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Feasibility Study of Mohawk Industries Water Bottle Recycling Program with Automated Compactor/Baler

Brody Cook
Kennesaw State University

Chris Yeager
Kennesaw State University

Parker Cook
Kennesaw State University

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Feasibility Study of Mohawk Industries Water Bottle Recycling Program with Automated Compactor/Baler

Team Mohawk

Team Members and Titles: Brody Cook (Project Manager), Chris Yeager (Resource Manager), Parker Cook (Engineering Manager)

Industrial and Systems Engineering Students

bcook61@students.kennesaw.edu

cyeager3@students.kennesaw.edu

pcook24@students.kennesaw.edu

Advisor: Chris Cook - Sr. Manager of Robotics, Automation, & Analytics at Mohawk Industries

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ISYE 4900: Senior Design Project

FDR - Formal Report

Kennesaw State University, Southern Polytechnic College of Engineering and Engineering Technology

1. Executive Summary

Mohawk Industries requested a senior design project for a feasibility study of a compactor/baler program. The compactor/baler program has the potential to reduce Mohawk Industries' polyethylene terephthalate (PET) recycling center costs, thereby increasing the company's profits. Mohawk Industries uses PET from recycled plastic bottles as a raw material to extrude carpet yarn fibers. Currently, Mohawk Industries has two methods to obtain the PET required to extrude the carpet yarn fibers: purchase recycled bottles from landfills/recycling centers and extrude into PET pellets, or purchase PET pellets from an outside source at a much higher cost. The compactor/baler program would introduce a third option for Mohawk Industries to obtain polyethylene. This program would source the recycled bottles directly from consumers at major sporting facilities such as LakePoint Sports Community located in Cartersville, GA. Compactor/baler recycling bins would be placed throughout the major sporting facility. These compactor/balers would compact recycled plastic bottles into bales containing the polyethylene that Mohawk Industries uses to extrude carpet yarn fibers. These bales of recycled plastic bottles would be transported to Mohawk Industries Recycling Center located in Summerville, GA. Mohawk Industries' recycling center would sort, filter, wash, and extrude the recycled plastic into PET pellets that can be extruded into carpet yarn fibers.

This senior design project was an evaluation of the feasibility of a compactor/baler program at LakePoint Sports Community. Technical and non-technical requirements for the compactor/baler program were determined including safety and aesthetic aspects of the compactor, size and binding materials used for the bales, and compacting and weight requirements for the ejected bales. Material handling requirements for the compactor/baler programs were identified as collection, storage, and transportation conditions. Current state processes were directly compared to a future state process implementing the compactor/baler program. The process flow models of the compactor/baler program show a streamline and simplified system for collecting, recycling, and transporting plastic bottles containing PET. Logistical analysis proved Mohawk's tractor-trailers could transport the compacted bales at the lowest possible cost from LakePoint Sports Community in Cartersville, GA to Mohawk Industries Recycling Center in Summerville, GA. However, the cost justification showed LakePoint Sports Community's insufficient amount of PET bottles sold. Therefore, the senior design team deemed it not feasible to implement the compactor/baler program at LakePoint Sports Community, based on the facility's current size. LakePoint could be reevaluated in the future, after a significant expected growth over the next 5 years.

A lot was learned from the process, such as the calculations for shipping costs. The senior design team had difficulty finding material on this topic and required a significant amount of time in order to find the correct information. The team also learned how painstaking it can be to obtain information from management. There were long wait times for crucial information. Kennesaw State University's senior industrial and systems engineering students took on Mohawk Industries' request for a feasibility study of implementing a compactor/baler program eager to become the next generation of engineers.

Table of Contents

Feasibility Study of Mohawk Industries Water Bottle Recycling Program with Automated Compactor/Baler	0
1. Executive Summary	1
Table of Contents	2
List of Figures	4
List of Tables	5
2. Overview	6
2.1 Introduction	6
2.2 Overview	6
2.3 Objective	6
2.4 Justification	6
2.5 Project Background	7
2.6 Problem Statement	7
3. Literature Review	8
4. Problem Solving	10
4.1 Design Verification Plan	10
4.2 Minimum Success Criteria	10
4.3 Project Requirements and Concepts	10
4.4 Gantt Chart	11
4.5 Schedule	11
4.6 Flow Charts	12
4.7 Project Management	12
4.8 Responsibilities	13
4.9 Budget	13
4.10 Material Required/Used	13
4.11 Resources Available	13
5. Current/Future State	14
5.1 Mohawk - Current State	14
5.2 Mohawk - Future State	14
5.3 LakePoint - Current State	15
5.4 LakePoint - Future State	16
6. Material Handling	18
Kennesaw State University	2

6.1 Mohawk's Material Handling Transporting	18
6.2 LakePoint's Material Handling Product Movement	18
7. Logistics	19
7.1 Alternatives	19
7.2 USPS	19
7.3 UPS	19
7.4 Recycling at \$0.15 per pound	20
7.5 Recycling at \$0.50 per pound	21
7.6 Current Recycling Rate	22
7.7 Future Recycling Rate	26
8. Results and Discussions	29
8.1 Results	29
8.2 Future Projects	29
9. Conclusion	31
10. References	32
Appendix A: Acknowledgements	33
Appendix B: Contact Information	34
Appendix C: Reflections	35
Appendix D: Contributions	36

List of Figures

Figure	Page
1. Gantt Chart	11
2. Schedule	11
3. DMAIC Cycle	12
4. Mohawk's Current State	14
5. Mohawk's Future State	15
6. LakePoint's Current State	16
7. LakePoint's Current Recycling Can Placement	16
8. LakePoint's Future State	17
9. LakePoint's Future Recycling Can Placement	17
10. Soda Bottle Weight	23
11. Water (Dasani) Bottle Weight	23
12. Powerade Bottle Weight	23

List of Tables

Table	Page
1. Group Responsibilities	13
2. USPS Shipping Cost	19
3. UPS Shipping Costs	20
4. Recycling at Rate of \$0.15 per Pound	20
5. Recycling at Rate of \$0.50 per Pound	21
6. Current Amount of Plastic Sold at LakePoint	22
7. Recycling at LakePoint	24
8. Cost at \$0.15 per Pound at Current Capacity	25
9. Cost at \$0.50 per Pound at Current Capacity	25
10. Future Amount of Plastic Sold at LakePoint	26
11. Cost at \$0.15 per Pound at Future Capacity	27
12. Cost at \$0.50 per Pound at Future Capacity	27
13. Cost of Recycling Cans Needed	29
14. Pounds of Plastic at Mercedes Benz Stadium	30

2. Overview

2.1 Introduction

Mohawk Industries is seeking a way to increase their profits by reducing the cost of buying plastic. To do this, the company is trying to team up with local businesses to start a recycling program so that Mohawk Industries can do their own recycling, as opposed to buying all the plastic required for manufacturing. The goal of this project is to help find a way to make this recycling program feasible and viable. Mohawk Industries' Management Team decided that a large sports facility might be the best place to collect as much plastic as possible. The sports facility chosen is LakePoint Sports Complex in Cartersville, Georgia.

2.2 Overview

Mohawk Industries (Mohawk) wants to study the feasibility of providing plastic water bottle compactor/balers at outdoor sport complexes to recycle the polyethylene terephthalate (PET) which Mohawk uses as a raw material to extrude carpet yarn fiber. [1] Jonathan Skelly mentioned in an interview with our team that Mohawk buys PET bottles every day to make their yarn. These plastic bottles are bought in large quantities. Each block of plastic is usually around 500 pounds. Once the PET bottles are bought, they are shipped to Mohawk's cleaning facility in Summerville, Georgia. From there the PET bottles are sorted into different types, based on whether they are clear plastic, colored, or non-plastic, such as aluminum cans. Once sorted, all the PET plastic is washed of impurities and then cut into flakes of plastic. The flakes of plastic are extruded into pellets which can be sent to Mohawk facilities to create yarn. The plastic pellets can also be bought on the market but are much more expensive than extruding them from plastic at Mohawk's own facility.

