Duke Athletics Zero Waste to Landfill Initiative

by

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Abstract

Landfills are a growing threat to public health, releasing emissions to air, soil, and water. With space and resource constraints, recycling and composting are becoming increasingly economically attractive. Duke, as a leading academic institution, has the opportunity to become a leader in waste reduction. Piloting a zero waste to landfill initiative at Cameron Indoor Stadium will bring the Duke community together to reduce waste while garnering public attention. A zero waste program, in which 90% of waste is diverted from the landfill, can be achieved through upstream, downstream, and courtside changes. Through consumer behavior observations, technology evaluation, and empirical data for waste segregation, we have recommended educational, operational, and product packaging changes to achieve Zero Waste at Cameron Indoor Stadium. These recommendations focus on the addition of composting capacity at Duke, educational initiatives for game attendees and staff, the sourcing of products with easily recyclable or compostable packaging, and negotiations with local recycling facilities to increase acceptance of a variety of materials. This long-term project has the opportunity to expand throughout Duke University and to peer institutions to make the greatest impact.

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Introduction

Duke University is a leader in environmental stewardship among top-tier academic institutions. However, while the university strives to achieve carbon neutrality by 2024, it must also make a concerted effort to reduce its landfill waste. A zero waste program, defined herein to be the achievement of a 90% diversion rate of waste from the landfill, is an emerging strategy which can reduce Duke's negative environmental impacts.

Cameron Indoor Stadium represents an ideal starting-point for a zero waste program at Duke. The stadium integrates students, employees, faculty, community members, and vendors at Duke University. In addition, the stadium boasts a controlled waste stream in which the majority of waste produced during a game has originated from in-stadium concessions during that game. Lastly, Cameron Indoor Stadium is public facing, with an inherent educational component to the University as a whole.

Our research question is as follows: What technological and organizational changes can be made—upstream, downstream, and courtside—to divert 90% of Cameron Indoor Stadium's waste away from the landfill?

This project seeks to answer this research question through a combination of consumer behavior observations, technology evaluation, and empirical data for waste segregation. Upstream, we have examined potential product packaging changes. Downstream, we have collaborated with Duke Facilities Management, Duke Athletics, and the Duke Office of Sustainability to refine and expand existing waste practices as well as to develop new ones. Courtside, we've examined changes in stakeholder engagement and design and labeling of receptacles.

Objectives

1. Quantify the types and volumes of products being used in at sporting events held by Duke Athletics.
    a. Requires support from Duke Stores and Duke Purchasing as well as Duke Athletics Purchasing. Students and advisor will also be attending events to do surveys.

   b. Will be sorted by type of material (i.e. food, food related such as paper cups, office supplies, chemicals etc.).
   c. Are there opportunities to work with upstream suppliers to purchase products that can be better managed post-use?
2. Quantify the types and volumes of "wastes" being generated at sporting events held by Duke Athletics and how they are managed.
3. This will require support from Duke Facilities.
   a. Students and advisor will also be attending events to do surveys.
   b. Are materials going to landfill or being recycled?
   c. How are materials being segregated?
   d. Which internal or external organization(s) are managing the materials?
4. Document current Environmental and Economic costs.
   a. Based on the management method for the wastes or recyclables, what are the costs associated for their management per ton or per event?
   b. What types of revenues are being generated for the recycling?
   c. What are the missed economic opportunities due to current management methods?
   d. What are the Environmental impacts i.e. greenhouse gas emissions, energy, water, ecosystems etc. via Life Cycle Analysis?
   e. What are the opportunities to reduce Duke's environmental footprint and liabilities? This includes other management opportunities for post-use materials.
5. Examine Consumer Behavior and Technologies
   a. Document how staff and fans are currently being educated (passively and overtly) to more effectively manage their wastes?
   b. Where are management containers located and how are they communicating a zero-waste to landfill message?
   c. Are there opportunities to use best management practices from other universities or professional sporting venues? This includes different types of on-site technologies, containers, signage or promotional programs.
   d. Are there opportunities to engage with the upstream suppliers to assist with consumer facing and education?
6. Conduct On-Site Tests for Communication and Technologies (with prior approval).
   a. Primarily at sporting venues with prior review and approval from Duke Athletics and

Duke Facilities. Can include signage, entry education materials, different types of containers etc.

7. Provide a Written Report and Management Plan based on items 1-6.
    a. Major focus is on Best Management Practices that can be replicated across campus and across the country. The team will also document our process, findings, successes and less successful efforts and ultimately the team recommendations based on quantifying environmental & economic benefits.

Background

Duke University is a private educational institution located in Durham, North Carolina. The university spans over three adjoining campuses encompassing a total of 8,600 acres. Duke University is home to 6,526 undergraduates and 8,220 postgraduates. There is currently 3,200 academic staff as well as 7,905 administrative staff.

Duke is constantly held in high esteem for their academic and athletic excellence. Duke undergraduates study at either the Trinity School for Arts and Sciences or the Pratt School of Engineering. Graduates are able to study at any one of Duke's nine schools, which include Divinity School, Pratt School of Engineering, Fuqua School of Business, Sanford School of Public Policy, the Graduate School, School of Medicine, Nicholas School for the Environment, School of Law, and School of Nursing.

Duke athletics remain an integral part of the Duke experience as well. Duke University is a competing member in the NCAA Division I Atlantic Coast Conference. There are 647 student-athletes, which are split between twenty-six varsity teams known as the Blue Devils. In total, Duke teams have won twelve NCAA team national championships. According to a 2006 NCAA study Duke student athletes had the highest graduation rate of any institution in the nation.

A Collegiate Athletic Department Sustainability Survey Report by The Association for the Advancement of Sustainability in Higher Education (AASHE) indicates that there is a tremendous lack of sustainability efforts surrounding college and university athletic departments. While around 80 percent of these athletic departments have established recycling initiatives, less than five percent are measuring recycling rates or setting goals for improving these rates. With each NCAA University on average supporting more than 17 intercollegiate sports, the environmental impact from sporting events and athletic facilities is substantial.

The majority of waste from Duke is currently disposed at the City of Durham's Waste Disposal and Recycling Center, with the exception of medical research waste and some hospital waste. This waste is placed into orange bags to be taken to Waste Industries transfer station (Bryant et al., 2012).

To advance Duke University's leadership in environmental sustainability, the Duke Center for Sustainability and Commerce has collaborated with Waste Management to evaluate technical and organizational strategies for Duke University's athletic facilities and events. These strategies will then be used to move forward the University's goal of achieving zero-waste-to-landfill.

Duke has several environmental programs supporting recycling efforts. Recycle for the Children, Cameron Recycling, Camp Out Recycling, Green Event Planning, the Green Grant Fund, and Green Purchasing Policy. In addition, there is an Environmental Management Advisory Committee, which helps to review and coordinate environmental projects on campus. Currently, there is waste collection data that is gathered for the University, Hospital, and School of Medicine. However, it lacks the level of detail needed for adequate analysis. Attendance numbers and recycling diversion rates have been recorded for football seasons 2005-2011, however the data contains no information on the properties of the waste streams.

The project teams strategy is to both engage upstream vendors and suppliers and downstream consumers and participants. Upstream, the aim is to work with Duke Stores and the vendors it contracts with to provide products that are more sustainably sourced, produced, and packaged as well as help move towards industry wide standards and goals. Downstream, a joint effort with Duke Facilities Management, Athletics, and the Office of Sustainability is progressing to refine and expand existing waste practices as well as develop new ones.

The project team has interviewed a number of composting technology companies including: Green Mountain Technologies, BiobiN, and BW Organics in order to determine the feasibility and cost-effectiveness of establishing Duke's own on-site composting program. The team has also been in contact with Duke Campus Farms and their existing composting partner, Brooks Contractors, to understand composting feasibility at athletic events. The project team further researched what types of trash and recycle bins would be the most cost effective while also matching the outdoor or indoor aesthetics of Duke University's stadiums.

In addition, the project team worked in coordination with athletics and facilities management staff at both Duke University and other collegiate institutions to determine existing best practices that is feasibly replicable and scalable through life cycle impact assessments. Notable examples of zero waste athletic programs at other universities include University of Colorado Boulder, The Ohio State University, and Pennsylvania State University. Researchers also attended the 2012 Chik-Fil-A Sports Sustainability Summit in Atlanta, Georgia and reviewed panel discussions from the 2011 Green Sports Alliance Summit to learn how other groups are helping promote smart waste practices within and outside their own organization.

Research of educational information, strategies, and incentives has been explored. These tools will be used to motivate athletes and fans to become more involved in composting and recycling during events. The project team then plans to develop and implement a strategic sustainability plan to provide a framework and future benchmarks to expand and improve upon existing environmental practices and technologies. The team then hopes to transition from our stadiums to our dorms, offices, and other places on campus.

Cameron Indoor Stadium

Duke University's basketball stadium was constructed in 1940 and was the largest indoor stadium in the South and the second-largest stadium on the East Coast (GoDuke.com, 2013). The stadium contained seating for 8,800 attendees, including 3,500 folding chairs for undergraduates, and boasted a maximum capacity of 12,000 (GoDuke.com, 2013). While the facility has undergone several renovations in the years since its construction, the current seating capacity has not changed, making Cameron Stadium one of the smallest stadiums today. This small size is one of the greatest obstacles to instituting a zero waste initiative in the stadium. Space for receptacles was not included in the original design, concourses are narrow and crowds become obstacles to recycling, and capacity for volunteers is low. The narrow concourses do, however, include space for concession stands. This controlled source of food and products within the stadium offers opportunities for change.

