

# An Analysis of Centro de Acopio de Reciclables in Ciudad del Saber, Panama

by  
**Xavier Curney**  
**Hoang (John) Do**  
**Ethan Graham**  
**Katherine Pawlak**



# **An Analysis of Centro de Acopio de Reciclables in Ciudad del Saber, Panama**

An Interactive Qualifying Project  
Submitted to the Faculty of  
WORCESTER POLYTECHNIC INSTITUTE  
in partial fulfilment of the requirements for the  
Degree of Bachelor of Science

Submitted by:  
Xavier Curney  
Hoang (John) Do  
Ethan Graham  
Katherine Pawlak

Date of Submission:  
15 October 2020

Report submitted to:

Ms. Alessa Stabile  
Fundación Ciudad del Saber

Professor James Chiarelli and Emeritus Professor Robert Kinicki  
Worcester Polytechnic Institute

# Abstract

In Ciudad del Saber, Fundación de Acción Social Panamá operates a recycling center that faces a budget deficit, inefficiencies with its operation, and an unsuccessful public education effort. Through working remotely with our sponsor, Fundación Ciudad del Saber, the team strived to uncover the problems, improve the recycling operation, and educate the visitors about the importance and correct practices of recycling. By using literature review, an online survey, four interviews, and two virtual tours, we discovered the biggest issue at the center is material contamination. Using this result and others, we proposed six recommendations about workers' training/retraining, tailored education programs, visual control usage, layout rearrangement, equipment usage, and forecasting and scheduling.

# Executive Summary

Panama is one of the fastest growing economies in the world, second fastest in the Latin America and the Caribbean region. Unfortunately, as the economy grows, so does the amount of waste generated, and many developing countries like Panama do not have the strong recycling infrastructure such as municipal recycling services to accompany this rapid generation of waste. For instance, in 2010, recycled materials were only 5 percent of the total waste collected (Ciudad del Saber, 2020). When compared to a developed country like the United States who recycled 35.2 percent of its waste in 2017, our team believes that recycling in Panama needs to be improved (U.S. Environmental Protection Agency, n.d.).

For this project, our team worked remotely from Worcester, Massachusetts with our sponsor, Fundación Ciudad del Saber (FCdS) in Panama. FCdS's main function is to manage the Ciudad del Saber (CdS) campus, a community just outside of Panama City and the Panama Canal. One of their core values is creating a sustainable future for Panama and other nations (Ciudad del Saber, n.d.).

Another company, FAS Panama (FAS), operates the recycling center in CdS, or CAR. FAS offers two recycling services at CAR: CdS on campus recyclable material collection and material drop-off for visitors. At the center, FAS employees classify collected materials and prepare them for vendors to purchase and pick-up. There are many inefficiencies with the operation of the center, and the process that visitors use to drop off their recyclables. Both of these issues contribute to the center currently having a backlog of material waiting to be classified.

Through working with Ciudad del Saber and FAS in Panama, our team strived to improve the recycling operation, and educate the visitors about the importance and correct practices of recycling. The team planned to achieve this goal by implementing four main objectives. The first objective was to gain an understanding of the waste management process at Ciudad del Saber. The team also needed to gain an understanding of how much the citizens in and near this community were actually recycling. After gaining a general understanding of recycling in Panama, the next two objectives were to recommend improvements to the waste management system already in place, and suggest new signage and education programs to improve the understanding about recycling. In this project, we considered six key stakeholder groups: FCdS Employee, CdS Resident, CdS Tenant, CAR/FAS Employee/Volunteer, Visitor to CAR, and Visitor to CdS.

To achieve the objectives of the project, the team utilized three methods. The first method was survey. The sponsor aided our survey distribution using two media: Slack workspace and FAS's social media platforms. The survey was first sent out on September 25 on Slack, and on October 5 on Instagram, and the team collected 228 responses in total. We also conducted interviews to obtain information from the FAS workers and to learn more about the specific processes of the center as told from the workers. There were two types of interviews: "Delegated" and "Direct". "Delegated" implies that an FCdS employee conducted the interview on behalf of the team, and there were three of such interviews. "Direct" implies that the team conducted a live virtual interview of two FAS workers with an FCdS employee as a translator. Thirdly, the team gathered information through virtual observations. These included taking two virtual tours of the center provided by our sponsor and watching the workers at their station while working.

With the data collected from the three methodologies, the project developed 12 findings concerning current issues at the recycling center and its operation:

1. **The current method FAS uses to measure and weigh the materials are not precise and lead to potential losses in profit.** Recyclables from on-campus collection service go through the weighing process twice at CAR: when they arrive at the center, and a second time after the employees have classified the materials. Recyclables from voluntary donations only go through the weighing process once after classification. Because of this practice, the employees assume the collected weight is the same as the classified weight recorded, which is inaccurate. This method of measurement also does not provide a record of backlogged materials at CAR, leading to insufficient data to analyze the rate of processing recyclable materials.
2. **Workers and volunteers lack formal training, retraining, and confidence for their job at the center.** Through interviews, the team learned that FAS employees and volunteers had initial training when they began working/volunteering at CAR. However, the trainers do not have formal documentations of the training process, leading to confusion and a longer time for a worker to thoroughly understand the operation. The workers also do not go through retraining, leading to lack of compliance (Finding 3) and confidence. Due to the low confidence level, the workers are hesitant to instruct the CAR visitors to separate recyclables before leaving the center, causing an increase in material contamination (Finding 8).
3. **Workers lack compliance to the assigned tasks and duties, leading to the prioritization of non-value-added tasks.** Through the interviews with our sponsor and FAS workers, we found out that while working at CAR, the employees will often disregard their current task to assist other workers with theirs, causing a disruption to their initial value-added task or leading to lower quality work. During an interview, one employee told us that he had to pause his classifying task (value-added) to help with transporting materials (non-value-added). From our literature review, we observed that the monthly operation reports of FAS have inconsistent content, look, and reporting time, delaying the analysis to improve the center. During a virtual tour of the center, the team saw that the Administrative Staff member was on the recycling floor helping the other employees. This employee is responsible for compiling the aforementioned reports. We believe that this issue is likely due to the employee not prioritizing the paperwork, which is his designated job.
4. **There are maintenance issues with the equipment causing a few tasks to require more labor or to be slowed down.** Through interviews with FAS workers and virtual observation, our team noticed that the center has a broken scale, a broken jack lift, and missing signages. The broken scale contributes to bottleneck at the weighing task. The broken jack lift forces the workers to move heavy bales and sacks by hand, leading to increased transporting time and potential injury.
5. **Workers do not use most of the equipment and choose less efficient methods to perform the same task.** In the interviews and virtual observations of the center, the team

noted the under-utilization of equipment. One example is the bins with wheels. The bins are deep which makes it hard and difficult for the workers to use at times. However, the lack of use of these bins leads to the physical strain on the workers to carry the materials, causing the process to take longer than necessary.

6. **There are misconceptions and a lack of knowledge about recycling practices among visitors to CAR.** Responses to survey question 3.5 - “which of these items are or are not accepted at CAR?” showed that many visitors to the center have misconceptions about materials that CAR does and/or does not accept. In fact, only 49.6 percent of the total responses were correct identifications of items that CAR does or does not accept. These misconceptions lead people to drop off non-recyclable materials at the center. In the 2019 FAS monthly report, trash made up 7.6 percent of all materials FAS collected from voluntary donations. FAS workers need to deal with these non-recyclable items by sorting them out and throwing them away, costing valuable time.
7. **FAS could further improve the layout of the recycling center in terms of workstation arrangement and visual control.** Currently, the floor layout of CAR is illogical, as consecutive tasks require the workers to travel a long distance. This long distance leads to an increase in processing time. Additionally, the workers do not follow the floor markings that divide the storage space and the walkway. This lack of compliance leads to material overflowing into the walkway, increasing the time a worker spends to move across the center. Moreover, the transporting task becomes unnecessarily straining for the workers, as they have to move heavy materials (up to 250kg) across the entire center.
8. **Materials contamination is a significant issue of the recycling process.** From the interviews, we learned that there are two types of recyclable contamination: recyclables mixed with non-recyclables, and recyclable mixed with different types of recyclable. Contamination not only slows down the recycling process by increasing the need for sorting, but it also is a major health concern for the workers.
9. **The monetary value of the processed materials is important information for the fiscal health of CAR.** A big issue with the center is that the materials that CAR received the most by weight tend to be low-value. For example, plastic is one of the most popular items that the center receives. This turns out to be a burden however, since it takes a long time to classify and has a low resale price. Without having to focus on materials with lesser value, FAS would be able to spend time on materials that generate more of a profit, thus leading to better fiscal health.
10. **The two main sources of the materials, voluntary donations and on campus pick-up, lead to a difference in the amount of specific materials collected, affecting the revenue of the center.** Through analyzing the 2019 reports, we learned that the CdS tenants donated lots of paper to FAS’s on campus collection program, as compared to voluntary

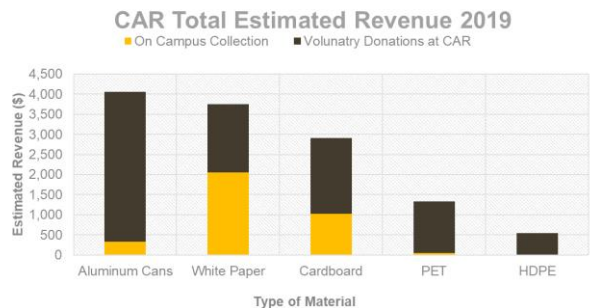


Figure 1: Chart comparing the total estimated revenue from materials collected at CAR in 2019

donations that comprised a great amount of plastics. Based on **Figure 1**, paper yields almost double the revenue compared to sales of PET and HDPE plastics combined. Thus, FAS should encourage more paper donations than plastic donations.

11. **There is a lack of defined tasks and schedules at CAR which causes disruption in the process.** There are several inefficiencies in terms of scheduling. The first is that employees classify materials based on the volume of material at a certain time. A schedule would organize the classifying process so that no material backlogs too much. Another issue at the center is the incompleteness of tasks. In some cases, workers would start working on a task, then move onto a different task before completing the first one. This leads to a longer time for any material to go through the whole process.

12. **The processes for different materials have uneven flow rates, causing bottlenecks in the operation.** The issue arises from the decision the employees have to make between prioritizing high-value materials (such as paper) and prioritizing high-volume materials (such as plastic). When the employees prioritize high-value materials, they are unable to process high-volume materials, leading to the existence of backlog. For examples, there were 4803kg of backlogged materials in May 2019. However, if they prioritize plastic, one of the high-volume materials, the recycling process of high-value materials would take longer before FAS can sell the materials to earn revenue.



Figure 2: Overfilled cages showing the backlog materials over time at CAR

With the 12 findings, the team made a set of six major recommendations that align with our goal of improving the efficiency of CAR.

1. **The team recommends that FAS implement formal training and retraining of employees and volunteers** to increase compliance and empower workers. Specifically, we suggest that FAS documents the training, and have fellow FAS workers, rather than the supervisor, train new employees. This would educate workers on their tasks in the center, and encourage workers to comply to their role, reducing distraction or interruption during the workday. FAS should also retrain their workers for specific tasks and difficult topics twice a year in order to give workers the confidence to speak to visitors who do not know how to sort or are confused. Our team also concluded that FAS should use an anonymous feedback form for FAS workers to develop a habit of providing feedback to their supervisors.
2. **The team recommends that FAS utilize a tailored education program** to bridge the knowledge gaps and increase participation and source separation. Instagram posts, and signages around CAR would be excellent methods of conveying information on correct recycling practices, common misconceptions about recycling, and the process that goes

on at CAR. Indeed, FAS has already started to make some of these videos for the COVID-19 reopening process at the center.

3. **The team recommends CAR maintain and improve visual control.** CAR should continue using the traffic markings for the visitors and the mobile-style signages at the drop-off area (**Figure 3**) as they are easy for visitors to understand and follow. The team also suggests the installation of new signs on the poles of the cages to mark where FAS stores each material and the remarking of designated areas on the floor to replace the faded one. We also recommend FAS to use its task board on a more consistent basis in order to ensure that all workers stay on task and organized.



*Figure 3: Current Visual Control at CAR*

4. **The team recommends CAR to rearrange the floor layout,** to minimize transporting distance and maximize space usage. Specifically, CAR should implement cellular layout for plastic storage and processing to standardize the workflow and minimize the distance for transporting plastic between the tasks. The proposed layouts also include two dedicated material entrances and one material exit to prevent material pick-up from blocking material drop-off. To help the employees with their work, we also recommended more Point-of-Use Storages so that the employees have quicker access to the necessary equipment.
5. **The team recommends that FAS maintain their equipment more regularly.** In addition to quickly identifying when a machine fails, regular maintenance would help prevent future breakdowns, which would in turn save time on repairing. There are many integral machines and tools at CAR that would be disruptive if they break down, such as the baler which increases the value of plastic and cardboard, so it would be preferable to have frequent maintenance.
6. **The team recommends the center utilize forecasting and scheduling.** Forecasting would allow the center to predict what the resale price of a certain material will be with relatively good accuracy. CAR should implement a time series method for short term forecasting and a regression model for long term forecasting, as these models would offer the most accurate results for predicting material values. Using information from the models, the center can then create a schedule for classifying materials in which they can prioritize higher value materials while also minimizing the amount of backlog.

As Ciudad del Saber is an innovative community that drives social change in Panama City and throughout the nation, the team hoped that the findings and recommendations to improve the recycling center would have a ripple effect and spark positive changes in the area of recycling and sustainability development throughout Panama.



# Authorship

| Section  | Task       | Author                 |
|--|------------|------------------------|
| Abstract                                       | Writing    | All                    |
| Executive Summary                              | Writing    | All                    |
|  | Editing    | All                    |
| Acknowledgements                               | Writing    | Ethan                  |
|  | Editing    | Katherine              |
| Table of Contents                              | Writing    | All                    |
| List of Figures                                | Writing    | All                    |
| Acronyms                                       | Writing    | All                    |
| 1. Introduction                                | Writing    | All                    |
|  | Editing    | All                    |
| 2.1. Recycling                                 | Writing    | Katherine              |
|  | Editing 1  | John                   |
| 2.2. Waste Management and Recycling in Panama  | Writing    | John                   |
|  | Editing 1  | Ethan                  |
| 2.3. Environmental Education                   | Writing    | Ethan                  |
|  | Editing 1  | John                   |
| 2.4. Workforce in Recycling                    | Writing    | John                   |
|  | Re-writing | Xavier                 |
| 2.5. Ciudad del Saber and Sustainability       | Writing    | Xavier, Katherine      |
|  | Editing 1  | John, Ethan            |
| 2.6. FAS Panamá and the Recycling Center (CAR) | Writing    | Katherine              |
|  | Editing 1  | John                   |
| 2.7. COVID-19 Updates                          | Writing    | Ethan, Katherine, John |
|  | Editing 1  | Ethan, Katherine       |
| 2.8. Quality Management and Lean Systems       | Writing    | John                   |
|  | Editing 1  | Katherine              |
| 2.9. Stakeholders                              | Writing    | Katherine              |
|  | Editing 1  | Xavier                 |
| 3.1. Overview                                  | Writing    | Ethan                  |
|  | Editing    | All                    |
| 3.2 Survey                                     | Writing    | Katherine              |
|  | Editing    | John                   |
| 3.3 Interview                                  | Writing    | Xavier                 |
|  | Editing    | Katherine, John        |
| 3.4 Virtual Observation                        | Writing    | John                   |
|  | Editing    | Katherine              |

|                                   |         |                  |
|-----------------------------------|---------|------------------|
| 3.5 Summary of Methodology        | Writing | Ethan            |
|                                   | Editing | All              |
| 4 Results and Analysis            | Writing | All              |
|                                   | Editing | All              |
| 4.1 Measurement Finding 1         | Writing | Xavier           |
|                                   | Editing | Katherine, John  |
| 4.2. Personnel Finding 2          | Writing | John             |
|                                   | Editing | All              |
| 4.2. Personnel Finding 3          | Writing | Xavier           |
|                                   | Editing | Katherine, John  |
| 4.3. Machines Finding 4           | Writing | Katherine        |
|                                   | Editing | All              |
| 4.3. Machines Finding 5           | Writing | Ethan            |
|                                   | Editing | All              |
| 4.4. Environment Finding 6        | Writing | Katherine        |
|                                   | Editing | All              |
| 4.4. Environment Finding 7        | Writing | John             |
|                                   | Editing | Xavier           |
| 4.5. Material Finding 8           | Writing | Xavier           |
|                                   | Editing | Katherine, John  |
| 4.5. Material Finding 9           | Writing | Ethan            |
|                                   | Editing | John             |
| 4.5. Material Finding 10          | Writing | Katherine        |
|                                   | Editing | All              |
| 4.6. Methods Finding 11           | Writing | Katherine, Ethan |
|                                   | Editing | John             |
| 4.6. Methods Finding 12           | Writing | John             |
|                                   | Editing | Xavier           |
| 5 Conclusions and Recommendations | Writing | All              |
|                                   | Editing | All              |
| 5.1 Summary of Results            | Writing | John             |

|  |         |                  |
|--|---------|------------------|
|  | Editing | Katherine        |
| 5.2 Recommendations                    | Writing | Xavier           |
|  | Editing | All              |
| 5.2.1                                  | Writing | Katherine        |
|  | Editing | John, Katherine  |
| 5.2.2                                  | Writing | Katherine        |
|  | Editing | Ethan, Xavier    |
| 5.2.3                                  | Writing | John             |
|  | Editing | All              |
| 5.2.4                                  | Writing | John             |
|  | Editing | Katherine, Ethan |
| 5.2.5                                  | Writing | Xavier           |
|  | Editing | John             |
| 5.2.6                                  | Writing | Ethan            |
|  | Editing | All              |
| 5.2.7                                  | Writing | John             |
|  | Editing | All              |
| 5.3 Recommendations of Future Projects | Writing | John, Katherine  |
|  | Editing | Ethan, Xavier    |
| Bibliography                           | Writing | Katherine, Ethan |
|  | Editing | Xavier, John     |
| Appendix                               | Writing | Ethan, John      |
|  | Editing | All              |

# Acknowledgements

Our team would like to collectively thank our sponsor, Alessa Stabile, for her support and perseverance while we worked on our project virtually. Her virtual tours and translation assistance during interviews and on the survey were pivotal during the methodology phase of our project. Her adaptiveness to the project becoming virtual was instrumental in the overall success of the project. Our team would also like to thank Mabely Cedeño and Lúa Delgado for providing the team with the previous year's CAM reports and other information essential to the project. Also, a special thank you to Mabely for orchestrating the interviews for the team. Along those lines, the team would like to acknowledge the workers who took the time out of their days to answer the interview questions. Also thank you to the FAS Director for posting the team's survey on their Instagram Page. It was responsible for over 220 responses to the survey. Finally, the team would like to thank Professor Robert Kinicki and Professor James Chiarelli for being our advisors throughout the project. It is in no small part due to their continued hard work and dedication that our team was able to successfully complete this project.

# Table of Contents

|  |       |
|--|-------|
| <b>Abstract</b> .....                                      | iii   |
| <b>Executive Summary</b> .....                             | iv    |
| <b>Authorship</b> .....                                    | ix    |
| <b>Acknowledgements</b> .....                              | xii   |
| <b>Table of Contents</b> .....                             | xiii  |
| <b>List of Figures</b> .....                               | xvi   |
| <b>List of Tables</b> .....                                | xviii |
| <b>Acronyms</b> .....                                      | xix   |
| <b>1. Introduction</b> .....                               | 1     |
| <b>2. Background</b> .....                                 | 4     |
| <b>2.1. Recycling</b> .....                                | 4     |
| <b>2.2. Waste Management and Recycling in Panama</b> ..... | 6     |
| <b>2.3. Environmental Education</b> .....                  | 7     |
| <b>2.4. Workforce in Recycling</b> .....                   | 9     |
| <b>2.5. Ciudad del Saber and Sustainability</b> .....      | 10    |
| <b>2.6 FAS Panamá and the Recycling Center (CAR)</b> ..... | 12    |
| <b>2.7 COVID-19 Updates</b> .....                          | 17    |
| <b>2.8. Quality Management and Lean Systems</b> .....      | 18    |
| <b>2.8.1. Swimlane Chart</b> .....                         | 20    |
| <b>2.8.2. Fishbone Diagram</b> .....                       | 21    |
| <b>2.9. Stakeholders</b> .....                             | 23    |
| <b>3. Methodology</b> .....                                | 24    |
| <b>3.1. Overview</b> .....                                 | 24    |
| <b>3.2. Surveys</b> .....                                  | 25    |
| <b>3.3. Interview</b> .....                                | 28    |
| <b>3.4. Virtual Observation</b> .....                      | 30    |
| <b>3.5. Summary of Methodology</b> .....                   | 32    |
| <b>4. Results and Analysis</b> .....                       | 33    |
| <b>4.1. Measurement</b> .....                              | 34    |

|   |    |
|---|----|
| <b>Finding 1: The current methods used to measure and weigh the materials are not precise and lead to potential losses in profit.</b> .....                             | 34 |
| <b>4.2. Personnel</b> .....   | 35 |
| <b>Finding 2: Workers and volunteers lack formal training, retraining, and confidence for their job at the center.</b> .....  | 35 |
| <b>Finding 3: Workers lack compliance to the assigned tasks and duties, leading to the prioritization of non-value-added tasks.</b> .....                               | 37 |
| <b>4.3. Equipment</b> .....   | 39 |
| <b>Finding 4: There are maintenance issues with the equipment causing a few tasks to require more labor or to be slowed down.</b> .....                                 | 39 |
| <b>Finding 5: Workers do not use most of the equipment and choose less efficient methods to perform the same task.</b> .....  | 41 |
| <b>4.4. Environment</b> .....   | 43 |
| <b>Finding 6: There are misconceptions and a lack of knowledge about recycling practices among visitors to CAR.</b> .....   | 43 |
| <b>Finding 7: FAS could further improve the layout of the recycling center in terms of workstation arrangement and visual control.</b> .....                            | 44 |
| <b>4.5. Material</b> .....  | 49 |
| <b>Finding 8: Materials contamination is a significant issue of the recycling process</b> .....   | 49 |
| <b>Finding 9: The monetary value of the processed materials is important information for the fiscal health of CAR.</b> .....  | 50 |
| <b>Finding 10: The two main sources of the materials lead to a difference in the amount of specific materials collected, affecting the revenue of the center.</b> ..... | 52 |
| <b>4.6. Methods</b> .....   | 54 |
| <b>Finding 11: There is a lack of defined tasks and schedules at CAR which causes disruption in the process.</b> .....  | 54 |
| <b>Finding 12: The processes for different materials have uneven flow rates, causing bottlenecks in the operation.</b> .....  | 55 |
| <b>4.7. Results and Analysis Summary</b> .....  | 60 |
| <b>5. Conclusions and Recommendations</b> .....   | 61 |
| <b>5.1. Summary of Results</b> .....  | 61 |
| <b>5.2. Recommendations</b> .....   | 62 |
| <b>5.2.1. Implement formal training and retraining of employees and volunteers</b> .....  | 62 |
| <b>5.2.2. Utilize a tailored education program</b> .....  | 64 |
| <b>5.2.3. Maintain and improve visual control at CAR</b> .....  | 68 |
| <b>5.2.4. Rearrange the floor layout</b> .....  | 74 |

|  |     |
|--|-----|
| 5.2.5. Maintain and increase usage of equipment.....         | 77  |
| 5.2.6. Implement forecasting and scheduling.....             | 77  |
| 5.2.7. Ranking of Recommendations .....                      | 79  |
| 5.3. Recommendations for Future Projects .....               | 80  |
| Bibliography .....   | 81  |
| Appendices.....  | 85  |
| Appendix A: Survey-related Materials.....                    | 85  |
| A1: Official Survey .....                                    | 85  |
| A2: Instagram Graphics for Survey Distribution .....         | 94  |
| A3: A Message for Survey Distribution via Slack.....         | 95  |
| Appendix B: Delegated Interview Materials .....              | 96  |
| B1: Delegated Interview Protocol .....                       | 96  |
| B2: Delegated Interview Note 1 .....                         | 98  |
| B3: Delegated Interview Note 2 .....                         | 101 |
| B4: Delegated Interview Note 3 .....                         | 104 |
| Appendix C: Direct Interview and Observation Materials ..... | 107 |
| C1: Direct Interview Questions.....                          | 107 |
| C2: Color Code .....   | 108 |
| C3: Coded Katherine’s Note (September 17).....               | 109 |
| C4: Coded John’s Note (September 17).....                    | 111 |
| C5: Coded Xavier’s Note (September 17).....                  | 114 |
| C6: Virtual Tour 1 Note (September 11) .....                 | 117 |
| Appendix D: Cause-and-Effect Diagram .....                   | 119 |
| Appendix E: Proposed Layout 2 (Counter- clockwise).....      | 120 |