2.3 Objective

The objective of this project is to find an additional way for Mohawk to acquire plastic to make yarn. Instead of just buying plastic, Mohawk would like to be able to collect recycled plastic to save on costs and become a more sustainable organization. With the help of LakePoint Sports Community, the goal of this project is to study the feasibility of implementing compacting recycling bins to collect recycled plastic and use that plastic in the production of yarn and carpets. While Mohawk looks to expand the collection of plastic, LakePoint is a good starting point to see if this is a feasible project. LakePoint is the largest sports park in the Southeast with over one million visitors every year.

2.4 Justification

To justify the project, the cost of Mohawk the having their own collection process must be cheaper than purchasing the plastic. Currently the cost of purchasing plastic is \$0.15/lb, until the plastic producers runs out of plastic, at which point they end up buying plastic pellets for \$1.00/lb. The cost to get from unprocessed plastic to plastic pellets is around \$0.50 per pound. Therefore, there will be a secondary goal of ensuring the cost is below \$0.50 per pound. Every

year Mohawk must buy plastic pellets because there are not enough other completely-priced forms of plastic that can be bought. If Mohawk can collect enough plastic from LakePoint to beat the \$0.15 per pound goal, then Mohawk may not have to buy plastic pellets at all. However, beating the goal of \$0.50 per pound is still better than buying plastic pellets.

2.5 Project Background

Currently, Mohawk does no recycling of their own and instead just purchases their plastic from the market for \$0.15/lb. Mohawk plans to work with the mechatronics team at KSU to produce a compactor baler to collect their own plastic. The compactor baler program must be evaluated to determine if it is feasible to collect the plastic required. The compactor baler will be used to collect as much plastic as possible. The compactors will be able to compress the plastic to collect more weight of plastic per recycling can. The project will aim to determine how many recycling cans are needed at LakePoint and the amount of plastic that can be collected. All calculations for logistics will be done using a 2.5-year return, since Mohawk requests for the program to payback in this timeframe. There are two main options for buying the compactors. The first is from the mechatronics team, the other will be from online. [7] The online compactors are likely to be supplied by Krushr, but other companies will also be looked at in the future.

2.6 Problem Statement

The issue that Mohawk faces is that they cannot get enough plastic to fulfill their needs. Because there is a limited supply of plastic that Mohawk can purchase at \$0.15/lb, they resort to buying the plastic pellets at \$1.00/lb. This cuts into their profits, which is why Mohawk is looking for a way to reduce the amount of excess plastic they must buy at \$1.00/lb. Mohawk aims to start collecting their own plastic so that the company does not have to rely on others to get their plastic.

3. Literature Review

In this section, we will look at literature that has helped identify important factors for the feasibility study. The literature reviewed presents a guideline for the study and shows past projects that have been successful and what the team should aim for in the study.

In [2] Georgia Tech's feasibility study of LakePoint, there are indications of the economic growth of the area surrounding LakePoint. The authors can predict the number of visitors to LakePoint and are able to give good insight into what is expected in the near future. The expected growth, from the current one million visitors a year, is upwards of five million visitors in the next five years.

[3] North Carolina's research team wrote a paper, "Selection and Placement of Recycling & Trash Containers on Campus", which gives an insight of where to place recycling bins. The paper gives tips on how to put recycling cans in high traffic areas such as entrances and doorways. The other importance of this is that people are already trained to expect trash cans and recycling bins at doorways. North Carolina's research team also describes the idea of clusters and how it's possible to reduce the number of cans by removing a cluster of cans and replacing them with one can.

[6] Mark Piscopo's feasibility study template gives a good idea of what should be expected of a project. The template gives a good outline of how a project should be. The marketing techniques discussed in the study were not used too much throughout this project, but the scheduling was a big help along with the executive summary. The executive summary gives a good guideline of how the executive summary was written for this paper.

[7] Krushr's article on their compactors was a good basis for what to expect of compactors. Krushr can have their home compactors crush recycling by 85%. The 85% is this project's standard for what the recycling bins by the mechatronics team will have to meet. This also will help keep the plastic from being too heavy that the employees cannot lift the can but compact enough to save space.

[11] Qualcomm Stadium's analysis of the recycling program gave a good idea of what to expect from NFL stadiums. NFL stadiums will be looked at for future use of the recycling program by Mohawk. If LakePoint is unable to support enough plastic for Mohawk, looking at the Mercedes Benz Stadium in Atlanta might be a good idea. Using the calculations of Qualcomm were used to calculate the expected plastic at the Mercedes Benz Stadium.

[12] Maggie Caldwell's article gives good insight on what it's like to use compactor. The article gives a good idea of what prices to aim for in the project and things to expect from the compactor. The biggest thing the article mentioned was the idea that the compactors should be moveable. This will be a constraint for the compactors at LakePoint.

[13] An article on public recycling was useful to calculate weights of plastic. While a large portion of the plastic was weighed personally, some of the weights in this article were able to display what the weights of plastic should be. If the weight is unable to be calculated, the weight will be collected from this article.

[14] Indiana did a feasibility study on recycling at their university. The team shows how important it is for there to be recycling cans. They show surveys of students who would like recycling cans at an area if there are not. 89.3% of the students want a recycling can, and 10% did not care or did not want them. The feasibility study gave the Mohawk senior design team a good idea of important recycling is and how important it is to have recycling cans are every spot possible.

[15] The economical income feasibility study observed families participating in sporting events at the LakePoint facilities. The study provides the average home incomes for each type of sporting event. The conclusion was made that some sports have a much higher average home income. It was discovered that higher income families relate to specific sporting events. The families at these higher income sporting events are more educated.

[16] Coca Cola opened up their own recycling plant in 2009. Coca Cola planned to recycle over 100 million pounds of plastic. They were only able to recycle a third of their goal. The article shows how hard it is to recycle in certain areas. The United States recycles PET at a rate of 28% in 2009, while Europe does 50%. This is because the lack of programs in the United States recycling programs.

4. Problem Solving

4.1 Design Verification Plan

To solve this problem, the goal will be to have a lower cost of collecting plastic than buying plastic. This will be best done by looking at the amount of plastic that LakePoint Sports Complex is able to produce for Mohawk. There will be a lot of data collecting based on the number of patrons visiting the sports complex and how much plastic they are able to produce. Using the amount of plastic produced is one variable, but other variables include shipping costs, holding costs, and man hours. See Section 7 for more detail of the exact costs of each of these variables.

4.2 Minimum Success Criteria

The goal will be to beat a cost of \$0.15 per pound, with a secondary goal of beating \$0.50 per pound. Section 7 goes into more detail about the costs and Section 10 shows the results to these calculations and if the minimum success criteria has been met.

4.3 Project Requirements and Concepts

The following section provides requirements for the output of this project. They are divided into technical and non-technical requirements.

Technical Requirements:

- The compactors shall be no larger than 3 feet wide, 2 feet long, and 4 feet high.
- The compactors shall be labeled with LakePoint on them.
- The compactors shall be blue with recycling symbols on them.
- The compactors shall be able to be wheeled around.
- The compactors shall have a hole only large enough for plastic bottles to be put inside.
- The compactors shall be deep enough that no child can stick their hands in.
- The compactors shall compact plastic by at least 85%.
- The Mohawk truck shall be able to carry over 6,000lbs.
- The Mohawk truck shall be able to be used once every two months.

Non-Technical Requirements:

- The compactors shall cost no more than \$5,000.
- There shall be no more than 10 compactors.
- The process shall cost no more than \$0.15 per pound.
- The process shall have a current state.
- The process shall have a future state.

4.6 Flow Charts

An effective way to set up a project is by using different types of flow charts. One that will help for this project is having a DMAIC model flow chart. The DMAIC model is useful in that it helps for improving and stabilizing businesses designs using six sigma principles. Shown in Figure 3 is the DMAIC model applied to the Mohawk Industries project.