Duke Recycles began providing recycling bins in Cameron Stadium during the 2009 basketball season. However, the bins were placed during basketball season they will remain in the stadium throughout the year. By working closely with Duke Athletics, Duke Recycles were able to overcome obstacles on their part and ours that were inhibiting the institution of this program.

Drivers for a Zero Waste to Landfill Program

Economic

Current tipping fees at the Durham landfill are $42.50 per ton of waste, and this number can be expected to continually rise as land becomes scarce (Long, 2013). Additionally, landfill "waste" is a collection of valuable, often non-renewable resources that are difficult to recover once in a landfill. As resources become constrained and increasingly valuable, the incentive to recycle those materials to conserve resources will be high.

Social

The majority of game attendees at Cameron Indoor Stadium are residents of Durham County. As a result, a reduction in landfill waste by duke has benefits to the entire community, as a means of minimizing the negative impacts listed herein. Another social benefit is the educational potential of this program at Duke: information on proper waste disposal can be learned at games and carried home by the game attendees, enhancing recycling education in the community.

Leadership

Peer academic institutions are beginning to adopt zero waste programs in their athletic facilities, as are some national athletic facilities. Duke is a leader in carbon neutrality, and should consider leadership in waste reduction. Waste is a crucial element of a strong sustainability strategy for any institution. As an added benefit, a zero waste program can reduce landfill emissions of greenhouse gases, a Scope 3 source of emissions that Duke University can tackle in its carbon neutrality goal.

Duke has an economic incentive to take a leadership role in waste reduction: as landfill tipping fees raise, the University will have an advantage over schools without zero waste programs established.

Environmental

In addition to the land use and resource use impacts, engineered landfills release harmful emissions to air, water, and soil. The table below details the life cycle mid point impacts of an engineered solid waste landfill, based on a landfill containing a functional unit of 600,000 tons of municipal solid waste. As demonstrated, landfill releases affect humans and the environment through increased impact to climate change, ozone depletion, acidification and eutrophication of aquatic ecosystems, ecotoxicity to soil and water, and toxicity to humans.

Figure 1. Engineered landfill impact indicators. Source: Ménard et. al., 2004.

Scale	Environmental Impact Category	Impact
Global	Global Warming Potential (GWP)	1.98E+11 grams CO_2 eq.
	Ozone Depletion Potential (ODP)	8.38E+2 grams CFC_{11} eq.
Regional	Acidification Potential (AP)	1.67E+9 grams SO_2 eq.
	Eutrophication Potential (EP)	5.46E+8 grams NO_3 eq.
	Photochemical Ozone Creation Potential (POCP)	5.90E+7 grams C_2H_4 eq.
Local	Ecotoxicity – Water (ETW)	1.31E+10 cubic meters water/gram
	Ecotoxicity – Soil (ETS)	9.84E+6 cubic meters soil/gram
Local	Human Toxicity - Air (HTA)	2.88E+12 cubic meters air/gram
	Human Toxicity - Water (HTW)	2.85E+10 cubic meters water/gram
	Human Toxicity - Soil (HTS)	3.24E+6 cubic meters soil/gram

Data Collection: Phase I

Methodology

Measurement is critical for proper management, so the first step was to determine what data Duke already has on record regarding waste management at athletic events. Next, the team needed to gather empirical data on the waste stream from Cameron Stadium. After that initial waste audit, we came up with a strategy based on our findings and set intervention strategies. Lastly, we conducted another waste audit to test our interventions, record the data, and determine our final recommendations.

In order to find the existing waste management data, we reached out to the Duke Office of Sustainability and Duke Facilities. The team received generous support from Tavey Capps, Director of the Office of Sustainability, and John Noonan, VP of Facilities. Before beginning, we needed to define "waste" for this project. There are four types of waste: recyclables, compostable, hazardous waste, and solid waste. For this project, "waste" refers to recyclables, compostable and solid waste; not to hazardous waste. "Trash" refers specifically to solid waste, which is traditionally destined for a landfill. We are defining solid waste as the Environmental Protection Agency's category of 40 CFR Part 260.

The team's initial findings were that, while Duke University has data on solid waste and diversion, it is campus-wide. The granularity of specific facilities did not exist. We did have waste diversion rates for certain athletic events such as football games, however the waste stream was not broken out to reflect materials that could have been recycled and composted. To obtain this data, the team then coordinated waste audits of Duke basketball events.

The experimental design necessitated that the team start out by conducting a baseline waste audit to determine the current diversion rate in Cameron and the first dumpster dive was conducted on November 28th at the Duke v. Ohio State Men's basketball game. This game was sold out, with an attendance of approximately 9,300 people. After meeting with the operations staff, the initial scope of the project included the consideration of bags from both the exterior and interior of Cameron Indoor Stadium.

Duke Athletics staffed expressed a concern for the exterior waste stream, as the waste is generated by game attendees prior to, but as a result of, the games. The exterior of Cameron includes all of the trash cans and recycling bins located in "Krzyzewskiville", an area where undergraduate students wait in line and often camp out to gain admission to games. The exterior was initially included in the scope because it is within the scope of what is managed by game day operations. The interior of Cameron includes all of the trash cans and recycling bins on the upper concourse, the trash cans and recycling bins at both first floor entrances and the trash cans and recycling bins in the Hall of Honor. Duke Athletics and Duke Facilities strive to ensure trash bins and recycling bins are within sight of one another at games.

During the basketball game, the team observed behavior in relation to the interior trash and recycling bins. Exterior bins were not observed. This behavioral observation focused on the following questions:

- Were people recycling items that could be recycled?
- Were there any barriers to throwing trash away/ recycling?
- How did the design of the concourse affect people's ability to recycle?
- What food items were most popular?
- Are the bins placed in appropriate locations based on foot traffic?

Before the game we documented 21 trash and 19 recycling bins within the stadium. We also took note of the locations of concession stands and inventoried the food and packaging options sold at the game. This information was then used to determine what opportunities are available for packaging changes. Game day behavioral observation ended mid-way through the second half.

The following morning the team returned to Cameron Stadium before trash was collected, to label the interior and exterior bags to be included in the audit. Fifteen trash bags from the exterior of Cameron and 14 bags from the interior of Cameron were tagged. After discussing with the waste haulers, we agreed that they would bring the 29 labeled trash bags and all of the recycling bags to the Duke Recycling facility at 117 South Buchanan.

During the transfer to this facility, four exterior bags and one interior bag were misplaced. The audit took place December 1, 2012. The team, along with volunteers, separated the contents of each trash bag into the categories of plastics, glass, metals, compost, other plastics, coated paper, cardboard and trash. The team defined compost as all food and paper; other plastics as plastics such as filmy wrappers and nacho containers, which are not currently recyclable at Duke; and coated paper as paper with a wax or thin polyethylene plastic coating. The cardboard waste stream was made up almost exclusively of pizza boxes.

The waste in each category was weighed and all data was recorded in terms of weight. After weighing the contents of the trash bags, the team weighed five recycling bags from the interior and five bags from the exterior. Because fewer recycling bags were tagged for the audit, the team multiplied the weight of those five bags to extrapolate the recycling data to a sample size equivalent to that of the measured trash bags.

After the waste audit, the team decided to exclude the exterior bags from the scope of our research, as no behavioral observations occurred in this zone and the waste stream is unique and unpredictable as compared to the stadium's interior. While there is overflow between waste produced in the exterior and disposed of in the interior, and vice versa, this overflow is likely minimum.

Observations

During the first half of the game, minimal waste was disposed of. However, during half time, the councourse became busier. The South Lobby entrance, used by graduate students, faculty, staff, and community members, does not sell concessions. However, the lobby contained two sets of receptacles, which were used mainly by security guards disposing of food and drink carried in by fans. At the North Lobby entrance, where most of the undergraduates buy concessions, there are receptacles on either side of the concession stand. Much of the food and drinks purchased here, though, were taken back to the stands by students, as they did not have reserved seats. Waste in the stands is collected and sorted by the local non-profit TROSA, and was thus not included in the project scope. The upstairs concourse seats faculty, staff, and the Durham community. These attendees had seats for the game, and as a result made greater use of the councourse including concession stands and concourse receptacles.

Results

The Phase I waste audit demonstrated a 48% diversion rate at Cameron Stadium: 48% of total waste, by weight, was discarded in recycling bins, while 52% was discarded in trash bins. We will treat this 48% as the baseline diversion rate for Cameron Indoor Stadium. The exterior rate was very similar: 49%. This higher rate, despite a greater range of materials, may be due to the greater amount of space and time available to reduce rushed decision-making. As discussed, the exterior waste was ultimately excluded from the project scope.

Diversion Rates: Phase I Audit	Interior	Exterior
Recyclables in recycling (5 bags) in lbs.	63.2	72.2
Equivalent to 14 bags (interior) or 10 bags (exterior) in lbs.	176.96	144.4
Overall diversion rate	48%	49%

Figure 2. Landfill waste diversion rate at Cameron Indoor Stadium: Phase I waste audit.

The weight of each stream is detailed in Figure 3. In order to better compare the bags collected from the interior with the bags collected from the exterior, the team determined the percentage of each waste stream. The exterior bag data are marked gray due to the decision to exclude the exterior from the scope.