# List of Figures

|   |      |
|---|------|
| Figure 1: Chart comparing the total estimated revenue from materials collected at CAR in 2019 vi                                    |      |
| Figure 2: Overfilled cages showing the backlog materials over time at CAR.....vii   | vii  |
| Figure 3: Current Visual Control at CAR.....viii  | viii |
| Figure 4: Average cost per ton estimates of single stream versus dual stream recycling (Container Recycling Institute, 2009)..... 4 | 4    |
| Figure 5: Circular Economy of Recycling (Smith, 2019)..... 5  | 5    |
| Figure 6: Flowchart of the current Waste Management Model in Panama (Ineco, 2017)..... 6  | 6    |
| Figure 7: An Advertisement as part of the 'Deal with the Consequences' Campaign (van Gulp, 2011) ..... 8                            | 8    |
| Figure 8: Ciudad del Saber on the map of Panamá (Google Maps, Panama, 7 May 2020) ..... 11  | 11   |
| Figure 9: Floor Plan of CAR..... 13   | 13   |
| Figure 10: The baler (left), the sorting sacks, and the storage cages at CAR (FAS Panama, 2019) ..... 14                            | 14   |
| Figure 11: The sorting sacks (left), the sorting table (center), and the visitor parking (right) at CAR ..... 15                    | 15   |
| Figure 12: Differences in Weight Collected of Each Material from Voluntary Donations to CAR in 2019 ..... 16                        | 16   |
| Figure 13: A swimlane chart of restaurant service (Russell & Taylor, 2011) ..... 20   | 20   |
| Figure 14: A fishbone diagram for patient bed turnaround time at North Shore University Hospital (Russell & Taylor, 2011)..... 21   | 21   |
| Figure 15: Recycling at CdS Survey Flow and Organization Graphic..... 26  | 26   |
| Figure 16: FAS posted our graphic on their Instagram account to collect survey responses ..... 27                                   | 27   |
| Figure 17: A FAS employee showing the volunteers the layout of the recycling center in 2019 (FAS Panama, 2019)..... 36              | 36   |
| Figure 18: Wheeled bin for material transportation at CAR (FAS Panama, 2018)..... 41  | 41   |
| Figure 19: Unused material storage cage at CAR in September 2020 ..... 42   | 42   |
| Figure 20: Responses to survey question 3.5, “Which of these items are or are not accepted at CAR?”..... 44                         | 44   |
| Figure 21: CAR transporting paths and distances for plastic containers recycling process ..... 45                                   | 45   |
| Figure 22: Annotated Floor Plan of CAR..... 46  | 46   |
| Figure 23: Annotated photograph of how a cardboard pickup vehicle would disrupt the loop traffic flow at CAR ..... 47               | 47   |
| Figure 24: (a) Use of yellow lines in front of sorted cage 2; (b) Overfilled cage 7 and the missing yellow lines ..... 48           | 48   |
| Figure 25: Total Weight Percentages of Classified Materials from Voluntary Donations at CAR in 2019 ..... 50                        | 50   |



|  |    |
|--|----|
| Figure 26: Variation of price per kilogram for the recyclable materials resale at CAR (modified) (FAS Panama, 2020).....             | 51 |
| Figure 27: Total Weight of Classified Materials at CAR in 2019 .....   | 52 |
| Figure 28: Total Estimated Revenue at CAR in 2019 .....  | 53 |
| Figure 29: Overfilled CAR cages showing the backlog of materials over time (FAS Panama 2019).....                                    | 56 |
| Figure 30: Weights of Collected and Classified Containers (plastics, aluminum cans, TetraPak) from On-Campus Collection in 2019..... | 57 |
| Figure 31: Weight of Collected and Classified Paper and Cardboard from On-Campus Collection in 2019 .....                            | 58 |
| Figure 32: Swimlane charts that show the processes of (a) plastics and (b) battery at CAR .....                                      | 59 |
| Figure 33: Responses to survey question 5.3, “What would you specifically want to learn more about?” .....                           | 64 |
| Figure 34: Responses to survey question 6.9, “How did you hear about CAR/FAS?” .....   | 65 |
| Figure 35: (a) Sample question and (b) poll using Instagram.....   | 66 |
| Figure 36: Responses to survey question 3.3, “Who is (are) the most frequent recycler in your household?”.....                       | 67 |
| Figure 37: Traffic flow markings at CAR.....   | 68 |
| Figure 38: A large truck at CAR leaves less room for other vehicles to maneuver (FAS Panama, 2018).....                              | 69 |
| Figure 39: Mobile-style signages above the sorting sacks at CAR in September 2020 .....  | 70 |
| Figure 40: A sample sign for Cage 3 .....  | 71 |
| Figure 41: An example of a shadow board in a workplace (Superfactory, 2008) .....  | 72 |
| Figure 42: A mock-up of a visual task board for CAR.....   | 74 |
| Figure 43: Proposed Layout (clockwise).....  | 75 |

# List of Tables

Table 1: A cause-and-effect matrix to weight the causes for patient bed turnaround time at North Shore University Hospital (Russell & Taylor, 2011)..... 22

Table 2: Gantt Chart of our Project’s Methodology ..... 32

Table 3: The five standard tasks at CAR ..... 33

Table 4: The formats of Table 2 in the monthly CAR report (missing in June 2019 report): Usual format (top) and August 2019 format (bottom) ..... 38

Table 5: Cause-and-Effect Matrix for the six recommendations..... 79

# Acronyms

|       |  |
|-------|--|
| CdS:  | Ciudad del saber or City of Knowledge                          |
| CAR:  | Centro de Acopio de Reciclables or the Recycling Center in CdS |
| FAS:  | Fundación de Acción Social por Panamá                          |
| FCdS: | Fundación Ciudad del Saber                                     |
| IWC:  | Informal Waste Collector                                       |
| NVA:  | Non-Value-Added  |
| VA:   | Value-Added  |
| VSM:  | Value Stream Mapping   |
| WPI:  | Worcester Polytechnic Institute                                |

# 1. Introduction

In the modern world, waste management has become one of the main issues for many countries. Poorly managed waste leads to many problems, including contamination of the world's ocean, transmission of diseases, and a decrease in air quality. For developing countries, the matter is even more urgent due to the high rate of waste generation accompanying their fast economic growth (Kaza et al., 2018, p. 1). Indeed, Panama falls within this category.

Panama is one of the fastest growing economies in the world, second fastest in the Latin America and the Caribbean region. Inherently, one side-effect of economic growth is increased amounts of generated waste. In 2010, Panama produced on average 1.22kg of waste per inhabitant each day (Pan American Health Organization, 2010, p. 104), 95% of which ended with incineration or in a landfill. This is equivalent to only 5 percent of the waste being recycled in Panama (Ciudad del Saber, 2020). In comparison, the United States recycled or composted 35.2 percent of its waste in 2017 (U.S. Environmental Protection Agency, n.d.). Similar to many countries, it is vital for Panama's recycling programs to become more eminent and efficient in combating its rapid generation of waste.

Recycling is the process of converting waste into something new and reusable. This process reduces the amount of materials being sent to landfills and incinerators (U.S. Environmental Protection Agency, 2016). Incinerators release carbon dioxide. As items in landfills decompose, they release methane and carbon dioxide into the atmosphere (U.S. Environmental Protection Agency, n.d.). Both gases are greenhouse gases meaning they trap heat in the Earth's atmosphere and take 300 to 1000 years to break down (Buis, 2019). These gases act like insulation around the Earth and prevent heat energy from escaping the atmosphere (Union of Concerned Scientists 2009). This heat energy is causing the lower atmosphere to heat up and create negative effects such as climate change that impact human life.

One strategy for improving the waste management situation is to advance the existing recycling system in Panama. This project focuses on the operations of the recycling center in Ciudad del Saber (CdS), located just outside Panama City. To complete this project, we worked with CdS as

our sponsor, also referred to as the City of Knowledge, which is a community of students, scientists, artists, and leaders who work alongside community and government leaders, non-profit organizations, and businesses committed to sparking societal change (Ciudad del Saber, n.d.). As our direct contact with CdS, Ms. Alessa Stabile (Sustainability Manager of CdS) was the representative that provided our team with background knowledge and facilitated our data collection in Panama as we worked remotely from Worcester, Massachusetts. The team also interacted with two other FCdS employees from the same office, Ms. Lúa Delgado (Sustainability Coordinator) and Ms. Mabely Cedeño (Environmental Safety and Waste Management Specialist).

Previous WPI teams had worked with CdS on projects related to sustainability. In 2015, a WPI team investigated the possibility of a composting program in CdS in order to limit the amount of organic waste being sent to landfills. In 2018, another group produced a report on the carbon-emissions of the community to assess CdS's carbon footprint. Furthermore, this group suggested community strategies to improve its carbon emissions in the future. One of the suggestions was to improve their recycling center (Milsark, Mittleman, & Van Tronk, 2018, p. viii).

Through working with Ciudad del Saber and FAS Panamá, our team strived to improve the recycling process currently in place, as well as to educate the visitors to the recycling center about the importance and correct practices of recycling. In order to assist CdS and FAS Panamá, and gain insight on how to improve their current recycling operation, the team identified four main objectives:

- 1) Understand the current waste management process at Ciudad del Saber.
- 2) Determine the current level of understanding about recycling.
- 3) Recommend improvements to the current waste management process at Ciudad del Saber.
- 4) Propose new signage and education programs.

Our team completed this project virtually from Worcester, Massachusetts due to the COVID-19 pandemic affecting safety and travel regulations. To achieve the project objectives, our team utilized three methods: survey, interview, and virtual observation. The first method was survey.

The survey helped to explain the input of materials at the center, and what visitors understand. The sponsor aided our survey distribution using two forms of media: Slack workspace and FAS's social media platforms. The team collected 228 responses in total. We conducted interviews of the FAS workers to learn more about the specific processes inside the center, and what they think are the current issues affecting their work. Thirdly, the team gathered information through virtual observations. This included taking two virtual tours of the center and watching the workers at their stations. Virtual observation provided more evidence and data to back up the claims the team made using the first two methods.

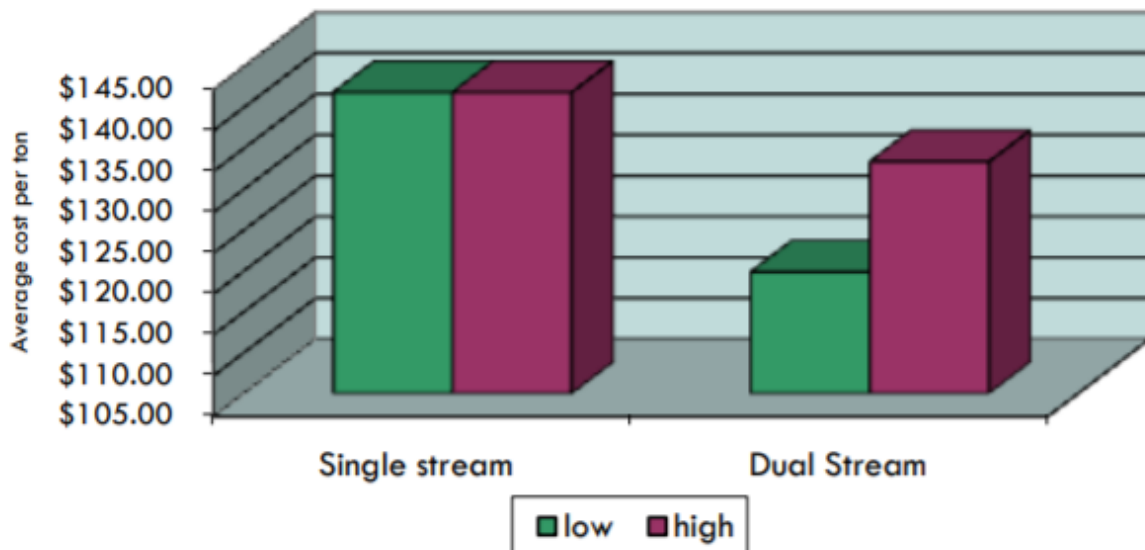
Our team produced 12 findings based on the results of our investigation of the issues identified at the center. After organizing these findings into six categories: Measurement, Personnel, Equipment, Environment, Material, and Methods, the team provided FAS and CdS with six specific recommendations to achieve the aforementioned goal. As CdS is an innovative community that drives social change in Panama City and throughout the nation, the team hoped that the findings and recommendations to improve the recycling center would have a ripple effect and spark positive changes in the area of recycling and sustainability development throughout Panama.

## 2. Background

### 2.1. Recycling

Recycling is the process of converting used materials previously thought to be waste into materials that society can reuse rather than thrown out. There are a variety of methods for collecting recyclable materials such as curbside pick-up as well as centers where people can drop off their recyclables themselves (U.S. Environmental Protection Agency, n.d.). Generally, there are two standard methods of sorting the recyclable materials into groups based on their material.

Those two methods are single stream and source separation. The single stream method allows for one single bin at the drop off point. Recycling center workers then sort this bin after collection. In contrast, source separation entails multiple bins at the source, and consumers place the items into bins based on material type. Therefore, source separation reduces the need for recycling center workers to sort recyclables. From the worker's perspective, source separation is favorable as it saves processing time and increases productivity. However, citizens view single stream recycling as favorable because it is more convenient to place all the recyclables in one bin rather than sorting them. In this case, the citizen may be more likely to recycle. However, single stream separation does have its costs (see **Figure 4**).



*Figure 4: Average cost per ton estimates of single stream versus dual stream recycling (Container Recycling Institute, 2009)*

**Figure 4** depicts the results of a study conducted by Metro Waste Paper Recovery in Ontario, Canada that “looked at the system costs of the three single-stream and four dual-stream programs” (Container Recycling Institute, 2009). The results show that single stream separation incurs a higher operating cost than dual stream separation.

Additionally, single stream separation often results in contamination of certain materials due to the mixing of other materials (Rogoff, 2014). Due to the severity of this issue, in 2018, China enacted the National Sword policy, banning the importation of most plastics and other materials to its recycling processing plants. The policy caused a global crisis as China had previously been handling nearly half of the world’s recyclable waste (Katz, 2019). On the other hand, stream separation reduces contamination, as well as maximizes revenue by organizing scrap material and limiting the cost for sorting at the facility (Rogoff, 2014).

People often describe recycling as a circular economy model (see **Figure 5**): a product is manufactured, used, reused, collected, recycled, and processed into raw material for remanufacturing. Analyzing the model, every stage is crucial for the flow of goods around the loop. However, recycling in many countries, including Panama, is not an efficient process, due to the existence of bottlenecks. In the case of Panama, the issue lies mainly in the underdeveloped collection process.



*Figure 5: Circular Economy of Recycling (Smith, 2019)*



## 2.2. Waste Management and Recycling in Panama

As a consequence of the increased economic activities and population, Panama generates a huge amount of waste. Panama City alone generated more than 36,000 metric tons of waste in January 2019 (Ineco, 2017). With the exception of medical waste, there are generally no public or government organizations separating generated waste for the four million residents living in Panama. However, several private businesses separate their waste and sell the recycled materials to reduce collection fees and to minimize environmental impact. These private businesses utilize various techniques to store their waste, such as using carnatas, or industrial-sized trash bins. Municipalities then collect the waste, using either their own means or private contractors. In many regions of Panama, waste treatment and recovery are not available post-collection. Nevertheless, recently, both the government and private organizations have made efforts to treat collected waste before the final deposition, especially in the region of Panama City. The process ends with burial at landfills or incineration.

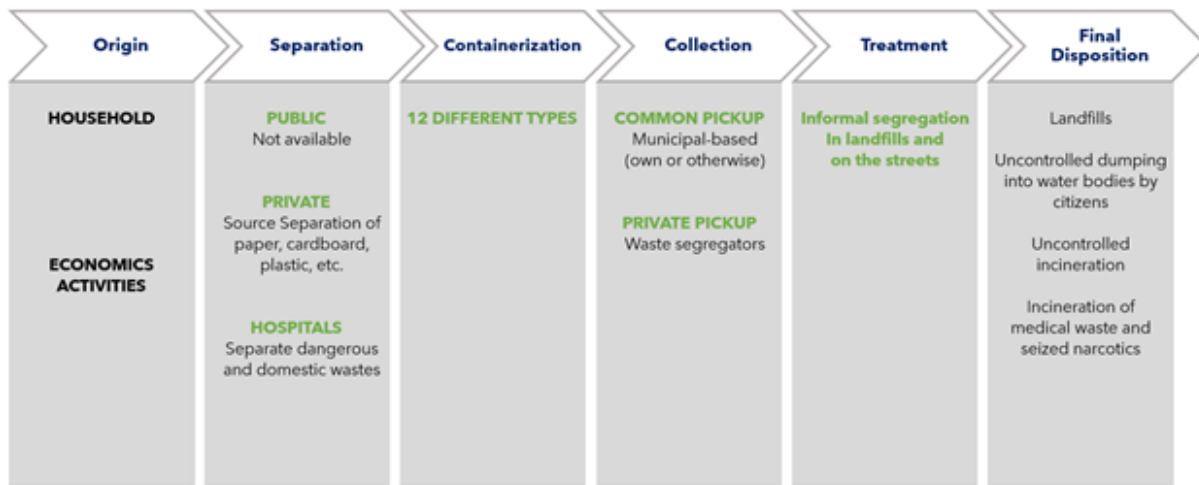


Figure 6: Flowchart of the current Waste Management Model in Panama (Ineco, 2017)

Overall, the waste management system in Panama (see **Figure 6**) is lacking in many aspects, especially in the area of separation and treatment, which are part of the collection stage in the circular economy model. Realizing these shortcomings, local authorities have initiated actions toward a green Panama, such as the launch of the Zero Waste Program and the publication of the National Plan for Integrated Waste Management (Ineco, 2017). However, due to the unequal distribution of wealth, the intensity of actions taken is uneven throughout the nation with most of

the efforts concentrated in large cities, such as Panama City and Colón. Additionally, recycling is not a main focus for the government's waste management plan, as seen through the lack of municipal recycling services and centers.

It is noteworthy that the concept of recycling is not novel to the nation. The Zero Waste Program in Panama City is an example of how the authorities are trying to raise awareness for the recycling practices by setting up recycling bins and publishing educational materials. Indeed, to effectively tackle the waste issue, additional emphasis on public education concerning recycling is crucial to cultivate a more proactive mindset and engender cultural change.

### **2.3. Environmental Education**

As mentioned above, investment in infrastructure supporting recycling is only one component of the solution set to improving waste management. Public education on the importance and processes of recycling has the significant effect of increasing participation in current recycling practices and improving the quality of recycling activities. It is important to have good facilities and materials to recycle, but it is equally as important for people to use them correctly. Through education and improving awareness of the problem, significant growth in participation of recycling will hopefully start to happen in Panama.

There are a couple of approaches and settings that could be effective in raising awareness on the recycling issue in Panama. The first would be educating young children on the topic.

Unfortunately, according to the "Global Competitiveness Report" Panama is ranked 129th in the world for Primary Education (Mattson & Teran, 2011). However, it may be possible to educate Panamanian children on recycling despite the poor education rankings. In fact, there are many tested strategies that have worked in other countries. There are a couple of approaches to incorporating recycling into the school curriculum. The first is by downloading previously created recycling plans from online. There are many lesson plans that generous people have made available free of charge for teachers to use in their classrooms. This eliminates the need for teachers to make the plans themselves and instead ensures that teachers with prior knowledge are teaching the material. Another technique is to play a recycling bingo game. Children love to play games, so it can be very effective to play a recycling-themed bingo game in which the teacher would take time to educate the children on recycling between rounds of the game (Tornio, 2018).

Additionally, there are other opportunities for children to learn and practice recycling outside of the classroom. One method involves parents taking their children to a park or beach. With animals walking and flying around, parents can educate their kids on how the trash left on the ground affects the wildlife. Another nice and simple scheme is to read bedtime stories to children. An example would be the Lorax by Doctor Seuss. There are also many other children's books on recycling that parents and teachers can use to educate kids in a fun format (Shapley, 2019).

Outside of educating just children, awareness campaigns are great for all age groups. One successful campaign, the “Deal with the Consequences” campaign in Brazil (see **Figure 7**), shows the public the damaging effects of not recycling and not taking care of the environment (2020). The campaign uses facts to support its claims which is effective when aiming at adults. Simply scaring adults into recycling will not work, however. There has to be a balance between using facts and statistics to show potential negative outcomes and words of encouragement.



*Figure 7: An Advertisement as part of the 'Deal with the Consequences' Campaign (van Gurp, 2011)*

## 2.4. Workforce in Recycling

As part of an economy, available labor is an important factor to consider for the success of any initiative. Similar to many countries, due to lack of government intervention, Panama faces the issue of a small workforce involved in recycling.

In some under-developed countries, including Panama, there exists a group of Informal Waste Collectors (or IWCs) who scavenge and salvage recyclable materials and sell them directly to sorting or recycling facilities. In these cases, the government does not tax their proceeds. On the other hand, private companies employ Formal Waste Collectors to collect their waste. When both of these groups co-exist, the number of IWCs is usually small as they earn very little income. In Oshakati, Namibia, an IWC makes US\$0.08 per hour of labor (Bennett, Chretien, Gomarlo & Hurly, 2017). Though there are no statistics available on the income of an IWC in Panama, one can assume the figure is a small number. With their income being low, only people who do not have employable skills often become IWCs. Furthermore, IWCs in Panama have to face other issues such as the ban on scavenging and the lack of access to open-air landfills in Panama (Ariel Montenegro, 2017). These measures created a scarcity of recyclable materials, preventing the IWCs from collecting additional recyclable materials to increase their income. Hence, unless the government intervenes, the small workforce in recycling will remain an issue in Panama.

Upon closer speculation, one reason for the low income is that contamination causes the majority of the recycling cost to focus on cleaning and sorting materials (Gentle, 2020). Subsequently, intermediate buyers of recyclables cannot afford to pay much to the sellers. The current solution for the middle-man centers is to recruit volunteers and seek 'free' labor. In Panama, EcoSólidos embarked on a project through partnering with a local penitentiary center and the International Committee of the Red Cross to fuse "the activity of recycling, re-socialization and the reinsertion of inmates" (Ciudad del Saber, 2019).

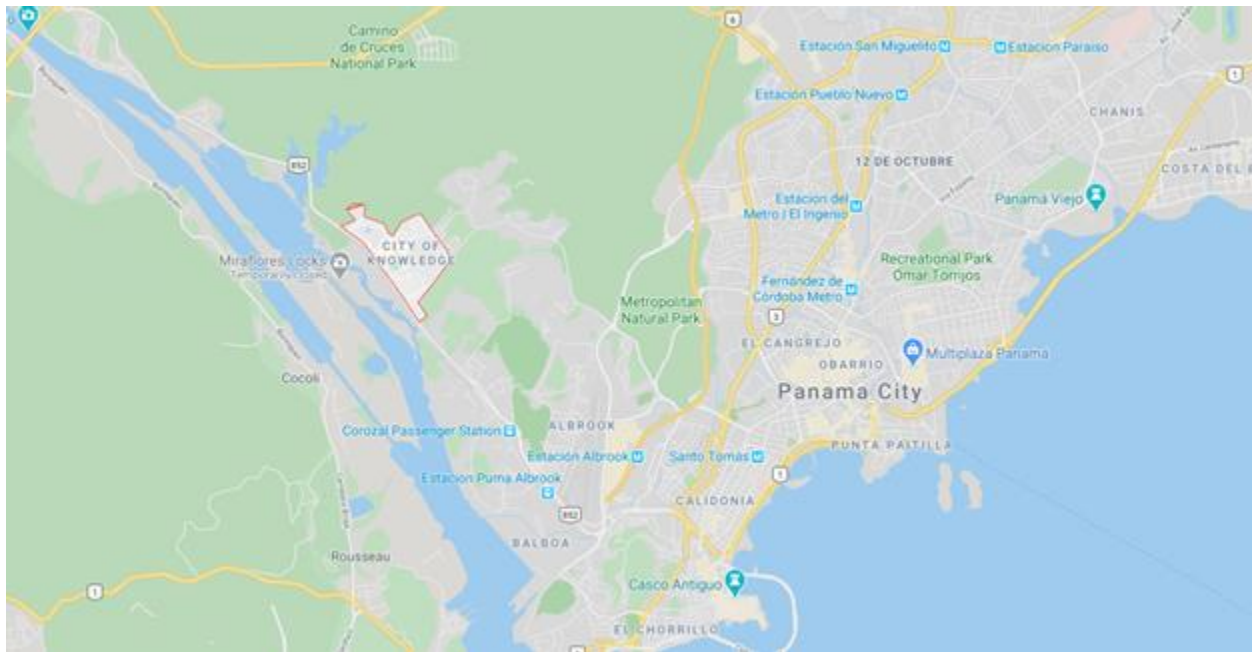
In the case of the recycling center in Ciudad del Saber, the center employs seven employees (not counting the Director) and volunteers come to the facility once a month to help sort through the collected recyclables. For both the volunteers and employees at the center, they all go through training when they first come to the center. Upon beginning his job at a new workplace, an employee goes through training to learn about the workplace, its operations, and the specific job

that he will do. As there are two factors that affect job performance: ability and motivation, initial training and frequent retraining can help an employee become fluent at his job, reducing the chances of him making mistakes. Additionally, retraining can help improve the quality of work an employee does, as well as empower him to be a valuable team player. An example of retraining is job enrichment, which has six principles according to Frederick Herzberg (Russell & Taylor, 2011). The first two principles are vertical and horizontal job enlargements. Vertical job enlargement “allows the employees control over their own work and some of the supervisory responsibilities for the job, while retaining accountability” (Russell & Taylor, 2011). Horizontal job enlargement allows the employees to feel a sense of closure and achievement by assigning an employee with a complete unit of work, with defined start and end points (Russell & Taylor, 2011). The next principle is to provide authority and freedom for employees, to empower them to make decisions. An instance of this principle is a feedback loop between the employees and the supervisors which allows the employees to voice their opinion in the decision-making process. The fourth principle is to make periodic reports available to workers instead of just supervisors, so that everyone is well-informed. The fifth principle also helps with creating a sense of achievement for the employee through the introduction of new and more difficult tasks. The last principle is to encourage development of expertise by assigning individuals to specialized tasks. This last principle can have a ripple effect of future training of new workers. As there are more experts who are also the employees, they can train the new workers and volunteers directly. Through training other workers, an employee can also understand the task better and gain non-technical skills that can help them accomplish their job better.