- Define: The issue is that Mohawk is unable to obtain enough competitively-priced plastic per year and wants to try and collect its own plastic.
- Measure: Measure the amount of plastic that would be able to be collected from LakePoint Sports Complex.
- Analyze: Use the data to see if it is worth the cost to collect from LakePoint and transport the plastic to Mohawk's recycling center.
- Improve: Use recycling compactors instead of regular recycling bins to increase the amount of plastic. This way less plastic will be thrown away since the bins will not be full and people just throw away plastic.
- Control: Keep statistics on the new proposed plan to see if the gathering of plastic is any better. Look at the expected number of customers at LakePoint and if it will affect the amount of plastic collected.



Figure 3. DMAIC Cycle

4.7 Project Management

The project was divided evenly among three members. One was assigned the scheduling and planning of the process. A second was responsible for the excel spreadsheets and calculations

of logistics. The third was responsible for the cost justification and bringing the whole project together.

4.8 Responsibilities

This section lists the responsibilities of each of the team members. These assignments are not set in stone and change based on what task needs to be done.

Name	Role	Responsibility
Brody Cook	Project Manager	Responsible for assigning duties, scheduling milestones, and ensuring adequate progress.
Chris Yeager	Resource Manager	Responsible for communication and logistics.
Parker Cook	Engineering Manger	Responsible for cost analysis.

Table 1. Group Responsibilities

4.9 Budget

There was no budget for the project. Mohawk had no requirements for the cost. None of the programs cost any money either.

4.10 Material Required/Used

The most extensive part of the project was done using Microsoft Excel and Microsoft Word. All the data was collected and calculated using Microsoft Excel. Both programs were accessible through the Kennesaw State University website.

4.11 Resources Available

All the resources that were available were either through the internet or through the University. Other resources were research papers and professors who have guided the team through this project. The internet was able to provide a lot of suggestions on what type of models to use.

5. Current/Future State

5.1 Mohawk - Current State

The following figure (Figure 4) shows Mohawk's current recycling state. Mohawk Industries buys plastic bottles from recycling centers at \$0.15 per pound of plastic. The recycled bottles are transported from recycling centers to Mohawk's recycling plant located in Summerville, Georgia. At the facility, the plastic bottles enter a process to be cleaned and sorted by color. The process cuts up the plastic bottles and forms the plastic pieces into pellets. These plastic pellets are transported to one of Mohawk's extrusion plants. Mohawk extrudes the plastic pellets into yarn to produce carpet. Mohawk is only able to buy a limited amount of plastic from the recycling center. The limit on the number of plastic bottles is a constraint based on the amount of plastic the recycling centers have in inventory. Once Mohawk exceeds the amount of plastic being purchased from the recycling center at \$0.15 per pound, Mohawk then must buy plastic pellets from a supplier. Because the pellets are being purchased and not plastic bottles, the pellets can skip the Mohawk recycling plant operation. This enables the purchased plastic pellets to be delivered straight to the extrusion processes. However, the cost of the pellets per pound are much higher than the plastic bottles per pound. The pellets purchased from the supplier are bought at \$1.00 per pound of pellets. Because of the high cost of pellets and the limited number of plastic bottles, Mohawk is seeking other ways of obtaining plastic bottles.

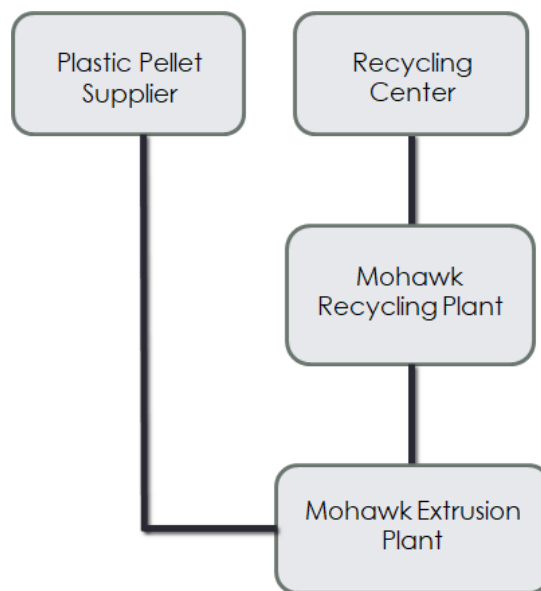


Figure 4. Mohawk's Current State

5.2 Mohawk - Future State

Although the current state will be kept as the primary source of the recycling process, a future state is created to assist the current state. The assistance from the future state is used to obtain

more recycled bottles by a less expensive process than buying the plastic pellets from a supplier. Mohawk's future state consists of multiple possible solutions. A primary requirement is to introduce the optimal solution and other solutions that are feasible to Mohawk's recycling process. The project, as previously defined, is to study the implementation of a recycle compactor program at LakePoint sport facility. The recycle compactors will collect recycled plastic bottles to be shipped back to Mohawk to extrude the plastic into yarn. Possible logistic solutions to transport the recycled plastic compacted bottles from LakePoint to Mohawk's recycling plant are listed below:

1. Mohawk provides pickup with a semi-truck. Mohawk's expense for the transportation is \$1.70 per mile.
2. Outsource the logistics to companies such as UPS or the USPS. Mohawk will pay the shipment cost if this solution is found to be feasible.
3. LakePoint ship the plastic bottles to a recycling center that supplies Mohawk.

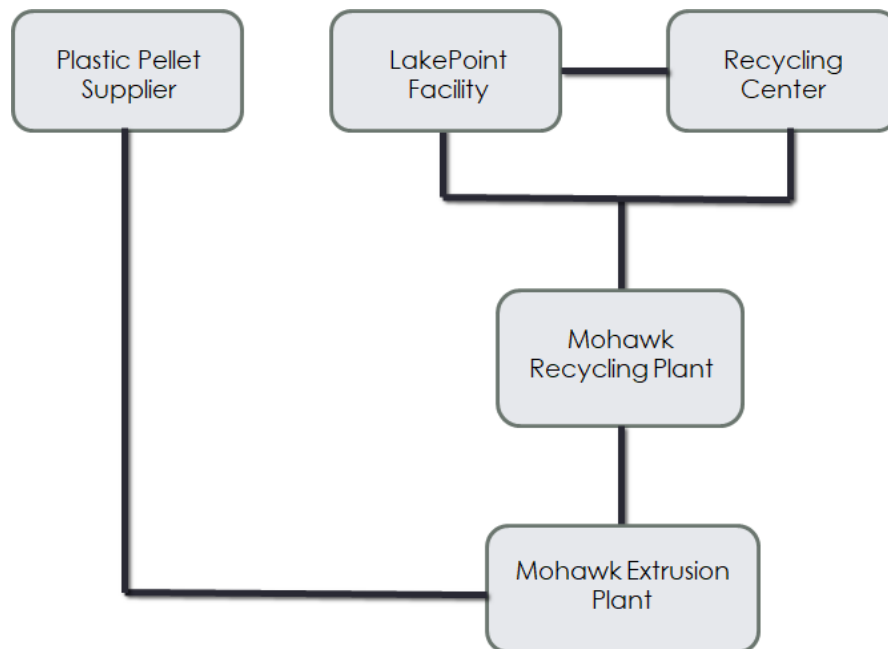


Figure 5. Mohawk's Future State

5.3 LakePoint - Current State

[2] In an interview with management at LakePoint, the team was given information on how the current recycling works at LakePoint. Currently the recycling at LakePoint is done by having each can placed in a certain area, and at the end of the day, an employee goes around and collects the recycling and replaces the can with a new bag. This happens every day and is a very time-consuming task for employees at LakePoint. Currently, LakePoint has 38 recycling bins, 4 at the soccer fields, 10 indoors, and 24 at the baseball fields. Below in Figure 6 is a flow diagram of the recycling process, and in Figure 7 is a layout of their facility and where the recycling bins are located. The recycling bins are represented by stars.