The total potentially divertable waste within trash bags was 45% of the total waste stream. Some of these products, such as compost, other plastics, and coated paper, are not currently recyclable at Duke, but can be recycled with technological changes. Through these technological changes and behavioral changes, that 45% potentially recyclable material represents a large opportunity to increase the diversion rate at Duke.

Waste Stream Composition	Interior	%	Exterior	%
Number of bags tagged	14		10	
Plastics	24.25	28%	22.7	23%
Glass	0.6	1%	16.6	17%
Metal	0.8	1%	8.2	8%
Compost	36.7	42%	29.2	30%
Other plastics	1.9	2%	4.3	4%
Coated paper	11.5	13%	4.3	4%
Cardboard	10.8	12%	12.9	13%
Total divertable waste thrown away	86.55		98.2	
Non divertable (actual) trash	103.7		51.6	
Total thrown away	190.25		149.8	
% Of trash that was non-trash (opportunity)	45%		66%	

Figure 3. Phase I waste audit results.

Figure 4 is a visual represenation of the amount of the waste stream that was thrown away versus recycled in Phase I.

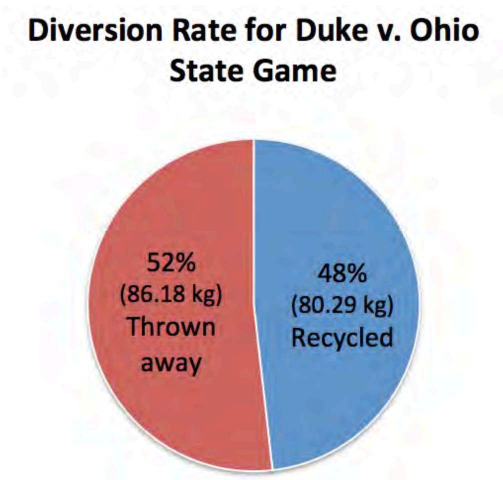

Figure 4. Diversion rate in Phase I waste audit.

Figure 5 looks at the waste that was thrown away and its composition. It shows the 45% future opportunity rate, and breaks that rate down to reveal the makeup of the potentially divertable waste that was thrown away. Compost and plastics were the largest waste streams and glass and metal (two materials not sold within the stadium) were the smallest. This demonstrates the necessity of greater educational initiatives to increase plastic recycling, and the introduction of composting technology to Cameron Stadium's waste stream.

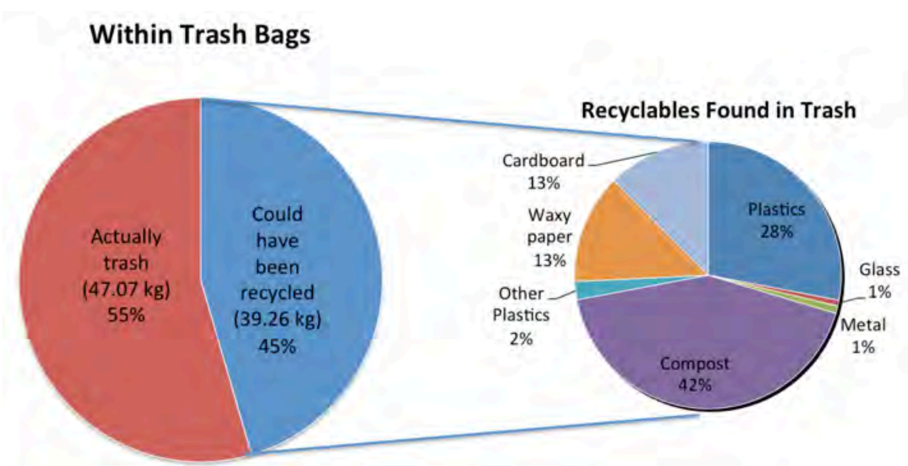

Figure 5. Composition of waste stream in Phase I waste audit.

Looking ahead, in order to determine our strategy, the team analyzed the opportunity. The baseline diversion rate was 48%. Of the 52% that was thrown away, 45% could have been diverted through currently available technology and educational initiatives, or 24% of the overall waste stream. This 24% added to a 48% baseline diversion rate brings the potential diversion rate within the scope of this project to 72%. Since the team's diversion goal is 90%, there is an additional 18% gap that can only be achieved through changes in product packaging. That change is something our the team will pursue next year with the help of our colleague Liza Schillo.

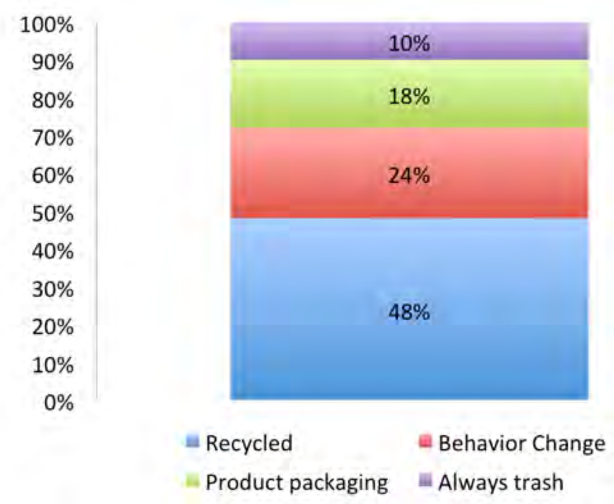

Figure 6. Strategy breakdown for achieving zero waste at Duke.

Strategy

Overall Strategy

The strategy to reach zero waste has three dimensions: to increase recycling of those products which can be recycled, to offer composting and recycling options for those products which cannot currently be recycled at Duke, and to make packaging changes to those products that cannot be recycled or composted. The first can be done through education initiatives, organizational changes in Cameron Stadium, and better labeling. The second can be done through a joint effort with the local recycling facility and the addition of composting technology through purchase or contract. The latter can only be done through working with vendors and reconsidering sourcing options, a future objective of the Zero Waste project.

Recycling can be confusing: rules for which products can or cannot go into the bin differ by neighborhood or even facility. Duke University contracts with the Durham MRF (materials recovery facility), one of the most advanced facilities in the region. This means that many products can be recycled at Duke that many game attendees cannot recycle at their homes.

Products sold

Key examples of products currently recyclable at Duke that require greater education to increase their recycling rates are plastic souvenir cups and cardboard pizza boxes. The souvenir cups, in which all soft drinks are sold at Duke Concessions during basketball games, are made of #5 PP (polypropylene) plastic. This resin type is not always recyclable, but recycling acceptance is somewhat common. They can be recycled at Duke, and sharing this knowledge can help game attendees make informed recycling decisions. While many fans keep the cups for household reuse, many of the cups are thrown in both recycling and trash bins.

A further challenge to the recycling rates of a range of commonly recyclable products, including souvenir cups as well as aluminum foil, is the misconception about the requisite cleanliness of disposed packaging. Many recycling signs, including that on the bins at Cameron Stadium, call for containers to be clean. However, most facilities can handle a somewhat high level of contamination: for Duke, this level is at about 10 percent (Buchholz, 2013). Because most products in the recycling stream are quite clean, some items can have significant food or beverage contamination without sacrificing the quality of the recycling stream.

Similarly, pizza boxes are also commonly unrecyclable due to contamination by grease and cheese. Many modern recycling facilities, such as the facility in Durham, now have the technology to separate this contamination from the cardboard pulp in the recycling process. Papa Johns personal pizza boxes make up a significant portion of the waste stream from the upper concourse of Cameron Stadium, and have an effect on the diversion rate. In fact, cardboard is banned from landfills in Durham, and large institutions like Duke are expected to take leadership in complying with this ban. For game attendees aware of previous guidance to not recycle pizza boxes, education of this change can increase diversion rates.

A full list of products sold at Cameron Indoor Stadium is detailed below:

Figure 7. Product and packaging inventory for Cameron Stadium.

Product	Packaging
Soft drinks	PP plastic souvenir cups
Bottled water	PET plastic bottle
Papa Johns personal pizza	Small cardboard pizza boxes
Nachos	#6 plastic tray
Popcorn	Polyethylene coated paper bucket
Minute Maid frozen lemonade	Polyethylene coated paper cup
Bojangles chicken sandwich	Combined foil and paper
Hot dog	Aluminum foil
Chips	OPP#5 plastic film
Candy bars	Mixed plastics
Peanuts	Paper bag
Cotton candy	Paper bag
Cracker jacks	Cardboard
HWY 55 cheeseburger	Aluminum foil
Hog Heaven Bar-B-Q sandwich	Aluminum foil
Papa John's pizza slice	Polyethylene coated paper plate
Blue Bunny ice cream bar	Thin plastic
Blue Bunny ice cream sandwich	Thin plastic
Drink trays	Pressed cardboard
Condiments	Plastic/foil wrappers
Straws	Paper wrapper, plastic straw

Peer institutions

Duke Athletics can model a Zero Waste strategy after peer institutions with similar strategy in athletics facilities. The following universities have been considered as models for Duke Athletics Zero Waste, with football stadium waste initiatives.

Ohio State University

Organization: Ohio State University
Facility: Ohio State Football Stadium
Location: Columbus, Ohio
Contact: Corey Hawkey, Sustainability Coordinator, hawkey.13@osu.edu
Link: http://sustainability.osu.edu/zerowaste

Waste Reduction	Recycling	Facilities	Consumer Ed.	Compost
Yes	Yes		Yes	Yes

Figure 8: OSU football stadium zero waste station. Source: CURC, 2011.