## **2.5. Ciudad del Saber and Sustainability**

Ciudad del Saber (City of Knowledge) is an area just outside of Panama City and the Panama Canal at the former site of Fort Clayton, formerly a U.S. military base which, along with the Panama Canal itself, has since been turned over to the Panamanians (see **Figure 8**). In 1995, the Panamanian government established Fundación Ciudad del Saber (FCdS), a non-profit organization that leads the community towards social change. The vision of this community is to transform Panama through research, education, and to inspire people through humanistic

problem solving. One of their core values is creating a sustainable future for Panama and other nations (Ciudad del Saber, n.d.).



*Figure 8: Ciudad del Saber on the map of Panamá (Google Maps, Panama, 7 May 2020)*

Based on this value, improvement in sustainability in the CdS community could be the catalyst for change for the rest of Panama. Indeed, the community has policies regarding the sustainability of their buildings, water and energy use, transportation, landscaping, and the spread of knowledge in addition to waste management (Ciudad del Saber, n.d.). To transform this concept into actions, CdS focuses its efforts around three pillars of sustainability: Governance, Environmental Impact, and Community.

The first pillar, Governance, aims to achieve transparency in its sustainability actions on campus. In other words, employees, residents, stakeholders, and visitors of CdS should be aware of CdS's sustainability strategies and policies. The second pillar, Environmental Impact, focuses on researching and implementing measures to reduce waste and improve environmental qualities. The last pillar, Community, concentrates on increasing community involvement in sustainable activities. Workshops about waste reduction, or education on recycling are effective at achieving this pillar.

Currently, both source separation and single-stream recycling methods exist on campus. In more public areas, such as La Plaza food court and dormitory buildings, there are source-stream recycling bins, which residents and visitors can access. However, throughout the campus, single-stream recycling bins have a more dominant presence. As an effort to translate the mentioned pillars into visible action, and to process the collected recyclable materials, the CdS community has a Recyclable Collection Center (CAR).

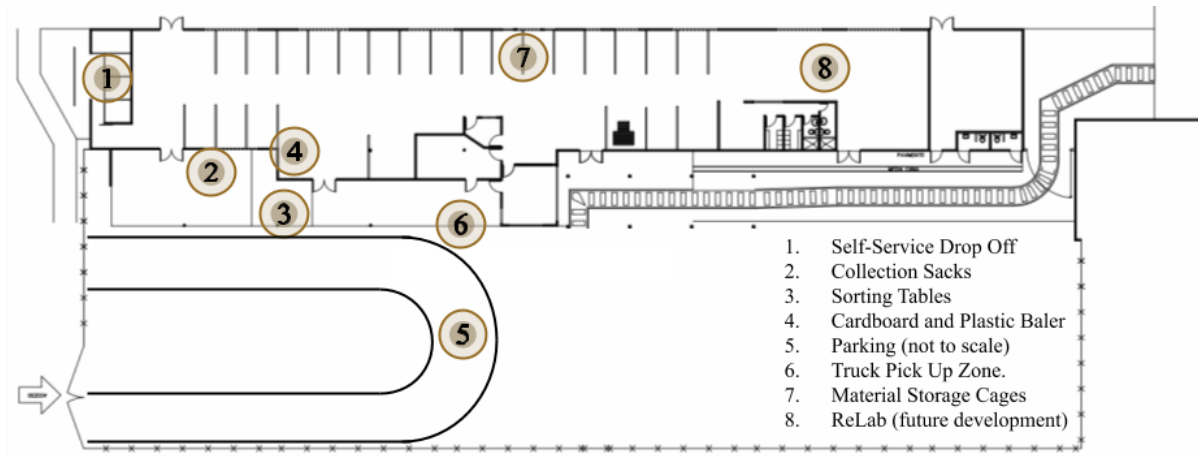
## **2.6 FAS Panamá and the Recycling Center (CAR)**

Fundación de Acción Social–Panamá (FAS) is an external company hired by CdS to collect recycling from the bins on campus. Currently, many people on campus throw their waste into both the trash and recycling bins without concern for which bin is which. FAS employees collect these bins and return them to the recycling center to sort them by material (on-campus collection). They currently face a problem because these recycling bins also contain non-recyclable materials. Every time FAS collects the recycling bins, they must then throw out the collected materials rather than recycle the majority of the bins as it is inefficient to sort a bin that is mostly trash.

FAS Panamá operates the CdS recycling center known as CAR. At the recycling center, FAS also accepts voluntary donations of recyclable materials from off-campus. Although CAR is a private business, it is providing a service similar to what other countries would consider a municipal collection center. As mentioned in section 2.2, Panama has no formal recycling collection centers, or any form of recycling services provided by the government. CAR is one of the few reputable recycling centers around Panama City, with people coming from all over and around Panama City to bring their recyclables to the center.

CAR expects visitors to clean their recyclables prior to arrival and to sort the recyclables into sacks (see **Figure 10**) outside the center based on their material. However, visitors often expect FAS workers to perform this sorting and cleaning task for them. According to our sponsor, many visitors to the center wrongly assume that CdS/FAS profit from their recyclables, and therefore the visitors think they are doing a service to CdS/FAS and should be able to drop off a bag of dirty, unsorted recyclables. Yet, CdS does not profit from the center, and is instead paying FAS the monthly deficit amount to operate it in order to keep providing a recycling service to Panama. Rather than forcing people to organize their recyclables, FAS workers sort these

materials themselves, wasting time and effort. The floor plan in **Figure 9** shows the layout of the center.



*Figure 9: Floor Plan of CAR*

Once the sacks outside the center (at location 2) are full of recyclable material, FAS workers empty the full sacks into large cages (at location 7) (see **Figure 9**) of the same material inside the center. These cages are typically overflowing with material. The center also has a plastic and cardboard baler (at location 4) (see **Figure 9**). Baling increases the value of these two materials because denser material is easier to transport. The baler (**Figure 10**) is currently next to the door as one moves into the center from the material drop off zone (see **Figure 11**).





*Figure 10: The baler (left), the sorting sacks, and the storage cages at CAR (FAS Panama, 2019)*

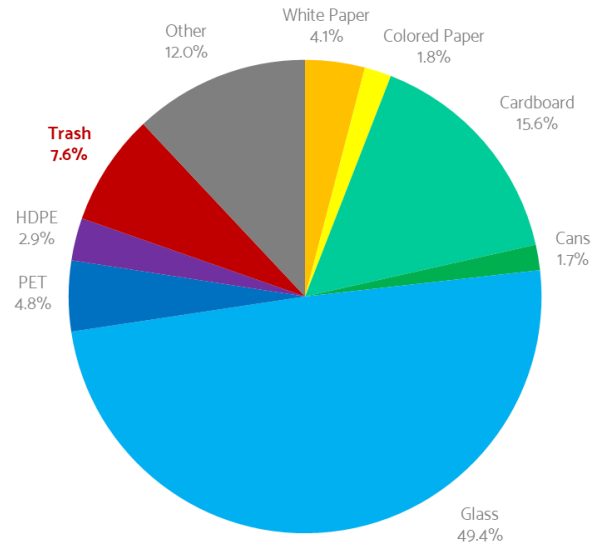
During normal operations, CAR is open on weekdays for normal drop off from 7 am to 3 pm, and weekends for self-service drop-off only. Currently, it is expensive to staff the center on weekends. The self-service drop-off point (location 1) is available for the visitors even when the center closes the gate. On weekdays, visitors drive through the access gate and park in front of the center (location 5). There are sorting tables (location 3) in front of the collection sacks where visitors can lay their materials out to sort (see **Figure 13**). As workers empty the collection sacks and materials build up in the storage cages, workers arrange for buyers to come pick up the recyclable material in bulk. There is a door at the center for material pickups (location 6) where a truck can back up to the edge of the center for loading.



*Figure 11: The sorting sacks (left), the sorting table (center), and the visitor parking (right) at CAR*

As part of the process at the center, FAS records the type of material purchased, weight of the material, and the amount paid by the vendor for each sale and individual purchase. FAS sends this data in a report to FCdS each month. Using these reports, our team conducted a literary review of the materials that FAS classified and sold in 2019. The team created **Figure 12** using these reports to show the total weight of classified materials from voluntary donations to CAR in 2019. This preliminary information enabled us to focus our future studies on certain materials rather than all of them.

### Differences in Weight Collected of Each Material from Voluntary Donations to CAR in 2019



*Figure 12: Differences in Weight Collected of Each Material from Voluntary Donations to CAR in 2019*

FAS Panamá recorded a total classification of 249,946 kg of materials in 2019 from voluntary donations. Trash makes up a significant 7.6 percent of the total materials collected by weight. Glass makes up almost half of the total weight of materials collected. It is important to note that glass and trash have no monetary value and are currently detrimental to the center.

## 2.7 COVID-19 Updates

Since December 2019, COVID-19 has gradually become a pandemic affecting many countries and their economic activities. Specifically, for Panama, as a measure to reduce the spread of the virus, the Panamanian government began issuing restrictions in March 2020. Consequently, CAR paused its operations on March 16th. This notion meant that the recycling center stopped receiving recyclable materials from the aforementioned date. In a conversation with our sponsor, Alessa Stabile, the Sustainability Manager at CdS, we learned that initially many visitors to the center still continued placing their recyclable materials at the self-service drop-off area. This action led to the accumulation of unsanitary materials that the center could not process until it reopened on October 5th. As a result, FAS Panama walled off this drop-off area using available materials. It is still unclear when FAS will reopen this area.

A positive impact of the COVID-19 pandemic has been the increase in usage of FAS social media. Since the center temporarily closed due to COVID-19, the community has interacted more over the FAS Panama's Instagram posts. There have been numerous educational posts about proper ways to recycle and how to keep the environment clean. There were notable increases in views, likes, and comments on the posts, many of which wondered when the center would reopen again. Social media interactions during the pandemic were vital to keeping their regular stakeholders engaged in the center. Additional information on how FAS social media is relevant to this project is available in the Methodology chapter.

Based on Panama's reopening plan, the center resumed its operations on October 5, 2020. With COVID-19 still a threat to public health, the center will provide visitors with strict guidelines on how to safely drop off their materials. Visitors will wait in line in their cars in front of the drop off area. Once the visitors are at the front of the line, FAS employees will ask the visitors to place the sorted and cleaned recyclables into sacks based on their material type. In a way, the COVID-19 regulations create an opportunity for CAR to require proper sorting and cleaning of materials in a manner that they could not enforce previously.

Overall, the COVID-19 pandemic has impacted the recycling center significantly. As the pandemic clears up, it will become clear which practices stay the same and which go back to the way they were before. Our team has decided to evaluate the center under the assumption that

some things will go back to normal. Therefore, we researched certain topics that may not have an immediate effect but would likely have an effect under normal operating conditions.

## **2.8. Quality Management and Lean Systems**

In order to proceed with our methodology to achieve the outlined outcome of reducing inefficiencies at the recycling center, we need to understand the tools available to analyze and improve a process. We utilized the DMAIC (Define, Measure, Analyze, Improve, Control) framework, as well as the concept of lean production - an integrated management system that emphasizes the elimination of waste and the continuous improvement of operations (Russell & Taylor, 2011). In the context of the internal processes at the recycling center, the ideal improvements would output the same or more products using less resources. As the organization of this report mirrors the DMAIC framework, this section focuses on the basic background on lean thinking, and some common tools for operation and supply chain management. These tools may serve as data collection instruments and deliverables for this project.

In a production, according to lean thinking, there are two types of task: value-added (VA) and non-value-added (NVA). For an individual to determine if a task is VA or NVA, the task must satisfy three conditions (Russell & Taylor, 2011):

1. The task must change the form or function of the product or service
2. The customer must be willing to pay for the change
3. The step must be performed correctly the first time

The goal of lean thinking is to minimize or remove NVA tasks as much as possible. However, it is crucial to understand that there are tasks that are NVA but are necessary for a process, such as weighing and inspection. Generally, there are seven sources of waste, defined as “anything other than the minimum amount of equipment, materials, parts, space, and time which are absolutely essential to add value to the product” (Russell & Taylor, 2011), to differentiate from the term “waste” in “waste management”:

1. Overproduction: this is because the work-in-progress and inventory does not generate income for the center.
2. Waiting: due to the different rates of work of the tasks, some tasks may have to wait on the materials processed by the previous task.

3. Transporting: this source of waste is the need to transport materials from one station to another.
4. Processing: this source of waste arises from processing steps that do not add value to the final product.
5. Inventory: this waste refers to the need to store and conduct inventory checks on materials.
6. Movement: this source of waste refers to the movements of the workers to look for tools or approval.
7. Defects: defects can cause a waste of time and resources as they may have to be reworked or discarded.

As part of our first two objectives, we will define the existing problems using the sources of waste mentioned above. To define the ideal result, the team worked with our sponsor to determine five outcomes:

1. Increase the income from material sales.
2. Increase the collected amount of high-value materials.
3. Increase the satisfaction level for the FAS employees
4. Decrease the sorting and classifying time for the FAS employees
5. Increase visitors' understanding about recycling

To measure and analyze our data, the project used the following two instruments: Swimlane Chart; and Fishbone Diagram.

### 2.8.1. Swimlane Chart

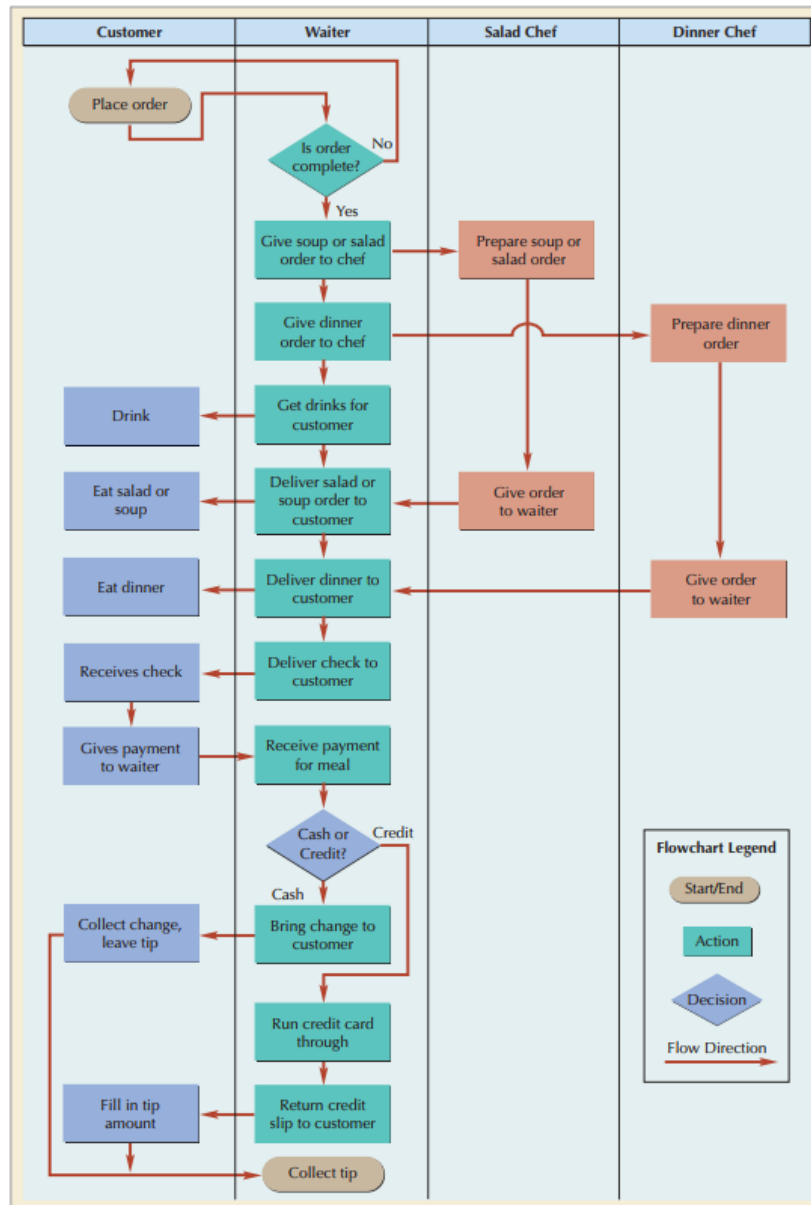
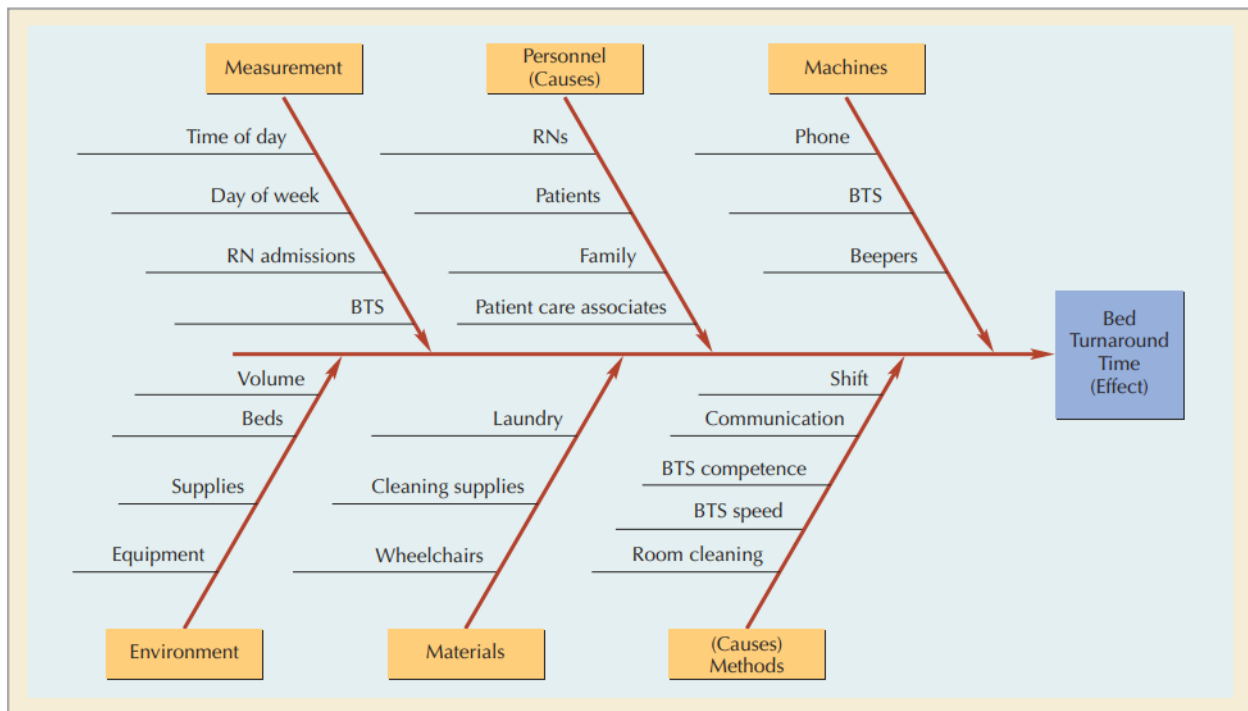


Figure 13: A swimlane chart of restaurant service (Russell & Taylor, 2011)

As seen in **Figure 13**, a swimlane chart has several ‘lanes’, each assigned to a specific individual or group. The tasks assigned to responsible personnel are visible in each lane, with different shapes corresponding to the different types of tasks, connected with each other by arrows to demonstrate their relationships. This flowchart can aid in a training process, as well as a quick diagnosis of how an issue may affect the process.

## 2.8.2. Fishbone Diagram

In this project, a cause-and-effect diagram, also known as a fishbone diagram (see **Figure 14** for an example), can prove useful to organize and categorize problems with the recycling and educational processes. In such diagrams, there are six categories for potential causes of a problem: Measurement, Personnel, Machines (Equipment), Environment, Materials, and Methods. The effect box is at the right end of the diagram, denoting the problem that needs correction.



*Figure 14: A fishbone diagram for patient bed turnaround time at North Shore University Hospital (Russell & Taylor, 2011)*

It is noteworthy that this diagram is only “a means for thinking through a problem and recording possible causes in an organized and easily interpretable manner” (Russell & Taylor, 2011). To quantify these causes, a cause-and-effect matrix can accompany the diagram (see **Table 1** for an example). The researcher then tabulates and weighs the potential causes (input variables) and the customer’s requirements (output variables). The calculated scores can then reveal which cause should take the higher priority due to its larger impact on customers’ satisfaction.



Table 1: A cause-and-effect matrix to weight the causes for patient bed turnaround time at North Shore University Hospital (Russell & Taylor, 2011)

| Key Input (X) Variables | Customer rank<br>Weight | Key Output (Y) Variables (CTQC's) |              |                |                 |              |                | Score | Rank of X Variables/ Importance to Customer |
|-------------------------|-------------------------|-----------------------------------|--------------|----------------|-----------------|--------------|----------------|-------|---|
|                         |                         | 1                                 | 2            | 3              | 4               | 5            | 6              |       |   |
|                         |                         | Turnaround time                   | Patient flow | Physician time | Emergency dept. | Patient time | Operating room |       |   |
|                         |                         | 1                                 | 3            | 2              | 5               | 6            | 4              |       |   |
| 1 BTS                   | 10                      | 9                                 | 8            | 10             | 8               |              | 5              | 348   | 3   |
| 2 Beepers               |                         | 7                                 | 5            | 8              |                 | 5            |                | 222   | 7   |
| 3 Volume                |                         | 7                                 | 10           | 6              | 7               | 5            | 5              | 338   | 4   |
| 4 Beds                  |                         | 4                                 |              | 9              |                 |              |                | 121   | 10  |
| 5 Time of day           |                         | 3                                 | 4            | 5              | 4               | 10           |                | 209   | 8   |
| 6 Day of week           |                         | 9                                 | 10           | 6              |                 |              | 6              | 282   | 5   |
| 7 Communication         |                         | 9                                 | 8            | 10             | 8               | 7            | 9              | 429   | 1   |
| 8 BTS competence        |                         | 10                                | 9            | 7              |                 | 7            | 7              | 349   | 2   |
| 9 Room cleaning         |                         | 7                                 | 5            | 3              |                 | 8            | 4              | 230   | 6   |
| 10 Supplies             |                         | 8                                 | 9            |                |                 |              |                | 161   | 9   |

(8)(10) + (9)(9) = 161

## 2.9. Stakeholders

Before we began planning the research approaches, our team identified several groups of stakeholders who are directly or indirectly involved with recycling in CdS. The various groups that have different influences on the recycling process in CdS are:

1. **FCdS Employee:** A person who works for Fundación Ciudad del Saber. Since FCdS manages the CdS campus, a FCdS employee can help with recycling through campus-wide enacting policies and guidelines.
2. **CdS Resident:** A person who resides in a Ciudad del Saber residential facility for at least one night. The residents are responsible for the quality and quantity of the recyclable that the CAR collects.
3. **CdS Tenant:** A person who operates or works for a business that leases space on the CdS campus from FCdS. Though recycling programs are not obligatory for the tenants, those who have such programs send their recyclable materials to the recycling center.
4. **CAR/FAS Employee/Volunteer:** A person who works at the recycling center. These are the people who directly process the collected materials.
5. **Visitor to CAR:** A person who drops waste off at the recycling center. These are individuals that contribute to the quality and quantity of the recyclable materials received.
6. **Visitor to CdS:** A person who comes to the CdS campus but does not fit into any of the previous categories. People who fit into this category may generate waste during their visit to the campus. Thus, understanding their perspective can help with determining the solution to the recycling issues

As we worked towards our goal, these are the stakeholders that we considered in our objectives in order to help FAS and CdS improve their current recycling processes.

