U.S. VIRGIN ISLANDS 2019 RESIDENTIAL WASTE CHARACTERIZATION

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LIST OF ACRONYMS AND ABBREVIATIONS

ACR	Average Commodity Revenue
ASTM	American Society for Testing and Materials
C&D	Construction and Demolition
CGTC	Caribbean Green Technology Center
DPNR	Department of Planning and Natural Resources
EPA	Environmental Protection Agency
EPS	Polystyrene
FY	Fiscal Year
GIS	Geographic Information System
HDPE	High-density polyethylene
HHW	Household Hazardous Waste
mm	millimeters
PET	Polyethylene terephthalate
RRS	Resource Recycling Systems
U.S.	United States
USVI	United States Virgin Islands
UVI	University of the Virgin Islands
VI EPSCoR	Virgin Islands Established Program to Stimulate Competitive Research
VIWMA	Virgin Islands Waste Management Authority

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Figure 1: Waste characterization team at sorting site in Bovoni disposal facility

EXECUTIVE SUMMARY

The U.S. Virgin Islands (USVI) is facing a waste management crisis. The average Virgin Islander produces approximately 9 lbs. of trash per day - almost 40% above the U.S. average[1] - an average public bin site in the Territory is estimated to serve slightly more than 7,500 residents[2] and the average dumpster at that site serves 1,350 people. Unfortunately, each dumpster, if emptied once daily, can only serve approximately 500 residents. This leads to illegal dumping, increased littering and resultant marine debris, which negatively impact natural resources. This reality increases the pressure on the USVI's two disposal facilities: Bovoni on St. Thomas and Anguilla on St. Croix, which are nearing capacity. To address this situation, it is important to first understand the nature and quantity of the solid waste generated in the USVI so appropriate policies can be designed.

The Caribbean Green Technology Center (CGTC) at the University of the Virgin Islands (UVI) and Resource Recycling Systems (RRS), in partnership with the U.S. Environmental Protection Agency Region 2 (EPA), conducted a 5-day **residential waste characterization** for each of the three islands' waste streams. Results suggest that **62% of the USVI's residential waste stream by weight could be diverted from the disposal facilities to either a recycling program**, with a potential revenue stream[3], **or towards composting.** Nevertheless, there are significant obstacles to recycling and composting efforts in the US Virgin Islands due to lack of economies of scale, the geographic separation of the three islands requiring duplication of efforts, and the distance from larger existing recycling initiatives and subsequent high transport costs. However, it is imperative to find methods for overcoming these challenges, as the diversion of recyclable and compostable materials can also benefit the community by reducing littering, land and marine debris, strengthening markets for recyclable materials, enhancing agriculture, landscaping, home gardening, erosion control and other compost-based or recycling-based engineering initiatives.

Out of the three islands, St. Thomas was found to have the highest potential for recycling and composting, where 70% of the waste by weight could be diverted from the disposal facility. For St. Croix and St. John, approximately 55% and 40% of the waste by weight is recyclable or compostable,[4] respectively. While these results do not intentionally include recyclable and compostable materials generated by commercial entities (hotels, bars and restaurants, landscaping companies, etc.), it is believed by VIWMA that many of these businesses utilize the public bins sites for waste disposal illegally. Results of the residential waste study are comparable to the previous waste characterization conducted 10 years ago. However, some notable variations include the decrease in paper products from 29% to 18% in the last decade, and the increase in plastics from 16% to 21%.

While recycling and composting efforts would be beneficial, due to the inherent challenges mentioned previously, the overarching goal for the USVI should be to consider ways to limit the influx and use of these materials.

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[1]Estimate was calculated according to 2010 U.S. Census data and the results from a 2009 waste characterization study.

[2]Location of bin sites provided by VIWMA. The population served was calculated with 2010 U.S. Census block data and with the assumption that each resident travels the shortest distance geographically to dispose of waste. This has limitations as it does not consider roadway routes and indirect paths taken by residents. Additionally, it does not consider the 14,000 residents served via door-to-door pickup.

[3]The potential revenue stream is estimated at $6 million and does not account for expected costs, shipping, and other logistical challenges. Further breakdown regarding this value will be elaborated on in the Project Results section and in Appendix III.

[4] Further breakdown of recyclable and compostable material for each island is elaborated on in Appendix II.

BACKGROUND AND PURPOSE

The U.S. Virgin Islands (USVI) is facing a waste management crisis. The Territory's two disposal facilities, managed by the VI Waste Management Authority (VIWMA) and regulated by the Department of Planning and Natural Resources (DPNR), are nearing capacity. On St. Thomas, the 69-acre Bovoni disposal facility (Figure 2) has been in operation since 1979. It contains more than 2 million cubic yards (cy) of waste and is more than 200 feet high. The Bovoni disposal facility receives residential and commercial waste from St. Thomas and neighboring islands St. John and Water Island, whose waste is transported to St. Thomas on trucks via barge. On St. Croix, the Anguilla disposal facility (Figure 2) is smaller (at 35 acres) and has been in operation since 1967. It is 220 ft high with 70 ft below ground-level. In general, only municipal solid waste is disposed of in the disposal facility. Industrial and hazardous materials, electronics, cars and scrap metals are diverted from both the disposal facilities.

Figure 2: Left: Bovoni disposal facility on St. Thomas is 69 acres and over 200 feet. Right: Anguilla disposal facility on St. Croix is 35 acres and 220 feet high.

Most residents in the USVI dispose of their garbage at public bin sites, although door-to-door pickup is also available for approximately 2,800 residents on St. Thomas and 11,300 on St. Croix. Bin sites usually have multiple dumpsters with an average size of 20 cubic yards. They are mostly open air, and often unpaved (Figure 3). Private haulers usually service and replace dumpsters at least once a day. VIWMA estimates that approximately 70 truckloads (20 cubic yards) of residential municipal solid waste are emptied at the disposal facilities daily.

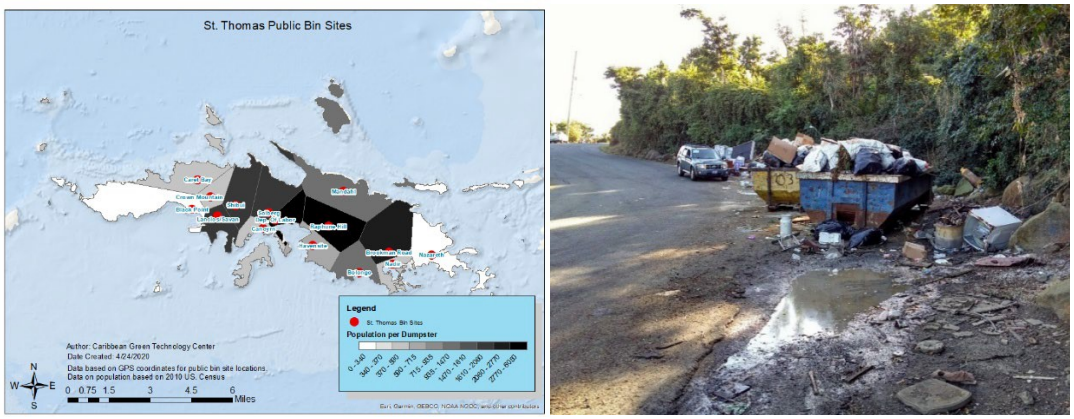

Figure 3: Left: St. Thomas public bin sites and population served per dumpster. The average population served per dumpsters on St. Thomas is 1,5000, over 3 times the capacity. Right: An overcrowded open- air bin site located on the Northside of St. Thomas. Garbage is overflowing from the dumpsters and into the nearby gut.

In addition to VIWMA, many local organizations are trying to find solutions to reduce the amount of municipal solid waste reaching the disposal facilities. The most active organization is Island Green Living on St. John. They own and operate a compactor and baler for aluminum cans, they recently acquired a chipper and started composting operations; and they are working on a variety of other projects aimed at reducing the amount of plastic and non-compostable products sent to the disposal facility. The Environmental Association of St. Thomas has also been quite active in trying to push for the composting of woody debris in the Territory. In addition, there are various groups that are trying to organize both ad hoc and organized recycling events. Plaza Extra, a supermarket chain on St. Thomas and St. Croix, is receiving, baling and shipping plastics to the U.S. mainland for recycling. The Coral Bay Community Council, also based on St. John, has successfully worked with a collection of restaurants to eliminate straws and non-recyclable to-go containers. The Caribbean Green Technology Center (CGTC) is acquiring recycling bins to start recycling plastic bottles and cans. Finally, DPNR, the VI Marine Advisory Service, VI-EPSCoR and other groups are active in organizing beach cleanup events and educating the public about the harm caused by marine debris and littering in general.

Together, the local organizations and the grassroots programs mentioned above have increased awareness to the waste management crisis in the USVI and they are creating valuable alternatives for residents to manage their garbage. Although the former USVI Governor, Mr. Mapp, convened a Recycling Task Force in December 2016 to develop a waste reduction policy, promote recycling, anti-litter and environmental protection, the resulting policy was never realized. Nevertheless, these various efforts have not significantly reduced the pressure on the Territory's overburdened disposal facilities. One of the reasons is that VIWMA has chronically been underfunded[5], which limits its ability to improve waste collection and disposal in the USVI. Following the 2017 hurricanes, VIWMA has noticed an increase in illegal dumping at residential bin sites. Some of this illegal dumping is likely caused by commercial entities which are dumping at the residential bin sites instead of directly at the disposal facilities. According to an interview with VIWMA, illegal dumping is a consequence of the lack of enforcement officers and lack of public education.

In order to help plan ways to address the waste crisis in the USVI, CGTC, in partnership with the U.S. Environmental Protection Agency Region 2 (EPA), conducted a residential waste characterization for each of the three islands' waste streams. The waste characterization effort followed ASTM standards, and provides an estimate of the type of waste generated by residents in the USVI. The results from this study can be used to identify and quantify the weight of recyclable and compostable items present in the waste stream on each island.

PROJECT DETAILS

Quality Objectives and Criteria for Measurement Data

UVI and EPA conducted a characterization, of the residential waste generated on St. Thomas, St. John and St. Croix. The effort took place at the St. Thomas and St. Croix disposal facilities between May 13th- 17th – waste from St. John is hauled to St. Thomas by barge. The characterization followed a protocol based on ASTM Standard #5231 "*Standard Test Method for Determination of the Composition*

[5]According to VIWMA's testimony at the FY 2020 legislative budget hearings in July 2019, "the recommended budget is not adequate to cover the current cost of essential solid waste and wastewater services provided to the community by the Authority." Additionally, VIWMA did not receive all the appropriations causing additional debt.

of Unprocessed Municipal Solid Waste" (https://www.astm.org/Standards/D5231.htm). CGTC and Resource Recycling Systems (RRS) staff led the effort for St. Thomas. Weston Solutions, supervised by EPA staff, led the study for St. Croix and St. John. The effort was conducted on flat, well-ventilated, and relatively clean locations, away from the normal waste handling and processing areas (Figure 4). All activities complied with health and safety standards (see Appendix V).

The characterization effort consisted of sorting and weighing all material found in randomly selected samples of waste being disposed at the disposal facility. The sorting team worked with the disposal facility managers to create samples by stopping haulers that were carrying residential waste to the disposal facility. Once selected, the team asked the hauler to discharge the contents of their dumpster on the ground of the general characterization area in one contiguous pile (Figure 4). This avoids gaps and facilitates collection of the samples. The sorting team ascertained the point of origin from the vehicle operator before the vehicle left the discharge area. Next, a loader mixed the material, the sort team visually separated the pile into six sections, and the sample to be analyzed was picked by rolling a die. The loader placed the sample on a tarp (gray and blue tarps in Figure 4) and discarded the rest of the waste.

Figure 4: Aerial view of the sorting area on St. Thomas.

Once the sorting sample had been placed on a tarp, the team put the contents of the sample into large storage containers and moved them to the sorting, handling and processing area (Figure 5). The team proceeded to empty the contents of the storage container onto a table and sort all material according to a material composition list (see Appendix II). All small containers, such as capped jars, paper bags, and plastic bags, from the sorting sample were emptied of their contents, and their contents were sorted appropriately. Sorting continued until the maximum particle size of the remaining waste particles was approximately 0.5 in. (12.7mm). Note that the list was treated as a living document as other waste components not mentioned in the ASTM D5231-92 standard were defined on the spot and sorted, such as lumber. This list was turned into a data sheet (Appendix II), along with a description of each waste component.