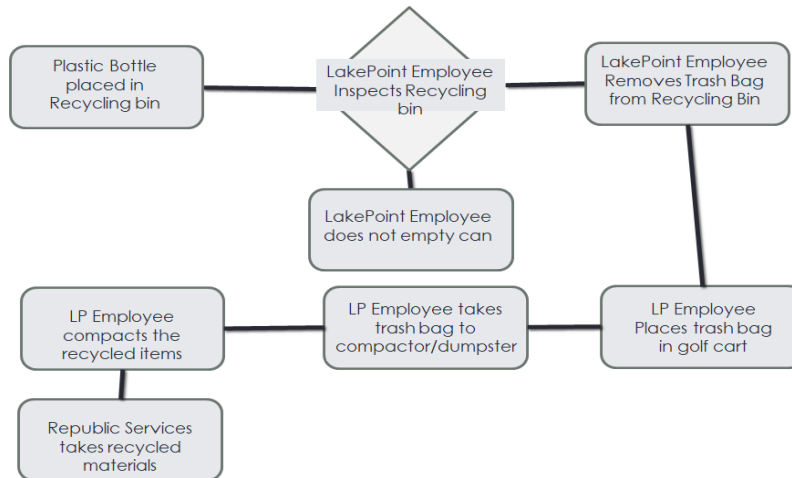


Figure 6. LakePoint's Current State

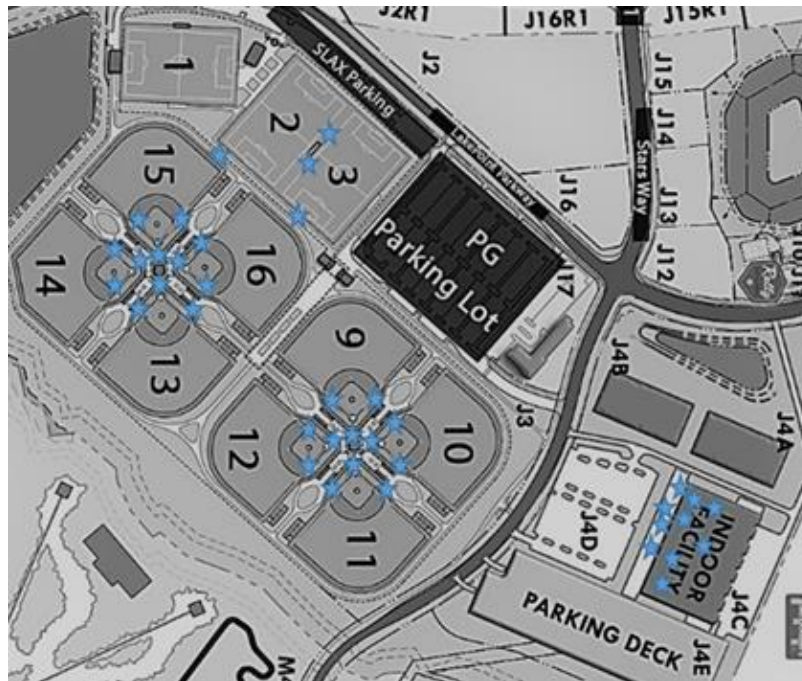


Figure 7. LakePoint's Current Recycling Can Placement

5.4 LakePoint - Future State

LakePoint's future state will be a lot simpler. Instead of an employee having to go around every day to collect recycling, the future state will require an employee to collect once a week. Figure 8 shows the future state of LakePoint. Each recycling can will hold up to 20lbs of plastic before spitting out a block of plastic to be collected. The plastic will be in a locked part attached to the recycling can, so no one can access it but employees. LakePoint will also be able to reduce the number of recycling cans from 38 to 10 by using the method of cluster. [3] Philip's explains the idea of clusters in his article "Selection and Placement of Recycling & Trash Containers on Campus." There are many places where there are multiple recycling bins at each location, such as inside and outside of a door. This is unnecessary and will be able to be replaced by one

recycling bin. The new recycling bins will be able to handle more plastic, because of the compactor, and so combining bins will work well. With the clusters there will be one bin at the soccer field, 3 indoors, and 6 at the baseball fields. The new process is shown below in Figure 9. Table 7 goes into more detail about how Figure 9 is set up and how many of the original cans is at each of the new compactors.

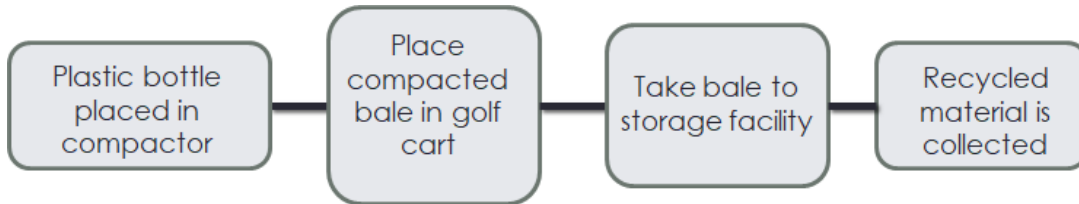


Figure 8. LakePoint's Future State

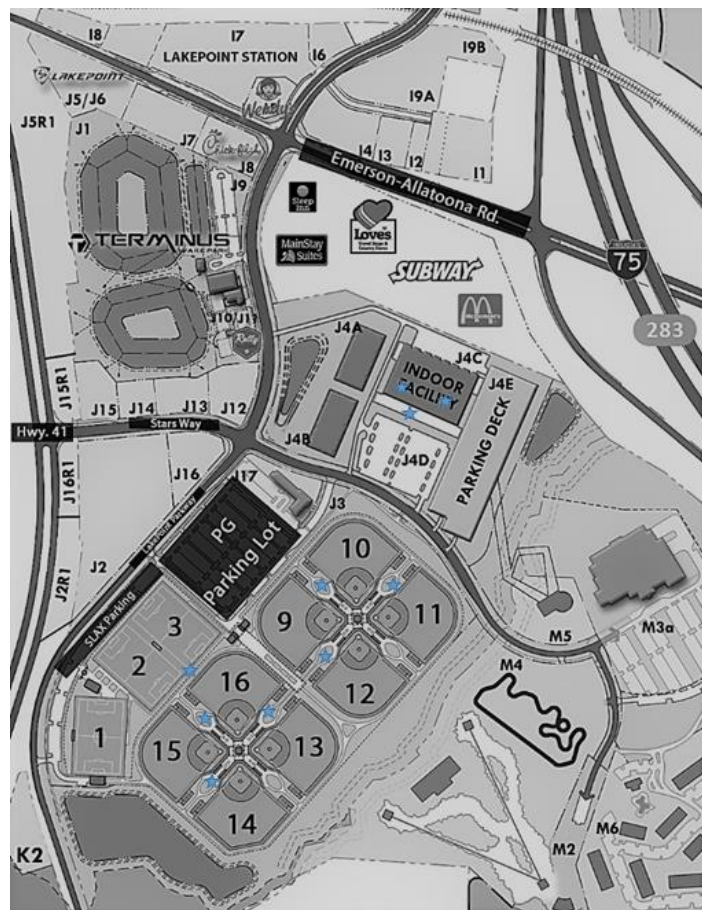


Figure 9. LakePoint's Future Recycling Can Placement

6. Material Handling

6.1 Mohawk's Material Handling Transporting

Based on the current recycling process at Mohawk's Summerville recycling plant, the incoming trailers are cubing out rather than grossing out. This means the tractor trailer loads are filling up before the weight limit is reached. The trailers are averaging 36,000 pounds of compacted plastic per trailer load. [5] Because plastic on average is approximately 27 grams per PET water bottle, the transport loads will be similar in load size and weight. The similar trailer load characteristics provides the assumption that trailer loads from LakePoint will also cube out before grossing out.