## 3. Methodology

### 3.1. Overview

Our project's main goal was to research and analyze the recycling processes of Ciudad del Saber. Using knowledge gained during our literature review, we hoped to be able to assist Ciudad del Saber in making their recycling operation at CAR more efficient. Our team has identified four main objectives in order to help CdS improve their current recycling processes:

- 1) **Understand the current waste management process at CdS.** Identifying the existing problems and successes in the system allowed us to propose solutions that are relevant and effective.
- 2) **Determine the current level of understanding about recycling.** This objective provided our team with a foundation for an education program, as we uncovered knowledge gaps of the CAR visitors with respect to recycling techniques.
- 3) **Assist in improving the current waste management process at CdS.** Our team provided CdS with feedback on the efficiency of current operations, as well as recommended actionable items on how to operate CAR more efficiently.
- 4) **Propose new signage and education programs.** With Fundación Ciudad del Saber (FCdS), we designed and suggested educational materials to inform the CdS tenants on the importance and the process of recycling.

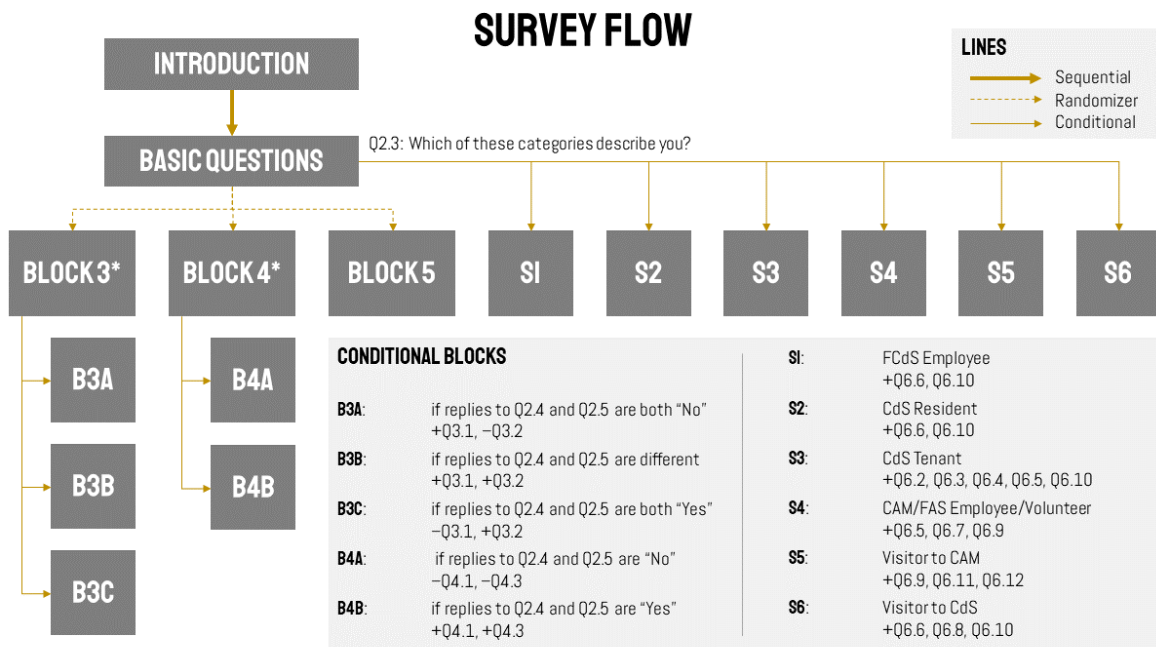
In order to achieve these objectives, we implemented three methods for data collection: conducting surveys, interviewing FAS workers, and virtually observing processes at the recycling center. From this point of the report onward, all references to money will use US dollars as unit (1 US Dollar = 1 Panamanian Balboa).

## 3.2. Surveys

The first method that our team chose to use was a survey. A survey is a research method used to gather specific data from a predetermined group of people. A survey is a good tool to gather the motivations, and knowledge of a targeted audience. With enough responses, a survey can produce statistically reliable qualitative and quantitative data and the analyst may determine common trends in the data collected (Ponto, 2015). For our survey, qualitative data comes from the open ended questions and allows the team to determine why people feel the way they do about a topic. Quantitative data in our survey comes from more direct and/or multiple-choice questions and allows the visualization of the results using graphs and charts. Combining the qualitative and quantitative outcome collected from our survey, we could understand the trends in our data and attempt to explain the observed behavior.

In this project, the team designed the survey (see **Appendix A1** for the complete survey in English and Spanish with the question numbers) to target all of the six stakeholders. However, due to COVID-19, we expected it to be much more difficult to distribute the survey to a wide range of people. Fortunately, by 12:00PM on October 12, 2020, we have collected 228 responses from all the six stakeholder categories.

The survey consists of two parts: general information questions and stakeholder-specific questions. The general information questions begin with every respondent answering the same four questions about age, stakeholder group, and if they recycle at home and in the workplace. After these four questions (Q2.2 – Q2.5), the survey randomly assigns one of three question blocks to the respondent to answer. **Figure 15** visually explains these blocks and the breakdown of the survey.



*Figure 15: Recycling at CdS Survey Flow and Organization Graphic*

As shown above, the random blocks are blocks 3, 4, and 5. Each block has five to six questions that are relevant to each other. Block 3 (Q3.1 - 3.6) seeks to uncover the individual’s motivations for recycling or not recycling as well as who in their household recycles the most and their knowledge on what can/cannot be recycled at CAR. Block 4 (Q4.1 - 4.5) aims to determine what people find inconvenient about proper recycling and what incentives they think could convince them to recycle properly despite these inconveniences. Block 5 (Q5.1 - 5.5) is about educational recycling programs at CdS to determine what people would find interesting and worth attending or paying attention to. Blocks 3 and 4 have conditional questions indicated by the (\*) in **Figure 15**. These questions rely on the respondent’s answer to a previous question. Each respondent only answers the questions from one block and the block is randomized each time someone clicks the link to our survey. We chose to randomize the survey by block in this manner in order to lower the number of questions and therefore the response time. Our team made this decision as an effort to increase participation because the shorter the survey the more likely people are to participate.

The last section of the survey is the stakeholder-specific questions. Looking at **Figure 15**, note that the last few questions of the survey are based on the response to the question at the beginning that identifies the respondent’s stakeholder group. This facilitates asking specific questions to each stakeholder. For instance, if a visitor to CAR takes the survey they would have a question at the end asking which days of the week are best for them to drop off their recyclables.

To increase participation, the team translated the survey into Spanish and had our sponsor verified the survey and its translation before publishing it. The team and our sponsor mostly conducted the survey virtually using an anonymous link to Qualtrics. After speaking with our sponsor, we received the approval to post the link to our survey in the FCdS employee Slack workspace, as well as on the FAS Panama Instagram. The FCdS employee Slack workspace got us responses mainly from the FCdS employees, and the FAS Instagram post reached a wider range of audience from the other stakeholder categories. In order to attract interest in our survey link, our team produced visual graphics (see **Figure 16** and **Appendix A2**) that FAS posted alongside our survey link.



*Figure 16: FAS posted our graphic on their Instagram account to collect survey responses*

The survey method has a direct relation to all four of our project objectives. For objective 1, understanding the current waste management process at CdS, the survey determined the people who were recycling and who were not, and some similarities and differences between the two groups. These questions would also reveal what respondents viewed as inconveniences in the current recycling process at CdS. For objective 2, many of the questions in the survey let the team determine the common gaps in stakeholders' knowledge. For objective 3, recommending improvements to the current waste management process at CdS, the survey had questions about the stakeholders' preferred kind of improvements to the waste management process at CdS and what changes FAS could make to improve processes. Finally, for objective 4, the survey had questions regarding the educational topics the respondents might find interesting and appealing, so that we could use the results to design and propose additional educational programs for FAS and FCdS.

### **3.3. Interview**

An interview is a series of questions for the interviewer seeking detailed information from an individual or individuals. Compared to a survey, an interview is more personal and direct, and will usually call upon specific experiences that are relevant to what the project objectives seek to address. The main intent of our interview questions was to gain more qualitative data that a survey would have been unable to accurately provide by providing semi-structured prompts for the interviewee to discuss.

We chose interview as a method to gain information directly from FAS workers who have valuable firsthand experience at the recycling center. Our team gathered finer details about the specific processes within the recycling center.

The stakeholders involved in our interviews are the FAS workers who we interviewed, along with two of our sponsor representatives, Ms. Alessa Stabile and Ms. Mabely Cedeño.

The team used two different methods to we conduct the interviews: Delegated and Direct. The first way used the questions in **Appendix B1**. As the name "Delegated" suggests, a staff member from FCdS (Ms. Cedeño) represented our team and interviewed three FAS employees. She conducted three Delegated interview and sent the video recordings and notes, using the template

in **Appendix B1**, to our team afterwards. The “Direct” interview had our team and Ms. Stabile as the interviewers. We only conducted one Direct interview of two employees. For this interview, our team used a list of about 15 supplementary questions (see **Appendix C1**) on top of the questions in **Appendix B1**. The main topics that the questions covered were: who the FAS workers were, what they did, what improvements they would like to see, and how donors handled recyclables. During this interview, our group was also able to ask clarifying questions and follow tangents that occurred during the interview.

The first question in **Appendix B1** (used in both interview methods) was an introduction which helped the team to note the workers position in FAS. The follow-up question was to find out what they did throughout the day in CAR. There were also two questions about how the recycling center operated. We designed these questions with the intention of learning about the employees’ current predicament and their thoughts on potential improvements. The next several questions hone in on inefficient situations and areas for improvement. The final questions in the interview were to gauge the FAS workers perception of the donors. We also asked questions about what the donors (CAR Visitors) could be doing better. These questions gave us information on what improvements can be made to education efforts.

After the initial completion of the “Delegated” interviews, we added several clarifying questions for the Direct interview (see **Appendix C1**) to further understand what the FAS employees meant from their previous answers. These questions also complemented the observations (see section 3.4 for the detailed methodology) by asking questions to verify our observations were correct.

Our Direct interview used Microsoft Teams as the communication medium. After we asked a question, Ms. Stabile acted as our mediator and translated the question and responses for our team. In addition, she asked some questions that she thought would help us gather more information.

The interview with the members of FAS directly assisted us in accomplishing our project objectives. Since the interviewed members of FAS had firsthand experience of working with CAR, we could understand the current waste management process at CdS. Furthermore, we attained their suggestions for improvements along with their thoughts on the well-performing



parts of the process. To help us determine the current level of understanding about recycling, the workers revealed the common contaminants for the different types of recyclables. To recommend improvements to the current waste management process at CdS, our interview covered what the FAS employees considered to be the most and least effective parts of the waste management process. The employees also told us ideas for what they want FAS to improve.

### **3.4. Virtual Observation**

Although the two research instruments above were useful in gathering information, we decided to also use virtual observation to minimize the effect of our presence on the activities of the workers and volunteers. Moreover, observations yield insight on matters we might have overlooked while designing the interview and survey and avoid potential problems with self-reported data. A limitation to this method is the researcher's inability to control different variables to confidently establish the cause-and-effect relationship between the observations. Hence, we cannot repeat the research and expect the same data collected.

For this method, the main stakeholder involved was the CAR employees, as they directly work on the recycling process. Their interview(s) revealed some potential causes for inefficiencies. However, through observation, we could visualize their processes and descriptions, as well as to note any other useful information not included in the results of the two other methods.

Due to the COVID-19 restrictions, we could not observe the center operation under "normal" conditions. However, we had two virtual tours of the recycling center, saw a demonstration of the paper classifying process by a FAS employee, and received many photos of CAR from Ms. Cadeño. During the virtual tours, Ms. Stabile walked around with her phone, live streaming the facility, and described the different locations, tasks, and printed educational materials to our team. During the first tour on September 11, we identified and marked on a digital copy of CAR's floor plan the locations of the tasks. We also noted several visual sources for improvements to the current process. After the first tour, our team consolidated the notes (**Appendix C6**) and identified areas in the floor plan where we needed more information. For the second tour on September 17, we clarified our questions and asked the employee to show us the educational materials displayed at the center. As a result, we successfully made a more elaborate

floor plan. During both tours, all present members of our team took note separately, so that we could compare and contrast our notes later to ensure the validity of the observations.

The team also asked a FAS employee to conduct a demonstration of the tasks and processes at the center. Our team defined a demonstration as the execution of the tasks and processes without any interruption from the observer. To prevent interruption, we asked the FCdS employee holding the recording device to only follow the demonstrator, who is a FAS employee, and asked the demonstrator to act as if the camera was not present, meaning that they should not narrate the task they are doing to the observers. This demonstration was of the paper classifying task. Ms. Cadeño recorded this demonstration and sent the video to our team on September 29.

With the detailed floor plan, we constructed the swimlane chart. Since the floor plan is to scale with the recycling center, our team could calculate the average distance between the workstations by using a ruler and multiplying the measurements by the scale factor. Through trial-and-error, we attempted to relocate the locations of the material storage space, the baler, the classifying stations, the collection points, and other stations and to calculate the total distance traveled for each trial. Our proposed improvements would be the rearrangement with the shortest total distance traveled for all the tasks in the process flowchart. To help improve the trial-and-error method, we used two guiding principles to explore the more logical rearrangement first: to minimize waste of movement and transporting, and to only rearrange if necessary. In other words, the first principle means that CAR should place workstations that are the most dependent on each other closest to each other, while those that do not interact should be further away. The second principle is to minimize the time for and cost of implementation of the proposal.

Similar to the first two methods, virtual observation contributes to the four objectives. When paired with the interview method, observation helped visualize the processes described by the FAS employee. Moreover, the floor plan and the demonstration yielded quantitative data that could provide insight into the process's performance level. Ultimately, these results produced a better understanding of the process at the recycling center. For objective 2, the observations let our team see where the signages were, and what the instructions on those signages were. When paired with the interview and survey, our team analyzed the data and brainstormed how the process and the education efforts could improve, contributing to objectives 3 and 4.

### 3.5. Summary of Methodology

The Gantt chart in **Table 2** shows our tasks schedule over the span of our seven-week virtual project. In addition to the tasks in the Gantt chart, the team continuously edited and updated the different sections of the final report.

*Table 2: Gantt Chart of our Project's Methodology*



## 4. Results and Analysis

By analyzing the data collected in the survey, interview, and virtual observation approaches, our team identified several inefficiencies at the recycling center. Before we delve further into the findings, it is important for us to establish the basic process flow at the center and define several terms.

Using virtual observations, the team determined that there are five standard tasks:

*Table 3: The five standard tasks at CAR*

| Task Number | Task Name   | Description  |
|-------------|-------------|--|
| 1           | Sorting     | Separating recyclable materials from non-recyclables                   |
| 2           | Classifying | Further separating recyclables from each other                         |
| 3           | Weighing    | Placing the materials onto the scale and recording the weight          |
| 4           | Baling      | Using the baler to compress plastics and cardboards into cuboid blocks |
| 5           | Shipping    | Contacting the vendors and scheduling pick-up                          |

Task 3 happens more than once for a few materials, while Tasks 1, 2, and 4 may not happen. There are other activities that are part of the process as well, such as transporting materials and storing materials in between the five tasks.

As explained in chapter section 2.8.2, we utilized the cause-and-effect diagram as the main analysis framework (see **Appendix D** for the diagram). Using this framework, our team categorized the data collected from the surveys, interviews, and virtual observations using the six categories: Measurement, Personnel, Equipment, Environment, Material, and Methods. By using the information gathered, we developed the following 12 findings, sorted into these six categories.

## 4.1. Measurement

Measurement is integral to CAR's operation as all materials that the center collects must be weighed and recorded by the employees. This task is important as the recyclable material vendors pay FAS based on the weight of the recyclables.

### **Finding 1: The current methods used to measure and weigh the materials are not precise and lead to potential losses in profit.**

When recyclables arrive at the center, FAS labels them as "collected materials" (material recolectado). When an employee sorts (Task 1) and classifies (Task 2) the recyclables, they become "classified materials" (material clasificado).

The recyclables from the tenants (usarios) go through the weighing process (Task 3) twice at CAR: the first one occurs after the FAS employees collect and drop off the materials at the recycling center, and the second one happens after the classification process (Task 2).

Recyclables also come from members of the non-CdS community, known as donors (entregas voluntarios). During interviews, our sponsor and the FAS workers said that these recyclables often come unsorted, and because of this condition, employees must classify these materials first (Tasks 1 and 2) before they can weigh them (Task 3). Since FAS workers only weigh these recyclables once, they record this weight for both the "classified" recyclables and for the "collected" mixed recyclables that originally came from the donors.

Specifically for plastics and cardboard, Task 3 also happens after the baling task (Task 4) to ensure the bales have consistent weights.

One major issue with this current method of weighing is that a backlog that builds up amongst the unclassified recyclables that would not be apparent in the FAS monthly reports. This issue is because there is no record of how much waste needs classification still since workers do not weigh materials before classification. For example, if donors brought ten bags of materials to the center in January, and FAS could only sort eight in time, the January monthly report would reflect only eight bags being dropped off at the center.

## 4.2. Personnel

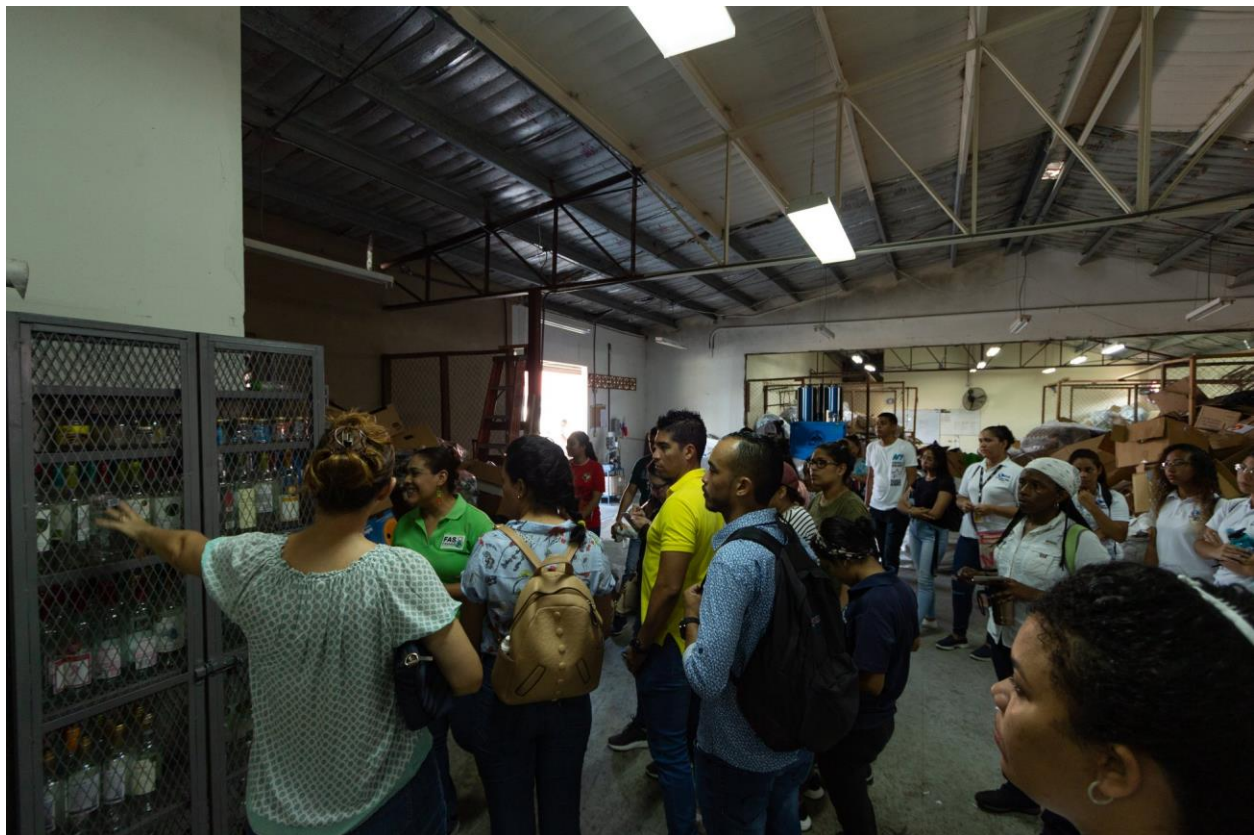
This category involves any issues associated with human resources such as lack of training and compliance to assigned roles at CAR. Labor is a valuable resource that can improve the quality of the process. For CAR, labor also has a significant impact as the processes are labor-intensive, rather than capital-intensive (more intensive use of machinery and equipment). There are two types of labor for CAR: FAS employees and CAR volunteers. Currently, FAS employs seven staff members (not including the FAS director) for its operations. For confidentiality, the eight individuals will be referred to by their main role: FAS Director, Team Coordinator, Administrative Staff, Truck Driver, Baler Operator, Material Receiver, Classifier 1, Classifier 2.

### **Finding 2: Workers and volunteers lack formal training, retraining, and confidence for their job at the center.**

From our interviews with the FAS employees, we learned that they did receive basic training upon joining the center. These trainings are the responsibility of two individuals at the center: the FAS Director and the Team Coordinator. According to the Direct interview with the Truck Driver and Classifier 1, to train the employees that conduct Tasks 1-3, namely the Classifier 1, Classifier 2, Material Receiver, and Truck Driver, one of the two trainers would show the new employee the layout of the center, give a talk on acceptable recyclable materials, and demonstrate how each material should be processed before the vendor's arrival. The Baler Operator went through a different training process due to the niche nature of Task 4. A certified representative from the baler manufacturer came to the center to train the Baler Operator and the Truck Driver on how to use the machine. However, only the Baler Operator uses the machine the majority of the time. Upon further interviewing the FAS workers, our team learned that the workers did not go through retraining, which can prove useful as mentioned in the background, except for the occasional workshops by the FAS Director whenever there were major changes to the process.

As mentioned in the background, volunteers aid the employees with specific tasks at CAR on the once-a-month volunteer day. When our team directly interviewed one of the FAS workers and asked how the training for the volunteers happened, he replied that there was no formal presentation, and that the training was similar to that of an employee. He also said that on the

volunteering day, the FAS Director would show the volunteers the layout of the center while giving a verbal presentation on how the center operates (see **Figure 17**). In his opinion, these presentations did not seem to have a well-defined outline. Usually, the FAS Director would demonstrate to the volunteers how to sort (Task 1) and classify (Task 2) the materials, and the volunteers would almost always have to relearn the tasks later on by watching the FAS employees doing their jobs. This suggests that the large-group presentation was not effective in ensuring that all volunteers understood their assignment because people were still confused and required further clarification after the presentation.



*Figure 17: A FAS employee showing the volunteers the layout of the recycling center in 2019 (FAS Panama, 2019)*

Another issue that ties in with worker's performance is the lack of motivation and confidence. From the interview with our sponsor, we learned that the employees did not feel empowered. She told us that the employees were hesitant to instruct the CAR visitors to separate the materials

before leaving the center. The workers felt that they were not in an authoritative position to do so, due to their background and lack of formal education. Another piece of evidence that pointed to this conclusion is that during the Direct interview, when our sponsor told the employees that they should be confident and firm when telling the visitors to properly deposit the materials, the employees smirked and chuckled. Our sponsor and the team interpreted this reaction as a sign of disbelief: that the workers did not think that they were in the position to enforce the rules. Furthermore, we observed that employees may not have sufficient opportunities to provide feedback to the team, potentially due to their low confidence level. When we interviewed the workers, our sponsor said that she was surprised to hear about our findings. For instance, our sponsor wanted to implement job rotation. After the interview, she told us that she did not expect the physical restrictions of the workers to prevent the implementation of job rotation, as Classifier 2 would not be able to lift heavy items.

When it comes to job performance, both ability and motivation are crucial factors. The worker's ability is the direct result of the task-specific training and the experiences they gain from repeating the task. On the other hand, motivation can be a less tangible concept that encompasses financial compensation, growth, sense of achievement, and more.

It is noteworthy that this finding relies mainly on the results from interview and observation. Errors in this analysis may arise from paraphrasing and translating issues from when the sponsor acted as the translator for the interview and from the subjectivity of the observation method.

**Finding 3: Workers lack compliance to the assigned tasks and duties, leading to the prioritization of non-value-added tasks.**

Through the interviews with our sponsor and FAS workers, we discovered that while working at CAR, the employees will often help out other workers with their assignment before finishing their own. This disruption results in a lower quality and consistency of work produced, as well as the prioritization of the non-value-added tasks (transportation and inventory) over the value-added ones (Tasks 1 and 2).

We learned from the Direct interview that the Administrative Staff's main role is to record the weight of recyclables and document it in a spreadsheet. They also need to record transactions with vendors, coordinate with buyers, such as getting them a schedule, and act as liaison (Task



5). The Administrative Staff does a large volume of paperwork that is integral to the efficient functioning of the recycling center.

