid waste stream that either becomes compost or gets disposed in the Nantucket landfill (Figure 12 with data from October 2017).



**Figure 12.** Nantucket's waste disposal system streams, Oct. 2017.

In the Sankey Diagram (Figure 12) above, each stream's width is representative of its percentage of the total waste processed at the DPW intake facility.

Recyclables are required to be sorted into separate clear plastic bags depending on their category before being dropped off or hauled to the MRF. Sorters then go through the bags, selecting and removing non-recyclable materials before the materials are baled and distributed. The recyclable materials break into two streams: plastic, tin/aluminum, and cardboard get baled, then sold and shipped off island, and glass gets reused on island in asphalt creation. The municipal solid waste stream breaks into compost and landfill streams. The compost stream represents 46% of the total waste processed at the DPW intake facility and comes from the organic municipal solid waste after being processed in the biodigester. Landfill waste is waste that doesn't break down in the biodigester and gets dumped into the landfill; this waste represents 24% of the total waste processed at the DPW intake facility and is partly comprised of materials that could have been diverted, such as recyclables that were misplaced.

For Nantucket, recycling and composting are the only ways of diverting material from the landfill. The diversion of landfill waste to other streams is critical to the extension of its lifespan and a central goal of this project. Examples of materials and their ideal route through Nantucket's waste disposal system are detailed in Table 2.

**Table 2.** List of Materials and their Ideal Disposals

Material	Examples	Ideal Processing System	Ideal Final Disposition
Corrugated Cardboard	Package boxes	Recycling facility	Shipped off-island
Electronics	Cell phones, CDs and DVDs	Bulky waste	
Textiles	Clothes, towels, shoes	Bulky waste	
Hazardous Waste	Fertilizer, thermostats	Hazardous waste collection day	
Bulky Materials	Furniture, lawn mowers	Bulky waste	
Medical	Needles, pills	Fire department, pharmacy	
Non-Recyclable Plastics	Candy wrappers, package envelopes	Biodigester	Landfill
Styrofoam	Egg cartons, take-out containers	Biodigester	
Films	Garbage bags, ziplock bags	Recycling facility	
Non-Compostable Paper	Laminated or waxed paper	Biodigester	
Non-Compostable Organics	Bones, hair	Biodigester	
Paper	Cereal boxes, napkins	Biodigester	Diverted as Compost
Compostable Organics	Food waste	Biodigester	
Tin/Aluminum	Aluminum foil, soda cans	Recycling facility	Baled and shipped off-island
Recyclable Plastics	Coffee cups, shampoo bottles	Recycling facility	
Glass	Beer bottles, jars	Recycling facility	On Island Aggregate

#### 4.1.2 Analysis of Waste Characterization Study Data

During October of 2018, the DPW collected 702 tons of household waste. The sample of 1,781 lbs. analyzed during the waste characterization on October 30th, can be extrapolated to apply to this 702 tons for analysis. As illustrated in Table 3, 119 tons (17%) out of an approximately 702 tons of household waste are recyclable monthly. This recyclable waste includes the categories of; corrugated cardboard, recyclable plastics, textiles, recyclable glass, tin/aluminum, and other metals.

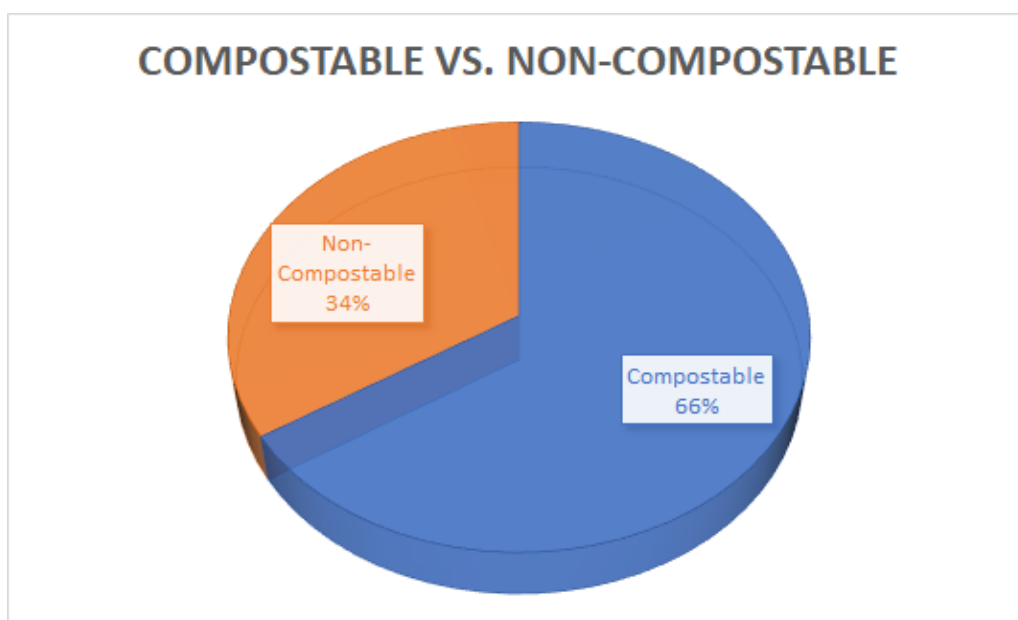
**Table 3.** Waste Characterization Results Subsections, Oct. 2018