6.2 LakePoint's Material Handling Product Movement

[6] The cost savings from an implementation of compactors at LakePoint will strictly benefit LakePoint's material handling when emptying recycling cans. LakePoint will have the potential to save time and money if the compactors are implemented by reducing the frequency that the cans are emptied and the labor time. With LakePoint's current population, the recycling cans are only emptied once per day. However, based on LakePoint's economic growth study the cans will have to be emptied up to five times per day. At this point there will be a more feasible need for the compactors to help LakePoint's recycling emptying occurrence rate decrease. The compactors will also help support LakePoint's material handling when loading and unloading the recycled material from the equipment used to transport the bales. Although the cost of implementing the compactors with the current population at LakePoint is unfeasible, expected growth in LakePoint's demand will drive the need for an improved material handling process. The expected increase in LakePoint's demand will also produce more recycled PET plastic materials.

7. Logistics

7.1 Alternatives

There are multiple ways that Mohawk will be able to transport their plastic from LakePoint to the Mohawk recycling center. The different methods available are using Mohawk’s own truck, using a U-Haul, UPS, and USPS. Using Mohawk’s own truck and a U-Haul will involve costs of price per mile and the cost of sending an employee. For UPS and USPS, the cost is only determined by the weight of plastic being shipped. All calculations for logistics will be done using a 2.5-year return. This is the timeframe Mohawk requests for a program to payback.

7.2 USPS

The first alternative looked at was shipping the packages through USPS from LakePoint to Mohawk’s recycling center. Using the information given on USPS’s price calculation website, the research team was able to determine for the size and weight of the blocks that the cost would be \$0.62 per pound. For calculating the cost, the project team would assume a best-case scenario where Mohawk buys 10 recycling cans at a cost of \$2,000 each from Krushr. Shown below in Table 2 is the calculation costs for using USPS for the current amount of recycling LakePoint generates, and then also the expected amount in five years.

Cost of Shipping for USPS over 2.5 years now					
Cost of the Recycling Cans	# of Recycling Cans	Shipping cost / pound	Total Cost	Cost Per Day	
2000	10	0.62	\$27,115.12	\$ 29.72	
Cost of Shipping for USPS over 2.5 years in 5 years					
Cost of the Recycling Cans	# of Recycling Cans	Shipping cost / pound	Total Cost	Cost Per Day	
2000	10	0.62	\$55,575.60	\$ 60.90	

Table 2. USPS Shipping Cost

7.3 UPS

The second alternative looked at was shipping the packages through UPS from LakePoint to Mohawk’s recycling center. Using the information given on UPS’s price calculation website, the project team was able to determine for the size and weight of the blocks that the cost would be \$0.84 per pound. For calculating the cost, the project team assumed a best-case scenario where Mohawk buys 10 recycling cans at a cost of \$2,000 each from Krushr. Shown below in Table 3 are the calculation costs for using UPS at the current amount of recycling LakePoint generates, and then also the expected amount in five years.

Cost of Shipping for UPS over 2.5 years now				
Cost of the Recycling Cans	# of Recycling Cans	Shipping cost / pound	Total Cost	Cost Per Day
2000	10	0.84	\$ 29,639.84	\$ 32.48

Cost of Shipping for UPS over 2.5 years in 5 years				
Cost of the Recycling Cans	# of Recycling Cans	Shipping cost / pound	Total Cost	Cost Per Day
2000	10	0.84	\$ 68,199.20	\$ 74.74

Table 3. UPS Shipping Cost

7.4 Recycling at \$0.15 per pound

The goal of Mohawk's endeavors is to beat a price of \$0.15 per pound of plastic. This is the price that Mohawk buys most of their plastic at from the market. Two alternatives to collect the recycling from LakePoint are using Mohawk's own truck or renting a U-Haul. The cost of a Mohawk truck is \$1.70 which includes the cost of an employee and gas. The mileage to LakePoint and back is 109.2 miles round trip. The cost for a U-Haul is the initial rental fee, cost per mile of \$0.79, and cost to have an employee drive the truck. The mileage to the U-Haul store, LakePoint, and back is 121.7 miles. Shown below in Table 4 is the cost of using either a U-Haul or Mohawk's truck, and at different intervals of when to pick up from LakePoint.

Calculating Costs of the Shipping to Mohawk Recycling							
Type	Cost of the Recycling Cans	# of Recycling Can	Shipping cost / mil	Miles to Ship	Cost to Rent Truck		
Uhaul once a week + buy from Mechatronics	5000	10	0.79	121.7	60		
Uhaul once a week + buy from Online	2000	10	0.79	121.7	60		
Mohawk Truck once a week + buy from Mechatronics	5000	10	1.7	109.2	0		
Mohawk Truck once a week+ buy from Online	2000	10	1.7	109.2	0		
Uhaul once a month + buy from Mechatronics	5000	10	0.79	121.7	60		
Uhaul once a month + buy from Online	2000	10	0.79	121.7	60		
Mohawk Truck once a month + buy from Mechatronics	5000	10	1.7	109.2	0		
Mohawk Truck once a month + buy from Online	2000	10	1.7	109.2	0		
Uhaul once every 2 month + buy from Mechatronics	5000	10	0.79	121.7	60		
Uhaul once every 2 month + buy from Online	2000	10	0.79	121.7	60		
Mohawk Truck once every 2 month + buy from Mechatronics	5000	10	1.7	109.2	0		
Mohawk Truck once every 2 month + buy from Online	2000	10	1.7	109.2	0		
Uhaul twice a year + buy from Mechatronics	5000	10	0.79	121.7	60		
Uhaul twice a year + buy from Online	2000	10	0.79	121.7	60		
Mohawk Truck twice a year + buy from Mechatronics	5000	10	1.7	109.2	0		
Mohawk Truck twice a year + buy from Online	2000	10	1.7	109.2	0		
# times in 2.5 Years	Hours for Employee	Employee Payrate	Total Cost	Plastic Needed (lbs)	Plastic needed per day(lbs)	Water bottles needed per day	Cost Per Day
130	3	20	\$ 78,098.59	520657.3	570.6	8888	\$ 85.59
130	3	20	\$ 48,098.59	320657.3	351.4	5474	\$ 52.71
130	0	0	\$ 74,133.20	494221.3	541.6	8436	\$ 81.24
130	0	0	\$ 44,133.20	294221.3	322.4	5022	\$ 48.37
30	3	20	\$ 56,484.29	376561.9	412.7	6428	\$ 61.90
30	3	20	\$ 26,484.29	176561.9	193.5	3014	\$ 29.02
30	0	0	\$ 55,569.20	370461.3	406.0	6324	\$ 60.90
30	0	0	\$ 25,569.20	170461.3	186.8	2910	\$ 28.02
15	3	20	\$ 53,242.15	354947.6	389.0	6059	\$ 58.35
15	3	20	\$ 23,242.15	154947.6	169.8	2645	\$ 25.47
15	0	0	\$ 52,784.60	351897.3	385.6	6007	\$ 57.85
15	0	0	\$ 22,784.60	151897.3	166.5	2593	\$ 24.97
5	3	20	\$ 51,080.72	340538.1	373.2	5813	\$ 55.98
5	3	20	\$ 21,080.72	140538.1	154.0	2399	\$ 23.10
5	0	0	\$ 50,928.20	339521.3	372.1	5796	\$ 55.81
5	0	0	\$ 20,928.20	139521.3	152.9	2382	\$ 22.94

Table 4. Recycling at Rate of \$0.15 per Pound

The row highlighted in green shows the best-case scenario. Management at LakePoint had concerns about leaving the recycling at their facility for more than two months due to various factors such as smell and the amount of available space. Therefore, the cheapest option was to use Mohawk's truck while buying the recycling bins online for \$2,000. The total cost across 2.5 years is \$22,874.60 or \$24.97 per day. The number of water bottles that would be needed per day is 2,593.

7.5 Recycling at \$0.50 per pound

As mentioned above, the goal of Mohawk's endeavors is to beat a price of \$0.15 per pound of plastic. This is the cost they buy most of their plastic at from the market. Every year Mohawk runs out of plastic to buy and therefore must buy the plastic pellets at a price of \$1.00 per pound. The cost of cleaning the plastic is around \$0.50 per pound, therefore a secondary goal is to beat \$0.50 per pound. While not ideal, if LakePoint is able to keep the cost of plastic under \$0.50 per pound, then Mohawk will be able to reduce the number of plastic pellets they have to buy. Shown below in Table 5 is the cost for using either U-Haul or Mohawk's truck.