During the second virtual observation, the Administrative Staff member was on the recycling floor helping the other employees. Our sponsor commented that she would prefer it if the Administrative Staff member completed the paperwork prior to going out and helping others with different roles. Though lending a hand is a courteous and supportive behavior, it can disrupt and delay the administrative and scheduling process. Indeed, the FAS Director and Administrative Staff do not send the FAS monthly report to FCdS on a fixed date or time period. This issue is likely due to the employees not prioritizing the paperwork. The evidence for this delay lays in the inconsistent reporting date for the monthly FAS report. An example of this inconsistency is that FAS did not send the October report until December 2nd while they sent other reports within the first three weeks after the month ended. Though sometimes there is a valid reason for the delay, such as the employee waiting to consolidate a brief yearly summary for the December 2019 report, the constantly different reporting dates are likely due to lack of compliance to the assigned duty. Furthermore, the report formatting is also inconsistent between reports, with the same table of different font sizes and colors (see **Table 4**), along with different sections appearing and disappearing by the month. For example, the June 2019 report had no table 2 shown in **Table 4**. Without receiving in-time reporting from FAS, the FCdS staff could not complete their financial report in time, as well as use the reported information for analyzing and improving the operation at CAR.

*Table 4: The formats of Table 2 in the monthly CAR report (missing in June 2019 report): Usual format (top) and August 2019 format (bottom)*

| Tabla 2  |                    |                 |  |                |                 |
|--|--------------------|-----------------|--|----------------|-----------------|
| Material clasificado del sector de usuarios y de entregas voluntarias en julio 2019    |                    |                 |  |                |                 |
| Sector/Materiales  | Papeles y cartones | Envases         | Chatarra electrónica y otros desechos especiales | Basura         | Totales         |
| Usuarios (*1)  | 2217.66            | 62.0            | 168.70   |                | 2448.36         |
| Entregas Voluntarias   | 5888.45            | 10690.21        | 1167.40  | 1166.90        | 18912.96        |
| <b>Totales (kg)</b>  | <b>8995.25</b>     | <b>10752.21</b> | <b>1336.10</b>                                   | <b>1166.90</b> | <b>21361.32</b> |
| *1 En este total están incluidos los 12604.09 kilos clasificados de material acumulado |                    |                 |  |                | 0.00            |

| Tabla 2  |                    |                 |  |                |                 |
|--|--------------------|-----------------|--|----------------|-----------------|
| Material clasificado del sector de usuarios y de entregas voluntarias en agosto 2019   |                    |                 |  |                |                 |
| Sector/Materiales  | Papeles y cartones | Envases         | Chatarra electrónica y otros desechos especiales | Basura         | Totales         |
| Usuarios (*1)  | 3402.25            | 66.2            | 170.10   |                | 3638.55         |
| Entregas Voluntarias   | 6876.81            | 12780.60        | 1277.37  | 1791.05        | 22725.84        |
| <b>Totales (kg)</b>  | <b>10279.06</b>    | <b>12846.80</b> | <b>1447.47</b>                                   | <b>1791.05</b> | <b>26364.39</b> |
| *1 En este total están incluidos los 12604.09 kilos clasificados de material acumulado |                    |                 |  |                | 0.00            |

As mentioned above, workers lending help to their colleagues may cause disruption to their work. Truck Driver and Classifier 1 are the only two workers that are capable of lifting heavy materials and would sometimes pause their sorting and classifying work (Tasks 1 and 2) to aid another worker. Specifically, Classifier 2 has physical restrictions that prevent them from moving heavy materials. As we heard from an interview with a FAS worker, the Truck Driver and Classifier 1 would be doing Task 2 when Classifier 2 or the Material Receiver would ask them to transport materials from one place to another. Although this task is necessary for moving the materials along the operation and can create a supportive work environment, the task itself does not directly add value to the classified recyclables. Furthermore, the transporting task disrupts the classifying task, a value-added task, that the two employees were doing. Thus, the goal is for the team and our sponsor to minimize, rather than to eliminate, this disruption as much as possible, by having a schedule for transporting materials so that the employees can know when the task needs to happen.

### **4.3. Equipment**

This Equipment category investigates any aspect related to the tools and equipment necessary for the recycling process at CAR. Though considered labor-intensive, the processes at CAR require specific tools to aid the workers complete their tasks. Three examples of those tools are the baler, the sorting table, and signages.

**Finding 4: There are maintenance issues with the equipment causing a few tasks to require more labor or to be slowed down.**

Currently, the center has two scales, one of which is broken. As material comes into the center from visitor donations and campus collection, the FAS employees weigh the material on the scale after the classification process. Having only one scale slows this process (Task 3) down because only one container of material can be on the scale at a time. This leads to increased waiting time, which is one of the seven sources of waste defined in section 2.8 of the background.

FAS workers do not weigh the material again before it leaves the center with a vendor (except for weighing of the bales). Instead, FAS relies on the vendors self-reporting the weight that they

received. The team and our sponsor are skeptical that this self-reported data is accurate. With only one working scale, weighing the materials as they leave the center in order to fact check this self-reported data is not very feasible.

Additionally, our sponsor informed us that the center has a jack lift that is currently broken. The purpose of the jack lift at the center is to lift heavy bags and boxes between the storage cages, the scale, and the baler. These bales are very heavy (250kg for each plastic bale, 200kg for each cardboard bale), and the bags large and cumbersome. Through the virtual observations and interviews with FAS workers we learned that without working equipment, FAS workers move the bales and bags slowly by hand. This leads to increased transporting time when moving the materials, which is another one of the seven sources of waste. Moving and lifting these heavy bales and bags are also potential sources of injury for the FAS workers.

During virtual observation of the center, our team also noticed a few signages that were outdated and in need of maintenance. FAS does have a whiteboard with a calendar on it for special events, workshops, deadlines, and other information for workers. When the team observed this board in September 2020, we noticed that the Administrative Staff had not updated it since March 2020. Updating the calendar whiteboard and encouraging the workers to view it daily would keep workers more organized and aware of the activities and deadlines at the center. We also observed that the FAS Panama operation hours and contact information sign is old, dilapidated, and hard to read. Furthermore, our sponsor remarked that the cages used to have signs on them to label what material goes into what cage. These signs are now non-existent. FAS originally placed them above the cages and when the material piled up in the cages below, it knocked the signs down. Signs on the cages would be helpful in ensuring volunteers and less experienced workers do not place materials in the wrong cages. Furthermore, if FAS decides to change the cage locations in the future, signs would be needed in order to direct workers to the new cage location. These signs would need to be in a different location than the old ones, given that these did not have a long lifespan.

**Finding 5: Workers do not use most of the equipment and choose less efficient methods to perform the same task.**

During our interviews with the employees and virtual observations of the facility, we noticed that the workers did not use equipment to its full potential. First, there are waste bins with wheels (see **Figure 18**) that FAS does not use often. FAS bought and received donated bins to significantly speed up the process of moving certain materials from one place to another. Better utilization of the bins would lead to more time for the workers to do other tasks. However, these bins are deep, leading to the workers having to put in extra effort to get the materials from the bottom of the bin. Yet, as a counterpoint, if the workers placed the materials in bags before they put them into the bins (see **Figure 18**), it would make it easier for them to take out the materials into storage cages or the central trash container. This would lead to an increase in the use of equipment at the center and would speed up the process.



*Figure 18: Wheeled bin for material transportation at CAR (FAS Panama, 2018)*

At the center, there are several unused cages. For example, as seen in **Figure 19**, the cage for electronic scrap was empty. The limitation to this claim is that **Figure 19** only captured the instantaneous moment of the cages. There is a possibility that the vendor has just picked up the material, leaving an empty cage.

Though unused cages might be an issue, the problem of underused equipment seems to be more prominent. The team observed from both virtual tours and our conversation with the sponsor that material storage only takes up the corner of the cage in a few cases. For example, compared to the overflowing plastic cage, the electronic scrap and tin can storage cages still have a lot of room in them (see **Figure 19**). FAS would save more space if workers placed items strategically and filled up the whole cage. In addition, CAR does have two additional new whiteboards currently stored in the Break Room, but the center does not use these boards at the moment. Using these whiteboards would allow the employees to see their assignments more conveniently, so that the employees would not need to walk a long distance to check the information. This concept could lead to an overall more efficient work environment.



*Figure 19: Unused material storage cage at CAR in September 2020*

## 4.4. Environment

This section explores how culture, education, and location affect the current processes at the center. These conditions are usually macro in scale and are more challenging to affect. However, in the case of CAR, these two findings can potentially lead to recommendations for improvement.

### **Finding 6: There are misconceptions and a lack of knowledge about recycling practices among visitors to CAR.**

As mentioned previously, visitors to CAR often drop off their recyclables without sorting or fail to sort their recyclables correctly by type. FAS workers must deal with this by sorting out the recyclables (Task 1) then throwing away the trash that remains, costing time. By analyzing the monthly FAS reports, the group discovered that donors brought 18,602 kg of trash to the recycling center in 2019 alone (excluding on campus collection). This accounts for 8.2 percent of the total material brought to CAR by voluntary donations throughout the year. This piece of information led to our hypothesis that the main reason for the large amount of trash is due to visitors not knowing what CAR accepts and what it does not accept. To confirm this hypothesis, we relied on our survey responses.

Indeed, we were able to substantiate the claim that the majority of visitors to the center have many misconceptions and knowledge gaps regarding recycling. **Figure 20** shows the results to survey question 3.5, “Which of these items are or are not accepted at CAR?”

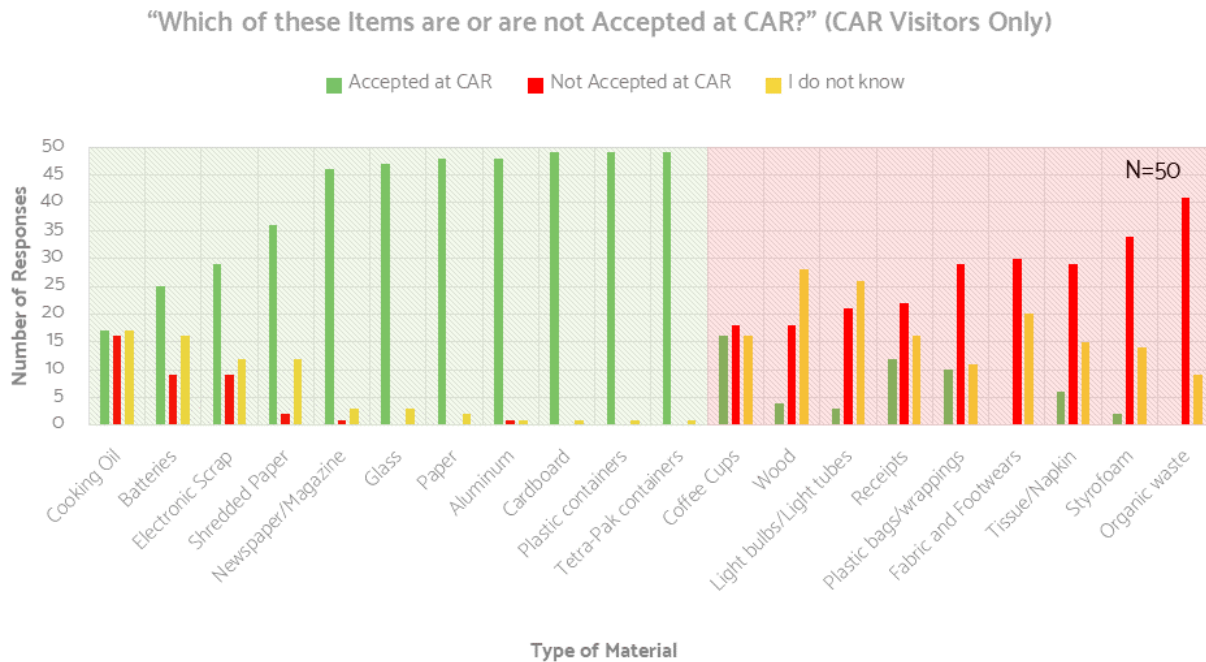


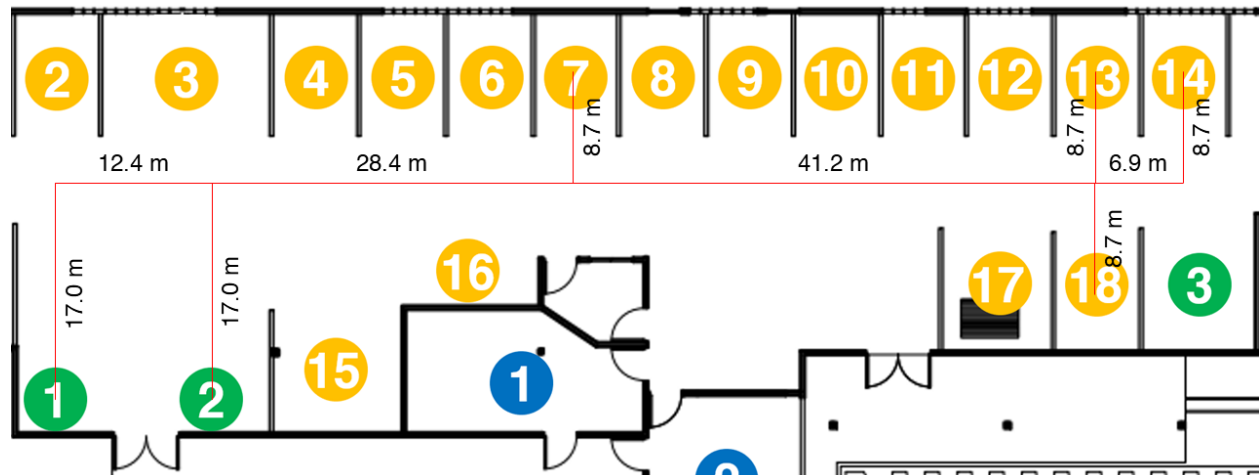
Figure 20: Responses to survey question 3.5, “Which of these items are or are not accepted at CAR?”

**Figure 20** shows materials that CAR actually accepts on the left in green, and materials that CAR does not accept on the right in red. The respondents could easily identify some materials, in terms of whether CAR accepts them, such as glass, cardboard, and organic waste. People seem to be especially unsure about cooking oil, batteries, electronic scrap, wood, light bulbs, receipts, coffee cups, and plastic bags. Based on these results, our group believes that it would be beneficial for FAS to make it clearer to recycling center visitors about the materials CAR does and does not accept, especially with these five materials.

**Finding 7: FAS could further improve the layout of the recycling center in terms of workstation arrangement and visual control.**

To help with the analysis process, we annotated the current floor plan (see **Figure 22**) with the help from our sponsor and the employees. Using this floor plan, our investigation identified two sources of waste, as mentioned in section 2.8, namely Transporting and Movement.

The waste of Transporting plastic and cardboard mainly arises from the current arrangement of the storage cages, as it makes the employees travel unnecessarily long distances between tasks. Looking at **Figure 21**, one can visualize the path taken by the workers for the weighing and baling processes of plastics materials. After weighing the sorted materials at the scale (denoted by the green circle labeled 2), the employees move the plastic containers to cages 7 and 18 (for PET) and cages 13 and 14 (for HDPE), traveling the distances of 54.1 m, 95.3 m, 95.3 m, and 102.2 m, respectively. The next process for plastics recycling is baling, which occurs at the location marked by the green circle labeled 1. To accomplish bailing, the employees must move the plastics from cages 7, 18, 13, and 14, to the baler. The employees also need to take several trips between these locations, as one bale of plastic might require several bags of plastic containers. The employees then move the bales back into one of the four mentioned cages. Considering that plastic is the main material that goes through the baling process, the locations of the sorted storage cages appear illogical. Meanwhile, materials that do not require much processing, such as electronic scrap (cage 8), are in cages closer to the baler.



*Figure 21: CAR transporting paths and distances for plastic containers recycling process*



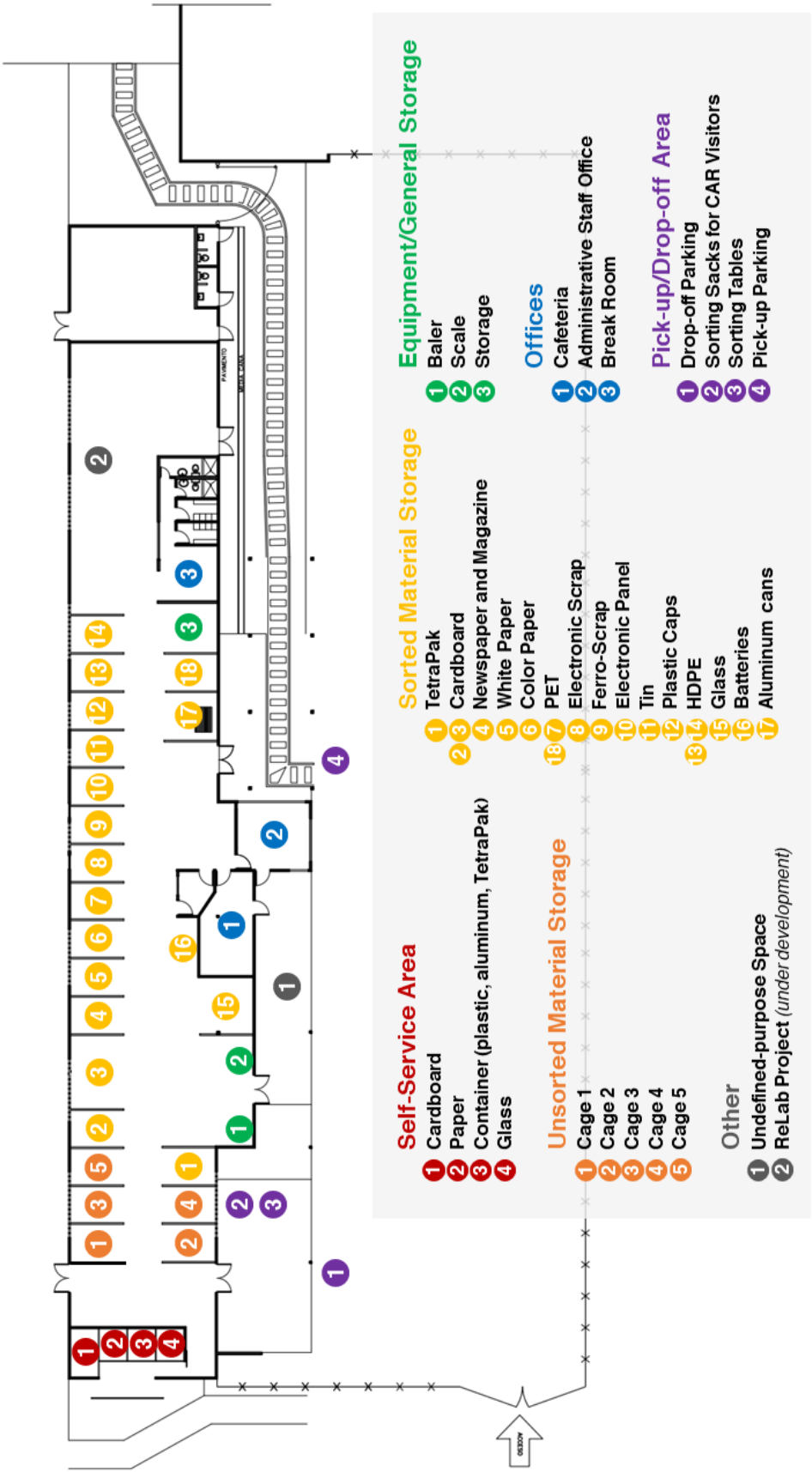
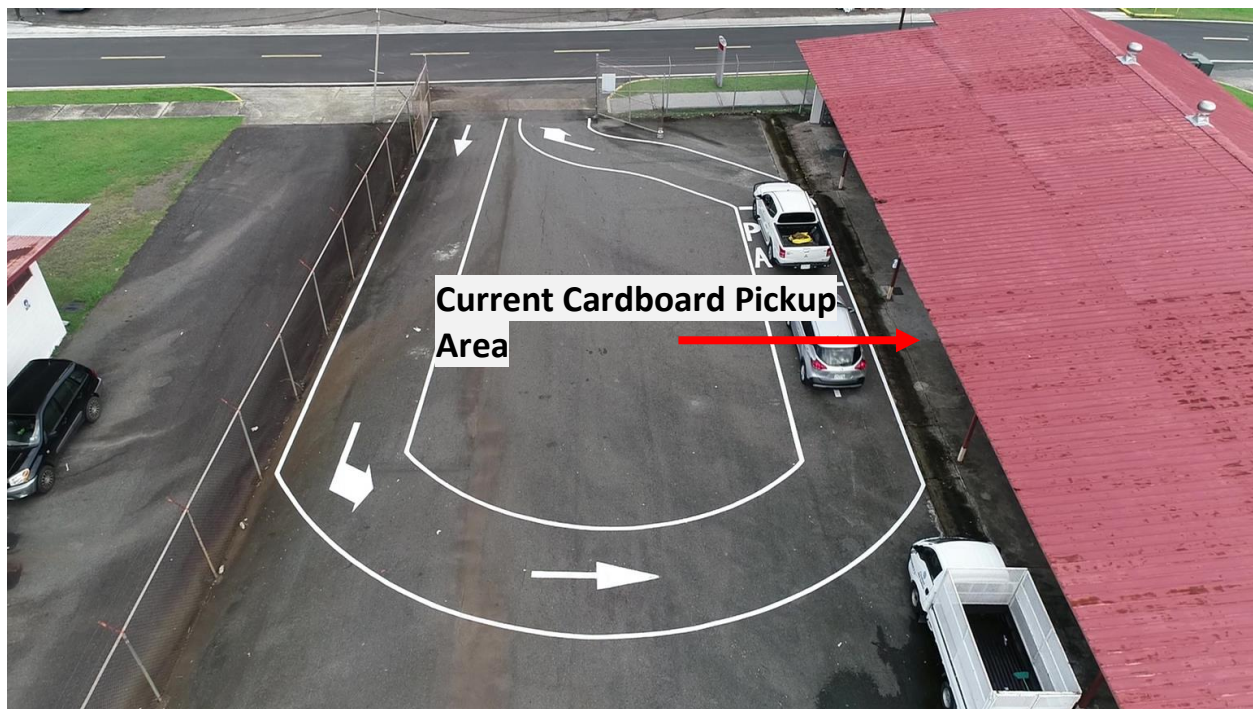


Figure 22: Annotated Floor Plan of CAR

For cardboard, the issue of waste of transporting is minimal, as the storage cages are near the scale and the pick up area. However, minimizing this transporting distance with the current arrangement posed a different problem. Looking at **Figure 22**, one can see that the exit next to the baler is the closest one to the cardboard storage cages (cages 2 and 3). Currently, that exit is the one in use for cardboard pickup by the vendors. However, that pickup area also serves as a drop-off area for CAR visitors. Due to this dual-purpose nature, the parking for material pickup would block the traffic flow of CAR visitors. To visualize this problem, **Figure 23** shows the direction of traffic flow and the location where a cardboard pickup vehicle would park.



*Figure 23: Annotated photograph of how a cardboard pickup vehicle would disrupt the loop traffic flow at CAR*

Based on the Direct interview of FAS workers and virtual observation results, the team identified Movement as the second source of waste. The first piece of evidence is the long distance between the daily/monthly assignment board and the Break Room (Blue circle 3 in **Figure 22**). Upon arriving at the center for work, the employees place their belongings in the lockers in the

Break Room. This room has the bathrooms and shower facility for the workers' needs. As an employee would usually go to the Break Room first when they report for daily work, it would be beneficial to have the daily/monthly assignment board inside or really close to the room, so that the employees can see the daily assignments while getting ready for work. However, currently, the board is on the wall behind the Self-Service Area. This means that the workers have to walk across the whole center to see their assignments, and then proceed to their assigned workstations. Additionally, this board is far from the Administrative Staff Office, meaning that the Administrative Staff would need to travel a long distance to update the information on the board.

This same Movement waste arises from the misplacement of tools and materials during the recycling process. During the virtual observation tour, our team noted that there are two yellow lines on the floor of the center to indicate the walkway, and to separate the walkway from the storage spaces. However, due to the large volume of materials, many cages overflow, and the center must place the excess materials within the walkway (see **Figures 24a and 24b**). Moreover, these yellow lines are incomplete, as the space in the **Figure 24b** lacks these lines. Additionally, equipment, such as wheeled bins, sorting sacks, and flatbed cart occupy the spaces in the walkway. As a result, it is challenging and hazardous for the employees to move around the center, especially when they need to move large containers of materials.



*Figure 24: (a) Use of yellow lines in front of sorted cage 2; (b) Overfilled cage 7 and the missing yellow lines*

## 4.5. Material

In the context of the recycling center, the Material category encompasses the quality and characteristics of the “collected recyclables.” Investigating the potential issues associated with the materials can lead to better control on the material input process.