The Ohio State University is home to the leading college stadium in waste reduction. It started a zero waste program in 2007, defining "zero waste" as a 90% diversion rate. Energy Services and Sustainability as well as the Department of Athletics direct the zero-waste program. The program requires the support on game day of 10-12 student volunteers, 75 zero-waste station attendants and 10 supervisors throughout the stadium (Hawkey, 2012).

The stadium has phased out trashcans, as everything that the stadium sells can either be composted or recycled. The identification of recyclable or compostable alternatives to every product was a major challenge. Their solution was to perform an inventory of all the products sold and to find a suitable alternative. The alternative product needs to be as effective, efficient and economically practical as the current product (Hawkey, 2012).

Another challenge was the educational aspect of the program with fans. This is because not all fans understand composting and recycling and may need to be educated to adjust to the waste containers. Posting signage and having volunteers help direct people to the appropriate containers proved effective. Another strategy employed during the game the scoreboard displays recycling statistics.

Ohio State has also taken steps to integrate the program into the classroom and research areas of the university (Hawkey, 2012).

OSU has one vendor in their stadium, Sodexo, who then contracts with additional vendors. Sodexo integrates sustainability as part of their employees' training. ProTeam Solutions and Sodexo provides volunteers who stand by waste bins to educate fans and concession volunteers, respectively. ProTeam Solutions provides training and employment opportunities to underprivileged, public high school students using a framework and educational materials provided by OSU. The 12 student volunteers that help out the other volunteers do not get paid or receive donations to their organization. The only incentive is free lunch and reception of service credit. The two main organizations that volunteered the most were Students for Recycling and Engineers for Sustainable World (Hawkey, 2012).

The program is structured without achieving cost savings. The only added cost to the university is the zero waste ambassadors that are paid to educate the fans and keep contamination out of the barrels. Clear signage throughout the stadium was considered a major element of the proposal for the program. Recycling extends to tailgating activities, where the university provides recycling bags and offers many recycling and waste bins throughout tailgating zones (Hawkey, 2012).

OSU put out a contract bid for waste hauling, which Rumpke won. Rumpke provides both financial support and in-kind donations. The Solid Waste Authority of Central Ohio also provides funding through the Sports Marketing Authority. In addition, IMG handles the sports marketing at OSU. The most challenging aspect is getting existing sponsors to change to support zero waste efforts (Hawkey, 2012).

Football stadium suites are also encouraged to recycle. Information is sent in ticket packets to members of suites requesting their participation in voluntary waste segregation. If they successfully segregate their waste for four games in row, the suite will be certified as "zero waste." In addition, their name will be put on the OSU website and given a special door decal (Hawkey, 2012).

University of Colorado

Organization: University of Colorado Boulder
Facility: Folsom Field football stadium
Location: Boulder, CO
Contact: Ed von Bleichert; Environmental Operations Manager, Edward.Vonbleichert@colorado.edu
Link: http://www.colorado.edu/cusustainability/greeningcu/Recycling.html

Waste Reduction	Recycling	Facilities	Consumer Ed.	Other
Yes	Yes	Yes	Yes	

Figure 9: University of Colorado football stadium zero waste station. Source: UCB, 2011.

The University of Colorado at Boulder has collaborated with Centerplate Inc., who has helped convert nearly all food and beverage containers into recyclable or compostable material. Eco-Products Inc. is one of the main suppliers of the compostable serving ware. There are no trash containers—only recycling and compost containers—throughout the public areas of Folsom Field. Plant-based compostable bags are used to collect compostable materials. They also replaced all roll-off bins with dumpsters, which are locked to prevent contamination (UCB, 2011).

There are 25 locations within the stadium that are monitored by student volunteers who advise patrons of proper materials separation steps. Education is also focused on regular staff, concessionaires, and whoever is working waste for the game, because much of the stadium waste is generated by staff operations. Custodial or temporary housekeeping regularly monitor the zero waste stations to empty them out and place them in front of dumpsters (Von Bleichert, 2012).

Eco-Cycle picks up the recyclables after the game is over. Any compost generated from the program is used on the CU Boulder campus for landscaping. At dawn the following day, ROTC cadets comb through the stadium to collect any remaining recyclable and organic waste (Von Bleichert, 2012).

The program overall cost for the first season was around $25,000. The cost of composting is more or less the same as landfilling. Additionally, even as landfill waste generation has dropped, concession sales have increased. Some existing challenges include suites, due to the need to have both aesthetically pleasing and functional ware and expanding collection to shrink-wrap and plastic bag waste (Von Bleichert, 2012).

Pennsylvania State University

Organization: Pennsylvania State University
Facility: Penn State Beaver Stadium
Location: University Park, PA
Contact: Al Matyasovsky, Supervisor of Central Support Services; aem3@psu.edu
Link: http://green.psu.edu/psuDoing/recycling/beaverstadiumprogram.asp
http://www.epa.gov/osw/conserve/rrr/rogo/documents/beaver.pdf

Waste Reduction	Recycling	Facilities	Consumer Ed.	Other
No	Yes	Yes	Yes	

Figure 10: Penn State football stadium waste section. Source: US EPA, 2009.

Recycling at Beaver Stadium entails both interior and exterior (tailgating spaces). Plastic, glass, and aluminum are collected. (US EPA, 2009). EcoReps and STATER's (Students Taking Action To Encourage Recycling) are involved in front-end recycling and help manage waste on campus and at various venues by volunteering at tailgating. They educate fans and make sure that the fans are making use of the blue recycling bags that they receive before entering the tailgating zone. They meet with the ground workers who are tasked with clean up and are educated by them. Contracted union employees handling the pick-up and sorting of post-game waste into roll offs. Bags are cut open and sorted to ensure that there is no contamination for compost and recycling. Once everything is collected after each game it is all weighed to determine recycling, composting, and landfill rates. All waste is also managed in-house with their own trucks and drivers (Matyasovsky, 2012).

All vendors on campus are in-house, and they are able to make any event "Zero-Waste" if requested, providing compostable ware & cutlery only when reusable ones are impractical. Cardboard is collected from concessions and #5 plastic cups & #6 plastic shells are taken to an exotic plastic facility. They are currently looking to make the waste management process more automated, primarily for health and safety reasons, and are doing a pilot program with the county to have a dirty MRF on campus (Matyasovsky, 2012).

Educational Initiatives

Volunteers

The easiest change to increase recycling and composting at Duke is to educate game attendees on which products are currently recyclable at Duke. With added recycling and composting capabilities in the future, fan education will continue to ensure the highest diversion rates. Because of confusing and ever-evolving recycling rules across counties, and even facilities, education is imperative to help even the most conscientious recyclers.

As was demonstrated at Duke's peer institutions with thriving zero waste programs, education can best be provided by volunteers standing at each waste station, offering guidance to game attendees. At Ohio State, volunteers next to the bins made a difference between 40% and 80% diversion rates.

Those who help with waste education, in addition to Duke Recycles, include student volunteers such as Crazies Who Care, who help direct fans to where recycle bins are and what is recyclable. Some promotional messages are used during games as well. For example, during football season, Coach Cutcliffe participated in a short video for the "Recycle for the Children" program, which was shown on the large scoreboard at half time. This can be replicated in Cameron Stadium and at other athletic events.

Staff One employees and members of TROSA (a residential substance abuse recovery program) are trained to collect recyclables left in the seating and concourse areas. Housekeeping also helps with waste collection during building cleanups by maintaining and removing bags, but play no role in sorting the waste stream.

Duke basketball faces greater space constraints and cannot as easily accept volunteers as they do for football. At most games there is an opportunity for some volunteers, however. Because Cameron is an indoor stadium, the carrying capacity becomes a factor, especially since the fire marshal is more stringent on how many people can be inside (Bryant et al., 2012).

Organizational Initiatives

Receptacle design

A major obstacle to recycling in Cameron Stadium is receptacle appearance. In contrast to the clearly labeled bins used at peer institutions, bins at Cameron are unclear in function. Figure 11, below, demonstrates this confusion. In the United States, the standard recycling bin is a bright blue similar to the "Duke blue" color. Because of this school color, as well as a history of Athletics-owned trashcans being relocated throughout the campus, Athletics has chosen this bright blue color for their trashcans. Trash bins are not labeled.

Figure 11. Waste receptacles at Cameron Stadium.

Recycling bins are a much darker shade of gray-blue. The only recycling label on these bins is a small sticker on the lid. However, this lid presents an obstacle to recycling, as game attendees must add an extra step of opening a receptacle lid before disposing of recycling. With the lid open, the bins have no visible label to identify them as recycling.

These obstacles are magnified in the basketball game setting, when the narrow halls of the stadium concourse are filled with people. The team estimates that the vast majority of waste is disposed of before and after games and during halftime. At these times, the waste bins are barely visible behind crowds, and are poorly accessible. Fans rushing to return to their seats have little time to choose a bin or open a lid. The recycling bin lid should be opened, with an identifiable label when the lid is lifted. More visible signage is necessary to distinguish bins in crowds.