Figure 5: Sorting of the waste for St. Thomas (left) and St. John (right).

Every item in the sample was placed into an appropriate, pre-labeled and tared container. Once all waste in the sample was sorted, sorters weighed the gross weights of the storage containers and of any waste items sorted but not stored in containers. The calibrated electronic weigh scale for the St. Thomas sort team had a capacity of at least 200 lbs. and a precision of at least 0.1 lb., while the teams for St. John and St. Croix used scales with a precision of 0.5 lb. After recording the gross weights, sorters emptied the storage containers and cleaned the sorting area. At the end of the day, the sorting site, as well as the load discharge area, was cleaned of all waste materials.

PROJECT RESULTS

CGTC and RRS classified the results of the study as recyclable, compostable or other. Recyclable materials include some plastics, metals, glass, small white goods, and uncontaminated C&D[6]. Compostable materials include paper, food and yard waste. Other items include non-recyclable plastics, rubber, textiles, residues and hazardous waste. We also provide an estimate of the current revenue potential for recyclable materials (Appendix III). For this report, revenues were estimated based on commodity prices from recyclingmarkets.net published in August 2019. Note that the market for recycled commodities plunged in 2018 and 2019 due to the recent China National Sword policy, which bans various plastic and paper from entering their country. However, in response to this change, the U.S. is building new reprocessing capacity, and over the next few years, we expect that recycled commodity prices will increase as the surplus materials are purchased and processed. Also, the pricing is based on the Southeast U.S. and does not fully capture the shipping costs of the material from the Virgin Islands to the processing facility. If a recycling facility or effort does not occur on island, the exclusion of the shipping costs will be significant as that is one of the main limiting factors for recycling in the Virgin Islands.

[6] Although most C&D waste can be recycled, there are some hazardous contaminants to consider for cement and lumber such as lead, asbestos and termiticides, respectively.

St. Thomas Waste Categorization

CGTC and RRS performed the St. Thomas waste characterization. Figure 6 indicates the types of waste and the composition of the total waste collected during the waste characterization. Approximately 44% of the material sorted is considered recyclable, while another 24% is considered compostable. Appendices II and IV provide more details on the types and amount of recyclable and compostable items. The remaining 32% is various wastes that would require special handling or in which disposal in a landfill or incineration for energy would remain the best disposal options. So together, recycling and composting on St. Thomas would reduce the disposal facility intake by 68%.

Assuming the Bovoni disposal facility receives approximately 250 tons per day from both St. Thomas and St. John[7], then we estimate that 84,430 tons per year are likely from St. Thomas. This estimate is based on the population distribution between the two islands as St. Thomas residents comprise 92% of the amount of trash going to the disposal facility. This would mean 37,525 tons per year could be recycled, with an approximate value of $122 per ton[8] before shipping. Additionally, 20,305 tons per year could potentially be composted, and the compost could be used for farming, landscaping, and home gardening.

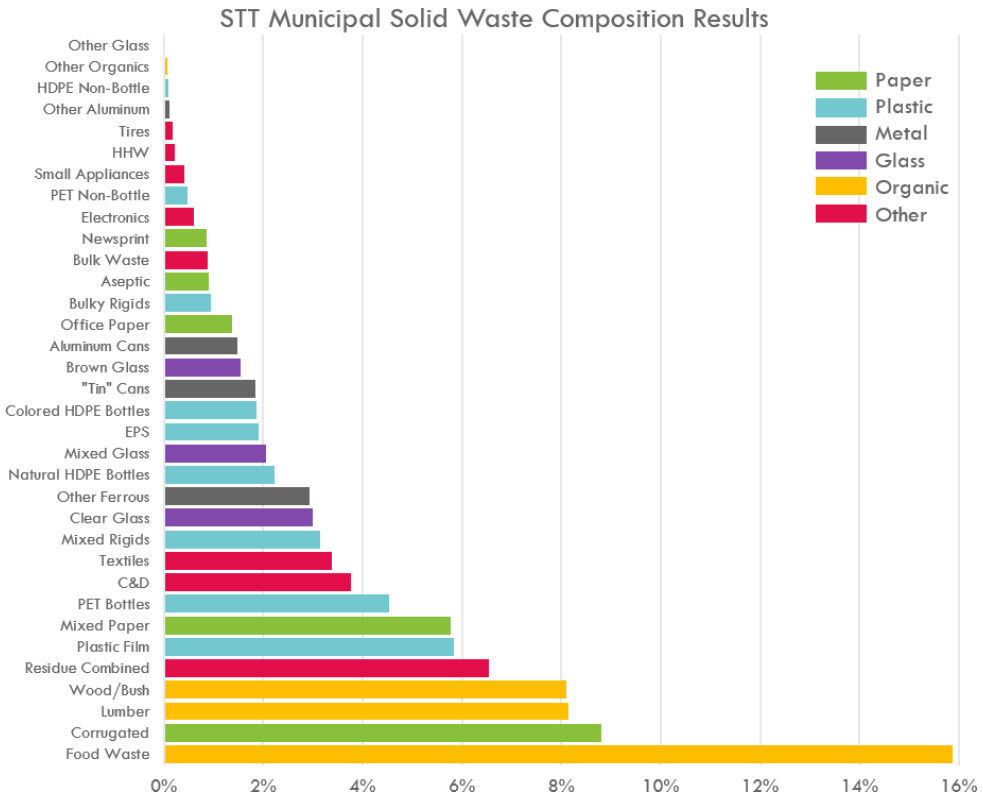

Figure 6: *Municipal solid waste composition results for St. Thomas, Bovoni disposal facility. General categories are sorted by color. Paper -18% (green); Plastic - 21% (blue); Organic – 32% (yellow); Metal – 6% (grey); Glass – 7% (purple); Other – 16% (red.*

[7]Estimate given by Bovoni landfill operator. Currently scales at the landfill are not operational.

[8] This value is an average based on the waste composition and includes all recyclable material even those with negative values. Recyclable materials with negative values would likely need to be subsidized to encourage waste diversion.

St. John Waste Categorization

Weston performed the St. John waste characterization. Figure 7 indicates the types of waste and the composition of the total waste collected during the waste characterization. Approximately 32% of the materials sorted are considered recyclable, while another 11% are considered compostable (Appendix II and IV). The remaining 57% are various wastes that would require special handling or in which disposal in a landfill or incineration for energy would remain the best disposal options. However, we found that the C&D and lumber categories were significantly larger. This is likely due to the timing of the effort, and the more significant hurricane reconstruction occurring on the island and to limited collection options for these wastes on that island. Nevertheless, recycling and composting on St. John has the potential to reduce the disposal facility intake by 43%.

Assuming the Bovoni disposal facility receives approximately 250 tons per day from both St. Thomas and St. John then, based on the population distribution between islands, then approximately 6,820 tons per year are likely from St. John. This would mean 2,170 tons per year would have value as recyclables, at $86 per ton[9] before shipping. In addition, 740 tons per year could be composted and the compost could be used for farming, landscaping, and home gardening. Note that it is likely that the amount of compostable material from St. John's waste is larger than what we captured during the weeklong effort as some residences use commercial landscapers for green waste.

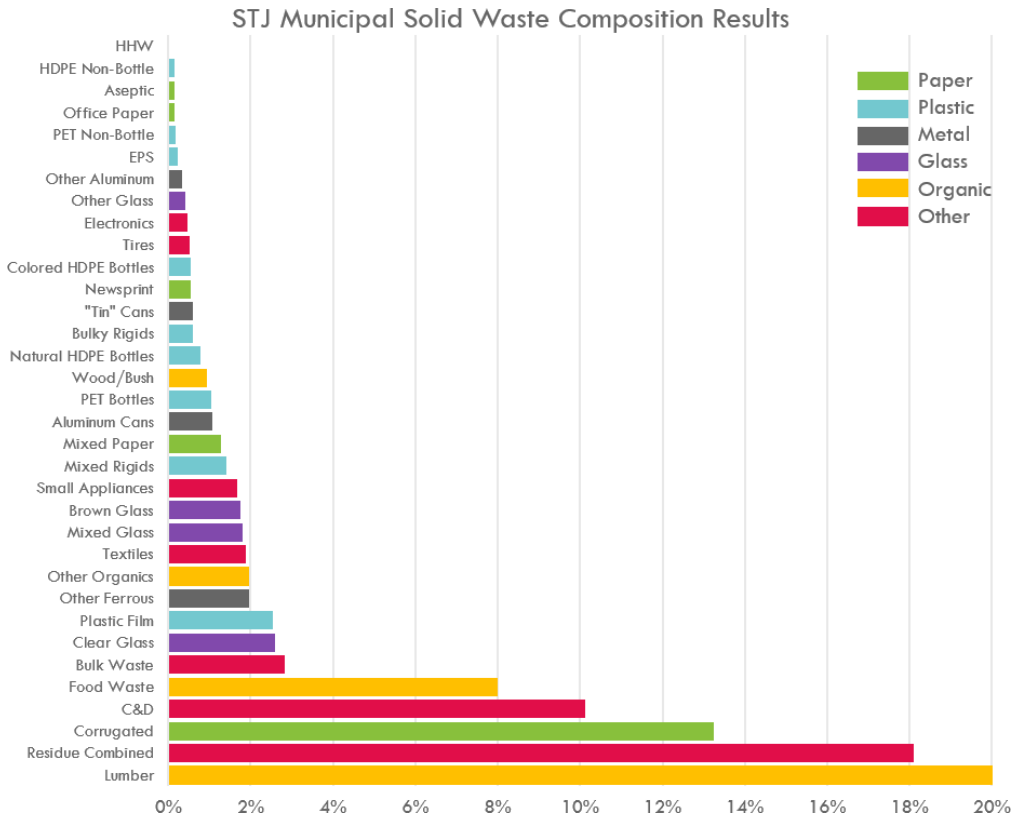

***Figure 7**: Municipal solid waste composition results for St. John at Bovoni disposal facility. General categories are sorted by color. Paper -15% (green); Plastic – 7.4% (blue); Organic – 31% (yellow); Metal – 4% (grey); Glass – 7% (purple); Other – 36% (red).*

9 This value is an average based on the waste composition and includes all recyclable material even those with negative values. Recyclable materials with negative values would likely need to be subsidized to encourage waste diversion.

St. Croix Waste Categorization

Weston performed the St. Croix waste characterization at the Anguilla disposal facility. Figure 8 indicates the types of waste and the composition of the total waste collected during the waste characterization. Approximately 42% of the materials sorted are considered recyclable in most areas, while another 14% are considered compostable. The remaining 44% are various wastes that would require special handling or in which landfilling or incineration for energy would remain the best disposal options. So together, recycling and composting on St. Croix would reduce the disposal facility intake by 56%.

Assuming similar waste generation rates as St. Thomas, St. Croix's slightly smaller population would send the Anguilla disposal facility approximately 82,740 tons per year. This would mean 34,760 tons per year would have value as recyclables, estimated to be worth approximately $61 per ton[10] before shipping. Additionally, 11,510 tons per year could be composted, and the compost could be used for farming, landscaping, and home gardening.