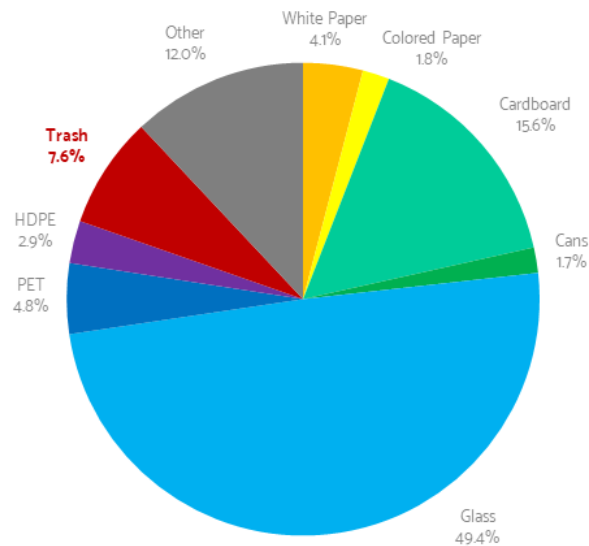
### **Finding 8: Materials contamination is a significant issue of the recycling process**

From the interviews, we learned that there are two types of recyclable contamination: recyclables mixed with non-recyclables, and recyclable mixed with a different type of recyclable. For the first type, an example of non-recyclables is organic materials. These contaminants may even cause recyclable materials to become non-recyclable, such as bottles stuffed with dirty napkins. To quantify this problem, our team used the data from the December 2019 FAS report. In 2019, CAR visitors brought almost 250,000kg of recyclables to the center, 8.2 percent of which FAS recorded as trash (see **Figure 25**).

Contamination not only slows down the recycling process by increasing the need for sorting (Task 1), but it also is a major health concern for the workers. During the Delegated interview, a common theme was contamination. When the FCdS representative asked what challenges he faces in the workplace, the Baler Operator replied that “the contamination of material could cause illnesses, like COVID-19 or skin illnesses”. When the interviewer asked him later what he thought were the most frequent contaminants, he replied “Tetra-Paks with maggots and in general material contaminated with food. Non-recyclable material, some people have even left dirty diapers.”

From both the Delegated and Direct interviews, our team identified the common sources of contamination for each material. For plastic, common contaminants are leftover liquid, paper stuffed inside, and different plastic types stuck together. Paper’s common contaminants list consists of mixed shredded paper, food stains, paper clips, and very dark paper. For other materials, contamination presents itself in the form of liquid, food, and other non-recyclable material. If the materials were clean, then the center would be able to recycle the materials and as a result generate a profit off of them.

**Total Weight Percentages of Classified Materials from Voluntary Donations at CAR in 2019**



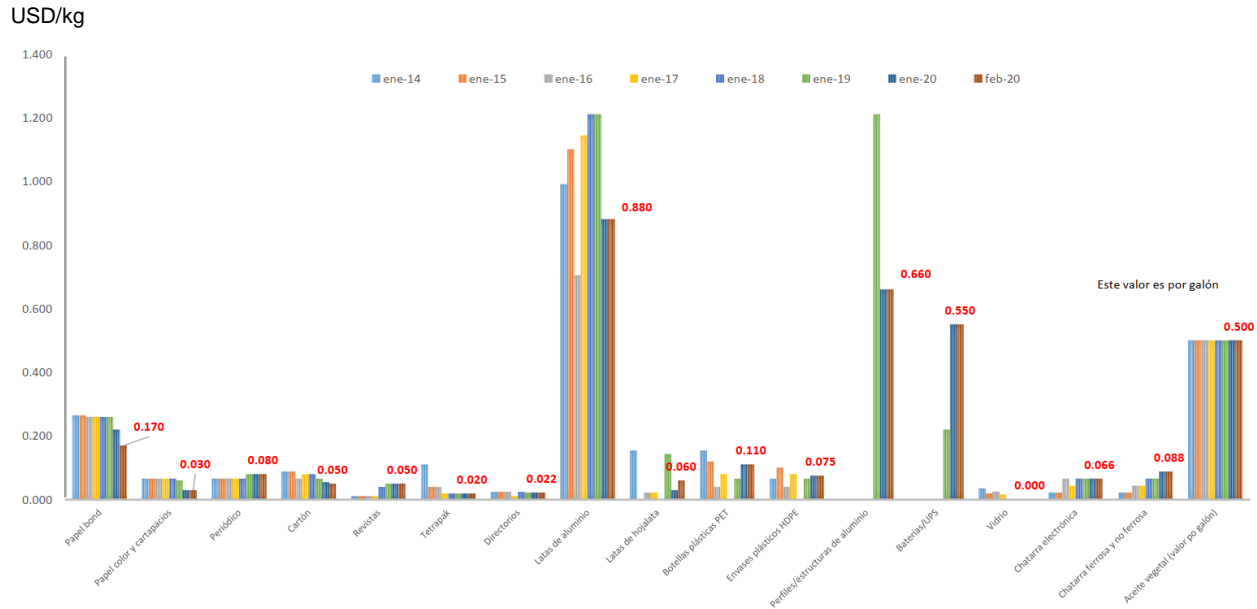
*Figure 25: Total Weight Percentages of Classified Materials from Voluntary Donations at CAR in 2019*

The second type of contamination, recyclables mixed together, such as white paper mixed with color paper, can also lead to an increase in processing time. This is because the employee would need to spend more time to complete Task 2. As mentioned by the Baler Operator in his interview, “(If) the bottles come (to the center) clean and without the tops, they (would) be ready for baling when they (the bottles) arrive.” With less need for Tasks 1 and 2, plastics can go through the value-added Task 3 right away, reducing the time the employees spend on the whole operation, and reducing the amount of backlog materials.

**Finding 9: The monetary value of the processed materials is important information for the fiscal health of CAR.**

Throughout the process, FAS workers do not prioritize valuable materials. This is due to several different factors. One reason is because several materials that CAR receives in large quantities do not have higher value. To reduce the issue of backlog, the employees decided to prioritize materials based on the volume and weight collected, rather than based on the per kilogram value.

For instance, it takes a long time to process and classify the plastic, due to the complexity of the process (see **Figure 32** in Finding 12). This would not be a big issue if it had a high value, but in fact plastic is one of the cheaper items (\$0.110/kg for PET, \$0.075/kg for HDPE) when compared to white paper (\$0.170/kg) and aluminum cans (\$0.880/kg) (see **Figure 26**). This makes the process of going through plastic not cost-effective.



*Figure 26: Variation of price per kilogram for the recyclable materials resale at CAR (modified) (FAS Panama, 2020)*

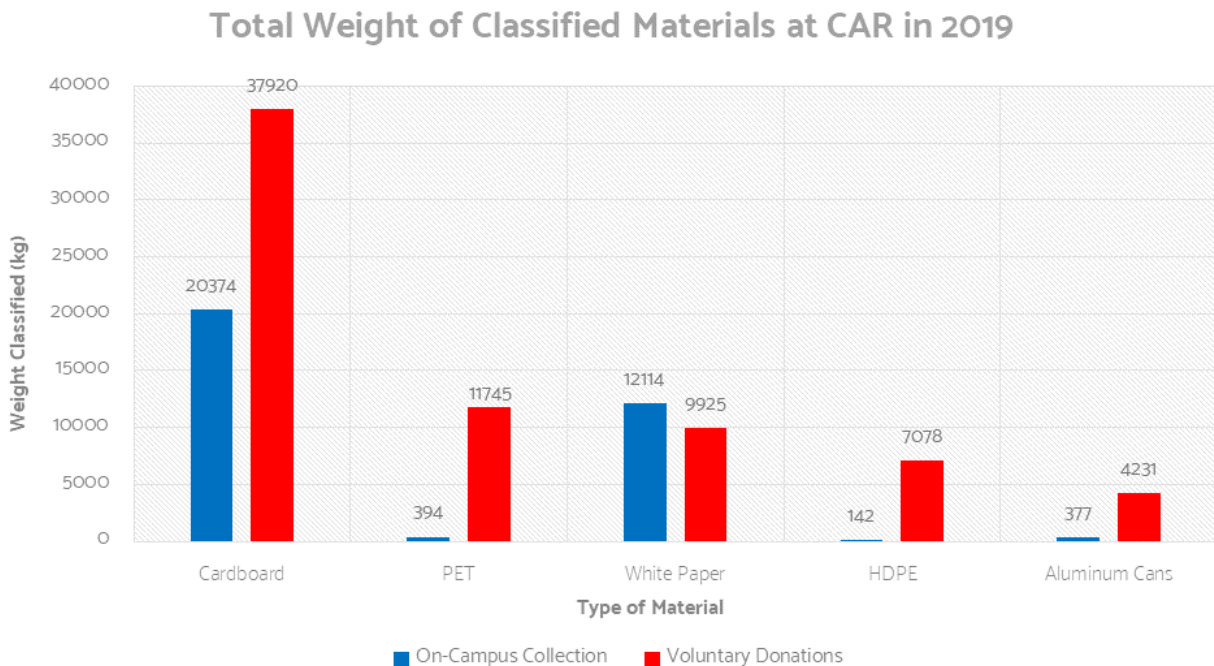
Looking at **Figure 26**, we can see the price variation of the materials over the years, from 2014 (ene-2014) to 2020 (feb-2020). For some materials, such as oil, newspaper, directories, and electronic scrap, the price per kilogram stays relatively constant. However, the price of paper has been decreasing since 2019. For other materials, such as PET and HDPE, the price fluctuated. From our conversation with our sponsor, we learned that for the first quarter of 2020, the prices of PET and HDPE have been lower than previous quarters. This was due to the lower price of oil, a key component for new plastic manufacturing, making it cheaper to make and buy newly produced plastic products, rather than recycling existing plastic containers.

From the above analysis, we concluded that forecasting the material price plays an important role in determining the production schedule at CAR. The team will further discuss the topic of scheduling in our recommendation chapter.

Before we discuss Finding 10, it is noteworthy that the employees have been attempting to prioritize higher-value materials (evidence in Finding 12). However, from the Direct interview with the Classifier 1 and the Truck Driver, one of them said that “If we don’t have to focus on classifying so much (voluntary donations), we can focus on classifying paper more.” This implies that the employees have realized that paper has higher value. Yet, due to the overwhelming weight of the other materials, it is challenging to prioritize those materials, as we will discuss in Findings 11 and 12.

**Finding 10: The two main sources of the materials lead to a difference in the amount of specific materials collected, affecting the revenue of the center.**

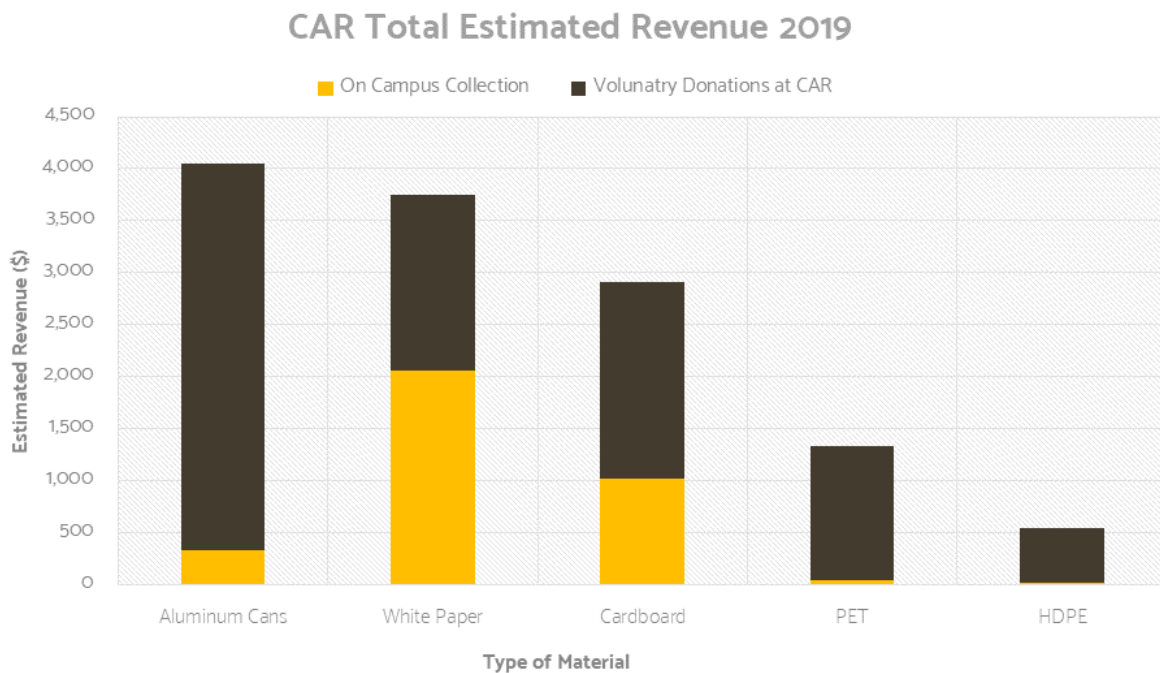
The 2019 monthly FAS reports identified two sources of recyclable material: on campus pick-up and voluntary drop offs to the center. **Figure 27** shows the differences in amount of material classified from both source streams.



*Figure 27: Total Weight of Classified Materials at CAR in 2019*

By analyzing the data, summarized in **Figure 27**, our team concluded that much more material comes from donations at the center than from collection on campus. On campus collection is almost entirely paper and cardboard, which makes sense given that most of the on-campus collection comes from the office buildings of CdS tenants. The amount of white paper from on campus donation was higher than that from voluntary donations, which is noteworthy given that the majority of total material comes from material drop offs to the center and not from on campus donations.

**Figure 28** shows the estimated revenue during 2019 that our team calculated by using the formula  $\text{Estimated Revenue} = \sum(\text{Weight of a material} \times \text{The material's average price per kilogram})$ .



*Figure 28: Total Estimated Revenue at CAR in 2019*



**Figure 28** illustrates that paper brings in almost double the revenue of PET and HDPE plastics combined. Therefore, it is in CAR's best interest to encourage more tenants to recycle, so that the center can receive more paper than plastics. Paper is also more compact and is easier to store in the center, while plastic material takes up space and does not stack easily. During virtual observation of the center, our team noticed plastic building up quickly and overflowing its cage. During the Direct interview, workers also claimed that the plastics come into the center and build up so quickly that workers often have to classify and sell the plastic instead of focusing on the paper.

Understanding the expected weight of materials from each stream of material collection and the per kilogram price (Finding 9) can help the employees prioritize the materials that earn the most revenues, such as paper and aluminum cans. This understanding also helps the FAS Director and Administrative Staff schedule and coordinate on-campus pickup and vendor purchase better, as we will discuss in the Recommendations chapter.

## **4.6. Methods**

In the last category, Methods, the team investigates the recycling center process performance and its requirements. Specifically, our team looked at the regulations and procedures of recycling at CAR and identified any area for improvement.

### **Finding 11: There is a lack of defined tasks and schedules at CAR which causes disruption in the process.**

In the recycling center, the employees do not have organized and scheduled tasks. Most of the time, the employees are completing the tasks based on the input of materials, as briefly mentioned in Finding 9. Currently, the workers prioritize the material to classify next based on the volume of that material stored at CAR, which can vary monthly, as opposed to classifying them in an organized fashion. Another piece of evidence that suggested the workers did not have a defined schedule is that the calendar whiteboard was not up-to-date during our observation, as mentioned in Finding 4.

As discussed in Finding 3, the lack of schedule also reflects itself in the lack of worker's compliance, causing interruption to the process. Another issue that we discovered via worker

interviews is that workers sometimes do not fully complete their job. For example, they would partly classify a material and then start classifying another one. This behavior leads to longer completion time for classification of a material, as well as the increasing need for storage space that does not add value to the final product.

**Finding 12: The processes for different materials have uneven flow rates, causing bottlenecks in the operation.**

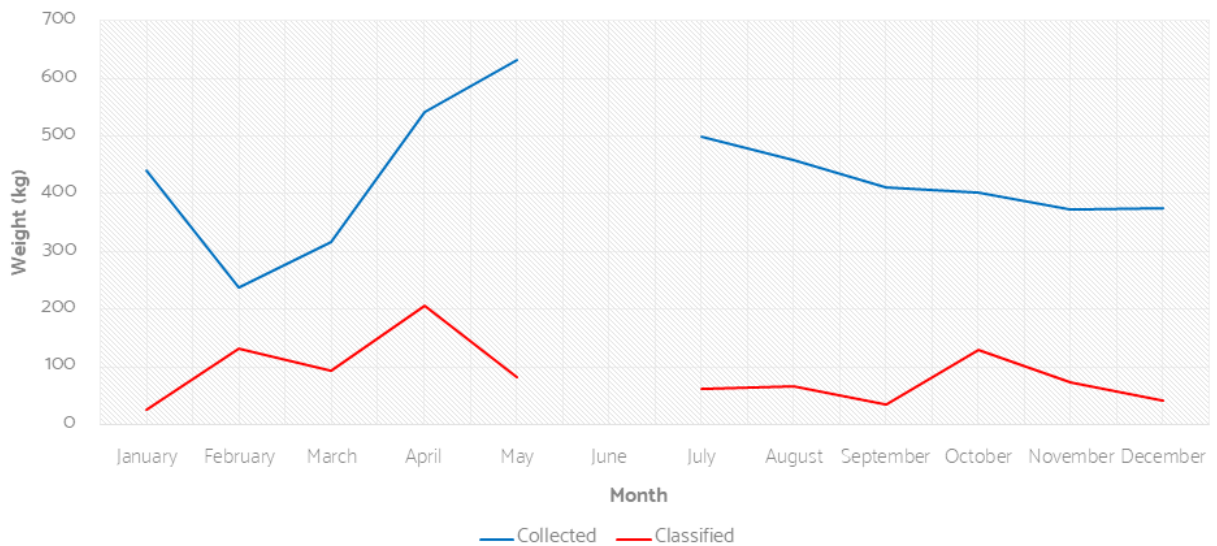
As seen in Finding 7 (see **Figure 22**), it is noticeable that the recycling center dedicates a large amount of space to storage, similar to that of a warehouse. This is because a bottleneck occurs during the sorting process, where workers must manually separate recyclables from each other and from non-recyclables. The first set of evidence is the photographs of the center over the months (see **Figure 29**). It is evident that there were materials piling up in the unsorted storage cages, suggesting that the workers could not process the materials as quickly as they arrived.



*Figure 29: Overfilled CAR cages showing the backlog of materials over time (FAS Panama 2019)*

However, as the photographs only captured the instantaneous moments at the center, they do not provide a summary of the other uncaptured moments that include the unsorted cages less filled. Hence, our team decided to look further into the monthly FAS reports for quantitative data.

## Weight of Collected and Classified Containers from On-Campus Collection in 2019

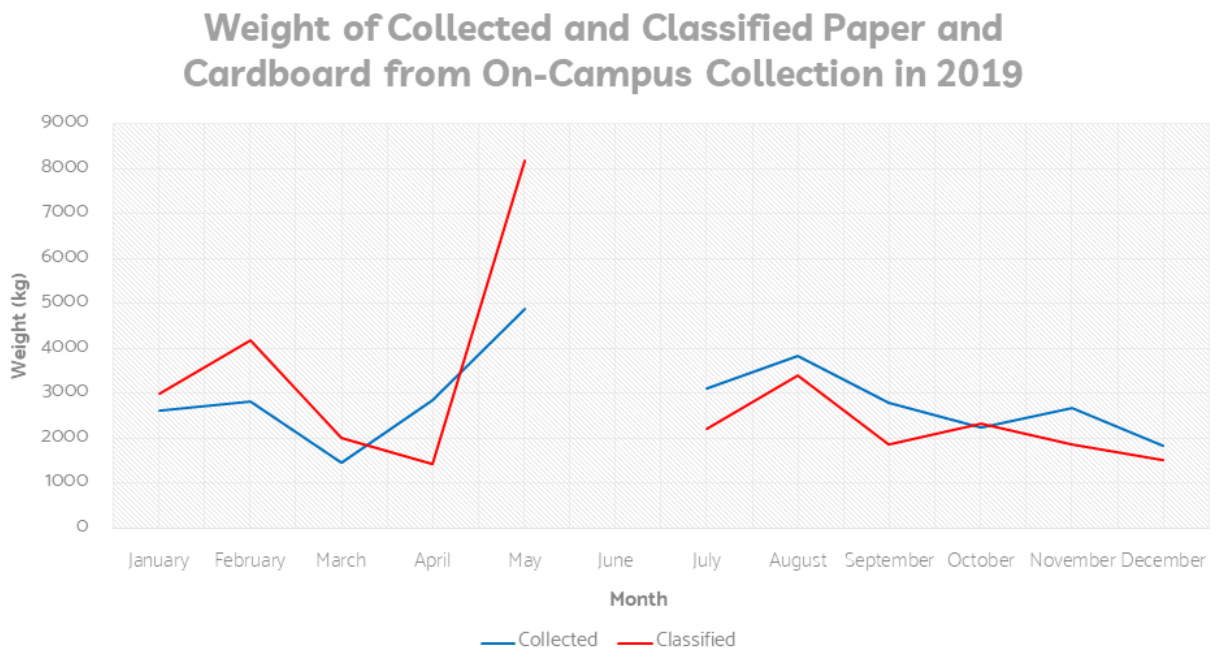


*Figure 30: Weights of Collected and Classified Containers (plastics, aluminum cans, TetraPak) from On-Campus Collection in 2019*

**Figure 30** depicts that the weight of containers classified, which are plastics, aluminum cans, and TetraPak according to FAS’s record, were consistently lower than the weight of containers collected. This information suggests that the workers could not classify the containers as quickly as the materials arrived, causing a backlog of unsorted materials. However, this explanation would mean that the weight of backlogged containers had been increasing throughout 2019, which might not be logical as that would mean there is an “infinite” queue of backlogged materials. A potential explanation for this data anomaly is that part of the difference is due to the amount of trash, as collected materials from on-campus go through weighing before Task 1 begins (mentioned in Finding 1). To use a simple mathematical expression,  $\text{Material Classified} = \text{Material Collected} - \text{Trash} - \text{Backlog}$ .

However, the rate of processing for the other materials does not always follow this trend. For paper and cardboard, there were more fluctuations in the data. **Figure 31** shows that in five different months (January – March, May, and October), the collected amount (blue line) was below the classified amount (red line). In the other six months, the classified amounts were

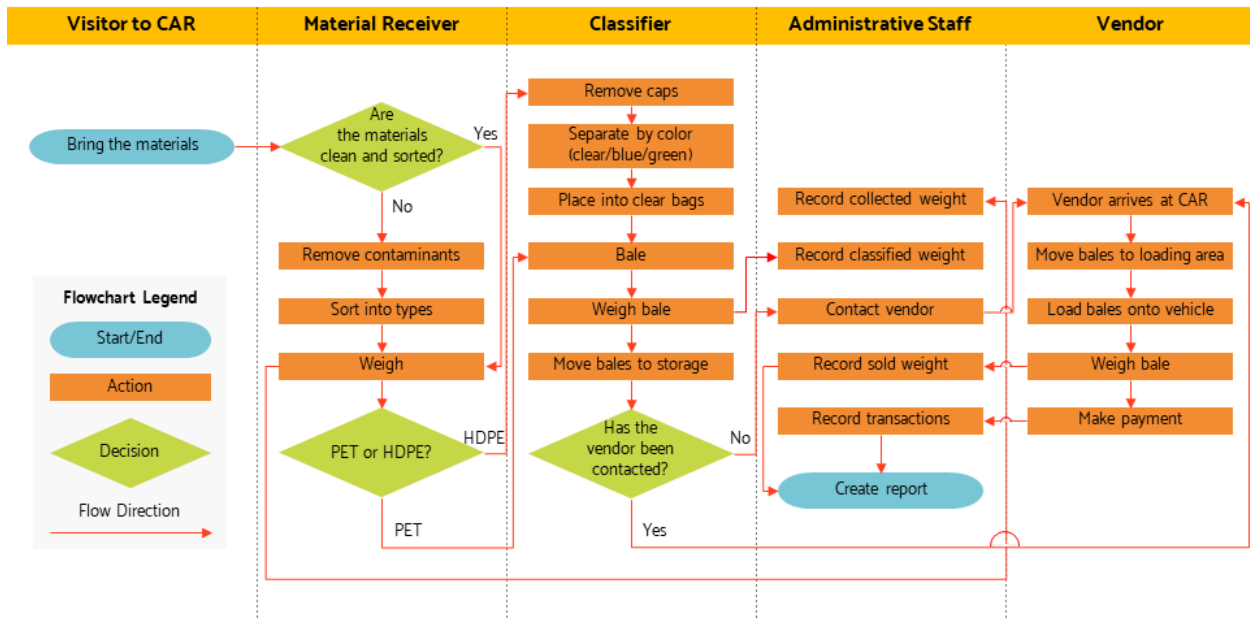
indeed above the collected amounts. It is noticeable that there is a drastic increase in the amount of paper and cardboard classified in May 2019. To explain this spike, the May 2019 report writes, “At the end of May, thanks to the support received to hire personnel to classify the large amount of material from the user sector accumulated for several months, a total of 4802.55 kilograms were classified.” (translated from Spanish), This means that there was a large amount of backlogged materials (including paper and cardboard) from previous months. Thanks to the additional manpower, they could process this backlog, leading to a significant increase in the amount classified.