Calculating Costs of the Shipping to Mohawk Recycling						
Type	Cost of the Recycling Cans	# of Recycling Can	Shipping cost / mi	Miles to Shi	Cost to Rent Truck	
Uhaul once a week + buy from Mechatronics	5000	10	0.79	121.7	60	
Uhaul once a week + buy from Online	2000	10	0.79	121.7	60	
Mohawk Truck once a week + buy from Mechatronics	5000	10	1.7	109.2	0	
Mohawk Truck once a week+ buy from Online	2000	10	1.7	109.2	0	
Uhaul once a month + buy from Mechatronics	5000	10	0.79	121.7	60	
Uhaul once a month + buy from Online	2000	10	0.79	121.7	60	
Mohawk Truck once a month + buy from Mechatronics	5000	10	1.7	109.2	0	
Mohawk Truck once a month + buy from Online	2000	10	1.7	109.2	0	
Uhaul once every 2 month + buy from Mechatronics	5000	10	0.79	121.7	60	
Uhaul once every 2 month + buy from Online	2000	10	0.79	121.7	60	
Mohawk Truck once every 2 month + buy from Mechatronics	5000	10	1.7	109.2	0	
Mohawk Truck once every 2 month +buy from Online	2000	10	1.7	109.2	0	
Uhaul twice a year + buy from Mechatronics	5000	10	0.79	121.7	60	
Uhaul twice a year + buy from Online	2000	10	0.79	121.7	60	
Mohawk Truck twice a year + buy from Mechatronics	5000	10	1.7	109.2	0	
Mohawk Truck twice a year + buy from Online	2000	10	1.7	109.2	0	

# times in 2.5 Years	Hours for Employee	Employee Payrate	Total Cost	Plastic Needed (lbs)	Plastic needed per day(lbs)	Water bottles needed per day	Cost Per Day
130	3	20	\$ 78,098.59	156197.2	171.2	2582	\$ 85.59
130	3	20	\$ 48,098.59	96197.2	105.4	1590	\$ 52.71
130	0	0	\$ 74,133.20	148266.4	162.5	2451	\$ 81.24
130	0	0	\$ 44,133.20	88266.4	96.7	1459	\$ 48.37
30	3	20	\$ 56,484.29	112968.6	123.8	1867	\$ 61.90
30	3	20	\$ 26,484.29	52968.6	58.0	876	\$ 29.02
30	0	0	\$ 55,569.20	111138.4	121.8	1837	\$ 60.90
30	0	0	\$ 25,569.20	51138.4	56.0	845	\$ 28.02
15	3	20	\$ 53,242.15	106484.3	116.7	1760	\$ 58.35
15	3	20	\$ 23,242.15	46484.3	50.9	768	\$ 25.47
15	0	0	\$ 52,784.60	105569.2	115.7	1745	\$ 57.85
15	0	0	\$ 22,784.60	45569.2	49.9	753	\$ 24.97
5	3	20	\$ 51,080.72	102161.4	112.0	1689	\$ 55.98
5	3	20	\$ 21,080.72	42161.4	46.2	697	\$ 23.10
5	0	0	\$ 50,928.20	101856.4	111.6	1684	\$ 55.81
5	0	0	\$ 20,928.20	41856.4	45.9	692	\$ 22.94

Table 5. Recycling at a Rate of \$0.50 per Pound

The cost for shipping at \$0.15 is the same as the cost for \$0.50. The cost is \$24.97 per day when using Mohawk's truck and buying the recycling bins from online. The most significant

change is the number of plastic bottles LakePoint will need to produce. Instead of the number of bottles being 2,593 per day, it is now only 753 bottles per day.

7.6 Current Recycling Rate

Right now, LakePoint is selling plastic at a rate of 11,476 pounds of plastic per year. The calculation for the weight of plastic per year is done by using LakePoint’s sales data for the last year. Shown in Table 6 below is the quantity of each type of plastic, the weight, and the total weight of them all. Shown in Figures 10, 11, and 12 are the weights of each main three plastic sellers at LakePoint.

<u>Products</u>	<u>Total Quantity</u>	<u>Weight (grams)</u>	
Fruit Cup	1,236	27	
Veggie Cup	17	27	
Bottled Soda	46,239	26	
Core power	1,407	27	
Gold Peak Tea	2,496	27	
Milk - YUP	27	27	
Orange Juice	784	27	
Powerade	49,336	38	
Vitamin Water	48	27	
Water - Dasani	71,514	25	
Total Bottles:	171,851	Total Grams:	5,027,327
Other plastic:	1,253		
Total Plastic items per year	173,104	Total pounds (lbs)	11,476

Table 6. Current Amount of Plastic Sold at LakePoint

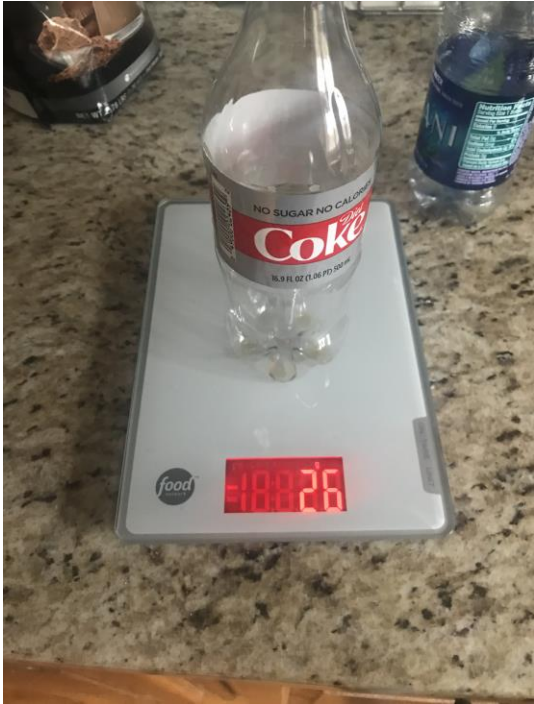


Figure 10. Soda Bottle Weight



Figure 11. Water (Dasani) Bottle Weight



Figure 12. Powerade Bottle Weight

Table 6 simply shows the amount of plastic that was sold at LakePoint and not the amount recycled. In order to determine the amount of plastic recycled, the project team collected data over the course of two weeks and compared the results to the amount of plastic sold. Shown below in Table 7 is the amount of plastic collected at LakePoint over the course of two weeks.

Type	Soccer			Baseball				Indoor					
Original Can #	1 to 4	5 to 8	9 to 12	13 to 16	17 to 20	21 to 24	25 to 28	29 to 32	33 to 36	37 to 38			
Proposed Can	1	2	3	4	5	6	7	8	9	10	Total Lbs	Legend	
Days												Total lbs over two weeks	
3/24/2018	4	4.1	3.8	3.5	3.8	3.8	4	6.3	5.8	4.2	43.3		Average lbs for each day
3/25/2018	3.7	3.9	4.3	3.5	3.4	3.7	3.6	6.6	5.7	4.1	42.5		Highest amount per day
3/26/2018	2.8	2.4	2.5	2.5	2.9	2.5	2.8	2.1	2.9	3.1	26.5		Lowest Amount per day
3/27/2018	2.4	2.4	2.1	2	2.3	2.7	2.6	2.4	2.8	3	24.7		
3/28/2018	2.8	2.4	2.4	2.5	2	2.3	2.8	2.1	2.2	3.3	24.8		
3/29/2018	2	2.8	2.8	2.7	2.9	3.1	3.2	2.8	3.1	2.5	27.9		
3/30/2018	3.1	3.1	3.1	3.1	3	3.6	3.8	3.1	2.5	2.8	31.2		
3/31/2018	3.5	4.5	5	5	5.2	5.6	5.5	4.8	3.5	3.8	46.4		
4/1/2018	4.1	4.8	4.2	4.9	4.3	4.8	5.9	5.3	3.6	3.4	45.3		
4/2/2018	2.5	2.4	2.3	2.4	2.4	2.5	2.1	3.2	2	3	24.8		
4/3/2018	2.1	2.8	2.9	2.8	2.8	2.6	2.2	3.6	2.5	2.1	26.4		
4/4/2018	2.9	2.1	2.9	2.2	1.9	3.1	2.9	2.3	2.4	2.3	25		
4/5/2018	2.3	2.4	2.5	3	3	3.1	2	2.6	2.5	2.4	25.8		
4/6/2018	2.5	2.8	2.3	2.8	2.6	2.8	2.5	3.3	3	2.5	27.1		
Total	40.7	42.9	43.1	42.9	42.5	46.2	45.9	50.5	44.5	42.5	441.7		
Average	2.91	3.06	3.08	3.06	3.04	3.30	3.28	3.61	3.18	3.04	31.55		