Signage

Any lasting change to signage must be approved by the Duke Athletics Director of Environmental Branding, a position currently held by Rachel Curtis, and by Duke Trademark Licensing, currently directed by Jim Wilkerson. The approval process is long, and temporary trials of signs are recommended before beginning this process. The Duke Office of Sustainability has created a sign that has been approved for use by the greater University, seen below in Figure 12. This sign can be improved for Cameron Stadium's controlled waste stream by picturing the specific items sold in the stadium with simple and clear wording.

Figure 12. Approved recycling signs for Duke University. Source: Duke Recycles.

Longer-term solutions include the purchase of receptacles that have represented products pictured on them. A prime example can be taken from the recent zero waste initiative at the 2013 Waste Management Phoenix Open golf tournament. Figure 13, below, demonstrates the lightweight, portable waste bins used at this game. Simple product images and bright colors helped game attendees easily understand how to recycle and, as a result, divert 97% of the game's waste (Phoenix Open, 2013). Such bins are ideal for Cameron Indoor Stadium due to space constraints: there is little space for heavy, semi-permanent bins.

Figure 13. Temporary recycling and compost bins at the 2013 Waste Management Phoenix Open. Source: Golden, 2013.

The open environment of the Wallace Wade football stadium represents an opportunity for permanent bins. Bins also become more inconsistent in type and signage as events grow in size. See Appendices for further information about which bins were found to be potentially cost effective and aesthetically feasible.

Receptacle location

As described, the concourse of Cameron Stadium is narrow, with no obvious areas to place bins. The bins are currently well distributed throughout the concourse, often near concession stands. However, the recycling and trash bins are often not placed together. When the concourse is empty, the two are, by an informal rule, always within sight of each other. However, in a crowded game setting, it becomes very difficult to see the each, and undesirable to move through the crowd for access to the proper bin—reducing diversion rates and increasing contamination rates. Duke Athletics and Duke Housekeeping are enthusiastic to ensure that bins are always side-by-side.

An added challenge is the placement of bins along the path of bathroom lines. Bathroom doors throughout the stadium are perpendicular to the concourse walls, with long lines accumulating along those walls. In many instances, the nearest receptacle for attendees is behind the line, and access is obstructed, placing stress on the decision-making process of even the most recycling-conscious game attendee. The placement of the bins directly on the other side of bathroom doors, out of way of the lines, can prevent this problem, which is common during halftime when a large amount of waste is disposed of.

Composting Technology

Composting is an important option to consider for the disposal of food and degraded paper waste, including paper towels and food-contaminated paper. There is currently no composting capability at Cameron Indoor Stadium. Compost is a challenge because it operates on a separate system from trash or recycling, with Brooks providing its own roll-off bins for compost collection to some eateries at Duke University. The cost of composting by Brooks is around the same as landfilling and therefore not that cost effective (Bryant et al., 2012). Duke also does not receive compost free of charge or at a discounted rate from Brooks (Barzee et al., 2009).

In addition, the majority of the compostable material coming from athletic events tends to produce a high volume of containers and low amounts of food waste, resulting in a largely dry mix with high carbon content. This means food waste from dorms, dining halls, and on campus restaurants will be needed to balance it out for the required carbon to nitrogen ratio. In addition, shredders or waste pulpers should be used to shred up waste before being composted to speed up the process. It is also suggested that Duke purchase an automated moisture addition system to do three things 1) maintain the necessary 120-130 degrees Fahrenheit for composting 2) saturate dry products to help them break down and keep from "floating up" to the top of the compost pile and 3) prevent the rare chance of a fire.

A 2009 feasibility study undertaken by Nicholas School students (Barzee, Bastert, Compas, Eren, & Safley) with Dr. Charlotte Clark analyzed existing composting practices at on campus eateries and various on-site composting methods. After reviewing the pros and cons of un-aerated static piles, passive aeration windrows, aerated windrows, in-vessel, and vermicomposting they concluded that vermicomposting would be the best option given its low upfront and labor/maintenance costs would work best. Moreover, the other systems involve issues such as maintaining necessary temperature and moisture conditions, leachate containment/treatment, permitting difficulties, space limitations, and/or financial costs (Barzee et al., 2009).

The project team agrees with their conclusions that the pile and windrows are impractical approaches given Duke's restricted space and inability to expand into Duke Forest or at Duke Campus Farm. Furthermore, with Duke's current scale of food waste generation and limited scope of agricultural research further makes it unfeasible. While vermicomposting may be appropriate for dining operations, they are unable to process oily or meat and dairy based products, which are commonplace at sporting events.

Therefore, the team has done extensive research into in-vessel composters and has contacted a few companies (Green Mountain Technologies, BW Organics, and BiobiN) to find out details behind the cost, operation, and ideal size of their composters. However, the larger the composter bought, the faster the payback period is to recoup costs even if it is more expensive (Calvez, 2012). Similar composting technologies are also available for lease by Waste Management.

Green Mountain Technologies was started in 1992 and is a based near Seattle, Washington. Their different in-vessel composting systems include their Earth Tub and Earth Flow models. Turning a handle on the lid of the tub manually operates the Earth Tub's auger. The Earth Tub works more with an input of organic waste in batches and has a ranged output of 50 lbs. with one tub and 150 lbs. per day with 2 tubs. The cost of an Earth Tub ranges from $10,000 to $12,000 and consumes 2-3 kWh per day. Some nearby schools with Earth Tubs are Washington and Lee University, University of South Carolina, University of Georgia, UNC (Asheville, Greensboro, Charlotte), and Guilford College (Calvez, 2012).

Figure 14. GMT Earth Tub. Source: Green, 2012.

The Earth Flow system is the largest GMT system designed for on-site use. It has an automated auger that mixes the compost along a pre-programmed path in a large stainless steel container to mix the compost recipe. Organic waste can be continuously added into the container with a ranged output of ¼ ton to 1½ tons per day. The cost of an Earth Flow ranges from $50,000 to $150,000 depending on its size and uses 4-5 kWh per day (Calvez, 2012).

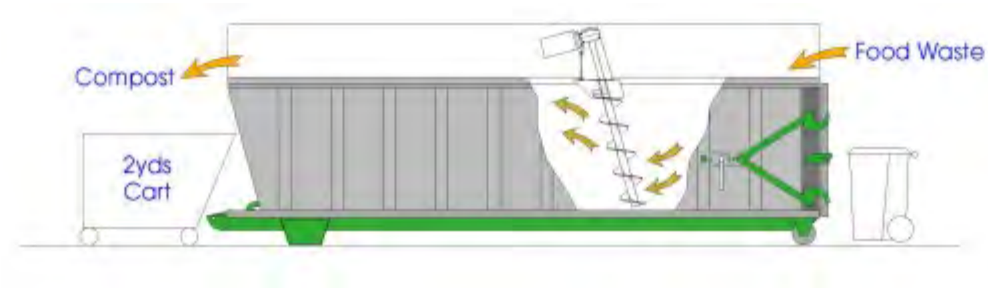

Figure 15. GMT Earth Flow. Source: Green, 2012.

All GMT systems come with a 1-year warranty, and if needed an additional 2-year warranty can be purchased. An automatic water sprayer can be added to the vessel's auger, which adds water as it turns and ensure adequate moisture levels (Calvez, 2012).

BW Organics is another in-vessel composting provider based in Sulphur Springs, Texas near Dallas and started constructing their trademark Green Drums in 1990. John Willis from BW Organics recommended their 205 Model, which outputs about 2 cubic yards or 1 ton of compost per day. The capital cost of the 205 Model is $26,850 with a $3,450 shipping cost, bringing the total to $30,300. The electrical motor for the Green Drum pulls 7.3 Amps and runs for about 4-5 hours per day, which Willis estimates to cost $8 to $15 per month. Local schools utilizing BW Organic's composting technology include Warren Wilson College, Davidson College, UNC Greensboro, and Clemson University (Willis, 2012).

Figure 16. BW Organics Green Drum. Source: Willis, 2012.

The last company looked at was BiobiN, which was started in Australia and set up a branch in the United States in 2009 with the help of Advanced Enviro Systems and Wawa. They offer two types of models; one is the route collection model that is 2 to 3 cubic yards in size. The second is the roll-off models, which come in 10, 15, 20 and 25 cubic yards sizes with output capacities from 12,000 to 30,000 lbs. Additional equipment are a bio-filtration system, an electrical motor, and a GFCI to cut the power in the case of a short-circuit (Chambers, 2012).

With an investment in composting technology, compostable product packaging and utensils may be considered. However, the project team does not recommend the adoption of compostable bio-plastic packaging and utensils, as is seen at Ohio State and some other athletic facilities, for two reasons. First, the messaging of recycling plastics, yet composting bio-plastics, can cause greater confusion to game attendees. Second, bio-plastics may have negative environmental impacts that exceed their positive impacts.

There is a steep environmental toll of industrially grown crop feedstock for bio-plastics. Their cultivation involves uses of excessive amounts of nitrogen fertilizer, herbicides and insecticides; these practices contribute to soil erosion and water pollution when nitrogen runs off fields into streams and rivers, causing eutrophication (Hunter, 2008). In addition, compost including bio-plastics as an input disqualifies farmers from meeting USDA Organic Standards because bio-plastic is synthetic (O'Connor, 2011). PLA and PET resin plastics also do not mix, and recyclers consider PLA a contaminant that is costly to remove from the recycling stream and dispose of. PLA containers dumped in a landfill will last "as long as a PET bottle." Estimates of this lifetime range from 100 to 1,000 years (Hunter, 2008).