General Category	Sub-Category	Total Wt (lb)	Wt % of Total	Total Weight Month Oct 2018 (tons)
<b>Paper</b>	Paper and Cardboard	429	24%	169
	Waxed Paper	30	2%	12
	Corrugated Cardboard	79	4%	31
<b>Organics</b>	Compostable Organics	668	37%	263
	Non-Compostable Organics	55	3%	21
<b>Plastic</b>	Non-recyclable plastics	158	9%	62
	Recyclable plastics	43	2%	17
	2020-Ban plastics	12	1%	5
	Films	93	5%	37
	Styrofoam	22	1%	9
<b>Other Waste</b>	Textiles	49	3%	19
	Other materials	-	0%	-
<b>Metal</b>	Tin/alluminum	64	4%	25
	Other metals	14	1%	5
<b>Glass</b>	Bottles/Jars	53	3%	21
	Other Glass	4	0%	2
<b>Electronics</b>	Electronics	11	1%	4
	Bulky Materials	-	0%	-
<b>Total Samples</b>		<b>1,781</b>	<b>100%</b>	<b>702</b>

Table 3 showcases the data collected during the October 30th test waste characterization study. Details about performing the study can be found in section 3.1. The table shows the eight general categories and 18 sub-categories, their total weights as measured during the sort, their percentage of the total weight collected during the sort, and their projected total tonnage for the

month of October 2018. The categories add up to 100% of the sampled waste, and will be re-categorized in different ways to form conclusions in the following analyses.

**Finding: 66% of the sampled waste was compostable** (Figure 13). Compostable materials consist of paper and cardboard, corrugated cardboard and compostable organics. Because of Nantucket's unique biodigester, it's important to consider the comparison between compostable materials, paper and food wastes that will break down and be diverted, and non-compostable materials, which will ultimately go to the landfill. This observation from the waste characterization study is important to the DPW because it means that 34% of the incoming waste will not break down in the biodigester and will subsequently add material to the landfill.



**Figure 13.** Compostable vs. non-compostable materials by weight.

An analysis of the categories that make up the compostable and non-compostable totals will provide the basis for a more focused approach to the issue of landfill preservation.

The breakdown of non-compostable materials is shown in Table 5, and contains many materials that could be targeted for diversion. Recyclable plastics, bottles/jars, and tin/aluminum account for 27% of the non-compostable material and could have been diverted via recycling. Furthermore, textiles make up an additional 8% of non-compostable material, and depending on their condition may have been diverted via the take-it-or-leave-it shop, also known as the Madaket Mall. The DPW is also considering a separate textile recycling program.



**Table 4.** Percentage of Non-Compostable Materials by Weight

<i>Non-Compostable Material</i>	<i>Total Weight of Non-Compostable Waste</i>
Non-recyclable plastics	26%
Films	15%
Tin/Aluminum	11%
Non-Compostable Organics	9%
Bottles/Jars	9%
Textiles	8%
Recyclable Plastics	7%
Waxed Paper	5%
Other	10%

The last part of the data analyzed was divertable and non-divertable waste.