Table 7. Recycling at LakePoint

There are 38 recycling bins that the project team took data from. Each is put in a cluster of 2 to 4 recycling bins to create 10 recycling bins. One is for the soccer field, 6 for the baseball field, and 3 for the indoor facility. On March 24 and 25th, there was a basketball tournament at the indoor facility and there is an increase in the amount of plastic recycled during those days. The following weekend, there was a baseball tournament on March 31st and April 1st, which makes sense why there is an increase in recycling at those cans. As shown below, LakePoint sells 31.44 pounds of plastic per day. In the table above, the average amount of plastic recycled per day is 31.55 pounds per day. The project team assumed that the recycling rate is 100% at LakePoint. The project team is not assuming that all plastic sold at LakePoint is recycled, but the project team assumed that people bring in plastic and recycle it to keep the rate at 100%.

Now, with the amount of plastic sold per year, it is important to calculate the profit from recycling at a rate of \$0.15 per pound or \$0.50. Shown below in Table 8 is cost of buying plastic at a rate of \$0.15 per pound.

Total Bottles Sold	Weight(grams)	Total Weight in Bottles(grams)	
6015	27	162405	Other Bottles
46239	26	1202214	Soda
49336	38	1874768	Powerade
71514	25	1787850	Water
173104		5027237	Total bottles (grams)
		29.04171481	grams/bottle
		0.0663	lbs/bottle
		11476.7952	Total lbs plastic per year
		31.44327452	Lbs plastic per day
		\$ 4.72	Revenue of Plastic Per Day
		Feasible if Cost per Day is less than \$4.72	
			Profit Over 2.5 Years
			\$ 18,478.13

Calculations done at buying plastic at \$0.15 per pound and at the expected capacity now.

Table 8. Cost at \$0.15 per Pound at Current Capacity

There is a loss of \$18,478.13 over the course of 2.5 years. The profit is calculated by using the revenue of plastic per day, \$4.72 and subtracting the cost per day, \$24.97, and multiplying by 365 days per year and then multiplying by 2.5 years.

If Mohawk is forced to buy plastic pellets, then they will be able to calculate the cost by using the plastic at a rate of \$0.50 per pound. Shown below in Table 9 is the cost of buying plastic at a rate of \$0.50 per pound.

Total Bottles Sold	Weight(grams)	Total Weight in Bottles(grams)	
6015	27	162405	Other Bottles
46239	26	1202214	Soda
49336	38	1874768	Powerade
71514	25	1787850	Water
173104		5027237	total bottles
		29.04171481	grams/bottle
		0.0663	lbs/bottle
		11476.7952	Total lbs plastic per year
		31.44327452	Lbs plastic per day
		\$ 15.72	Revenue of Plastic Per Day
		Feasible if Cost per Day is less than \$15.72	
			Profit Over 2.5 Years
			\$ 8,440.63

Calculations done at buying plastic at \$0.50 per pound and at the expected capacity now.

Table 9. Cost at \$0.50 per Pound at Current Capacity

There is a loss of \$8,440.63 over the course of 2.5 years. The profit is calculated by using the revenue of plastic per day, \$4.72, and subtracting the cost per day, \$15.72, and multiplying by 365 days per year and then multiplying by 2.5 years.

7.7 Future Recycling Rate

Currently, LakePoint is selling plastic at a rate of 11,476 pounds of plastic per year. The calculation for the weight of plastic per year is done by using LakePoint’s sales data for the last year. LakePoint is a relatively new facility, and management had a feasibility study done that predicts that LakePoint will grow five times as large in five years. Using this, it is possible to predict the amount of plastic that will be recycled using five times the number of visitors. Shown in Table 10 is the quantity of each type of plastic, the weight, and the total weight of them all.

Products	Total Quantity	Weight (grams)	
Fruit Cup	6,180	27	
Veggie Cup	85	27	
Bottled Soda	231,195	26	
Core power	7,035	27	
Gold Peak Tea	12,480	27	
Milk - YUP	135	27	
Orange Juice	3,920	27	
Powerade	246,680	38	
Vitamin Water	240	27	
Water - Dasani	357,570	25	
Total Bottles:	859,255	Total Grams:	25,136,635
Other plastic:	6,265		
Total Plastic items per year	865,520	Total pounds (lbs)	57,384

Table 10. Future Amount of Plastic Sold at LakePoint

With the expected amount of plastic sold per year, it is important to calculate the profit from recycling at a rate of \$0.15 per pound or \$0.50 per pound. Shown below in Table 11 is the cost of buying plastic at a rate of \$0.15 per pound in the future.

Expected Total Bottles Sold	Weight(Grams)	Total Weight in Bottles(grams)	
30075	27	812025	Other Bottles
231195	26	6011070	Soda
246680	38	9373840	Powerade
357570	25	8939250	Water
865520		25136185	Total bottles (grams)
		29.04171481	grams/bottle
		0.0663	lbs/bottle
		57383.976	Total lbs plastic per year
		157.2163726	Lbs plastic per day
		\$ 23.58	Revenue of Plastic Per Day
		Feasible if Cost per Day is less than \$23.58	
			Profit Over 2.5 Years
			\$ 1,268.38

Calculations done at buying plastic at \$0.15 per pound and at the expected capacity 5 years from now.

Table 11. Cost at \$0.15 per Pound at Future Capacity

There is a loss of \$1,268.38 over the course of 2.5 years. The profit is calculated by using the revenue of plastic per day, \$23.58, and subtracting the cost per day, \$24.97, and multiplying by 365 days per year and multiplying by 2.5 years.

If Mohawk is forced to buy plastic pellets, they will be able to calculate the cost by using the plastic at a rate of \$0.50 per pound. Shown below in Table 12 is the cost of buying plastic a rate of \$0.50 per pound in the future.

Expected Total Bottles Sold	Weight(grams)	Total Weight in Bottles(grams)	
30075	27	812025	Other Bottles
231195	26	6011070	Soda
246680	38	9373840	Powerade
357570	25	8939250	Water
865520		25136185	Total bottles (grams)
		29.04171481	grams/bottle
		0.0663	lbs/bottle
		57383.976	Total lbs plastic per year
		157.2163726	Lbs plastic per day
		\$ 78.61	Revenue of Plastic Per Day
		Feasible if Cost per Day is less than \$78.61	
			Profit Over 2.5 Years
			\$ 49,037.75

Calculations done at buying plastic at \$0.50 per pound and at the expected capacity 5 years from now.

Table 12. Cost at \$0.50 per Pound at Future Capacity

There is a profit of \$49,037.75 over the course of 2.5 years. The profit is calculated by using the revenue of plastic per day, \$23.58, and subtracting the cost per day, \$24.97, and multiplying by 365 days per year and then multiplying by 2.5 years. This is the only feasible method for collecting plastic from LakePoint.