*Figure 31: Weight of Collected and Classified Paper and Cardboard from On-Campus Collection in 2019*

Another aspect of this finding is the different requirements to process each material. Some materials, such as cooking oil and batteries, have a very simple recycling process. Other materials, such as plastic containers and paper, have a more complex process. After developing the two swimlane charts in **Figure 32**, one for plastics (complex process example) and one for batteries (simple process example), our team compared and contrasted these two processes.

**(a) PLASTICS (PET/HDPE)**



**(b) BATTERY/ELECTRONIC SCRAP/ELECTRONIC PANEL/FERRO-SCRAP**

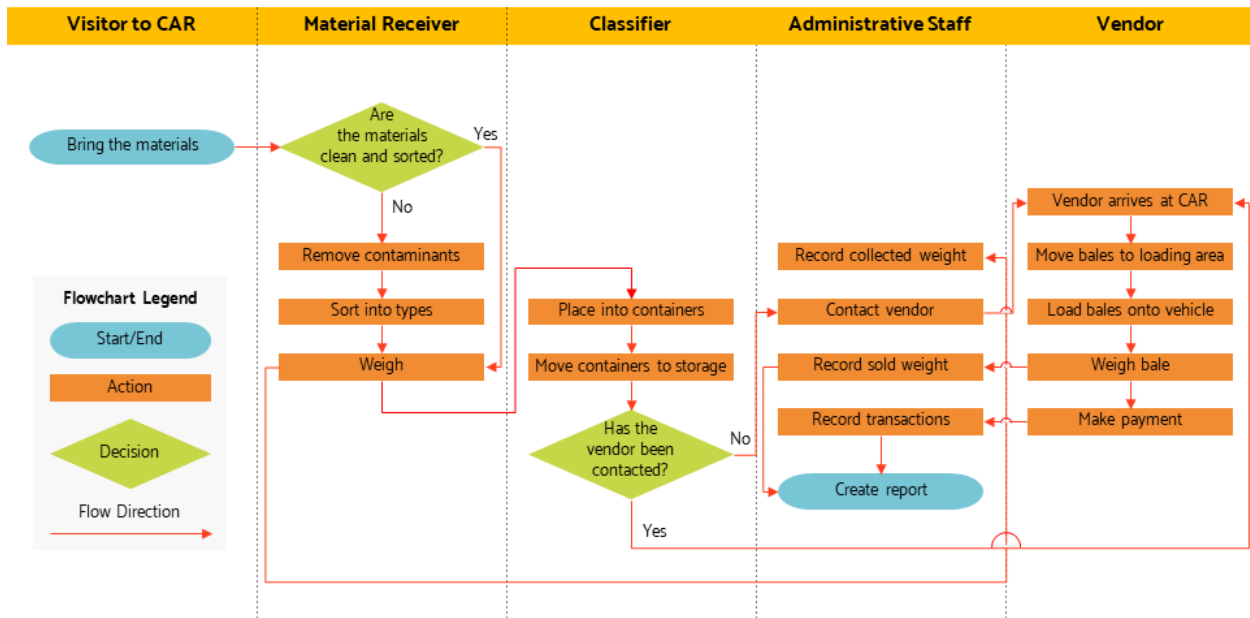


Figure 32: Swimlane charts that show the processes of (a) plastics and (b) battery at CAR

For both charts, there are five personnel that play a part in the process. The tasks done by the Visitor to CAR, the Administrative Staff, and the Vendor are exactly the same between the two

processes. The differences between the two types of process lay in the tasks done by the Material Receiver and the Classifier. For the more complex materials, there is usually an additional step done by the Material Receiver to further classify the material: separating plastic into PET and HDPE, and separating paper into colored and white. Moving to the tasks done by the Classifier, a complex process usually consists of an additional contaminants removal step: removing container caps and separating by color for PET, and removing paper clips and binders for paper. Specifically for plastic containers (both PET and HDPE), baling is an additional step to add value to the material as baled plastic sells at a higher price.

Our team needed to understand the complexity of the processes and how they differ between materials in order to identify the current inefficiencies at before we can propose our recommendations.

## **4.7. Results and Analysis Summary**

In this chapter, we analyzed how the weighing task (Task 3) is inconsistent (Finding 1) through the Direct interviews with the FAS employees. Using the same interviews, the team also discovered some issues with human resources (Findings 2 and 3). Additionally, these interviews, along with the virtual tours, provided insight on how the supporting equipment usage and maintenance contributed to the inefficiency at the center (Findings 4 and 5). In terms of the problems related to the Environment category, the team used the data from both the Delegated interviews and the observation methods to analyze how the current knowledge gaps (Finding 6) and the layout of the recycling center (Finding 7) led to an increase in processing time. As input (collected) recyclables play a significant role in the flow of the operation, we analyzed the value and weight of the recyclables (Findings 9 and 10), and verified the important problem of contamination (Finding 8). The evidence for this mainly comes from archival research in the FAS 2019 monthly reports, which had detailed quantitative data about material and cost breakdowns. Our team also looked at the regulations and procedures of recycling at CAR and identified any area for improvement (Findings 11 and 12). The team used observation and archival research to develop these findings.

## 5. Conclusions and Recommendations

This chapter provides a summary of the 12 findings and six recommendations for the recycling operations at CAR. With the background research and the three methodologies, the team uncovered facts to the recycling operation and its issues. The team analyzed the causes in the Results and Analysis chapter and proposes actionable items in this chapter. After reviewing the findings, we believe that these recommendations will improve the recycling process at CAR and aid in the education effort for the visitors that come to the center. This chapter also includes a few suggestions for future projects about the recycling center.

### 5.1. Summary of Results

The most significant problem that CAR is facing is material contamination (Finding 8). All three methodologies provided evidence that pinpointed towards this issue. This problem also has a close relationship with the five desirable outcomes of our sponsor. Contamination leads to an increase in sorting and classifying time, leading to an increase in the amount of work an employee has to complete. Contamination also affects the fiscal health of the center, as the employees must prioritize sorting to prevent backlog, while they could have used that time to classify high-value materials.

Another major problem that many of the 12 findings touch upon is the knowledge gaps of the public about recycling. These knowledge gaps cause the contamination to exacerbate, as we discussed in Finding 6. The survey result also suggests that the center could be collecting more materials to process and earn revenue, assuming CAR has the capacity, from visitors who currently replied “I do not know” to the accepted items at CAR.

The third major result relates to human resources issues. CAR is labor-intensive and any issue concerning labor would significantly impact the center. CAR employees are experienced, as they have been working at the center for a long time. However, they do not feel empowered, as mentioned in Finding 2. This leads to the lack of confidence of an employee to instruct a visitor to sort the material upon arrival at CAR. This also leads to the lack of feedback loop between the employees and the supervisors to continuously improve the center.



The last major result that affects the center operation is the use of infrastructure and equipment. Though the center is labor-intensive, the employees still use the infrastructure and equipment to help process the collected materials. The current floor plan is illogical in terms of storage cage placement, and the equipment is not in the optimal condition. With broken down equipment, the recycling tasks become more physically straining on the employees, affecting their morale. The issues with infrastructure and equipment also lead to a delay in the whole recycling operation, meaning that the center takes a longer time than it could have to earn revenue from material sales.

## **5.2. Recommendations**

This section introduces six recommendations that the team believes can improve the recycling operation. The last section, 5.2.7, provides a guideline on prioritization of the recommendations for implementation.

### **5.2.1. Implement formal training and retraining of employees and volunteers**

To tackle the human resources problem, our team recommends that FAS establish a formal training program. As mentioned in chapter 2.4, employee initial training is a pivotal step in introducing new employees and volunteers to the recycling center. Employees should go through training in order to learn about the recycling center, its mission, the processes in place, and their specific role. Currently, the supervisor is the person who trains all employees. Our team concludes that the supervisor or director should still conduct the initial tour of the facility.

During the tour, the supervisor or director should go over the mission of the recycling center and why they joined and continue to work for FAS. The purpose of the supervisor or director giving the tour is for the employee to feel welcomed, valued, and excited to work for FAS. Next, the supervisor should place the new employee or volunteer with a current FAS employee.

Experienced FAS employees are experts in their daily tasks and know firsthand the tips and challenges that the new employee can expect. Oftentimes, they lack the confidence to notice this in themselves. Our team concludes that having FAS employees train the new employees rather than having the supervisor perform this task serves threefold: to make the new employee feel more comfortable, to give FAS employees more confidence in their own abilities, and to increase

supervisor compliance to their own roles. We also suggest that FAS implements documentation of their training. FAS should document all tasks and locate these training documents near the location where an employee would normally perform the task that the document describes. For instance, there should be a document on how to sort plastic materials located at the plastics storage cage.

Next, our team recommends that FAS establish a retraining program for their workers. Retraining can help improve the quality of work an employee does, as well as empower them to be a valuable team player.

Worker retraining will increase compliance to the worker's roles in the center. Workers often leave their tasks to help other workers and sort recyclables prior to finishing their own work, leading to potential bottlenecks, disruptions, and delayed reports (Finding 3). Through retraining, the employees can be more aware of the importance of their role in the center so they can prioritize their assignments and avoid disruption to the operation. For example, the supervisor could review the standard tasks with the workers twice a year to go over safety and correct protocols, and how the tasks relate to each other. This practice should instill in the FAS workers a sense of accountability so that they can self-direct and make informed decisions.

FAS workers currently lack confidence in their own abilities (Finding 2) since the workers currently feel that they lack formal education. Retraining programs can introduce them to new topics, especially more challenging topics, so that they feel a sense of accomplishment upon completion of the program. The goal of retraining is also to increase the camaraderie between fellow FAS employees and to make workers more comfortable talking to their supervisor. Initially, FAS should implement an anonymous feedback system, so that the employees can build up a habit of providing feedback. FAS can later switch to using regular meetings between the employees and supervisors, where employees can provide valuable feedback. Moreover, the higher confidence level would empower the FAS employees to be candid when a visitor refuses to sort the materials.

### 5.2.2. Utilize a tailored education program

Our team concluded that contamination stems from a lack of knowledge about correct recycling practices among visitors to CAR (Finding 6). Visitors are confused about acceptable materials at CAR. Our team recommends that FAS educate CAR visitors on how to clean and sort materials pre-arrival, as well as what items CAR does not accept. This should reduce the amount of non-recyclable materials delivered to the center, as these are major issues that plague the classification process efficiency (Finding 8).

Our team suggests tailored education to bridge the knowledge gaps and increase participation and source separation. Organizations must tailor education differently based on their environment, such as the culture and current knowledge. In order to determine where the knowledge gap exists amongst our stakeholders, and to determine what FAS should focus their education programs on, our group asked survey question 5.3, “What would you specifically want to learn more about?” The results to this question are in **Figure 33**.

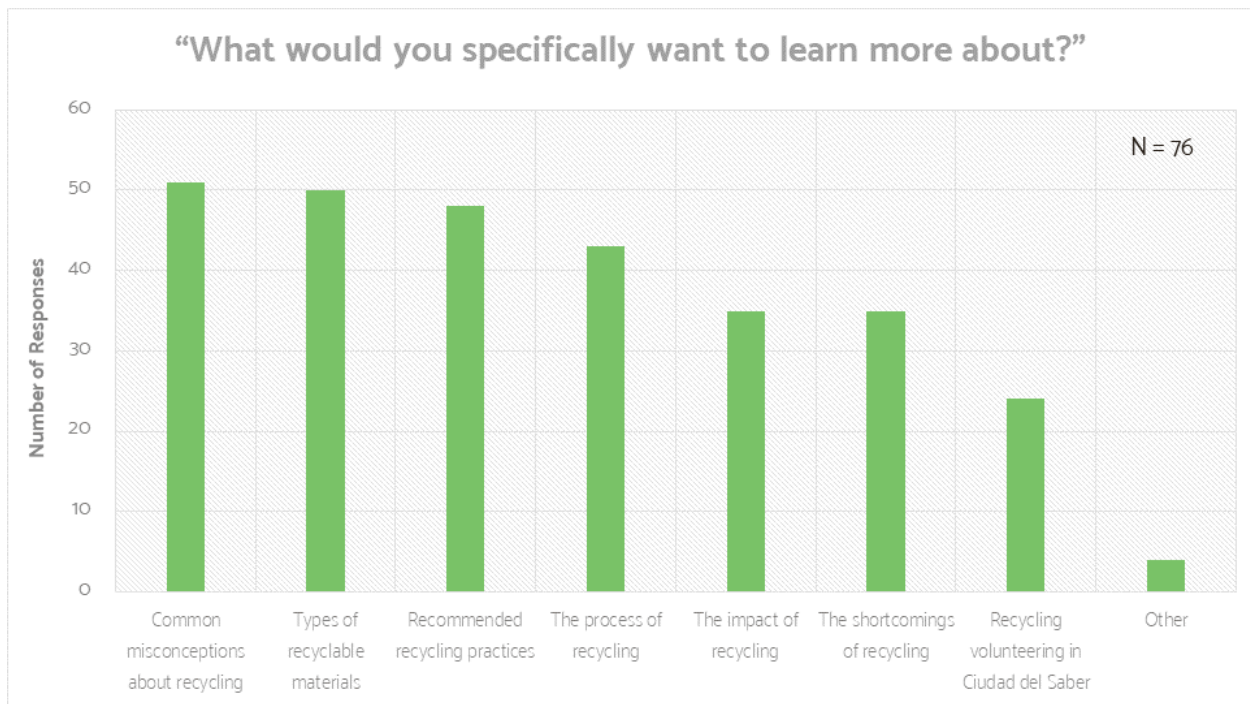
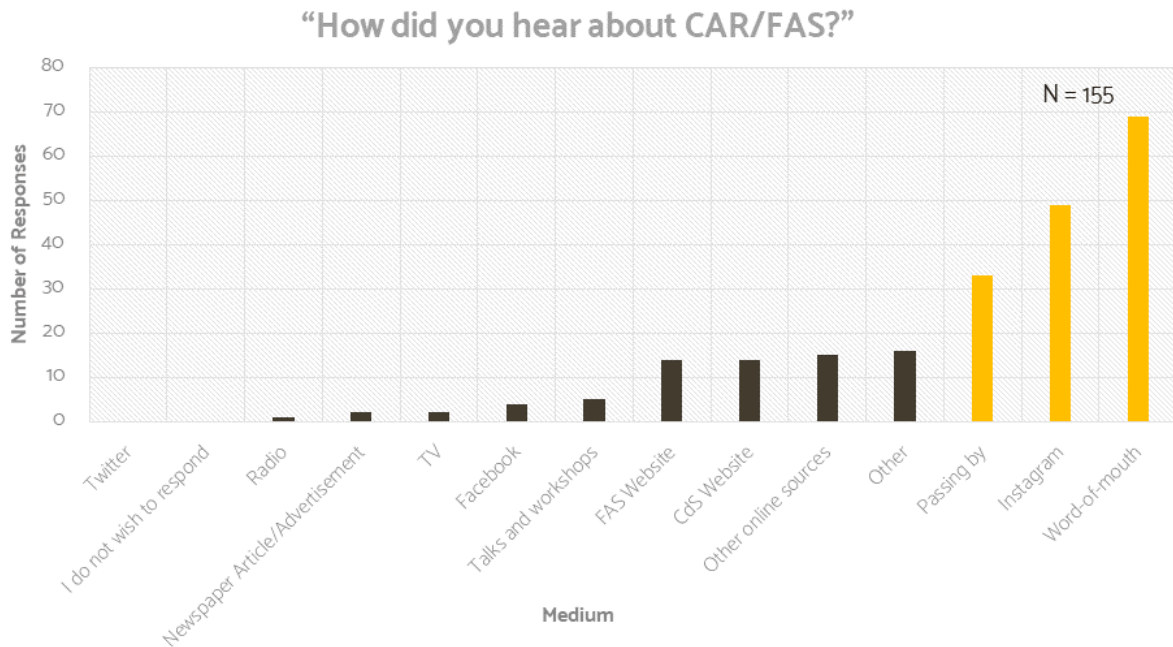


Figure 33: Responses to survey question 5.3, “What would you specifically want to learn more about?”

Based on the responses in **Figure 33**, our group suggests tailoring the education to be about common misconceptions of recycling, types of recyclable materials, and recommended recycling practices. Indeed, education on these topics would reduce improper use of the center such as visitors bringing materials that FAS does not accept at the center, and visitors not properly cleaning and sorting recyclable materials. FAS should also consider informing visitors about the process of recycling, as facts and statistics can prove as an effective education tool, as mentioned in section 2.3.

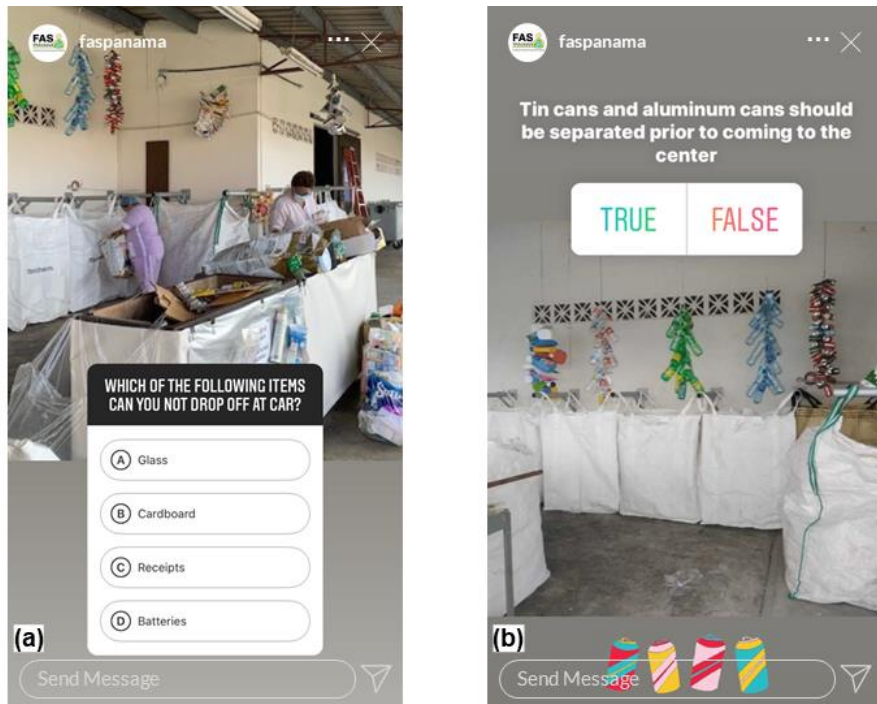
Next, our team investigated the best method of educating the visitors to CdS. Survey question 6.9 “How did you hear about CAR/FAS?” helps to understand what platforms our stakeholders typically get their information from. The responses to this question are in **Figure 34**.



*Figure 34: Responses to survey question 6.9, “How did you hear about CAR/FAS?”*

Based on the responses, most people get their information from word-of-mouth, Instagram, and passing by CAR (shown in yellow). Therefore, Instagram posts and signages around the building would be excellent methods of conveying information on correct recycling practices, common misconceptions about recycling, and the process that goes on at CAR.

Instagram has a feature that allows accounts like FAS Panama to ask questions implement polls that their viewers can answer. After someone answers the question, Instagram or the account owner displays the correct answer. This is a common tool used on Instagram, and the CdS Instagram account already uses quizzes and polls as a part of their marketing strategy. Our team recommends that FAS start a series on their Instagram where they quiz their followers each week. **Figure 35a** shows an example question (the correct answer is Receipts) and **Figure 35b** shows an example poll (the correct answer is True) on Instagram.

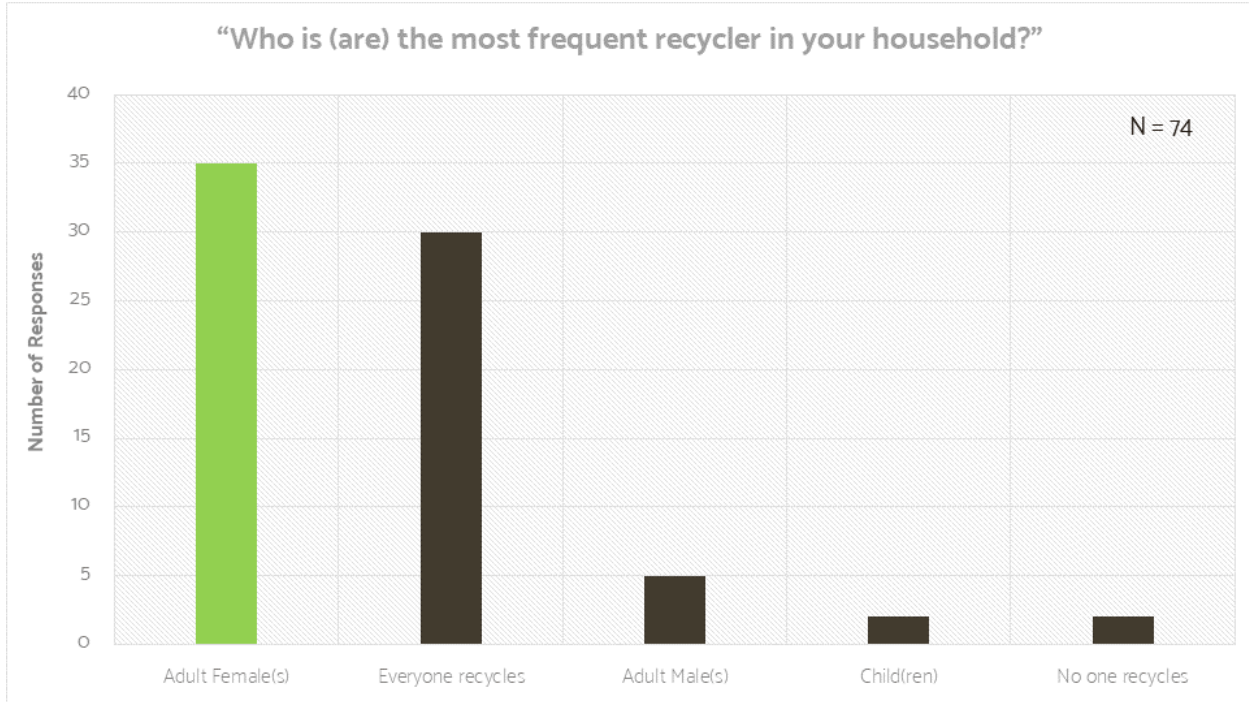


*Figure 35: (a) Sample question and (b) poll using Instagram.*

The goal of these questions on Instagram quizzes/polls is for FAS to educate the visitors on topics like misconceptions about recycling and the recommended recycling practices. These quizzes can also serve as progress checkers, as FAS could view how many people answered correctly on each question over time.

Another feature of Instagram is advertisements. Organizations like FAS and CdS can pay to advertise to a specific group of people on Instagram. Our group asked survey question 3.3 -

“Who is (are) the most frequent recycler in your household?” in order to identify the best group to direct educational efforts towards. The responses to this question are in **Figure 36**.



*Figure 36: Responses to survey question 3.3, “Who is (are) the most frequent recycler in your household?”*

Based on the responses in **Figure 36**, adult females are the most frequent recycler in the household. Therefore, our group recommends that FAS send out educational Instagram advertisements to adult females. To further narrow down the audience base for the advertisement, FAS can use the response to question 2.2 in the survey about the age groups of the survey respondents. FAS should address common misconceptions and correct recycling practices such as cleaning and sorting in these advertisements. Indeed, FAS has already started to post informative videos on their own Instagram account already. Our team encourages FAS to continue to post similar content in the future.

### 5.2.3. Maintain and improve visual control at CAR

Visual control refers to procedures or tools that make the information or problem visible, instead of using texts. Besides communicating information and instructions, visual control displays those materials in an easy-to-understand format even for people who are not familiar with the process, and allows the employees to detect problems faster. Seeing these benefits, the team recommends our sponsor and the employees to:

- **Maintain the traffic flow markings:** Currently, the newly painted U-shaped driveway has increased the organization of visitors to CAR (see **Figure 37**). This driveway allows visitors to drop off the materials in an orderly fashion. This system has an indirect benefit that visitors now have more time to properly sort and place recyclables into the correct sacks and containers.



*Figure 37: Traffic flow markings at CAR*

- **Add traffic flow markings for pickup vehicles:** The current markings at the center are only for visitors dropping off materials. We recommend FAS implement the same concept for pick up vehicles, so that vendors can avoid blocking each other during pick up with the large trucks (see **Figure 38**).



*Figure 38: A large truck at CAR leaves less room for other vehicles to maneuver (FAS Panama, 2018)*



- **Continue to use the mobile-style signages at the drop-off area:** FAS employees made mobile-style signages to indicate the corresponding material sacks and containers (see **Figure 39**) These signages show the actual materials accepted at the center, instead of written instructions, which can be confusing. We encourage CAR to continue using these, as they are easy to understand for the visitors.