**Finding: 83% of the sampled waste was divertable** (Table 6).

**Table 5.** Examples of Divertable and Non-Divertable Waste and their Prevalence

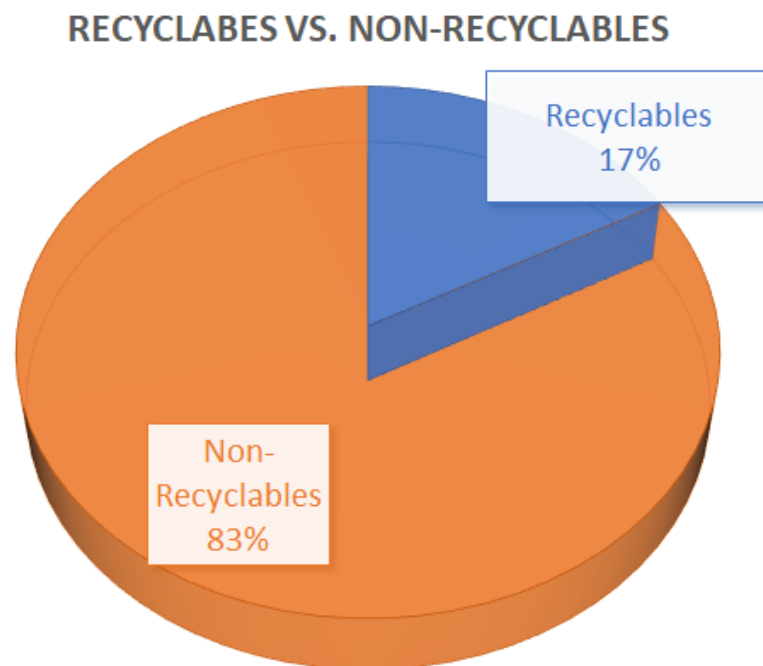
Non-Divertable Waste	Total in Waste Stream	Divertable Waste	Total in Waste Stream
Non-Recyclable Plastics	9%	Tin/Aluminum	4%
Films	5%	Bottles/Jars	3%
Non-Compostable Organics	3%	Textiles	3%
		Recyclable Plastics	2%
		Compostable Materials	66%
<b>Total</b>	17%	<b>Total</b>	83%

The DPW collected 702 tons of MSW during October 2018. Across 2017, 11,284 tons of MSW were collected, about 4,286 tons of that were collected during the off-season (Oct-April).

The data gleaned from the waste characterization study highlights the areas Nantucket can work towards to extend the life of its landfill. Firstly, one of the largest categories the study looked at was compostable materials (Table 5). It was determined by the DPW that the sample is representative of October 2018, and as such the compostable 66% from the sample can be extrapolated to conclude that 463 tons of the 702 total tons of MSW in October were compostable. Furthermore, it can be assumed that the remainder of the non-compostable MSW collected in October would end up in the landfill at the rate given by the waste characterization study. This means that 239 tons of the initial 702 tons of MSW would not be diverted as compost and would be deposited into the landfill. The other method of diversion is recycling.

**Finding: 17% of total waste in the sample could have been recycled (Figure 14).**

Materials that are recycled follow an entirely different waste stream than MSW and do not end up in the landfill.



***Figure 14. Recyclable materials vs. Non-recyclable materials.***

If all recycling opportunities are taken into consideration, an additional 17%, or 119 tons, could be diverted from the landfill. This is a best-case scenario, as it assumes that 100% of recyclables were properly disposed of and there were no recyclables in the MSW. If this were the

case, only 17% of the original 702 tons of MSW intake would actually be deposited into the landfill after all possible diversion methods are exhausted.

The following sections will explore how this hypothetical scenario at the core of our project can be approached through future waste characterizations and outreach materials.

## 4.2 Waste Characterization Guide

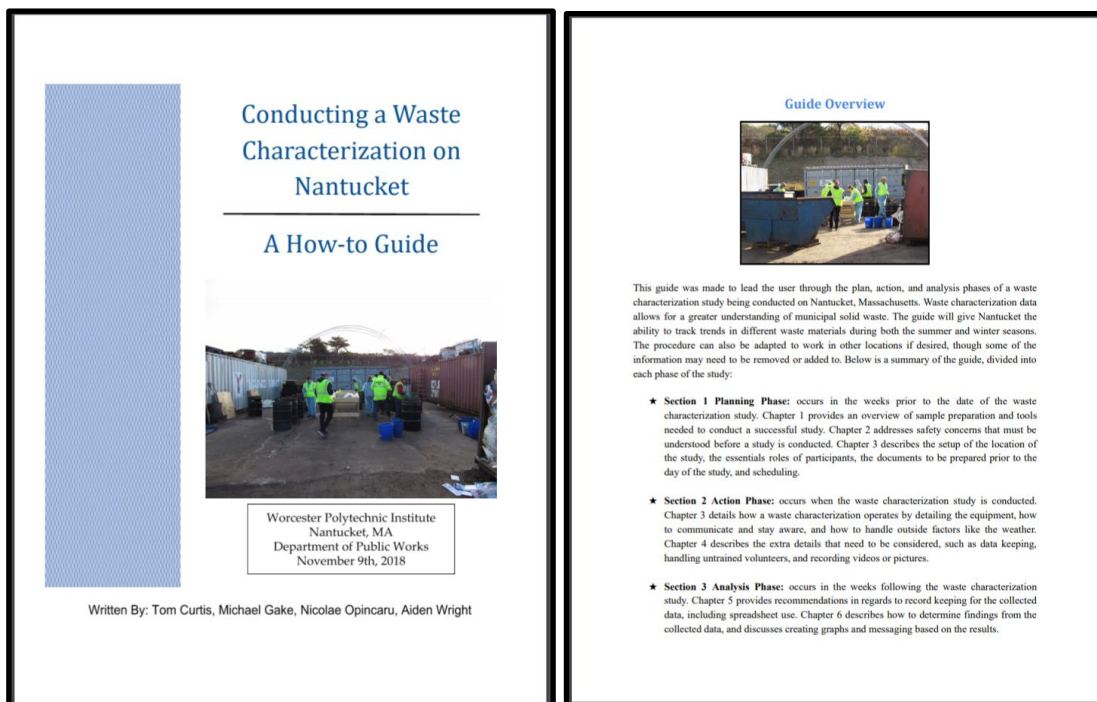
A major aspect of developing a waste characterization process for Nantucket was ensuring it would be repeatable and scalable in the future. The DPW has the intent of conducting future waste characterizations each summer and winter to see how their efforts are affecting Nantucket's waste disposal and recycling processes. To help with this, a "How-to" Guide that covers the plan, action, and analysis phases of a waste characterization study was created. The goal of the guide is to provide guidelines to a waste characterization study process that can be followed and modified to be used for Nantucket and other communities, as well. Additional information regarding the creation of the guide was discussed in Section 3.2.2.