8. Results and Discussions

8.1 Results

From the results of the data collected and logistics calculated, the project is not feasible at this time. The goal of beating \$0.15 per pound or \$0.50 per pound was not achieved. This does not mean that it will always be unfeasible. According to the LakePoint feasibility study, the team believes LakePoint’s annual patron numbers will grow five times as large in the next five years. This will make it feasible to begin the recycling program at LakePoint and beat the goal of \$0.50 per pound. The profit will be \$48,945.37 over 2.5 years. As of now, the variable cost of the program is relatively not expensive. The biggest cost of the program is the starting cost of the 10 recycling compactors. If there is a way to find a cheaper recycling compactor it will be possible to make a profit at LakePoint. Shown below in Table 13 is the cost of the recycling cans needed in order to support each alternative for LakePoint. The calculations were done using Microsoft Excel goal seeker. The value calculated in green is the cost needed for each recycling can if the project is to break even to the current value that Mohawk buys plastic at. This calculation was done by multiplying the cost of recycling cans by the number of recycling cans, then adding this cost to the shipping cost per mile, times the number of miles, and multiplied by the number of times recycling is collected from LakePoint over 2.5 years. This was all then divided by 913 days, the number of days in 2.5 years. The revenue per day was used from the corresponding calculations done in Tables 8, 9, 11, and 12. If Mohawk plans to beat the original goal of \$0.15/lb at current capacity, they cannot spend more than \$152.5 dollars per recycling can.

Goal Seek for # of Recycling Cans at \$0.15/lb at Current Capacity							
Cost of Recycling Cans	# of Recycling Cans	Shipping Cost/Mile	Miles	# Times in 2.5 Years	# Days	Revenue per Day	
152.476	10	1.7	109.2	15	913	4.72	
Goal Seek for # of Recycling Cans at \$0.50/lb at Current Capacity							
Cost of Recycling Cans	# of Recycling Cans	Shipping Cost/Mile	Miles	# Times in 2.5 Years	# Days	Revenue per Day	
1156.776	10	1.7	109.2	15	913	15.72	
Goal Seek for # of Recycling Cans at \$0.15/lb at Future Capacity							
Cost of Recycling Cans	# of Recycling Cans	Shipping Cost/Mile	Miles	# Times in 2.5 Years	# Days	Revenue per Day	
1874.394	10	1.7	109.2	15	913	23.58	
Goal Seek for # of Recycling Cans at \$0.50/lb at Future Capacity							
Cost of Recycling Cans	# of Recycling Cans	Shipping Cost/Mile	Miles	# Times in 2.5 Years	# Days	Revenue per Day	
6898.633	10	1.7	109.2	15	913	78.61	

Table 13. Cost of Recycling Cans Needed

8.2 Future Projects

While it might not be feasible at LakePoint at this time, there are other facilities in the Atlanta Area for Mohawk to consider. [8] One that might be feasible is the new Mercedes Benz Stadium. Mercedes Benz is the new stadium for the Atlanta Falcons football team and [9] Atlanta United Soccer team. [10] Between the two teams, and not including all other events at the stadium, there is over 1,462,305 people who visit the Stadium during their two seasons. There are little statistics about the Mercedes Benz Stadium since it is a relatively new stadium, but it is possible to look at data from other stadiums that also recycle. [11] One stadium that has

good information is the Qualcomm Stadium for the San Diego Chargers football team and their college team. They collect 30,738 pounds of plastic per year, with 490,000 people visiting the stadium each year. By taking the plastic per year and dividing it from the number of spectators, the plastic per spectator is .0627 pounds. This is the average weight of a plastic bottle. By using this average weight per spectator and applying it to Mercedes Benz, one could expect Mercedes to recycle over 91,731 pounds of plastic per year. Using the same data formulas and methods from before, Mohawk will be able to calculate the number of compactors needed and the cost for shipping the plastic. Shown in Table 14 is the calculations for the Mercedes Benz Stadium.

Qualcomm Stadium	Avg People	# Games	Total
Chargers	50000	8	400000
College	15000	6	90000
			490000
Plastic per year (lbs)	30,738		
Plastic per spectator (lbs)	0.06273061		
Mercedes Benz	avg people	# games	Total
Falcons	71960	8	575680
Atlanta United	886,625	1	886625
			1462305
Mercedes/Qualcomm			
			2.984295918
Suggested lbs of plastic per year at Mercedes			
			91731.28794

Table 14. Pounds of Plastic at Mercedes Benz Stadium

9. Conclusion

Mohawk Industries request for a senior design project that focused on the feasibility of implementing a compactor/baler program proved to be a challenge. The senior design team faced complications through much of the project with obtaining material, correct information, and struggling with communications between management at both LakePoint and Mohawk. After a full semester of working on the project, the team was able to analyze the possibilities of implementing a compactor/baler program at LakePoint Sports Community. The additions of compactor/baler recycling bins across the entire facility would allow Mohawk Industries to source recycled PET plastic bottles directly from consumers. This would streamline and simplify the collection process at LakePoint Sports Community and provide a cheaper alternative for Mohawk Industries Recycling Center. However, in justifying the cost of numerous automated compactor/balers through the outdoor and indoor facility, the senior design team found the implementation infeasible at LakePoint Sports Community's current population of visitors. The team finalized the project by making suggestions for other locations to implement the compactor/baler program.

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Appendix A: Acknowledgements

Below is a list of employees from both Mohawk Industries and LakePoint Sport. All the employees were helpful in every way needed. A special thanks to every employee listed below for the help provided to make this project educational and successful.

Jonathan Skelley - Mohawk Industries, Sr. Research and Development Engineer

Chris Behrends - Mohawk Industries, Sr. Director of Manufacturing

Chris Cook - Mohawk Industries, Sr. Manager of Robotics, Automation and Analytics

Leslie McMillan - LakePoint Sports Community, General Manager

The senior design team would also like to thank the faculty and staff at Kennesaw State University and our families and friends for their support and encouragement throughout this project and our time at Kennesaw State University.

Appendix B: Contact Information

Listed below is contact information. Please contact any member for questions about the study.

Brody Cook

Email: brody.cook@windstream.net

Mobile Phone: (706)581-2794

Parker Cook

Email: parker.cook@windstream.net

Mobile Phone: (706)581-4531

Chris Yeager

Email: chrisyeager37@gmail.com

Mobile Phone: (678)602-3550

Appendix C: Reflections

Throughout the feasibility study, many challenges were studied to overcome with adequate solutions. The project has been filled with learning experiences from communication with different organizations to exploring innovated solutions. To fully study and satisfy the project requirements, communication had to begin with two different organizations to help meet common goals. The project consisted of explaining how and why our team members could successfully study different solutions and possibly bring a healthy savings to both organizations. Other challenges consisted of exploring logistics and process flow alternatives. Many different companies were compared to find an optimal cost to transport the recycled materials. Also, different innovative ideas were discussed to provide the best suggestion for collecting, storing and compacting recycled PET.

Appendix D: Contributions

Contributions for each chapter are shown below. Each chapter was a team effort but was focused mostly on the team member(s) shown.

- Chapter 1: Parker
- Chapter 2: Chris and Parker
- Chapter 3: Brody and Chris
- Chapter 4: Brody and Parker
- Chapter 5: Brody
- Chapter 6: Brody
- Chapter 7: Chris
- Chapter 8: Chris
- Chapter 9: Parker
- Chapter 10: Parker, Brody, and Chris

The technical contributions are shown below.

Brody Cook	Brody was the Project Manager and in charge of managing the entire project. He was in charge of making sure that the project was on pace and determined what pace the team needed. He was the design team's main contact with Mohawk Industries and determined how they wanted the project to be done. Brody did the most research on the current and future state of the project.
Parker Cook	Parker was in charge of making sure the design team was meeting the goals for the cost benefit analysis. He was able to look at the cost of the program and the benefit and was able to write a conclusion, results and executive summary.
Chris Yeager	Chris was in charge of the logistics, which included the shipping prices of the different alternatives looked at. The costs were then calculated by him to see if the design team was able to make a profit on the program. He also looked for future projects and for areas where Mohawk might be able to take their talents.