Brooks Contractors encourage customers to use uncoated paper plates, stating that bio-plastic utensils that claim to be compostable and do meet the standard are slower to break down because they are thicker (Goldston, 2012).

In conclusion bio-plastics are both more expensive and still not readily accepted by composting facilities. They have also been seen as educational challenges in terms of educating the consumer on how to dispose of them, as they feel and look like plastic but should not be recycled. Therefore, the team recommends strengthening and expanding the existing recycling program in the stadium and sourcing uncoated paper plates and cups, especially those contain Post-Consumer Recycled (PCR) content (Dell, 2010).

Figure 17. BioBin roll-off (left) and route collection model (right). Source: Chambers, 2012.

Recycling Technology

Duke University's recycling stream is hauled to the Raleigh MRF (materials recovery facility). This advanced MRF accepts a wide range of materials. These include plastics #1-7, glass, aluminum cans and foil, cardboard, and traditional paper without plastic coatings (not including napkins or paper towels). A complete list of recyclable items at Duke can be found in the Appendix. In the short-term, the strategy for Duke Athletics should focus on increasing education of items that are recyclable.

A long-term strategy should include participation with the MRF to increase recyclable items. These items, detailed in the following section, are those with no current recycling or composting feasibility with Duke's contracted waste haulers. Detailed further below, these items can be recycled with new technology available for MRFs in the U.S. While the Raleigh facility is highly advanced, it does not currently recycle plastic films or polyethylene coated paper products, and Duke University should use its advantage as a major customer with a perspective on future recycling technologies to encourage the facility to recycle these products.

Product Packaging Options

Three materials make up a significant portion of the waste stream from Cameron Stadium. The first, while perhaps least significant, is the nacho tray. These thin plastic #1 PET (polyethylene terephthalate) trays, which would be recyclable if clean, become very contaminated with cheese when used. While cheesy cardboard can now be recycled, the recycling process is different for plastic and offers no opportunity to separate grease contamination from plastic. One option is to work with the Durham MRF to understand the impact of including a small amount of greasy plastic in the waste stream, or to evaluate new recycling technologies that can better clean materials before reprocessing. Another option is to offer thin cardboard trays, which can be composted, though this may come at an added cost.

Plastic films and bags are another common element of the waste stream, largely because of vendor bulk packaging disposal. Plastic bags and films are commonly composed of resin #2 HDPE (high density polyethylene) and #4 LDPE (low density polyethylene) (Howard, 2011). Both these resin types are often not recyclable, including at the Raleigh MRF, which only accepts these plastics in solid form. However, several facilities throughout the nation are able to accept these plastics and, with a greater push from the University, the local facility may invest in the technology needed to process these polyethylenes.

Polyethylene poses a further problem in the third key product up for consideration: grease-resistant paper products. These items at Duke basketball games—shiny paper cups, popcorn buckets, and pizza plates—are made of polyethylene-coated paper, which is difficult to break down because of the combination of plastic and paper (Judd, 2013). However four facilities exist in the U.S. with the capability to separate the polyethylene layer from the paper and recycle each material separately. The opportunity exists to encourage the Raleigh MRF to invest in this technology. In the short-term, compostable greaseproof paper products are available. However, these products rely on bio-plastics, which should be avoided. Duke Concessions may be able to save money through purchasing paper products without grease resistance. Because the products hold food for such a brief period, it is arguable that the coating is unnecessary.

Product packaging changes depend on collaboration with Duke Stores to put pressure on concessions and suppliers. This large task will rely on demonstrated low costs or cost savings of replacement materials. Duke Stores has instated a "Green Purchasing Policy," which can be used in enforcing many changes to more recyclable or compostable product packaging options. This policy states that "preference will be given to environmentally superior products, where quality, function and cost are equal or superior," and places a high value on post-consumer recycled content, the substitution of products for alternatives where possible, and the potential for safe disposal (Duke Stores, 2012). The policy also demands that Duke Stores work with suppliers and vendors to meet these criteria, which represents an opportunity to bring Duke Stores into negotiations on product packaging.

Data Collection: Phase II

Methodology

The second waste audit occurred on March 5th when the Duke Men's Basketball team played Virginia Tech. This game, like the OSU game observed in November, was sold out with an attendance of 9,314.

During the Game

Before the Virginia Tech game, the team met with the basketball operations staff to discuss logisitics. We agreed that it would be favorable to have less bins available during the game in order to control the research design more easily. In addition, we wanted to ensure that all bins came in a trash/recycling duo. In order to make this happen, some of the trash bins were removed from the upper consourse. This game had 2 bin pairs in lobby of the first floor and 8 bin pairs in the second floor concourse. The team observed those 12 bins, as opposed to the 14 observed in the Phase I audit. We did not consider the 4 bin pairs found on each corner near the court, as the team could not freely access the court.

Based on our previous observations, the team tested three different interventions. The first was to label bins with "trash" or "recycling" signs. The second was to station a volunteer next to the bins encouraging people to recycle. The third was to combine these two strategies, with both clear signs and a volunteer at the waste station. The hypothesis was that the combination of two strategies would provide the highest diversion rate, but each strategy was tested separately to test their relative effects.

The following maps depict the intervention station locations:

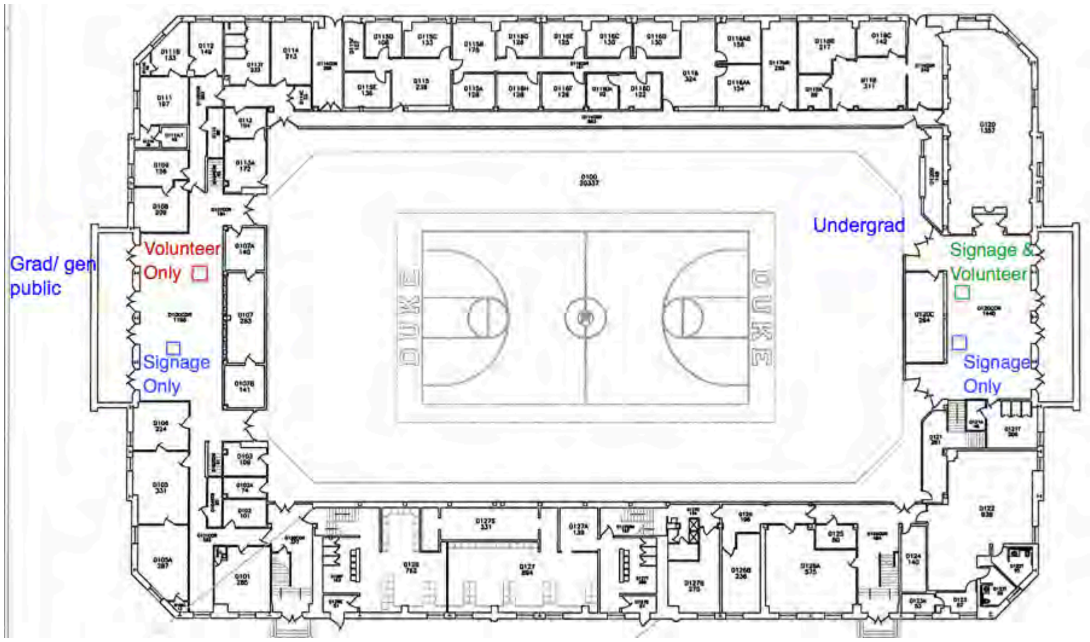

Figure 18: First floor bin placement

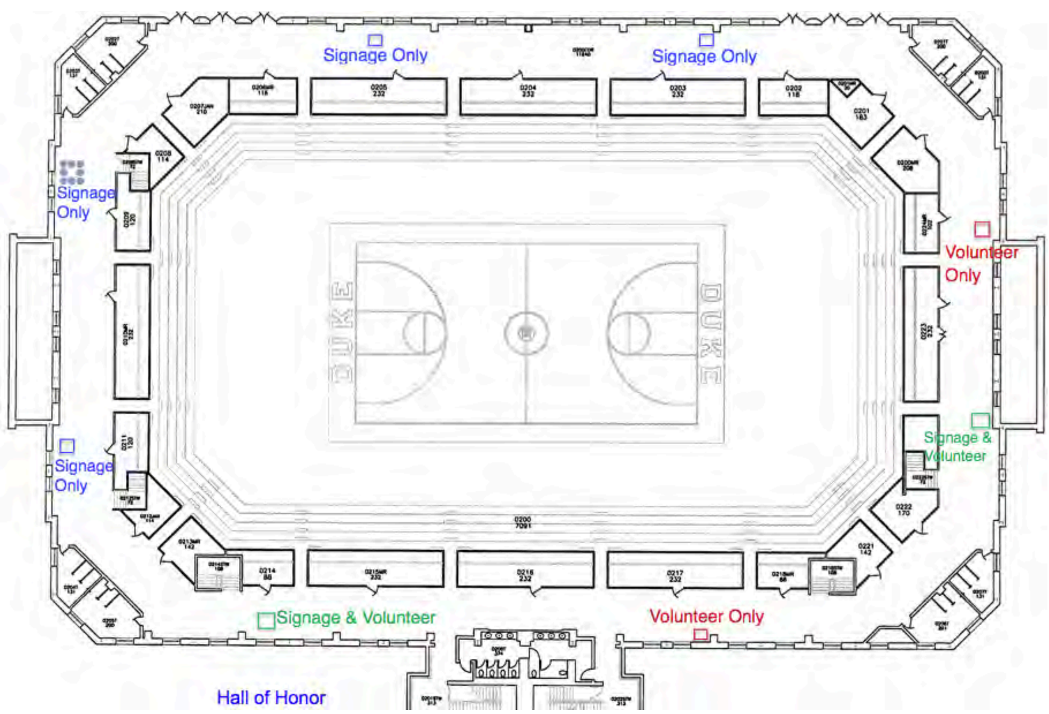

Figure 19: Second floor concurse bin placement

Three of the twelve bin pairs were volunteer only, three were signage and volunteer, and six were singage only. The decision to have more "singage only" bins than the others was made because we had a limited number of volunteers that could stand beside the bins, a challenge representative to many Duke basketball games with limited volunteer capacity. All three interventions were run simultaneously during the game.