The waste characterization guide was divided into three main sections: the planning phase, the action phase, and the analysis phase. The main components of each section are listed below:

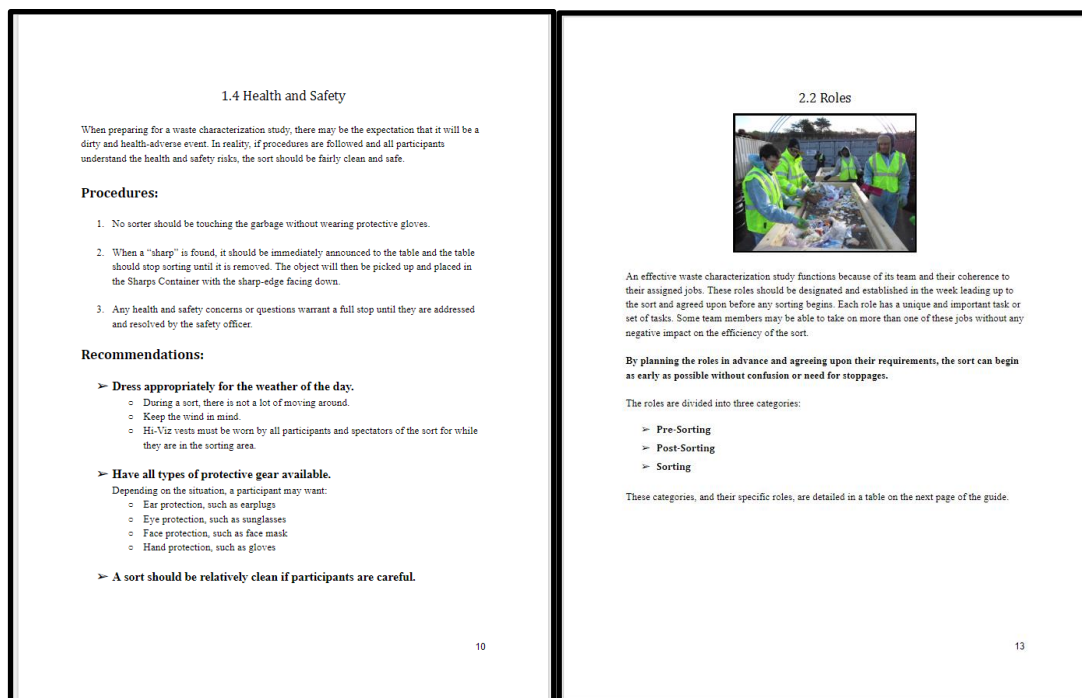
1. Planning Phase, which describes the necessary steps to take in the weeks prior to conducting the study, including:
  - Deciding on a category list
  - Preparing a waste sample and an equipment list
  - Deciding on health and safety procedures
  - Preparing the sorting location
  - Deciding on roles for the sort
  - Planning a schedule
2. Action Phase, which details what happens when the waste characterization study is executed, including:
  - Communicating and adapting during the sort
  - Recording data, video, and photos

- Handling volunteers and spectators
3. Analysis Phase, which describes the necessary steps to take in the weeks following the study's completion, including:
- Reflecting on the sort's successes and flaws
  - Inserting data into an available spreadsheet
  - Producing graphs to illustrate findings
  - Deciding on messaging of findings