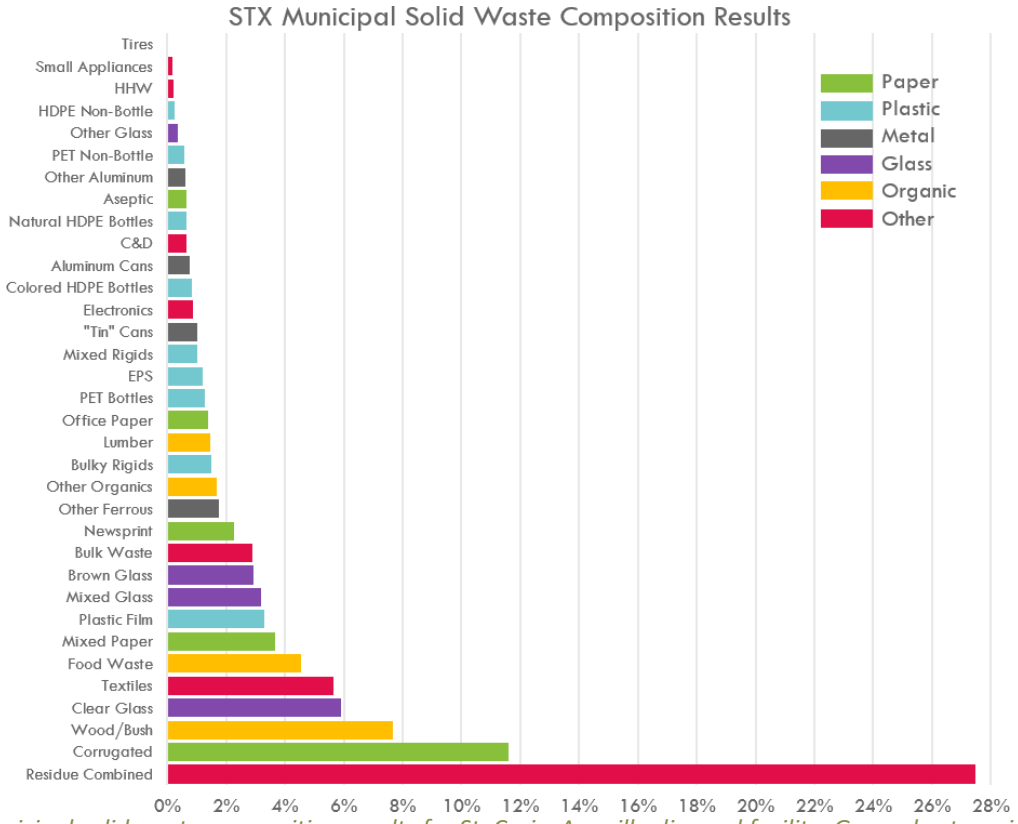

Figure 8: *Municipal solid waste composition results for St. Croix, Anguilla disposal facility. General categories are sorted by color. Paper – 20% (green); Plastic – 11% (blue); Organic – 15% (yellow); Metal – 4% (grey); Glass – 12% (purple); Other – 38% (red).*

[10] This value is an average based on the waste composition and includes all recyclable material even those with negative values. Recyclable materials with negative values would likely need to be subsidized to encourage waste diversion.

Territory-wide Results

The waste characterization results suggest that 62% of the USVI's residential waste stream by weight could be diverted from the disposal facilities to either a recycling or composting program. Figure 9 shows the percentage of total waste that could be recycled and composted per island. Among the three islands, the potentially recyclable waste stream ranges from 30-45% and the potentially compostable waste stream ranges from 10-25%.

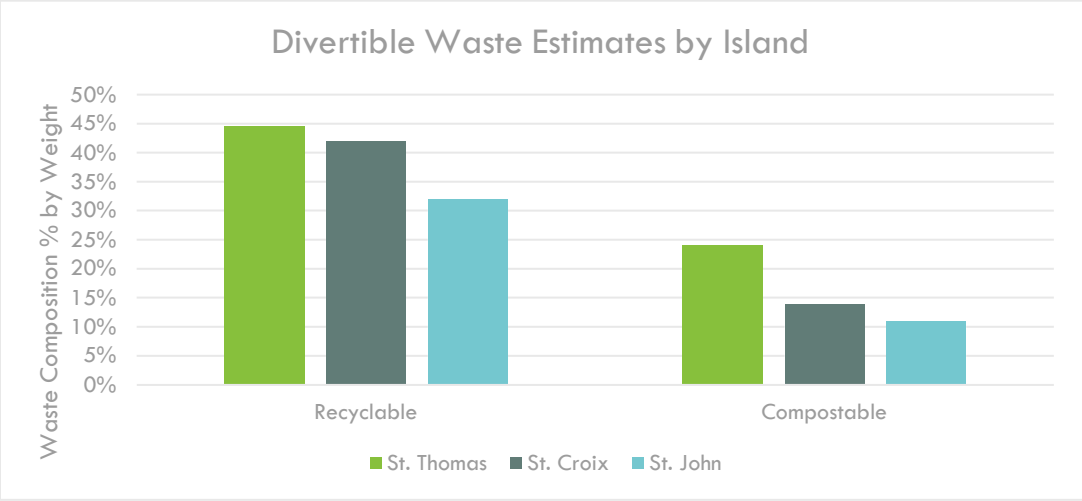

***Figure 9**: Potential Divertible Municipal Solid Waste estimates for each of the three Virgin Islands. St. Thomas has the highest potential to divert 68% of waste from the disposal facility by implementing recycling and composting programs.*

The commodity revenue for recycling is different for each island due to the differences in waste composition. Figure 10 shows the expected revenue from each island per ton of trash. These values do not account for expected costs, shipping, and other logistical challenges. This highlights the need for government and community support in sustainable materials management initiatives. Another potential revenue stream not accounted for are the costs avoided by diverting waste from the current disposal facilities. Additionally, this estimate does not account for potential revenue generated by existing small-scale recycling programs, for which we do not have data.

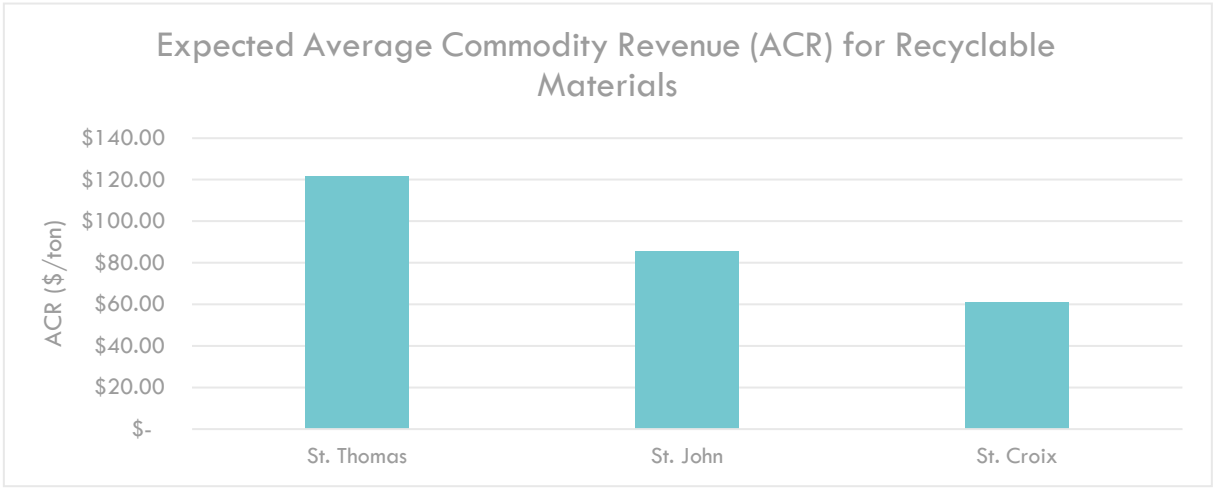

***Figure 10**: Expected ACR ($/ton) for each of the three islands based on waste composition (See Appendix III for information on methodology and sources for these ACR estimates).*

CONCLUSION

The Territory's disposal facilities are nearing capacity and bin sites are overused which contributes to litter and marine debris. Additionally, since the Territory is prone to extreme weather events, as seen by hurricanes Irma and Maria in 2017, spikes in waste generation are, and will likely remain, frequent. Although there are many dedicated groups and organizations aimed at tackling this waste management crisis, there are currently no Territory-wide recycling or composting programs.

CGTC, RRS and EPA conducted a residential waste characterization for each of the three islands: St. Thomas, St. John and St. Croix. The waste composition results of this study demonstrate a 62% disposal facility diversion potential through recycling and composting, with a potential revenue stream. Compost products could be used locally for agriculture, landscaping, and home gardening. Although similar, results differ from island to island. Some of these differences may be attributed to the fact that some of the data may still be affected by reconstruction following the 2017 hurricane season, especially on St. John. Also, although the data collected was standardized across the three islands, they were performed by different agencies which can lead to minor discrepancies. Finally, while many of the current results are quite comparable to the residential portion of the 2009 waste characterization, there are some notable differences: paper products have decreased from 29% to 18% in the last decade, and plastic usage has increased and currently comprises of 21% of waste in comparison to only 16% in 2009.

The high composition of plastic by weight is notable considering the low density of these materials. Additionally, there are health and environmental issues associated with the low degradation rate of plastic, as well as the creation of microplastics in the air, land and sea. While recycling plastics would be beneficial to reducing local pollution and reducing the carbon footprint, it is important for the USVI to consider ways to limit the influx and use of these materials.

This waste characterization study is a snapshot of the residential waste collected from the public bin sites in the US Virgin Islands (St. Thomas, St. John and St. Croix). While not all encompassing, the results of this report are beneficial for determining the recycling and compostable potential for the USVI that can be diverted from the various waste streams from the overburdened disposal facilities. This waste characterization is not all encompassing as it does not include commercial waste nor consider seasonal variations. The results of this study will also be utilized in future reports, such as a US Virgin Islands Commodities Market Analysis, which will investigate sustainable materials management strategies that are most effective for the Virgin Islands (based on waste volume, weight and composition). This waste characterization will allow the Virgin Islands to make more effective decisions, identify low-hanging fruit and identify areas for collaboration among entities. This will help determine the best sustainable waste management strategies which will have the highest impact.

BIBLIOGRAPHY

Data Files:

1. United States Census Bureau. “2010 Decennial Census” conducted on April 10, 2010. Data was based regionally in block via GIS files.
2. Bin Site Location GIS files and .pdf file maps provided by the Virgin Islands Waste Management Authority.
3. Email conversations with Olivia Robles at Virgin Islands Waste Management Authority. Oct 29, 2018. Provided information regarding bin site names, frequency of collection, number of dumpsters at bin sites and population serviced by door-to-door pickup

Legislative Hearings and Documents:

4. Title 19 Virgin Islands Rules & Regulations. Part VI Regulatory Provisions Concerning Public Health. Chapter 56: Solid and Hazardous Waste Management Rules and Regulations.
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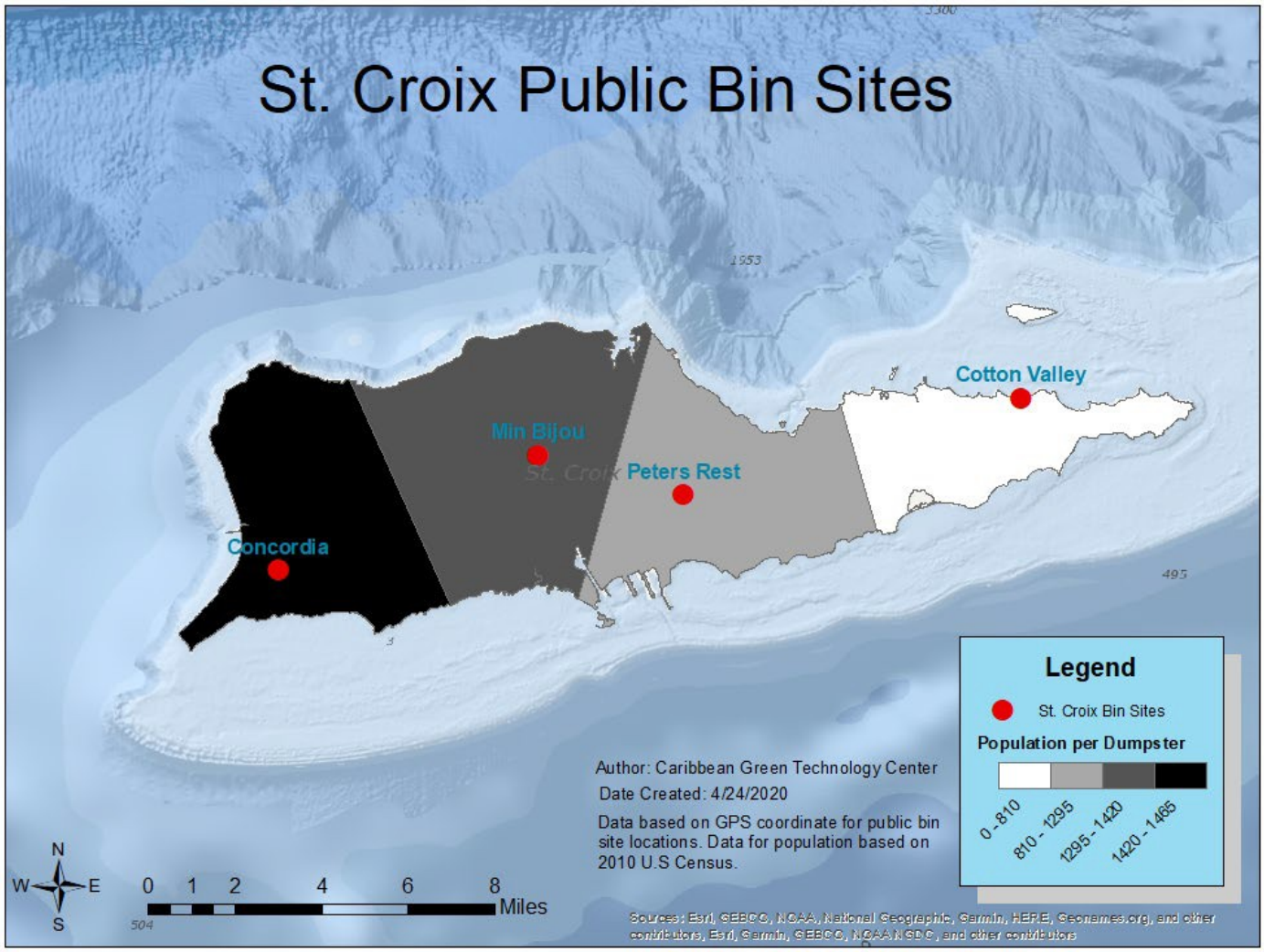
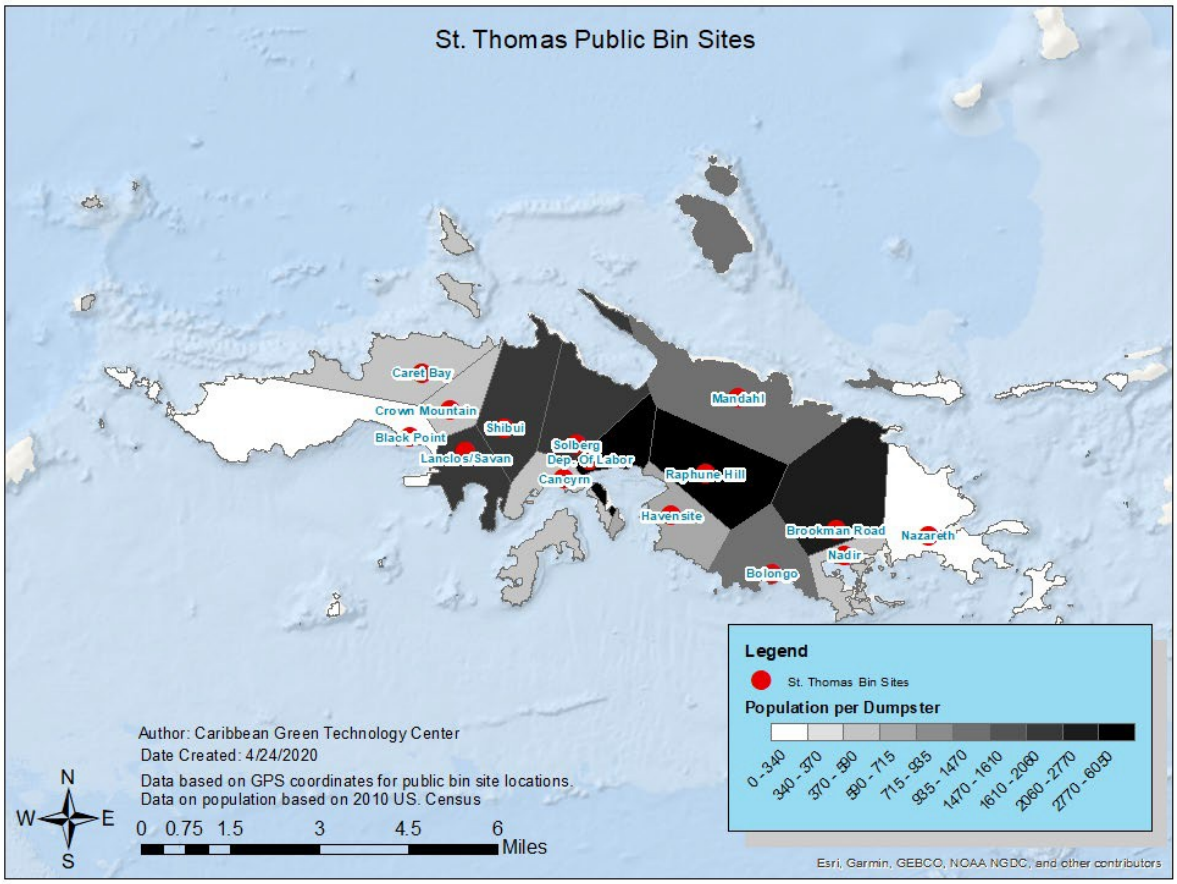
Appendix I: Maps of Public VIWMA Bin Sites and Population Served for USVI

The following maps were created using ArcGIS software. The population serviced per bin site was analyzed using Thiessen polygons and the U.S. Census population data. The public bin sites and number of dumpsters per bin site data were given by VIWMA and verified using GPS coordinates gathered by CGTC. Although the original list of bin sites was provided by VIWMA it is likely that it is outdated and incomplete. Therefore, it is likely that some bin sites may be missing, most notably Thomasville on St. Thomas and additional bin sites along centerline road on St. John. The population served per bin site was normalized using the number of 20 CY roll-off dumpsters per site. Each dumpster, if emptied once daily, can serve approximately 500 residents. On St. John, the Centerline Road dumpsters 1 through 5 (marked with an asterisk*) were smaller than the estimated 20 cubic yards so the population per dumpster is larger than the actual populations.

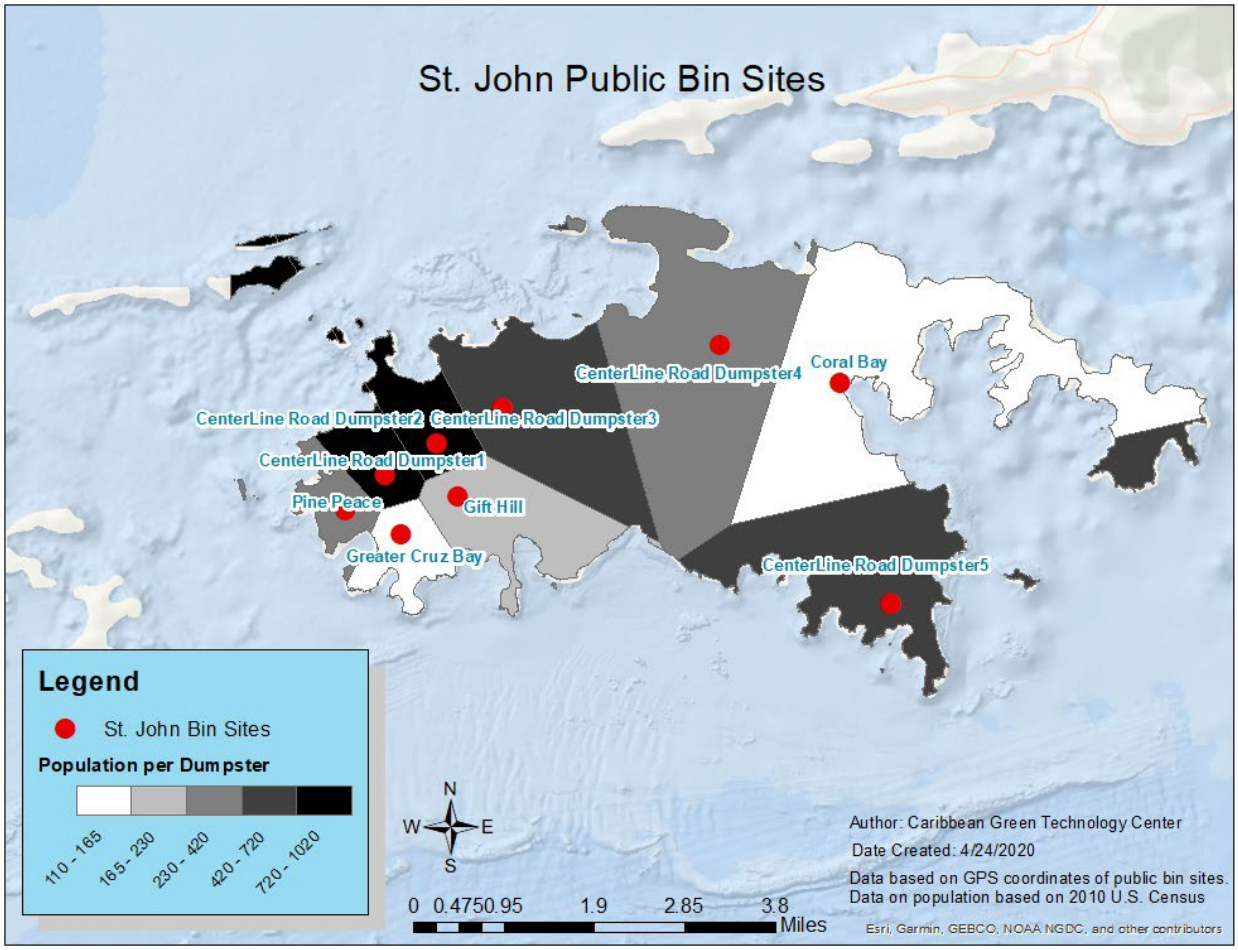


Island	Bin Site Name	Population Serviced	Population per Dumpster (20 Cubic Yards)
St. Croix			
STX	Concordia West	13179	1464
STX	Peter's Rest	19424	1295
STX	Cotton Valley	2427	809
STX	Mon Bijou	15571	1416
	Total	**50,601**	
	Average	**12,650**	**1,246**



Island	Bin Site Name	Population Serviced	Population per Dumpster (20 Cubic Yards)
St. Thomas			
STT	Bolongo	2808	936
STT	Nadir	1180	590
STT	Solberg	3223	1612
STT	Cancryn	3440	573
STT	Black Point	1696	339
STT	Mandahl Convenience Center*	7339	1468
STT	Crown Mountain	537	537
STT	Shibui	4119	2060
STT	Caret Bay	1120	373
STT	Lanclos	1844	1844
STT	Altona	6048	6048
STT	Brookman Road	8098	2699
STT	Havensight	1429	715
STT	Raphune Hill	5541	2771
STT	Nazareth	2717	340
STT	**Total**	**51,139**	
	Average	**3,409**	**1,527**

*Compactors at Mandahl Convenience Center are assumed to have a 4:1 ratio.
**Water Island and Thomasville bin sites and dumpsters are not included in the table or maps as they were not included in the first iteration of data from VIWMA.



Island	Garbage Collection Site Name	Population Serviced	Population per Dumpster
STJ	Gift Hill	454	227
STJ	Coral Bay	432	108
STJ	Pine Tree	1,165	388
STJ	Great Cruz Bay	247	165
STJ	Centerline Road 1	499	998*
STJ	Centerline Road 2	510	1020*
STJ	Centerline Road 3	286	572*
STJ	Centerline Road 4	209	418*
STJ	Centerline Road 5	358	716*
	Total	**4,160**	
	Average	**462**	**512**

*Centerline road dumpsters are smaller than the average 20 CY therefore the population per dumpster is larger than actual population served. However, this value is still relevant as it shows that some sites may be overburdened.