At the North Lobby entrance we placed one "signage and volunteer" bin-pair and one "signage only" bin-pair because there was a concession stand nearby where most of the undergraduates procure their snacks during the game. Since that spot could get especially busy during half time, it was best to have a volunteer there to increase diversion rates. At the South Lobby entrance the team placed one "volunteer only" bin and one "signage only bin," as there were no concessions sold there. On the second floor, half of the consourse was "signage only." For consistency these stations were adjacent. For the four remaining bin-pairs, two were "signage and volunteer" and the other two were "volunteer only." This meant that half of the upper concourse had volunteers and the other half did not. It is difficult to guage how far people travel away from their section to get food, but since many of the concession stands are similar, it is possible that many of the game attendees who sat on the side of the stadium without volunteers did not notice that there were volunteers at the game encouraging recycling.

Volunteers were wearing their own clothing and had nothing to indicate that they authority figures during the game. Volunteers were also only told to suggest that the game attendee recycled. The volunteers did not take waste from the game attendee and sort it themselves; instead the responsibility of sorting belonged to the individual who brought the waste to the bin. The signs were plain and simply said "trash," however the recycling signs were a bit more complicated, with images of recyclable items and instructions that may have been too complex in the fast-paced environment of Cameron Indoor Stadium. All of the recycling bin lids were opened to reduce any phsyical barrier to recycling.

During the second half of the game, the team labeled each bag with its associated intervention strategy. The labels were color-coded. Labeling took place during the sencod half to ensure that no bags tagged for the audit were emptied mid-way through the game by housekeeping staff. After the game all of the labeled bags were again taken to the Duke Recycling facility for the waste audit.

At the subsequent waste audit on March 7th, the team and volunteers separated all of the bags based on the labels. Many labels had unfortunately washed off during the rain the night of the basketball game. As a result, one "singage only" bag and one "signage and volunteer" bag were not labeled and thus not able to be accurately examined for the audit.

For consistency, the waste audit was conducted using the same methodology and waste stream labels as the previous Phase I audit: plastics, glass, metals, compost, other plastics, coated paper, cardboard and trash. This time, instead of extrapolating the recycling numbers, each recycling bag that was within the scope of the project was weighed. We were able to retrieve 12 recycling bags, segregated based on their respective intervention strategy stations.

Results

The results from the phase II waste audit are detailed below. Again, the team organized waste into the same categories as in the phase I audit. In addition, the bags were grouped and measured based on the scenarios used at the game. Unforuntately for many reasons that will be further discussed in the Discussion section, the diversion rates did not increase: these rates of waste diverted from the landfill through recycling and compost were 47%-48%, dependent upon the scenario. The loss of recycling bags led to the use of 3 volunteer only, 2 signage & volunteer, and 5 signage only bags in the audit. To equalize these disparities, the team compared percentages, but the sample size was quite small and these limitations led to data different than was expected.

Figure 20. Phase II waste audit results.

	Volunteer Only	Signage & Volunteer	Signage Only
Plastics (lbs.)	3.9	1.1	8.7
Glass (lbs.)	0	0	0
Metal (lbs.)	0.1	0	0.4
Compost (lbs.)	7.5	3.7	17.6
Other Plastics (lbs.)	7.7	4.2	6.2
Coated paper (lbs.)	3	2.3	5.2
Cardboard (lbs.)	3.1	1.6	5.6
Trash (lbs.)	13.9	6.6	13.8
Total in trash bags	39.2	19.5	57.5
Total things that could have been diverted	25.3	12.9	43.7
Potential to be diverted	65%	66%	76%
Actually trash	35%	34%	24%
Recycling	20.6	5.3	10.9
Recycling	7.2	6.3	20.1
Recycling	7.3	7.8	7.8
Recycling	0	0	7.6
Recycling	0	0	5.8
Recycling	0	0	5.6
Compost	0	3	0
Total recycling	35.1	17.1	52.2
Diversion rates	47%	47%	48%

As can be seen in Figure 20, the diversion rate was 47% for stations using volunteers and signage, and volunteers only. The diversion rate for stations using signage only was 48%. These diversion rates may not be the ideal metric to compare strategies, however, as the divertable waste within the bins may have varied with such a small sample size.

The team was specifically interested in the divertable plastics within the trash bags, as plastics represent the largest waste stream that Duke currently has the infrastructure to divert. Comparing the amount of plastics found in the trash in each of the three intervention scenarios, the results show that the stations with both signs and volunteers proved to be the most effective at keeping plastic out of the trash: less than 6% of the trash was comprised of recyclable plastics. These results were in line with our initial hypothesis.

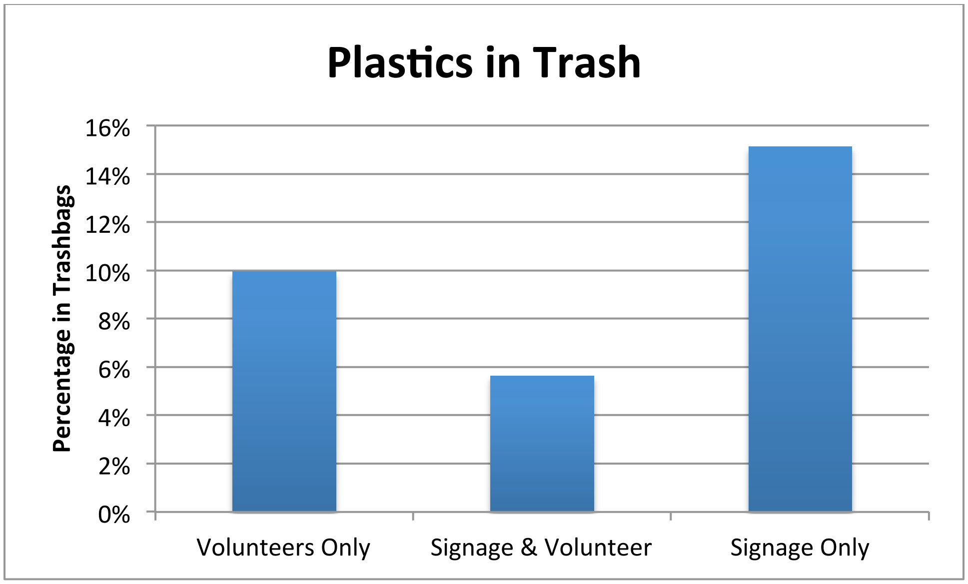

Figure 21. Pastics found in trash by intervention strategy.

The team also examined the total percentage of divertable waste in the trash cans across the three scenarios. In this case volunteers only and volunteers with sigange were the two most effective interventions, which is not surprising because it showed that people positiviely responded to our volunteers. Stations with volunteers had 64-66% divertible waste in trash, while stations without volunteers (signage only) contained 76% divertible waste within the trash. This result is also in line with our hypothesis.

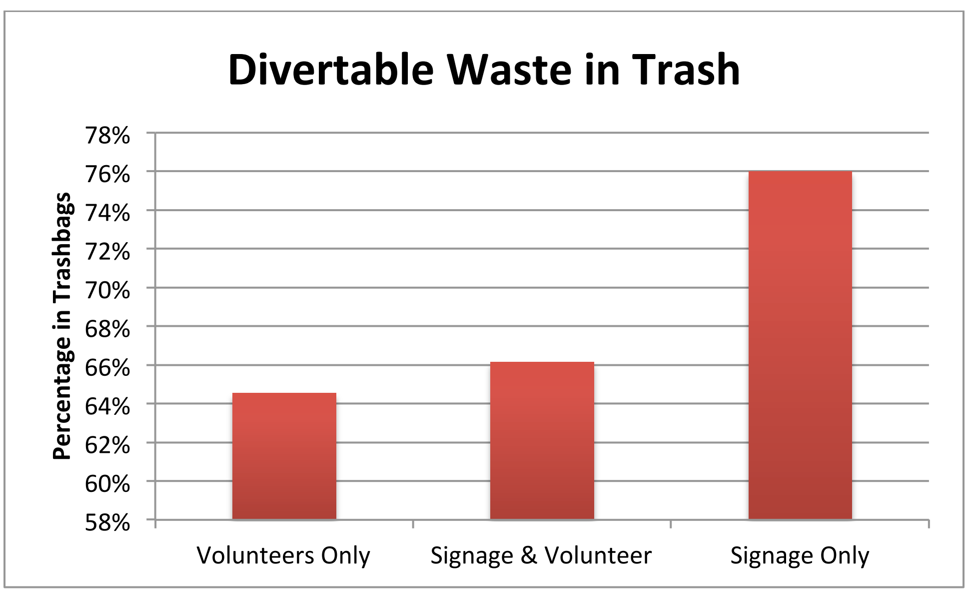

Figure 22. Recyclables found in trash by intervention strategy.