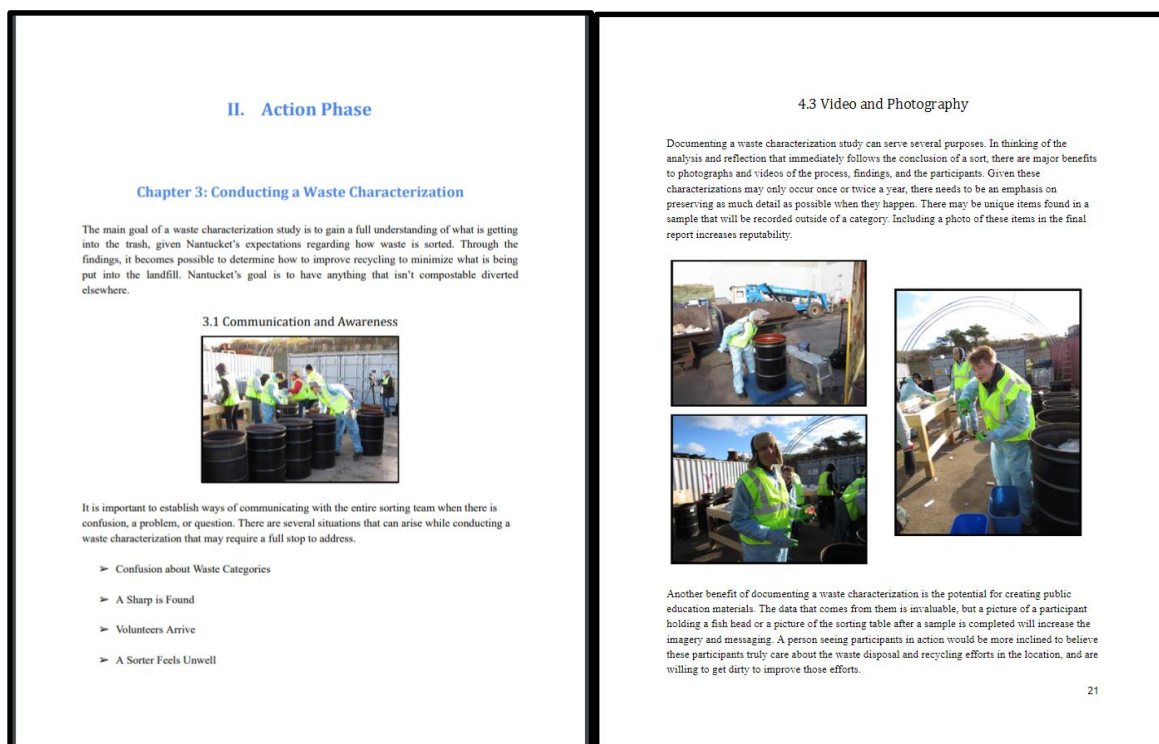
Examples pages from the guide are shown below. An online PDF of the complete guide can be found at: <https://wp.wpi.edu/nantucket/projects/2018-projects/dpw/>.



**Figure 14.** Title page and overview of the guide.



**Figure 15.** Excerpts from the planning section of the guide.



**Figure 16.** Excerpts from the action section of the guide.

### 4.3 Recycling Posters

In an effort to increase awareness about proper recycling techniques specific to Nantucket in order to maximize diversion rates, we created explanatory posters. They are tailored to Nantucket's unique system. There is one version designed for in-home use by community members who hire commercial haulers to pick up their recyclables and MSW, and one designed for those dropping off their recyclables and MSW at the DPW intake facility. The design for the DPW intake facility includes receptacles that one would find at the site on Nantucket; plastic, glass, tin/aluminum, corrugated cardboard, and organics. The design for in-home use includes receptacles that are generally picked up by private hauling companies on the island; plastic/tin/aluminum, glass, corrugated cardboard, and organics.

## NANTUCKET: WE RECYCLE LIKE NOBODY ELSE.

Nantucket prides itself on maintaining its health and beauty. Our biodigester breaks down organics and produces reusable soil. Play your part, recycle, and make use of this unique system! #ACKLOCAL

**AT THE LANDFILL: WHERE DOES IT GO?**



**1 PLASTICS**  
ALL PLASTICS including common recyclables, bottle caps, plastic bags, and films.



**2 TIN/ALUMINUM**  
Tin and aluminum items including beverage cans, soup cans, lids, and bottle caps.



**3 GLASS**  
Glass containers such as bottles and jars of all colors.



**4 CORRUGATED CARDBOARD**  
ONLY double-walled, corrugated cardboard: shipping boxes, for example.



**5 ORGANICS**  
Food waste and paper products including non-corrugated cardboard and pizza boxes.

**REMEMBER!**

- ★ If it's going in the recycling, it needs to be clean and free of food waste or other contaminants. Otherwise, it may not actually be recycled.
- ★ Using clear garbage bags is a requirement on the island.
- ★ YOU can make a difference!