US Virgin Islands (Normalized by Island Populations)

Total USVI Population:	105,900
Average per Bin Site:	7709
Average per Dumpster:	1353

Appendix II: Table- Composition for Each Island and for the U.S. Virgin Islands as a Whole, with Confidence Intervals

General	Specific Category	Destination	St. Thomas	St. John	St. Croix	All Islands
Paper	**Total**		**18.2% ±1.6%**	**16.4% ±2.2%**	**19.7% ±2.3%**	**18.5% ±1.5%**
Paper	Mixed Paper	Recyclable	5.8% ±0.6%	1.6% ±0.7%	3.7% ±0.6%	4% ±0.6%
Paper	Office Paper	Recyclable	1.5% ±0.4%	0.2% ±0.1%	1.4% ±0.4%	1.2% ±0.3%
Paper	Newsprint	Recyclable	0.8% ±0.2%	0.6% ±0.3%	2.3% ±0.5%	1.4% ±0.3%
Paper	Corrugated	Recyclable	9.2% ±1.4%	13.7% ±2.1%	11.6% ±1.6%	11.3% ±1.3%
Paper	Aseptic	Recyclable	0.9% ±0.1%	0.2% ±0.2%	0.6% ±0.1%	0.6% ±0.1%
Plastic	**Total**		**20.9% ±1.6%**	**7.9% ±1.7%**	**10.7% ±1.5%**	**13.6% ±1.7%**
Plastic	PET Bottles	Recyclable	4.5% ±0.4%	1.2% ±0.3%	1.3% ±0.3%	2.4% ±0.4%
Plastic	PET Non-Bottle	Recyclable	0.5% ±0.1%	0.3% ±0.1%	0.6% ±0.1%	0.5% ±0.1%
Plastic	Natural HDPE Bottles	Recyclable	2.3% ±0.3%	0.8% ±0.3%	0.6% ±0.1%	1.3% ±0.3%
Plastic	Colored HDPE Bottles	Recyclable	1.9% ±0.3%	0.6% ±0.2%	0.8% ±0.1%	1.1% ±0.3%
Plastic	HDPE Non-Bottle	Recyclable	0.1% ±0.1%	0.1% ±0.1%	0.3% ±0.1%	0.2% ±0.1%
Plastic	Mixed Rigids	Recyclable	3.2% ±0.3%	1.2% ±0.4%	1% ±0.1%	1.8% ±0.3%
Plastic	Bulky Rigids	Recyclable	0.9% ±0.3%	0.6% ±0.3%	1.5% ±1.5%	1.1% ±0.6%
Plastic	Film	Other	5.7% ±0.5%	2.8% ±0.7%	3.3% ±0.3%	4% ±0.5%
Plastic	EPS	Other	1.9% ±0.3%	0.2% ±0.1%	1.2% ±0.5%	1.2% ±0.3%
Organics	**Total**		**31.3% ±3.5%**	**15.5% ±2.4%**	**10.7% ±1.5%**	**24.3% ±4%**
Organics	Food Waste	Compostable	15.3% ±2.1%	7.3% ±4.8%	4.6% ±2.3%	8.9% ±2.3%
Organics	Wood/Bush	Compostable	8.2% ±2.3%	0.4% ±0.2%	7.7% ±0.4%	6.3% ±1.6%
Organics	Lumber	Other	7.7% ±2.5%	20.3% ±8.5%	1.5% ±0%	7.8% ±3.5%
Organics	Other Organics	Compostable	0.1% ±0.1%	2.1% ±1.8%	1.8% ±0.1%	1.2% ±0.6%
Metal	**Total**		**7.4% ±0.8%**	**4.7% ±2%**	**4.2% ±0.5%**	**5.4% ±0.9%**
Ferrous	"Tin" Cans	Recyclable	1.9% ±0.3%	0.7% ±0.2%	1% ±0.3%	1.2% ±0.2%
Ferrous	Other Ferrous	Recyclable	3% ±0.8%	2.3% ±1.6%	1.8% ±0.3%	2.3% ±0.7%
Aluminum	Cans	Recyclable	1.5% ±0.2%	1.2% ±0.9%	0.8% ±0.2%	1.1% ±0.3%
Aluminum	Other Aluminum	Recyclable	1.1% ±0.2%	0.4% ±0.2%	0.6% ±0.1%	0.7% ±0.1%
Glass	**Total**		**6.3% ±0.9%**	**7.1% ±2.2%**	**12.4% ±3.6%**	**9.1% ±1.7%**
Glass	Clear	Recyclable	2.7% ±0.5%	2.9% ±0.7%	5.8% ±2.3%	4.1% ±1%
Glass	Brown	Recyclable	1.5% ±0.3%	1.8% ±0.8%	3% ±1%	2.2% ±0.5%
Glass	Mixed	Recyclable	2% ±0.4%	2% ±0.7%	3.2% ±1.2%	2.5% ±0.6%
Glass	Other Glass	Other	0% ±0%	0.4% ±0.2%	0.4% ±0%	0.3% ±0.1%
Other	**Total**		**15.9% ±2%**	**33.8% ±6.2%**	**37.5% ±6.3%**	**29.2% ±3.8%**
Other	Textiles	Other	3.4% ±0.6%	2.1% ±1%	5.7% ±0.6%	4.1% ±0.6%
Other	Electronics	Other	0.6% ±0.3%	0.5% ±0.2%	0.9% ±0.1%	0.7% ±0.2%
Other	Tires	Other	0.2% ±0.2%	0.4% ±0.5%	0% ±0%	0.2% ±0.2%
Other	HHW	Other	0.2% ±0.1%	0% ±0%	0.2% ±0%	0.2% ±0.1%
Other	C&D	Other	4.1% ±2.2%	6% ±4.5%	0.6% ±0.1%	3.1% ±2%
Other	Bulk Waste	Other	0.9% ±0.5%	2.9% ±2.1%	3% ±1.1%	2.3% ±0.9%
Other	Small Appliances	Recyclable	0.4% ±0.4%	2.3% ±2%	0.2% ±0.1%	0.7% ±0.7%
Other	Residue Combined	Other	6.1% ±1%	19.5% ±4.4%	26.9% ±6.6%	18% ±3.5%

Appendix III: Table – Average Commodity Revenue (ACR) for Recyclable Materials on St. Thomas, St. John, and St. Croix Based on Waste Composition

The ACR per ton is based on commodity prices from recyclingmarkets.net for the Southeast United States. Shipping and other costs are not included and would need to be considered to calculate potential profit. Some materials are negative (noted by negative sign or parenthesis) meaning there is currently no recycling value in standard markets, and it costs to dispose of these materials. This is likely due to the high costs of separation and/or oversaturation of the markets.

Material Type	Waste Characterization Nomenclature	Recycling Markets Nomenclature	Price ($/ton)	St. Thomas Bovoni ACR	St. John ACR	Anguilla St. Croix ACR
Aluminum	Cans	Aluminum Cans (Sorted, Baled, ¢lb., picked up)	1060.00	$34.88	$35.48	$19.05
Cartons	Aseptic	Aseptic Cartons (#52)	22.50	$0.45	$0.11	$0.34
Glass	Clear	3 Mix ($/ton del. as Recyclable or Disposable)	-22.50	$(1.49)	$(1.83)	$(3.16)
Glass	Mixed	3 Mix ($/ton del. as Recyclable or Disposable)	-22.50	$(1.02)	$(1.27)	$(1.71)
Glass	Brown	3 Mix ($/ton del. as Recyclable or Disposable)	-22.50	$(0.77)	$(1.23)	$(1.57)
Metal	"Tin" Cans	Steel Cans (Sorted, Baled, $/Gross ton, picked up)	95.00	$3.87	$1.75	$2.28
Paper	Corrugated	Corrugated Containers (#11)	32.50	$6.31	$13.51	$8.96
Paper	Mixed Paper	Mixed Paper (#54)	-2.50	$(0.32)	$(0.10)	$(0.22)
Paper	Office Paper	Mixed Paper (#54)	-2.50	$(0.08)	$(0.01)	$(0.08)
Paper	Newsprint	Sorted Residential Papers (SRPN #56)	22.50	$0.42	$0.39	$1.22
Plastic	PET Bottles	PET (Baled, ¢/lb., picked up)	295.00	$29.56	$9.58	$9.06
Plastic	Mixed Rigids (1-7)	Commingled (#3-7, Baled, ¢/lb., picked up)	-30.00	$(2.08)	$(1.32)	$(0.72)
Plastic	Bulky Rigids (mixed bulky)	Mixed Bulky Rigid (Baled, ¢/lb., picked up)	60.00	$1.25	$1.11	$2.12
Plastic	HDPE Non-Bottle (tubs and lids)	N/A, (Small part of stream, substituting tubs and lids with PP)	260.00	$0.52	$1.15	$1.63
Plastic	Colored HDPE Bottles	Colored HDPE (Baled, ¢/lb., picked up)	235.00	$9.72	$4.05	$4.61
Plastic	Natural HDPE Bottles	Natural HDPE (Baled, ¢/lb., picked up)	415.00	$20.38	$10.01	$6.46
Plastic	PET Non-Bottle	Commingled (#3-7, Baled, ¢/lb., picked up)	-30.00	$(0.31)	$(0.17)	$(0.42)
Metal	Other Ferrous	N/A	80.00	$5.18	$4.95	$3.32
Metal	Other Aluminum	N/A	660.00	$14.84	$7.15	$9.63
Metal	Small Appliances	White Goods (Loose, $/ton, picked up)	42.50	$0.38	$2.24	$0.16
TOTAL	**TOTAL**	**TOTAL**		**$121.71**	**$85.53**	**$60.96**

Appendix IV: Detailed results of the waste characterization, for each island.

St Thomas	Static & Ordered	
Category	**%**	**Lbs.**
Food Waste	15.7%	1,515.72
Corrugated	8.7%	840.66
Lumber	8.1%	777.90
Wood/Bush	8.0%	772.71
Residue	6.5%	624.38
Plastic Film	5.8%	556.30
Mixed Paper	5.7%	551.35
PET Bottles	4.5%	433.57
C&D	3.7%	360.40
Textiles	3.4%	323.48
Mixed Rigids	3.1%	299.61
Clear Glass	3.0%	287.00
Other Ferrous	2.9%	280.10
Natural HDPE Bottles	2.2%	212.55
Mixed Glass	2.0%	196.58
EPS	1.9%	182.56
Colored HDPE Bottles	1.9%	179.05
"Tin" Cans	1.8%	176.25
Brown Glass	1.5%	148.56
Cans	1.5%	142.40
Office Paper	1.4%	130.80
Bulky Rigids	0.9%	90.40
Aseptic	0.9%	86.91
Foil	0.9%	85.55
Bulk Waste	0.9%	84.50
Newsprint	0.8%	81.60
Electronics	0.6%	58.80
PET Non-Bottle	0.5%	44.79
Small Appliances	0.4%	39.10
HHW	0.2%	20.43
Tires	0.2%	18.10
Other Aluminum	0.1%	11.76
HDPE Non-Bottle	0.1%	8.60
Other Organics	0.1%	6.80
Other Glass	-	-
Contaminants	-	-
Liquids	-	-

St John	Static & Ordered	
Category	**%**	**Lbs.**
Lumber	21.0%	1,227.50
Contaminants	15.0%	879.00
Corrugated	13.8%	807.50
Food Waste	8.7%	510.00
C&D	8.6%	504.50
Bulk Waste	3.1%	179.50
Clear Glass	2.7%	158.00
Plastic Film	2.4%	142.00
Other Organics	2.1%	124.50
Liquids	2.1%	123.00
Other Ferrous	2.1%	122.20
Mixed Glass	1.9%	110.00
Small Appliances	1.8%	107.00
Brown Glass	1.8%	106.50
Textiles	1.8%	104.00
Mixed Paper	1.3%	78.00
PET Bottles	1.2%	67.50
Cans	1.1%	66.00
Mixed Rigids	1.1%	64.00
Natural HDPE Bottles	0.7%	43.00
"Tin" Cans	0.6%	37.50
Bulky Rigids	0.6%	33.00
Newsprint	0.6%	33.00
Tires	0.6%	32.50
Electronics	0.5%	29.50
Colored HDPE Bottles	0.5%	29.00
Other Glass	0.5%	26.50
Other Aluminum	0.4%	22.00
Residue	0.3%	18.00
Wood/Bush	0.3%	17.00
EPS	0.2%	13.00
PET Non-Bottle	0.2%	11.50
Office Paper	0.2%	10.00
Aseptic	0.2%	10.00
HDPE Non-Bottle	0.2%	9.00
Foil	-	-
HHW	-	-

St Croix	Static & Ordered	
Category	**%**	**Lbs.**
Contaminants	20.7%	367.00
Wood/Bush	14.2%	252.00
Corrugated	13.3%	237.00
Textiles	7.5%	133.50
Lumber	4.8%	85.50
Bulk Waste	3.3%	58.50
Clear Glass	3.2%	56.00
Plastic Film	3.1%	55.50
Mixed Paper	2.7%	48.50
Newsprint	2.5%	43.75
Other Organics	2.4%	42.50
Other Ferrous	2.2%	39.75
Residue	2.2%	39.50
Mixed Glass	2.2%	39.50
Food Waste	1.9%	33.00
Bulky Rigids	1.7%	29.75
Mixed Rigids	1.4%	24.50
Brown Glass	1.3%	23.00
PET Bottles	1.2%	21.00
"Tin" Cans	1.0%	18.50
Aseptic	1.0%	17.50
Office Paper	0.8%	15.00
PET Non-Bottle	0.8%	15.00
EPS	0.8%	13.50
Colored HDPE Bottles	0.7%	11.75
Other Aluminum	0.5%	9.75
Natural HDPE Bottles	0.5%	8.00
Cans	0.4%	7.25
HDPE Non-Bottle	0.4%	7.00
HHW	0.4%	7.00
Other Glass	0.4%	6.50
Liquids	0.3%	5.00
Electronics	0.2%	4.25
C&D	-	-
Foil	-	-
Small Appliances	-	-
Tires	-	-

3Appendix V: Quality Assurance Plan

Quality Assurance Program Plan

Finding Treasure in Trash:
Quantifying the Recycling and Waste Diversion Potential of the Virgin Islands

Approved By: DocuSigned by: Gregory Guannel 5AA24A153454476... Date: 12/4/2018
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University of the Virgin Islands

January 2018 – September 2019

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1 Project Management

1.1 Distribution List

The following individuals shall receive a copy of the approved Quality Assurance Project Plan (QAPP), either in hard copy or electronic format, as well as subsequent revisions:

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1.2 Project/Task Organization

The project management team is described in Table 1.