Discussion

Observations

Several observations can account for the lack of change in diversion rate between the Phase I and Phase II waste audits.

First, Duke employees may have had an effect on the diversion rate. The vendors working at the concession stands disposed of significant amounts of packaging before the early arrival of volunteers. Much of this waste could have been recycled, but was not. Many of these employees were eager to learn about the zero waste projects and were receptive to changing their practices.

At entrances, in addition, security guards removed all food and beverage items carried in by game attendees, and disposed of these items in the trash. The majority of this "trash" was comprised of plastic beverage bottles, many of which were empty enough that they could have been recycled. In the Phase I waste audit, few, if any, bags from bins next to entrances were sourced. This is a unique waste stream that was not considered in research design and represents both a discrepancy in data sources and an opportunity for improvement through employee training initiatives.

Another unique waste stream was that of the bins in the upstairs concourse in close proximity to the Hall of Honor. This space, during games, hosts an assortment of vendors other than Duke Concessions, and as a result offers different products and packaging. Some unique packaging options in this space were Styrofoam beverage cups and paper ice cream cups.

Second, the team observed confusion surrounding composting. At the station that included composting with a volunteer and signage, there was a low but present rate of composting. At the composting station with no volunteer, composting did not take place. The signs, stating "Compost: food and paper," may not have been clear enough given the unfamiliarity of many game attendees with the concept of composting.

Third, the volunteers had trouble in predicting whether approaching attendees planned to dispose of an item until it was too late. Because of the narrow space, crowds came very close to waste stations without, often, disposing of items. A balance of outreach and respect was difficult to maintain. This challenge was likely amplified by the lack of distinguishing clothing worn by volunteers (all wore Duke gear). With zero waste vests or shirts, game attendees may more readily approach volunteers for recycling and composting help.

Lastly, our design case may have actually increased recycling but skewed our results: while most containers can be disposed of with food or drink still in them, many enthusiastic fans dumped liquids in the trash before recycling. This, combined with the rain that night, increased the weight of the paper products in the trash. Because Duke measures recycling and trash by weight, we saw a significant increase in the weight of compostable items in the trash, possibly skewing the diversion rate.

Recommendations

Our key recommendations to Duke Athletics for implementing a zero waste program are as follows:

1. **Improved composting capability**

Duke has the opportunity to close the loop between compost hauling from dining hauls and the purchase of mulch for landscaping with the purchase or lease of composting technology. Composting represents an opportunity to reduce food and degraded paper waste at the stadium, increasing diversion rates. This technology can range in cost from $10,000 to $150,000, depending on capacity, but can likely be leased at a lower cost.

2. **Better signage**

Signs should be large and noticeable—possibly overhead. They should be bright and simple, featuring images of game day items. If possible, new waste receptacles should be procured, including compost bins, with prominent signage incorporated into the bin design. Any future trash bins should avoid the “Duke blue” color.

3. **Volunteers at every game**

A volunteer program should be established. Duke Athletics should determine the number of volunteers each game can handle, given expected occupancy, and call upon a corps of trained volunteers. Volunteers should wear bright vests identifying them as waste education assistants. As an incentive to attract volunteers, individuals can be allowed to watch the game except in the time periods before and after the game and surrounding half time, when the majority of waste is generated.

4. Vendor and Employee training

Vendors and security guards should be trained, in a calm environment prior to games, on recycling practices at Duke—such as the capability of recycling glass and plastic bottles which are not empty. Both recycling and trash receptacles should be provided in close proximity to their stations, and volunteers can assist these employees during the game to relieve demands.

5. Recyclable product sourcing

Duke Stores should hold the Cameron Stadium concession stands accountable to their Green Purchasing Policy by enforcing consideration of similarly priced, more easily recyclable or compostable product serving goods, including popcorn buckets, paper plates, and paper cups.

6. Increased recyclability

Duke should work with the Raleigh MRF to encourage greater acceptance of materials that are currently difficult to recycle such as greasy plastics, plastic bags and films, and polyethylene-coated paper.

7. Long-term planning

Cameron has plans of expansion in the near future with suites around the upper concourse to provide pre-game lounge space. Space of waste stations should be incorporated into the design of these suites, and suite occupants should be provided with educational materials about recycling.

Next Steps

Legacy

A 90% diversion rate of waste-to-landfill is our ultimate goal at Duke Athletics. It is a long-term process, and Nicholas School students plan to continue the zero waste program for at least the next two years to begin implementation of the presented recommendations and to further investigate upstream changes. Our partner, Liza Schillo, will continue the Duke Athletics Zero Waste program as a Master's Project in the 2013-2014 academic year, with a focus on the Wallace Wade Football Stadium.

Additional goals include the development of life cycle assessments of current solid waste management methods to determine those methods that not only reduce waste, but also mitigate other impacts to the environment and the world resource supply. This will include a technological and economic evaluation of composting technologies.

Whole Campus

Our analysis will also examine how our efforts at Cameron can be scaled up to the entire University—and what new obstacles that entails, such as the large amounts of outside waste brought into dorms. An easy first step would be the capability of Duke University to offer assistance in zero waste event planning. Similar to Cameron Stadium, Duke events represent controlled waste streams, and the negative environmental impacts of these events should be mitigated.

Other Universities

From that, we hope to set an example to other schools and entities throughout the US, and work with them to help the nation go zero-waste. We have received generous assistance from peer institutions, and hope that Duke University can pay these favors forward to other universities in North Carolina and around the country.

Appendices

Accepted Recyclable Materials by Duke

Figure 23. Recyclable materials at Duke. Source: Duke Facilities Management, 2012.

BLEND PAPER

Acceptable Materials	Non-acceptable Materials
1. White paper	• Carbon paper
2. Colored paper	• Tape
3. White paper with colored ink	• Newspaper or Magazines Materials
4. Envelopes WITHOUT plastic windows or self adhesive labels	• Plastic Windows in Envelopes
5. Yellow legal paper	• Stickers
6. Adding machine tape	• Paper Towels
7. Manila folders	• Rubber Bands
8. NCR paper	• Wire or Plastic Notebook Binding
9. Post-it notes	
10. CPO/green bar/blue bar computer paper	
NOTE: Staples are okay	

NEWSPAPER and MAGAZINES

Acceptable Materials	Non-acceptable Materials
• Newspaper with glossy inserts	• String
• Kraft/Goldenrod Paper or Envelopes	• Hardbound Books
• Phonebooks/Booklets with newsprint	
• Magazines/Catalogues	
• Paper Bags	
• Chipboard/Paperboard	
• Glossy Magazines	
• Glossy Catalogs	
NOTE: Newspaper is now BANNED from the landfill and MUST be recycled	

CARDBOARD

Acceptable Materials	Non-acceptable Materials
• Corrugated Cardboard	• Styrofoam
• Clean Pizza Boxes	• Plastic packing material
NOTE: Corrugated Cardboard is now **BANNED** from the landfill and **MUST** be recycled	
Corrugated = Holes in side	

BOTTLES AND CANS

Acceptable Materials	Non-acceptable Materials
• All Colors of Glass	• Ceramics
• Aluminum Cans	• Plate Glass/Mirrors
• Aluminum Foil *Clean*	• Light bulbs
• Food Cans *Clean*	• Food
• Plastic Container (#1 thru #7)	

Trash and Recycle Bin information

Some bin designs are below with the first two bins for Cameron and the last two bins are for Wallace Wade.

The Recycle Cylinder Single-Stream

- Price: $260/$300 (depending on size)
- 15" x 32"/ 18" x 33"
- 24/35 Gallons
- 24/28 lbs.
- A lift-off top and a rigid plastic liner
- Durable recycling labels
- Available colors: Black, Blue and Green

Figure 24. The Recycle Cylinder Single-Stream. Source: recycleaway.com

The Evolution-40 Recycling Bin

- Price: $349.00
- Size: 41"H x 21.5"W x 16.25"D
- Weight: 35 lbs.
- Gallons: 35 gallons
- Wood front produced with excess wood directly from the factory
- Protective black rubber accent trim on deposit points and front edges
- Aluminum sides and hinging lid
- Steel back panel and internal frame
- "Cans and Bottles only" or "Paper" directly printed on the top

Figure 26. The Evolution-40 Recycling Bin. Source: recyclingbin.com

Recycle Bin I

- Price: $120
- 21-1/8" W x 21 -1/8" D x 42-1/2" H
- 21 lbs.
- 60 Gallons
- Designed for indoor or outdoor settings
- Good signage, bright colors, and restricted openings on this unit
- Comes in three colors (Blue, Green, Red, Black), and with three lid options
- Custom Logos are offered

Figure 27. Recycle Bin I. Source: recycleaway.com

Expanded Metal Recycling Receptacle

- Price: $180/$260 (depending on the optional liner)
- Dimensions: 23” x 33”
- 48 Gallons
- 31 lbs.
- Powder coat finish for wear resistance

Added vertical ribs for reinforcement

- See through mesh is great for added safety
- Flat top recycling lid has two 4" round openings
- Optional rigid plastic liner available

Figure 25. Expanded metal recycling receptacle. Source: recycleaway.com.

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