## OTHER MATERIALS



**Yard Waste and Brush**  
Yard waste such as leaves and trimmings can be disposed of at the landfill for free. Brush, such as logs and tree branches, can be disposed of at the landfill for a fee.



**Bulky Items**  
Items such as appliances, mattresses, smoke detectors, and alkaline batteries can be disposed of at the landfill.



**Hazardous Waste**  
There are six (6) Household & Commercial Hazardous Waste collection events per year. Items that may be collected during these events include:

NANTUCKET HOUSEHOLD & COMMERCIAL HAZARDOUS WASTE COLLECTION DAY

**AUTOMOTIVE PRODUCTS:** Antifreeze, Brake Fluids, Motor Oil, Oil Filters, Transmission Fluid, Solvents.  
**CLEANING PRODUCTS:** Bathroom Cleaner, Drain Opener, Furniture Polish, Metal Polish, Oven Cleaner.  
**PAINT & PAINT PRODUCTS:** Adhesives, Aerosol Cans (not empty), Epoxies, Paint, Paint Thinner, Paint Remover, Stains, Varnishes. NO LATEX PAINT.  
**PESTICIDES:** Fertilizer (with Weed Killer), Fungicides, Herbicides, Insecticides, Rat Poisons, Weed Killer.  
**OTHER PRODUCTS:** Asbestos\*, Batteries (Mercury and Lithium), Driveway Sealer, Gasoline, Mercury (Fluorescent Bulbs), Pool Chemicals, Photography (Chemicals), Fire Extinguishers and Aerosol Cans that are not completely empty (if empty and non-pressurized they can go into the metal bin).

**Not collected at the landfill:**

Take SYRINGES and other SHARPS to the Nantucket Fire Department. Call at (508) 228-2323.

Dispose of MEDICATION at local retail pharmacies during sanctioned and scheduled "Take-Back Days."

Harbor Fuel takes HOME HEATING OIL TANKS for a fee. Call at (508) 228-2950.

PROPANE TANKS for grills can be taken to Yates Gas. Call at (508) 228-0725.

For AMMUNITION and EXPLOSIVES call the Nantucket Public Safety Facility at (508) 228-1212

LATEX PAINT is non-hazardous and will not be accepted. Mix the can of latex paint with kitty litter, let harden and dispose of cans at the landfill in the metal bin.

**Figure 17.** Screen capture of the front (left) and reverse (right) of the poster designed for DPW intake facility use.





**Figure 18.** Screen capture of the front (left) and reverse (right) of the poster designed for in-home use.

Each receptacle has pictured examples of common materials that belong in it. Each reverse side features a list of commonly confusing items to act as a reference for community members who may not be sure how to dispose of something such as fire extinguishers or medical syringes. The poster either directly informs the viewer how to dispose of items, or notes where they can find more information. This approach is based on the other examples we've seen, as well as research in section 2.4.2, which concludes that community members with information about what materials are recycled and the recycling process itself are more likely to recycle. The poster is a combination of Nantucket's specific considerations and research about other towns' and organizations' recycling posters, websites, pamphlets and other educational materials.

The recycling system on Nantucket is currently undergoing changes, so these posters are meant to be well-developed drafts for the DPW to adapt to changes that the system might see. For example, there is a push on the island to put all plastics into the plastic recycling stream, as

they will be sorted through by the recycling sorters at the DPW intake facility. This will be done in order to minimize confusion on the public's behalf about which plastics should be put where. As considerations such as these are still being processed, they were not all represented on the poster, but were taken into consideration for leaving the poster open to future edits.

There are several unique audiences on Nantucket to consider when creating public outreach materials. The population fluctuation affects the waste stream greatly, and vacationers and summer residents are psychologically less likely to recycle when they're away in a tourist town like Nantucket (Oliver, 2011), especially when they don't have access to knowledge about that town's recycling system. For this reason, the poster is meant to be both broadly educational and encouraging of the idea to "play your part," and be a good Nantucket resident or visitor. Furthermore, there are two different audiences among both year-round and summer residents; those who hire commercial haulers to have waste and recyclables (with combined plastic and tin/aluminum) at their home, and those who travel to the DPW intake facility themselves to drop off their trash (with separated plastic and tin/aluminum). This is the reason for having a version for DPW intake facility users and a version for commercial hauler users.

Some topics are hard to communicate to all audiences, such as hazardous waste collection days. Without a survey, there is no way of knowing how much the general population knows about hazardous waste collection days; what can be collected, what cannot be collected, when they are, where they are. There was even an anecdotal story told by multiple stakeholders about how recently, someone had dumped enough paint into the water system that the purity of the single-source aquifer was put in jeopardy. Scenarios like this should ideally be avoided, and it's hard to know how to address the issue of unusual items without speaking directly to the public.