Table 1: Organizational Chart

Name	Project Job Title	Responsibility/Duties
Greg Guannel, UVI	Project Manager	- Review and evaluate the waste audit protocols and procedures - Ensure that QAPP and protocols are accurate and appropriate for sort team members - Ensure all sort team members on site are properly trained - Develop draft and final waste audit reports - Organize and lead meetings with steering committee
Resa Dimino, RRS	Sampling Supervisor, Quality Assurance Officer	- Help finalize QAPP and protocols - Assist in pre-sort health and safety training - Train sort team members on material types categories - Direct sampling team members during data collections on site - Ensure the quality, completeness of each data collection - Data analysis - Develop draft and final waste audit reports
Brennan Madden, RRS	Project Analyst	- Help finalize QAPP and protocols - Assist in pre-sort health and safety training - Train sort team members on material types categories - Direct sampling team members during data collections on site - Ensure the quality, completeness of each data collection - Data analysis - Develop draft and final waste audit reports
Martha Raymore, UVI	Project coordinator	- Assists project team with logistics in all phases of the project - Help facilitate necessary partnerships, and review materials - Help recruit paid sorters - Document events with photos and other media, and help disseminate results.

1.3 Special Training Needs/Certification

This project doesn't require any special training or certification.

1.4 Problem Definition/Background

1.4.1 Problem Statement

The U.S. Virgin Islands (USVI) is facing a waste management crisis. Littering and marine debris are a constant nuisance, and USVI's two landfills – Bovoni landfill on St Thomas, and Anguilla landfill in St Croix– have been near or at capacity for years, and have been ordered to close by 2022. On St Thomas specifically, composting and recycling are minimal, and the 69 acres Bovoni landfill (Figure 1), which has been in operation since 1979, contains more than 2 million cubic yards of waste, and is more than 200 ft high.

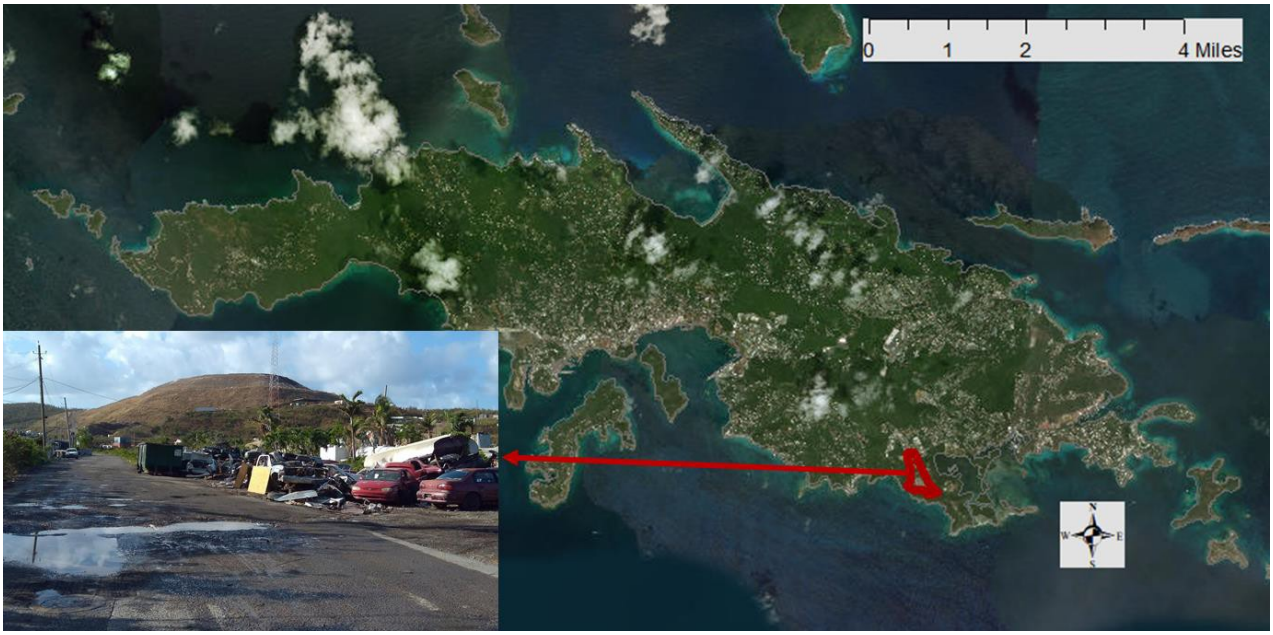

Figure 1: Bovoni landfill location and picture, on the island of St Thomas

Although Hurricanes Irma and Maria increased the amount of waste generated, the situation in the USVI improved enough that, according to the landfill operation manager, the current rate of disposal (now approximately 250 tons/day) is only slightly higher than before the storms.

To help remedy this problem, the USVI Governor convened a Recycling Task Force in December 2016 to develop waste reduction policy, promote recycling, and launch anti-litter and environmental protection efforts. In addition, there are many local organizations that are trying to tackle the waste problem in the USVI. The most prominent organization is *Island Green Living*, an organization that has been successful in doing some composting on the island of St. John, and for pushing for the composting of woody debris in the Territory following the hurricanes. Another organization is the *Coral Bay Community Council*, also based on St John, who has successfully worked with restaurants on that island to eliminate straws and non-recyclable to-go containers. *The Environmental Association of St. Thomas* has also been quite active in trying to push for the composting of woody debris in the Territory. Furthermore, the *St. Thomas Recovery Team* is an umbrella organization of over 50 NGOs that can be mobilized to increase community involvement. Finally, the *VI Marine Advisory Service*, VI-EPSCoR, and some of the other

groups mentioned above, are active in organizing beach cleanup events and educating the public about the harm caused by marine debris and littering in general. These latter two groups have existing and robust educational outreach programs and are excited at the prospect of incorporating responsible waste management techniques in their curriculum.

Nevertheless, these efforts have made little difference in the rate of waste generation and disposal in the Territory. According to the Bovoni landfill operations manager, approximately 250 tons of waste are currently disposed of every day, a number that is only slightly above pre-hurricane values. Thus, to help better understand how to better craft waste generation messages, but also recycling and composting strategies, UVI, VIWMA and partners propose to quantify the amount of recyclable material generated in the Territory via an audit of the waste-stream on the island of St. Thomas. The audit, an update of a previous one done almost 10 years ago, will consist of collecting, sorting, weighing, and classifying samples of waste over four days at the Bovoni landfill in St. Thomas.

1.4.2 Intended Usage of Data

Data collected as part of this efforts will be overseen and summarized by a steering committee, convened by UVI and VIWMA. Select members of the Governor's Recycling Task Force will be part of this committee to ensure coordination of efforts. Results will provide the initial raw data required to craft the design and communication of the Territory's long-term waste reduction and recycling program. This information will inform the Governor's Recycling Task Force in its efforts to craft recycling policy. This effort will also create a benchmark, and capacity in the Territory to conduct smaller, but ongoing, follow-up audits.

1.4.3 Previous Work

The only previous waste audit in the Virgin Islands was conducted in 2009 (Appendix A). Since then, the population of St Thomas has decreased by nearly 10% (the next census is in 2020), which would decrease the amount of waste generated. At the same time, the number of tourists increased by 400,000 (eight times the population of St Thomas). In addition, since the USVI is a major tourist destination, it is likely that a lot of the waste generated comes from visitors. Figure 2 shows the distribution of visits in the USVI in 2016, where more than 80% of visitors reside. However, we find that the summer months, when the audit is likely to occur, has the lowest visitation rate. Thus, conducting the audit in the summer months will provide a first estimate of what mostly Virgin Islanders throw away. It will also set the stage for a longer, more thorough analysis of waste generation by sector, but also by type of population (tourists vs residents).

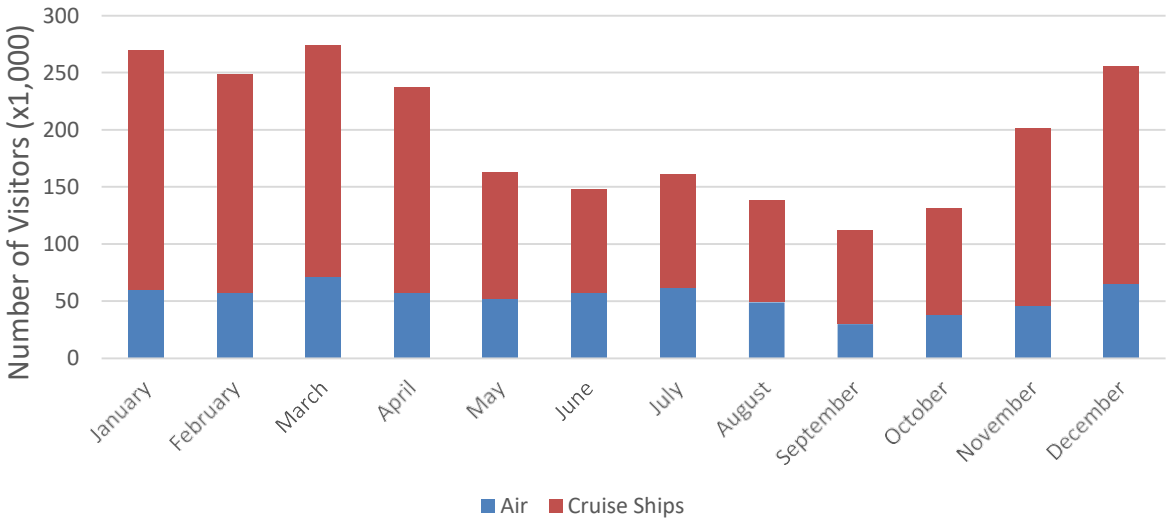

Figure 2: Total Air and Cruise Ships arrivals to the USVI in 2016

1.5 Task Description and Schedule

1.5.1 Task Description and Timeline/Work Schedule

Description of tasks and tentative schedule is presented on Table 2:

- Task 1. Project preparation and kickoff: completion of QAPP among project members (Table 1); creation and finalization of sampling protocols, with description of roles and responsibilities; finalization of sampling schedule; creation of the steering committee; and kickoff meeting.
- Task 2. Initial Mobilization: purchase/collection of sampling equipment (Appendix B); recruitment of paid sorters; completion of field logistics (transportation, lodging, schedule, etc.); conversion of data entry sheet included in the ASTM D5231-92 (Reapproved 2016; Appendix D) into electronic data entry database for use during the waste audit and all necessary paperwork for use during all data collections.
- Task 4. Waste Audit on St Thomas: mobilization on St Thomas; training of all team members and paid sorters on St Thomas; start of the audit
- Task 5. Analysis: analyze and summarize results; compare results with previous audit results.
- Task 6. Workshop: meet with steering committee to discuss waste audit results; discuss communication plan and next steps
- Task 7. Reporting: finalize results, prepare draft report and send for review to steering committee; finalize and publish report.
- Task 8: Inform Recycling Plan: Work with Governor's Recycling Task Force on the creation of a recycling plan for the Territory

Table 2: Schedule of Tasks

Task	Activity	Start Date*	Approximate Duration
1	Project preparation and kickoff	May	1 month
2	Initial Mobilization	June	2 weeks

3	Advertise and recruit sorters	May	1 month
4	Waste Audit on St Thomas	June/July	7 days
5	Analysis	July/August	2 weeks
6	Workshop	July/August	1 day
7	Reporting	August to September	1 month
8	Inform Recycling Plan	September to December	4 months

*Exact dates will be finalized during Task #1. They are a function of the various team members travel schedules and other commitments.