## 4.4 Focus Group Results

Once a variety of poster drafts had been constructed and any concerns about the posters from the DPW had been remediated, a penultimate draft of the poster was created. It had most of the information that needed to be conveyed, but still had room to be improved. In order to determine how the design could better appeal to locals, our team held a focus group on the matter. The respondents were fewer than expected, and there were only two participants; however, they were both longtime locals and extremely passionate about recycling.



When asked about their recycling knowledge prior to seeing the poster, participant 1 was able to accurately explain the recycling system, and participant 2 told us that she had taught the recycling system to her summer residents. Both participants, however, expressed a desire for more knowledge and more accessible resources with the details of Nantucket waste disposal.

When the poster was presented to the participants, they both got very invested. They had many notes and suggestions for how to organize the information better for the residents. They commented on the wording, tried to correct any misleading information, and gave ideas for restructuring parts to be easier to read and understand. Participant 1 even marked up the poster draft with recommended changes and additions. On the back of the poster at the time, there was a list of materials that were considered hazardous. This list was split into what the dump would accept during the hazardous waste days they have 6 times a year, and what waste needs to be taken elsewhere as they won't accept it. Participant 1 noted that the list was hard to understand because of how wordy it was, and it wasn't really sorted well because you would have to read the whole list to find out where an item would be in the first place. She suggested separating the lists into "what is accepted by the dump" and "what the dump will not accept" which has since been done and it is noticeably cleaner. Participant 2 noted that the yard waste and brush section had no mention of invasive species. She told us her experience with trying to take invasive species to the dump and how they sometimes don't even have the bin out. Adding a mention about the invasive species was a simple change and made a difference to this member of the community.

The last prompt was a brainstorming exercise that allowed the participants to give us ideas for how to improve the aesthetics and design of the poster rather than the information and its structure. Participant 2 told us to use more images to make it easier for spanish speakers to understand. Participant 1 suggested that a blurb be added about why the recycling was the way it was and to hint that recycling is a matter of civic pride, since the locals seem to value their culture highly.

The focus group overall was helpful to improve the poster deliverable. Throughout the many hit or miss suggestions and opinions, there was plenty of good advice that was worth implementing. As a result, the poster is a much stronger end product.

## Chapter 5: Recommendations

This chapter lists all of the major recommendations made after the process of conducting the waste characterization study, holding the focus group, creating the recycling poster, and writing the waste characterization guide. These recommendations, as well as the guide, will help the DPW continue to improve their waste disposal and recycling processes and their public education materials.

### 5.1 Recommendations for the DPW

With new and more accurate data on waste disposal and recycling on Nantucket, recommendations to the DPW on how to improve their website were made. This also involved using the research conducted on websites by other locations and companies focused on recycling. In particular, effective websites were referenced as ways to improve Nantucket's website by implementing similar methods.

Recommendation #1: The DPW should implement a search bar on their website that allows the user to search for any specific item of trash and find instructions for its disposal. Having this information on the website makes it more accessible and makes hazardous waste items easier to understand.

Recommendation #2: The DPW should upload a video to their website demonstrating and explaining the DPW intake facility. Allowing people to understand how the DPW intake facility works gives them the knowledge and impetus to make better decisions about recycling, like putting non-recyclable plastics in the recycling even if it seems counter-intuitive.

Recommendation #3: The DPW should ensure their front-line workers at the DPW intake facility are informed and ready to answer questions patrons may have about waste disposal and recycling.

Recommendation #4: The public bins in downtown need to be properly and clearly labeled. Visual audits confirm that waste often doesn't end up in the correct bin.

## 5.2 Focus Group Recommendations

Following the focus group conducted on drafts of the recycling poster, recommendations to the DPW based on feedback from participants were given. These recommendations revolve around possible improvements to the DPW's facilities, resources, and outreach with the public.

Recommendation #5: Distribute informational materials to community leaders and business owners, such as librarians, realtors, and DPW employees.

Recommendation #6: Necessary information should be made more accessible to the community through the DPW's website, ferry videos, and posters.

Recommendation #7: Private-haulers of household waste should have bins with them for batteries and other household hazardous materials.

## 5.3 Waste Characterization Guide Recommendations

After creating the waste characterization guide, recommendations were made to the DPW and other users of the guide for future waste characterization studies. These recommendations revolve around implementations of and improvements to the process that should be considered before conducting a study.

Recommendation #8: Conduct another waste characterization study in the summer season to expand the data collected during the winter season. Repeat the winter and summer characterizations each year to develop trends that can be used to test the efficacy of newer policies.

Recommendation #9: Implement the recommendations listed in the waste characterization guide to increase the efficiency, speed, and safety of the sorting process.

Recommendation #10: Increase the sample size of future sorts to ensure more accurate data.

Superfluous categories can be cut from future sorts in order to make larger sample sizes easier to sort through. 300-400 bags for the summer sorts should be possible with the improvements listed in the guide, fewer categories, and more volunteers.

## 5.4 Waste Characterization Data Recommendations

Following the analysis of the test waste characterization study, these recommendations were made to the DPW to focus on ways of collecting more applicable data during a waste characterization study.

Recommendation #11: Research methods for reducing the use of non-recyclable plastics and films to aid in reducing the use of the landfill. Non-recyclable plastics make up 26% of the non-compostable material entering the landfill, and the reduction of these plastics is the only way to reduce their impact as they cannot be diverted.

Recommendation #12: Create two lifespan predictions for the landfill. One based off of the current amounts of waste entering it, and one based off the potential minimum with all divertable waste removed. Show these lifespans to the public as a part of outreach in order to show the difference that recycling on island can make.

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## Appendix A: Research and Analysis of Waste Characterization Methods

To develop a clear idea of what exactly a waste characterization study will entail, we have conducted research on several comparable waste characterization studies. The details of these studies will provide a foundation on which our own waste characterization process will be built. Some of these details may be included in section 2.2 of the background chapter, but they are summarized here.

Location	Similarities	Summary of Methods
Millbury, Massachusetts	<ul style="list-style-type: none"> <li>- 4 to 5 sorters</li> <li>- Conducted in Massachusetts, operating under MassDEP guidelines</li> </ul>	<ul style="list-style-type: none"> <li>- 52 haul vehicles randomly sampled, drivers interviewed</li> <li>- Minimum 225 pounds from vehicle randomly selected as sorting sample</li> <li>- Sample sorted from a table into nine categories and 62 subcategories from MassDEP and weighed</li> </ul>
Pierce County, Washington	<ul style="list-style-type: none"> <li>- 4 to 5 sorters</li> <li>- Conducted by local public works association</li> </ul>	<ul style="list-style-type: none"> <li>- Project manager selects routes representative of the community</li> <li>- Random 200 pound sample taken from each route</li> <li>- Sample sorted from a table into 64 categories and weighed</li> <li>- Process repeated 170 times</li> </ul>
Worcester Polytechnic Institute, Massachusetts	<ul style="list-style-type: none"> <li>- Conducted by WPI students</li> <li>- Conducted in Massachusetts</li> </ul>	<ul style="list-style-type: none"> <li>- One day's worth of waste collected from 4 buildings and kept separate by building</li> <li>- 93 bags weighed</li> <li>- Contents of bags sorted into ten categories and re-weighed</li> </ul>
Multiple Towns in Maine	<ul style="list-style-type: none"> <li>- Repeated twice a year, once in the summer and once in fall</li> <li>- Seasonal population fluctuation</li> </ul>	<ul style="list-style-type: none"> <li>- Every n<sup>th</sup> bag dropped off or house collected from is chosen as the sample (week's worth of trash)</li> <li>- Sorted into nine categories and 60 subcategories and weighed</li> </ul>

Table 2: Analysis of Waste Characterization Methods

### Analysis of Strategies for Waste Characterization

The methods discussed above, implemented by four different municipalities, have various levels of possible effectiveness for our goal to conduct a Nantucket waste characterization.

### **Sample Size**

Currently our group projects the sample size for the waste characterization to be 100 bags of trash. With each bag weighing approximately 22 lbs, the expected total weight for this study will be about 1320 lbs, which while substantially lower than the characterizations listed above, should be enough to give adequate data. We expect this sample size to grow in subsequent sorts, especially during the summer, during which the trash generation increases substantially.

### **Collection Strategies**

With only 100 bags being analyzed within the Nantucket study, it is imperative to consider strategies for the collection of the samples. Nantucket has 37 districts, each with varying populations to consider. Ideally, to get accurate data, each district would be represented in the study proportionately to the percentage of the local population, but with the limited size of our samples, we may need to consider not representing certain districts in the study in order to ensure a limited standard deviation in the more populated areas.

### **Categorization**

Given the smaller sampling size that we project, sorting the waste into as many categories as Pierce County or Millbury will not be feasible. In order to maximize the effectiveness of the data, we will most likely choose 10 categories, with up to 10 additional subcategories for materials that stakeholders would like additional information on or that we see a necessary need to evaluate as we conduct the process. This will allow the most pertinent information to be gathered for the sponsors, while also granting the possibility to gather data on previously unnoticed trends.