1.5.2 Reporting

Progress reporting on this project will be included in quarterly reports. They will provide a summary of activities done and anticipated; a description of problems encountered, changes made or anticipated; and any QA issues identified. In addition, draft and final waste audit report will be shared and reviewed by the steering committee. The steering committee will use the report's findings to make recommendations to the Governor Recycling Task Force about needs for waste reduction and diversion infrastructure development, communication and implementation. The steering committee will also identify, with the Task Force, further funding opportunities to start implementing those recommendations.

1.6 Quality Objectives and Criteria for Measurement Data

This study will be executed by experienced scientists and paid sorters. The waste audit will be performed in close coordination with the Virgin Islands Waste Management Authority (VIWMA), following a protocol that based on ASTM Standard #5231 "*Standard Test Method for Determination of the Composition of Unprocessed Municipal Solid Waste*" (https://www.astm.org/Standards/D5231.htm). Project team members have ample experience with these standards and will lead the creation of that protocol.

Sampling protocols laid out below and in Section 2.1 will be reviewed by the steering committee for approval prior to the start of sampling. A comprehensive list of materials to be sorted will be determined by the project team and the Steering Committee to ensure all appropriate break-outs of material diversion. However, that list will be treated as a living document, as other waste components not mentioned in the ASTM D5231-92 standard can be defined and sorted. This list will be turned into a data sheet, along with a description of each waste component. This information will be provided to sorters in a format similar to the example shown in Figure 3, using the similar sort categories to that shown in Appendix A. The team will also use plastic containers, which they will set out for sorters to put sorted materials into according to appropriate container labels (titles and generalized pictures). The sort team will weigh the plastic containers each day, or more frequently, if necessary, to maintain an accounting of the tare weight. The calibrated electronic weigh scale will have a capacity of at least 200 lbs and a precision of at least 0.1 lb.

All activities will also comply with health, safety and other regulatory laws at the St. Thomas landfill. Health and safety equipment will be utilized and includes a first aid kit, traffic cones, traffic vests, leather (or other puncture-resistant material) gloves, hardhats, safety glasses and 'hard' boots. Specifically, prior to the start of field activities and sorting process, the sorters will be checked for appropriate protection, such as heavy leather gloves, dust masks, hardhats, safety glasses, and safety boots. They will receive a health and safety training, including a review of the hazards and procedures with the operating and sorting personnel. For example, personnel will be instructed of various types of danger (e.g., sharp objects, such as nails, razor blades, hypodermic needles, and pieces of glass), and provided with guidance on how to best prevent injuries and handle dangerous types of waste (e.g., brush waste particles aside while sorting rather than projecting their hands with force into the mixture). In addition, sorters will be informed of the various types of injuries that can occur during the sorting of

material, and how to best prevent them. For example, during the processes of unloading waste from collection vehicles and handling waste with heavy equipment, projectiles such as glass particles from breaking glass containers and metal lids from plastic and metal containers can burst under pressure when run over by heavy equipment. Sorters will thus be informed that a way to prevent injuries is to wear eye and head protection gear at all times, but also to keep safe distances from the pile when heavy machinery is in operation.

Waste Composition Data Sheet

Day/Date: _____ Collection Company: _____
Site: _____ Vehicle Type: _____
Weather: _____ Route No: _____
Recorded by: _____

Component	Weight in Pounds			Percent of Total
	Gross	Tare		
Mixed Paper				
High Grade Paper				
Computer Printout				
Other Office Paper				
Newsprint				
Corrugated				
Plastic				
PET bottles				
HDPE bottles				
Film				
Other Plastic				
Food Waste				
Wood				
Other Organics				
Ferrous				
Cans				
Other Ferrous				
Aluminum				
Cans				
Foil				
Other Aluminum				
Glass				
Clear				
Brown				
Green				
Other Inorganics				

TOTALS _____

NOTES: _____

Lab sample taken? Yes _____ No _____

Figure 3: Waste Composition Data Sheet Example

Vehicles for sampling shall be selected at random each day during the sampling period. For a sampling period of 4 days, the number of vehicles sampled each day shall be approximately n/4, where n is the total number of vehicle loads to be selected for the determination of waste composition. A dice roll will be used to identify which truck to select, to reduce bias into the selection. The sort team will direct the designated vehicle containing the load of waste to the area secured for discharge; a location that is flat and level, and swept clean or covered with a clean, durable tarp prior to discharge of the load. The waste sample will be unloaded in one contiguous pile to avoid gaps and facilitate collection of the samples. The sort team will collect any required information (e.g., point of origin, conditions of bin collection area, etc.) from the vehicle operator before the vehicle leaves the discharge area. Next, using a front-end loader with at least a 1 yd^3 bucket, the loader operator will be instructed to remove the material longitudinally along one entire side of the discharged load to obtain a representative cross-section of the material. The mass of

material shall be sufficient to form a pile which, on a visual basis, is at least four times the desired weight of the sorting sample (that is, approximately 800 lbs). The loader will then mix, cone, and split the material into six sections. The sort team will select one section to be the sorting sample by rolling a dice. If an oversized item (e.g., water heater) composes a large weight percent of the sorting sample, the sort team will add a notation on the data sheet and weigh it, if possible.

Once the sorting sample is selected, each waste item will be placed in the appropriately marked storage container and moved to the sorting, handling and processing area, which will be away from the discharge area. There, the team will position table, containers, scale and other equipment on a clean, flat, level surface, then it will weigh all empty storage containers and record the tare weights. The sort team will then empty all containers from the sorting sample, such as capped jars, paper bags, and plastic bags of their contents. In the case of composite items found in the waste, the team will separate the individual materials where practical, and place the individual materials into the appropriate storage containers. Where impractical, composite items will be segregated for classification according to the following order:

- If there are many identical composite items (for example, plastic-sheathed aluminum electrical conductor), they will be placed into the sort containers corresponding to the materials present in the item, and in the approximate proportions according to the estimated mass fraction of each material in the item.
- If there are only a few of the identical composite items, they will be placed in the storage container corresponding to the material that comprises, on a weight basis, the majority of the item
- If composite items represent substantial weight percentages of the sorting sample, a separate category will be established, for example, composite roofing shingles.
- If none of the above procedures is appropriate, the item(s) (or proportion it (them)) will be placed in the storage container labeled “other non-combustible” or “other combustible,” as appropriate.

Sorting will continue until the maximum particle size of the remaining waste particles is approximately 0.5 in. (12.7mm). At this point, the remaining particles will be placed in sort containers corresponding to the waste components represented in the remaining mixture. An apportionment shall be accomplished by making a visual estimate of the mass fraction of waste components represented in the remaining mixture.

Once all waste in the sample has been sorted, sorters will weigh the gross weights of the storage containers and of any waste items sorted but not stored in containers. Since loss of mass from the sorting sample can occur through the evaporation of water, the samples will be sorted as soon as possible after collection. Containers of liquids or other potentially dangerous wastes shall be put aside and handled by the project team leads. After recording the gross weights, sorters will empty the storage containers and weigh them again, if appropriate. Re-weighing is important and necessary if the containers become moisture laden for example, from wet waste. The sorting site will be cleaned, as well as the load discharge area, of all waste materials.

1.6.1 Data Representativeness

The waste audit will be conducted for 4 days at the Bovoni landfill on St Thomas. The number of samples will be determined as using the methodology laid out in ASTM D5231-92 Section 9 - Calculation (Appendix D), where each sample will weigh approximately 200 lbs. Based on past experience, it is reasonable to assume that we will achieve an 80% confidence interval in those 4 days: we will sort approximately 32 samples and at 200lbs/sample, which translates into 1,600lbs/day, 246lbs/hour. To achieve a 90% confidence interval, we will need to sort approximately 52 samples, or 2,600lbs/day, 400lbs/hour. We do not know at this point whether we will be able to achieve this rate. We will indicate final confidence interval at the end of the effort, once we’ve exhausted the 4 days of

sorting. Results will also be cross-referenced against previous results, and against the origin of the waste samples.

1.7 Documentation and Records

The collected data and associated forms will be stored in a Google Drive account associated with the email address usvi.waste.audit@gmail.com. This account will be managed indefinitely by the project manager, and shared with the project team.

1.7.1 Field Documentation

Data entry forms will be filled out by designated team members for consistency and entered in a Microsoft Excel spreadsheet at each day. All other notes taken by the project managers and other members of the project team will also be summarized in a Microsoft Word document at the end of each day. After data collection is complete, at the end of each day, the project manager and sampling supervisor team will compile all notes, pictures, data entries, and complete and finalize all electronic forms. Photos will be logged according to sequential photos taken and camera name saved on the camera being by those taking photos (photographers to be specified before the audit). These forms will then be stored on the shared project Google Drive.

1.7.2 Laboratory Documentation

We will not be using a laboratory for this project.

2 DATA GENERATION AND ACQUISITION

2.1 Sampling Design

Sampling at each site, during each day will follow the same design. The sampling supervisor will select a number of garbage trucks to be analyzed each day based on the schedule for that day. No prior information about the origin of the truck will be recorded during the selection process. Due to time constraints on the sort team, the number of trucks selected will be determined based on number of trucks available to sample during that time as well as the time available to sort the samples. Sorting efficiency (expressed in lbs sorted per hour) varies based on skill and number of sorters, therefore, to adhere to labor requirements, the number of samples will be determined based on the labor time available. As a selected garbage truck enters the landfill, the sampling supervisor, or team member will:

1- Interview the driver and record the following information on the data form:
   a. Recorder's name
   b. Date and time
   c. Sample number
   d. Hauler name
   e. Origin and Route
   f. Type of vehicle
2- The sort team will direct the designated vehicle containing the load of waste to the area secured for discharge of the load and collection of the sorting sample in one contiguous pile, that is, to avoid gaps in the discharged load to facilitate collection of the samples.
3- The sort team will visually inspect the load of waste and recyclables and record anything unusual about it on the top of the data form. For example, if an oversized item, such as a water heater, composes a large weight percent of the sorting sample, the sort team will add a notation on the data sheet and weigh it, if possible.

4- The front loader will mix, and split the material, as illustrated below, each sample will be visually divided into six areas. The sort team will then select one section to be the sorting sample, by rolling a dice, to eliminate or minimize biasing of the sample. .

1	2	3
4	5	6

5- Based on the result of the dice, the loader operator will be directed to the area from which to pull a sample of at least 200 pounds. Should the area selected by the die be larger than the width of one loader bucket, the dice may be rolled a second time to further identify the area for sampling. If the materials do not appear to be uniformly distributed, the sampling supervisor may ask the loader operator to mix the material before rolling the die to select the sample. Care will be taken when selecting samples to ensure the loader operator starts with the blade on the ground, and collects material through the center of the pile regardless of where the sample is initiated in the load.
6- The sampling load will be placed on a tarp.

Before the audit, team members will work with VIWMA staff to ensure that all parties are agreeable to this sampling process. Any changes to the QAPP sampling process will be clearly documented.

2.2 Sampling Methods

The intent of the sampling effort is to sort all samples in their entirety. For each sample, the sort team will sort all materials working toward the center, until approximately 200 pounds of material has been sorted. The team will conduct the following activities:

1- Set up the sorting area, which includes the following: a) Set up the customized sorting table that is flat and clean, contains walls to keep the sample material on the table, contains a 2-inch screen to filter larger items to the top for gross sorting, and a 0.5-inch screen to filter fines to be weighed then apportioned visually according to sort categories; b) Stage the safety and sorting equipment so they are easily accessible; c) Set up the scale in an area away from high activity on a clean, flat, level surface and the level adjusted if necessary, and weigh empty sort container on calibrated scale –tare weights of plastic sort containers will be subtracted from the gross weight during analysis; d) Place appropriate label on each container corresponding to each category and arrange the containers around the sorting table; e) Arrange tarps for storing samples.
2- Ensure all sorters have on their personal safety gear and are equipped with sorting equipment.
3- Conduct safety and technical training for all paid sorters on the material categories and appropriate sorting techniques.
4- Transfer the sample from the tarp to the sorting table as space permits.
5- Oversee the accurate sorting of all materials that remain on the sort table's 2-inch screen into the categories provided in Appendix C (gross weights will include wet weights in accordance with ASTM D5231-92 standard, which may impact categories that can soak up water more than others). The Sorting Supervisor will supervise sorting activity to ensure material is correctly sorted. Specific items will be handled as follows: a) cardboard boxes that have plastic film or EPS packaging that can be easily removed will be separated from these materials and sorted as corrugated cardboard. The film will be sorted as contamination; b) cardboard that is within plastic film, such as that from a case of bottled water, will be treated as contamination, and any cardboard that is attached to wood or other contaminants will be sorted as contamination; c) all bagged materials containing recyclables or contamination will be counted, weighed and the weight recorded to provide the total number and weight of bagged recyclables and bagged contamination; the bags will then be opened. Bags that are clearly full of trash or contaminated recyclables (i.e.,

recyclables that have been contaminated by the trash, such as food waste) will be sorted as contamination; all other bagged materials will be sorted by type of recyclable material or as contamination, as appropriate.

6- Remove the sort table's 2-inch screen and sort all materials that remain on the sort table's ½-inch screen, except glass, as contamination. All glass remaining on the sort table's ½-inch screen will be sorted as glass.
7- Remove the sort table's ½-inch screen and sweep any remaining materials into a container, which will be weighed and recorded as contamination.
8- Weigh all sorted materials and record the weight and any visual observations of each. If a container fills up before the entire sample is sorted, the sampling supervisor will weigh the materials, record the weight, empty the container, and return it to the sorting table.
9- Pile all sorted and analyzed items on a tarp for disposal in the landfill

2.3 Analytical Methods

After the sorting event, the project analyst will calculate material category total weights and determine the composition found in the waste audit according to proportion of total for each sort category, as well as the confidence intervals following ASTM's Standard Test Method for Determination of the Composition of Unprocessed Municipal Solid Waste; Designation D 5231-92 (Reapproved 2016). Individual sample data will also be provided in an appendix to the final technical memorandums. Any individual samples mutually agreed upon by team members to be outliers in the data set will be removed from the study results. Outliers will be determined as being significantly out of line with other samples, if the total weight is far out of line with the 200lb expectation, or if sort notes taken during the study show a clear explanation that is agreed to be especially unusual by stakeholders. For example, if an unusually-sized item such as a water heater composes a majority of the sample weight or spans several sample zones, then the randomly selected sample will be removed from the study results. Explanation for the sample rejection will be noted along with weight of problem item(s).

Analysis and summary of the results in St Thomas will compare results with previous audit results. The comparison will primarily consider the composition of the waste stream where categories can be compared directly or combined, and then compared to calibrate to the previous study's sort categories. This will allow the study to consider the both the current composition in reference to recycling commodity specifications, as well as how the composition has changed since the last audit.

2.4 Quality Control

Team members will remain on site until all sorting and clean up tasks are completed. Completeness entails complete and total removal of waste from the study area; ensuring that all equipment gets cleaned up; finalizing and saving all data entered into electronic forms, recording of notes in electronic forms, and uploading of all pictures into project folder. In addition, project team will ensure that weighing equipment will be calibrated and maintained according to the specifications of the scale user manual.

3 DATA VALIDATION AND USABILITY

3.1 Data Review, Verification, and Validation

After each data collection, the project manager will write a report of how daily activities, review data with sampling supervisor and project analyst for any errors. This team will identify any significant sample outliers in composition that need to be flagged, checked, or omitted. We will also review the amount of samples sorted every day to adjust the schedule as needed for completing the study with at least an 80% confidence interval. We will also pay attention to the type and difference in material sorted every day, and compare our results with the origin of the waste sorted each day for a qualitative indication of the potential

seasonal bias. This will be qualitative only, since our methods do not allow for a more precise estimation of the originator of the waste being analyzed.

The most significant validation of this effort will be to build capacity and value in the USVI for establishing repeat, smaller scale efforts that will also further investigation of seasonal bias, weather impacts, tourism impacts, but also a larger audit for the entire Territory. This effort thus will create a baseline for comparison in future waste characterizations. Furthermore, this project will also create greater awareness among the population and could at as the impotence for further education and social efforts concerning waste problems.

Appendix A: Results of Waste Audit for St Thomas

Results of the 2009 Waste Characterization Study for St Thomas, extracted from "2009 Waste Stream Characterization Study; Prepared for the Virgin Islands Waste Management Authority by Gershman, Brickner & Bratton, Inc."

Waste Stream Characterization Study
(by Gershman, Brickner and Bratton, Inc.)

Recyclable **Compostable** **Potentially Compostable or Recyclable** Demolished concrete and masonry can be used for retaining walls and recycled for other types of construction.

Table 22 – St. Thomas, Overall Waste Composition

Category	Material	Estimated MSW Annual Tons	Estimated Bulk Annual Tons	Estimated Total Waste	Percent Composition
PAPER		***13,364***	***5,407***	***18,771***	***28.7%***
1	Newsprint	743	163	906	1.4%
2	Office Paper	814	179	993	1.5%
3	Magazines	577	127	704	1.1%
4	Corrugated Cardboard (OCC) & Kraft Paper	5,916	3,771	9,688	14.8%
5	Paper Board	862	189	1,051	1.6%
6	Other Paper - Dirty	4,452	978	5,430	8.3%
PLASTIC		***8,416***	***2,157***	***10,574***	***16.1%***
7	PET (#1) Containers	857	188	1,046	1.6%
8	HDPE (#2) Containers - Natural	405	89	494	0.8%
9	HDPE (#2) Containers - Colored	433	95	528	0.8%
10	Dirty Plastic	3,309	727	4,036	6.2%
11	Foam - Polystyrene (#6)	365	80	446	0.7%
12	Other Rigid Plastic	1,471	323	1,794	2.7%
13	LDPE - Film Plastic (bags, sheet, etc.)	1,575	346	1,921	2.9%
GLASS		***2,784***	***611***	***3,395***	***5.2%***
14	Glass - Clear	1,077	236	1,313	2.0%
15	Glass - Green	867	190	1,057	1.6%
16	Glass - Brown	840	185	1,025	1.6%
METALS		***1,791***	***548***	***2,339***	***3.6%***
17	Ferrous Metals	1,118	400	1,518	2.3%
18	Non-Ferrous Metals (Incl. Al Cans)	674	148	822	1.3%
ORGANICS		***11,424***	***10,017***	***21,441***	***32.7%***
19	Yard Waste	2,973	3,125	6,098	9.3%
20	Wood Waste	2,225	5,525	7,750	11.8%
21	Food Waste	6,227	1,368	7,594	11.6%
22	Miscellaneous Organics	0	0	0	0.0%
SPECIAL WASTES		***3,017***	***5,977***	***8,994***	***13.7%***
23	Rubber – Except tires	0	0	0	0.0%
24	Textiles	1,043	229	1,272	1.9%
25	Household Hazardous Waste (HHW)	0	0	0	0.0%
26	Tires	0	0	0	0.0%
27	Appliances & Electronics incl. Dry Cell Batterie	437	312	750	1.1%
28	Used Oil	0	0	0	0.0%
29	C&D	0	4,635	4,635	7.1%
30	Miscellaneous Inorganic	574	589	1,163	1.8%
31	Fines	963	211	1,174	1.8%
TOTAL	***Estimated Annual Waste Quantity (tons)***	***40,797***	***24,718***	***65,515***	***100.0%***

Appendix B: Equipment and Supplies for Waste Audit

Items	Number
Shipping and Receiving Digital Scale - 400 lb capacity	1
Penn Scale P-22 Top Loader Scale 22lb capacity	1
5 Gallon Buckets	15
20 Gallon Tote	4
32 Gallon Trash Can	1
Push Broom - 18" Bulldozer	1
Snow Shovel	2
Metal dustpan	1
Mini Rake	1
Tongs	1
Folding tables 6'	2
Sort Screens	2
White boards	2
First Aid Kit	1
Reflective Safety Vest	7
Risers for tables	2
Safety glasses	7
Subtotal	
Shipping	
Tarp 10'x12'	2
Rope	1
Duct Tape	1
Clipboard	2
Cut Resistant 100% Kevlar Gloves	10
Glove liners latex (box)	1
Protective Coveralls	21
Hand sanitizer	1
Hand wipes	2
Face masks (box)	1

Appendix C: Material Categories for Waste Audit

#	Material Categories	Description of Categories
1	Newspaper	Newspaper (loose or tied) including other paper normally distributed inside newspaper such as ads, flyers, etc. Newspaper found inside plastic sleeve will be removed from plastic and sorted accordingly.
2	Corrugated Cardboard (OCC)	Brown "cardboard" boxes with a wavy core (no plastic liners or packaging Styrofoam). Does not include small pieces of OCC within shrink wrap plastic such as that from a case of bottled water.
3	Residential Mixed Paper	Printed or unprinted paper including white, colored, coated and uncoated papers, manila and pastel colored file folders, magazines, telephone books, catalogs, paperboard, chipboard, brown paper bags, mail, shredded paper, paperback books, blueprints, gift bags, wrapping paper, and other printed material on glossy and non-glossy paper. Paper that is coated with plastic or foil or that has other items affixed to it are not included in this category.
4	Aseptic Containers	Gable top milk cartons, juice boxes, and other similar containers.
5A	PET Bottles (SPI #1) Polyethylene terephthalate	Clear and colored plastic bottles coded PET #1 such as soda and water bottles. Does not include loose caps. Any liquids are emptied into Liquids category.
5B	Non-Bottle PET	Clear and colored plastic items labeled PET #1 such as clamshell containers, frozen food trays, disposable cups, and other items labeled PET #1.
6	Natural HDPE Bottles (SPI #2) High-density polyethylene	Clear /natural plastic bottles coded HDPE #2 such as milk jugs, vinegar bottles, and gallon water bottles. Does not include loose caps and lids. Any liquids are emptied into Liquids category.
7A	Colored HDPE Bottles (SPI #2) High-density polyethylene	Pigmented plastic bottles coded HDPE #2 such as detergent, shampoo, and orange juice bottles. Does not include loose caps and lids. Any liquids are emptied into Liquids category.
7B	Non-Bottle HDPE	Wide-mouthed tubs and containers labeled HDPE #2 including lids.
8	Other Mixed Plastic Container	All plastic containers coded #3-#7 such as pill bottles, fruit juice gallon jugs, etc.
9	Bulky Rigid Plastics	Consists of non-container rigid plastic items such as plastic drums, crates, buckets, baskets, toys, refuse totes, lawn furniture, flower pots, laundry baskets, and other large plastic items. Does not include electronic toys.

10	Expanded Polystyrene	Container and non-container expanded polystyrene such as clam-shell containers, packaging peanuts, and other packaging.
11	Plastic Film	Loose and bagged plastic bags, garbage bags, shrink wrap, re-sealable bags, etc.
12	Mixed Glass Containers and Jars	Clear, Green, and Amber glass bottles and jars as well as broken glass pieces larger than ½ square inch.
13A	Aluminum Cans	Aluminum soft drink, beer, and some food cans.
13B	Other Aluminum	Aluminum foil, pie plates, and clean catering trays.
14A	Tin/Steel Cans	Tin-plated steel cans, usually food containers and aerosol cans, including labels. Also includes steel caps.
14B	Scrap Metals	Non-container ferrous scrap metals such as pipes, coat hangers, pots and pans, and miscellaneous scrap metal.
14C	Small Appliances	Small household and kitchen appliances.
15	Contaminants	Materials not included in the other categories, such as bagged garbage, fast food lids and straws, CDs, VHS tapes, composite materials, Christmas lights, hoses, electronics, recyclable items full of food (non-liquid). All loose caps will be sorted as contaminants.