*Figure 39: Mobile-style signages above the sorting sacks at CAR in September 2020*

- **Repaint the yellow lines inside the building:** As mentioned in Finding 7, there are yellow lines on the floor of a section of the center to indicate the walkway in between them. The team encourages the sponsor to repaint the existing lines as the color has faded. We also recommend the sponsor to extend these lines throughout the whole building so that inexperienced CAR volunteers can quickly learn the layout of the center.

- Update and display signages on each storage cage:** Although FAS employees are familiar with the current layout of the cages, they may forget accidentally or occasionally. Moreover, inexperienced volunteers are unlikely to remember where a specific storage cage is. To reduce the time a worker spends looking for the correct location, the team recommends FAS to put up signages for each cage. We also recommend FAS to place the signs at eye-level and on the vertical beam of each cage. **Figure 40** shows an example of how a sign might look.



*Figure 40: A sample sign for Cage 3*

- Display labeled floor plans throughout the center:** When combined with the cage signages, these floor plans can help volunteers and visitors find where they need to go quickly.

- **Implement a shadow board system for equipment:** A conventional shadow board shows the outline of the tools to help with organization (see **Figure 41**). Such a board can reduce the time a worker spends looking for a tool as each tool has a designated spot on the board. The board also informs a worker if a tool is in use, as it would be missing from the storage spot. The team recommends our sponsor apply the same concept for tools and large equipment storage at the center. For the large equipment, such as the jack lift, the flatbed cart, or the baler, the outline can be on the floor instead of on a board.



*Figure 41: An example of a shadow board in a workplace (Superfactory, 2008)*

- **Implement a visual task board (Kanban board):** The team recommends our sponsor to implement a visual task board (see **Figure 42** for the proposed design) to help the employees keep track of their daily assignments. The proposed design has five rows for four standard tasks and transporting, as mentioned in the previous chapter. There are three columns for each task: *To Do*, *In Progress*, and *Completed*. At the beginning of each day or week, the Administrative Staff should add the *To Do* items onto the board for the four standard tasks, using colored sticky notes, with each color corresponding to each employee. Each note would include information on what the assignment is, and who is responsible for doing that assignment. The employees should move the sticky notes to the *In Progress* column when they pick up the assignment, and to the *Completed* column when they finish the assignment. These sticky notes would allow the employees and any inexperienced employee to see the work progress at a glance. Moreover, the employees can also request help with lifting and transporting by adding the sticky note to the Transporting row whenever necessary. These colored sticky notes on the board will inform the Truck Driver and Classifier 1 when they need to move materials along the operation without the need for verbal communication. They can then complete their current assignment without interrupting the workflow. In order for this system to be successful, we recommend each assignment on the sticky note be broken down as much as possible. For example, an activity of “Making five bales of plastics” should be on five notes, each says “Make one bale of plastics.” This practice ensures that the workers update the progress more frequently, and that there is buffer time before each transporting task assignment to prevent interruption to any ongoing assignment. Our sponsor should also locate this board at a central location, so the employees do not need to travel far to update the board.

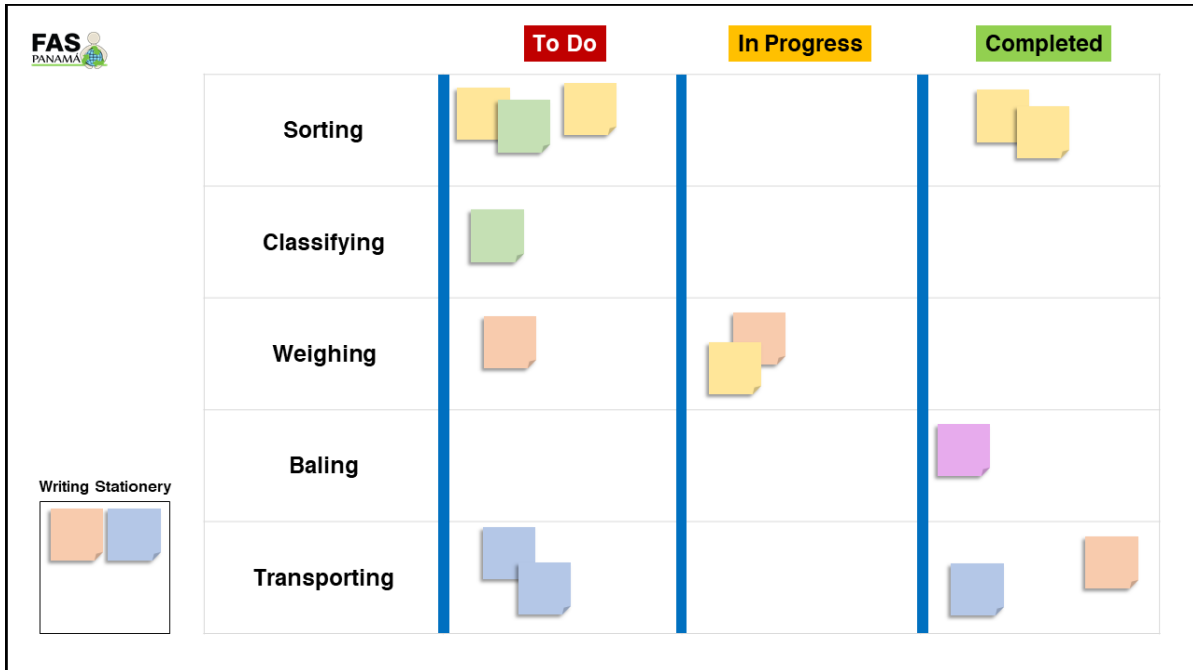


Figure 42: A mock-up of a visual task board for CAR

#### 5.2.4. Rearrange the floor layout

As discussed in Finding 7, the locations of the storage cages are not ideal, as the current layout forces the employees to transport heavy materials for long distances between tasks. Thus, we recommend that the center consider rearranging the storage cages using either of the two proposed layouts. To design these layouts (see **Figure 43** for proposed layout 1 (clockwise), see **Appendix E** for proposed layout 2 (counter-clockwise), the team used two guiding principles, as mentioned in section 3.4: to minimize the movement and transporting between two consecutive tasks, and to only rearrange if necessary.

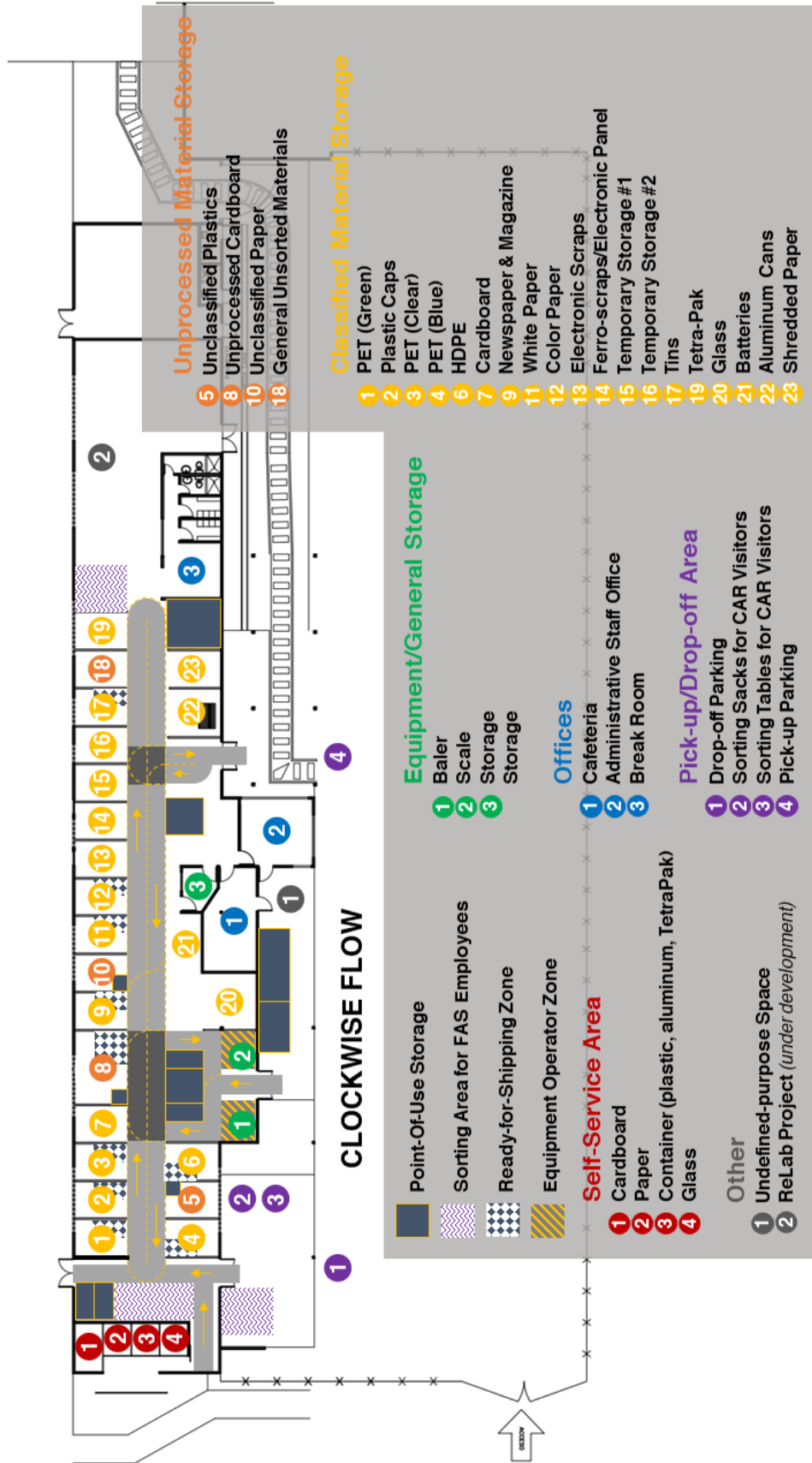


Figure 43: Proposed Layout (clockwise)

Since every material goes through weighing, rearrangement of storage cages does not significantly affect the distance a worker travels between a cage and the scale. Moreover, the current location of the scale is ideal for weighing the materials from the drop-off area. Thus, the scale remains at the same location in the proposed layouts. Since glass is quite heavy and it does not go through much processing, the material should be near the entrance door. Hence, the glass storage cage also stays at the same location. As the baler is unmovable, and that only plastics and cardboard go through baling, plastics and cardboard cages should be as close to the baler as possible. The proposed location of the plastics is also near the entrance door from the drop-off area so that FAS workers do not need to move the sorted plastic very far to its storage cages.

The proposed layouts include the designation of two entrances and one exit for the materials, and the addition of equipment storage spaces. Since any material pickup happening at either of the two left doors would block off the visitor traffic flow (Finding 7), the only door available for output material loading is the right-most one. To facilitate material transportation, we also divide the current walkway into a two-way path, using a path divider. It is crucial for the employees to strictly follow the indicated flow direction to avoid path-crossing. However, they can cross the path divider when they are across from the destination cage. The team also added several equipment storage spaces (Point-Of-Use Storage) throughout the center so that the workers would have quicker access to the necessary tools. The exact location of each piece of equipment is dependent on its demand. For example, the jack lift and wooden pallets should be in the storage space nearest to the baler, so that the employees can quickly load and unload the baler.

It is important for the implementation of this proposal that CAR uses visual control to mark the floor, as we mentioned in section 5.3. Moreover, each layout has its own advantages and setbacks. For layout 1 (**Figure 43**), the workers would not need to cross the path divider (and cut through opposite-direction flow) as many times to deposit the materials into the correct cages when compared to the other layout. However, the flow in layout 1 is clockwise (left-hand traffic). This flow is less intuitive since Panama uses right-hand traffic, meaning that the employees would need more time to get used to this new layout. On the other hand, layout 2 (**Appendix E**) uses right-hand traffic flow (counter-clockwise), which is more familiar to the employees. However, the workers would need to cross the path divider more often for the cages on the right-hand side of the recycling center.

### 5.2.5. Maintain and increase usage of equipment

CAR currently has many underutilized tools at its disposal. The operation would be more efficient if they use these tools properly. CAR also has broken down equipment. Hence, the team recommends our sponsor and FAS employees to:

- **Continue to have regular inspections of current equipment,** to prevent and spot future degradation of equipment the team recommends that CAR conducts regular inspections of current equipment. Similar to how a worker would test a fire alarm's capabilities, FAS employees should inspect each piece of equipment such as the scale, baler, and other heavy equipment following the manufacturer's recommendation, or at least once a month.
- **Repair currently broken equipment:** CAR currently has a broken scale and a broken jack lift. FAS should prioritize fixing the scale to reduce weighing time, and the jack lift to ensure the safety of the FAS workers who move the heavy bales and to speed up the transporting time.
- **Continue to use the monthly schedule board:** It is important for FAS employees to know the monthly schedule, so they are aware of any upcoming events, reducing the chance of unexpected disruption. The team recommends that the Administrative Staff and the FAS director continue to regularly use and update the schedule board for this purpose.
- **Increase equipment usage:** Currently CAR has access to a few wheeled bins (**Figure 18**) that are underused. FAS workers using the wheeled bin would allow moving multiple bags at a time with less effort.

### 5.2.6. Implement forecasting and scheduling

Forecasting of the price of materials positively affects the overall efficiency and profitability of a company. If FAS can predict when the resale price of a certain material is high or low, FAS would know when to sell and when not to sell a certain material. Using this information, the



center could backlog a certain material until the resale price would go up, and then sell it at that point in time. The team recommends CdS to:

- **Use time series methods model for short-range forecasting:** Time series methods use previous and historical data to predict what will happen in the future, specifically the near future. A simple time series method model for FAS to use is the moving average model. The moving average model simply takes the most recent data into consideration when predicting near future demands. For example, if at the end of a week, the demand for plastic price dictates \$0.11/kg, then the forecast for next week would also be \$0.11/kg. The advantage of the moving average model is that outside of an unnatural or unusual spike in demand at any given moment, the forecast should be accurate.
- **Implement regression models for long range forecasting:** As opposed to time series methods, regression models are better for long term resale price forecasting. Regression models focus on historical data and factors as to why the data behaves a certain way. Since regression models take into account these extra factors, this model can find trends from year to year in order to forecast the resale price for a certain material for an entire year. For example, a regression model would notice if a certain model tends to have a lower resale price at CAR in a certain month or time of the year and uses this information to predict a price for that material in the next year as well.
- **Create schedules based on the forecasting models:** Once FAS has implemented both the short-term and long-term models, CAR can implement schedules using the modeling information. For example, if the regression model states that plastic's resale value normally doubles in the month of March, it would be wise for the center to backlog extra plastic until March when the price is high. The short-term time series methods model would become valuable in scheduling if prices start to rise at a certain point in time not predicted in the regression model. FAS can then modify their schedule based on the new information.

## 5.2.7. Ranking of Recommendations

As the six recommendations would introduce significant changes to the operation at CAR, we decided to rank them in terms of how effective they are to achieve the five desirable outcomes, according to our sponsor, as mentioned in section 2.8. To do so, the team used the cause-and-effect matrix (**Table 5**) mentioned in section 2.8.4.

*Table 5: Cause-and-Effect Matrix for the six recommendations*

|                         |                               |               | Key Output (Y) Variables            |                                       |   |  |  |       | Rank of X Variables / Importance to Customer |
|-------------------------|-------------------------------|---------------|-------------------------------------|---------------------------------------|---|--|--|-------|--|
|                         |                               |               | 1                                   | 2                                     | 3   | 4  | 5  |       |  |
|                         |                               |               | Increase income from material sales | Decrease sorting and classifying time | Increase collected amount of high-value materials | Increase visitors' understanding about recycling | Increase FAS employees' satisfaction level |       |  |
| Key Input (X) Variables |                               | Customer Rank | 1                                   | 4                                     | 2   | 5  | 3  | Score |  |
|                         |                               | Weight        | 10                                  | 8                                     | 9   | 5  | 9  |       |  |
| 1                       | Formal Training/Retraining    |               | 3                                   | 8                                     | 5   | 2  | 10   | 239   | 3  |
| 2                       | Tailored Education Program    |               | 2                                   | 5                                     | 9   | 10   | 9  | 272   | 1  |
| 3                       | Visual Control                |               | 0                                   | 10                                    | 5   | 7  | 8  | 232   | 4  |
| 4                       | Floor Layout Rearrangement    |               | 0                                   | 9                                     | 0   | 0  | 5  | 117   | 6  |
| 5                       | Equipment Maintenance & Usage |               | 1                                   | 9                                     | 1   | 2  | 9  | 182   | 5  |
| 6                       | Forecasting & Scheduling      |               | 10                                  | 4                                     | 9   | 0  | 3  | 240   | 2  |

For the X-variable column of the matrix, we filled in the six recommendations. For the Y-variable rows, we filled in the five outcomes. The number underneath each outcome indicates the order of importance of that outcome is to our sponsor: Increase income from material sales is the most important outcome, and Increase visitors' understanding about recycling is the least important outcome. The team then asked the sponsor to further quantify the level of importance of each outcome, by assigning a weight to each income (blue row), with 10 being extremely important and 0 being not at all important. The team then quantified on our own how each X-variable affects each Y-variable, using a scale from zero to ten, with 0 being X does not affect Y and 10 being X significantly affects Y. It is noteworthy that the score does not apply for how Y affects X. To calculate the final score for the yellow column, the team summed up the product of each green cell with the corresponding blue cell. For example, for Formal Training/Retraining,  $\text{Score} = 3 \times 10 + 8 \times 8 + 5 \times 9 + 2 \times 5 + 10 \times 9 = 239$ . The last column in red shows the ranking of the six recommendations in terms of their effectiveness in achieving the five outcomes.

Hence, the ranking of the recommendations, in order from most effective to least effective, is Tailored Education Program, Forecasting & Scheduling, Formal Training/Retraining, Visual Control, Equipment Maintenance & Usage, and Floor Layout Rearrangement. Thus, we recommend our sponsor to use this ranking to prioritize recommendations for implementation.

### **5.3. Recommendations for Future Projects**

The analysis and recommendations in this project focus on the recycling center at a macro-scale. Many of the actionable items in section 5.2, such as choosing a rearranged layout, would require a significant amount of researching and planning before implementation. We encourage future researchers to use the results and recommendations in this report as guidelines for their projects if applicable.

Additionally, our sponsor informed the team that CAR would relocate in the near future. Future projects can research how the recommendations in this report can become applicable at the new site.

From the monthly reports, we identified that about half of the material received at the center by weight is glass, yet the center is not earning revenue from glass. Future projects should determine practical options to repurpose glass into profitable products.

During the course of this project, we also learned about a new project that CdS and FAS have been working on. The ReLab project aims to turn CAR into a Transformation Center for plastic materials, using the concepts from Precious Plastic. The FAS Director is currently building a plastic shredder for her own project and CdS is looking to help turn the project into a source of income for the center.

# Bibliography

- Ariel Montenegro, E. (2017, October 10). *Autoridades Inician Negociaciones con Recicladores en La Chorrera*. Panama America. Retrieved April 25, 2020, from <https://www.panamaamerica.com.pa/provincias/autoridades-inician-negociaciones-con-recicladores-en-la-chorrera-1085785>
- Basura Cero. (2019, March 25). *Estación para Reciclaje #26*. Alcaldía de Panamá. Retrieved April 20, 2020 from <https://basuracero.mupa.gob.pa/estacion-para-reciclaje-26/>
- Biddle, D. (1993). *Recycling for Profit: The New Green Business Frontier*. Harvard Business Review, 71(6), 145.
- Buis, A. (2019, October 09). *The Atmosphere: Getting a Handle on Carbon Dioxide*. NASA. Global Climate Change. Retrieved May 1, 2020, from <https://climate.nasa.gov/news/2915/the-atmosphere-getting-a-handle-on-carbon-dioxide/>
- Ciudad del Saber. (n.d.). *Nuestra Mision*. Ciudad del Saber. Retrieved May 7, 2020, from <https://ciudadelsaber.org/nuestra-mision/>
- Ciudad del Saber. (2019, August 21). *Recycling, Resocialization and Reinsertion: How a Penitentiary is Giving New Meaning to the 3Rs*. Retrieved March 28, 2020, from <https://ciudadelsaber.org/en/2019/08/21/recycling-resocialization-and-reinsertion-how-a-penitentiary-is-giving-new-meaning-to-the-3rs/>
- Ciudad del Saber. (2020, January 31). *Sustainability*. Retrieved March 28, 2020, from <https://ciudadelsaber.org/en/sustainability>
- Ciudad del Saber. (2020, March 25). *What is the City of Knowledge?* Retrieved March 28, 2020, from <https://ciudadelsaber.org/en/what-is-the-city-of-knowledge/>
- Container Recycling Institute. (2009). *Average Net Cost Estimates - Single Stream vs Dual Stream 2007* [Bar Graph]. Retrieved April 18, 2020, from <http://www.container-recycling.org/assets/pdfs/reports/2009-SingleStream.pdf>

- Container Recycling Institute. (2009). *Understanding Economic and Environmental Impacts of Single-Stream Collection Systems*. Retrieved May 8, 2020, from <http://www.container-recycling.org/assets/pdfs/reports/2009-SingleStream.pdf>
- deOliveira Hyme, B., Monk, D., & Tremblay, C. (n.d.). *Recycling Stories: Lessons from Community Arts-Based Process and Exhibition in Brazil*. *Journal of Adult and Continuing Education*, 22(2), 216–232.
- FAS Panama (2018) [FAS Employees Happy] Retrieved from <https://www.facebook.com/faspanama.org/photos/a.156607074536373/799509656912775>
- FAS Panama (2018) [Truck] Retrieved from <https://www.facebook.com/faspanama.org/photos/a.156607074536373/941455846051488>
- FAS Panama (2018) [Wheeled bin] Retrieved from <https://www.facebook.com/faspanama.org/photos/a.156607074536373/839352279595179>
- FAS Panama (2019) [Inside the Collection Center] Retrieved from <https://www.facebook.com/faspanama.org/photos/a.156607074536373/1118003378396733>
- FAS Panama (2019) [Volunteer Day Inside] Retrieved from <https://www.facebook.com/media/set/?vanity=faspanama.org&set=a.1168116056718798>
- Gentle, Carrie. (2020, March 13). *Cleaning and Sorting Adding to Cost of Recycling*. The Falmouth Enterprise. Retrieved April 23, 2020, from [https://www.capenews.net/falmouth/news/cleaning-and-sorting-adding-to-cost-of-recycling/article\\_8bbe97fe-de55-5e30-a5fb-8636ec027217.html](https://www.capenews.net/falmouth/news/cleaning-and-sorting-adding-to-cost-of-recycling/article_8bbe97fe-de55-5e30-a5fb-8636ec027217.html)
- Ineco. (2017). *Plan Nacional de Gestión Integral de Residuos 2017-2027*, Illustration 16, pp 92, Autoridad de Aseo, Retrieved May 5, 2020, from <http://aaud.gob.pa/plangestion/Docs/PNGIR.pdf>
- Katz, C. (2019, March 07). *Piling Up: How China's Ban on Importing Waste Has Stalled Global Recycling*. *Yale Environment 360*. Retrieved May 08, 2020, from <https://e360.yale.edu/features/piling-up-how-chinas-ban-on-importing-waste-has-stalled-global-recycling>

- Kaza, Silpa, et al. (2018). *What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050*. Washington DC: World Bank.
- Pan American Health Organization. (2010). *Regional Evaluation on Urban Solid Waste Management in Latin America and the Caribbean*. Retrieved May 10, 2020, from <https://publications.iadb.org/publications/english/document/Regional-Evaluation-on-Urban-Solid-Waste-Management-in-Latin-America-and-the-Caribbean-2010--Report.pdf>.
- Ponto J. (2015). *Understanding and Evaluating Survey Research*. *Journal of the Advanced Practitioner in Oncology*, 6(2), 168–171.
- Mattson, S., Teran, A. (2011, September 6). *Education Trap Threatens Panama's Economic Boom*. Reuters. Retrieved April 28, 2020, from <https://www.reuters.com/article/us-panama-education/education-trap-threatens-panamas-economic-boom-idUSTRE7857D420110906>
- Milsark, M., Mittleman, A., & Van Tronk, J. (2018, October). *Ciudad del Saber: Carbon Footprinting*. [Interactive Qualifying Project, Worcester Polytechnic Institute]. WPI Electronic Project Collections.
- Paglia III, J. (2019, May). *The Importance of Community Outreach and Public Education*. *Waste Advantage Magazine*, 10(5), 20.
- Rogoff, M. (2014). *Solid Waste Recycling and Processing : Planning of Solid Waste Recycling Facilities and Programs* (2nd ed.). Waltham, MA: William Andrew Publishing.
- Russell, R. S., & Taylor, B. W. (2011). *Operations Management: Creating Value Along the Supply Chain* (7th ed.). Hoboken, NJ: John Wiley & Sons.
- Shapley, Haley. (2019, September 10). *Teaching Kids to Recycle*. Retrieved May 7, 2020, from <https://earth911.com/home-garden/teaching-kids-to-recycle/>
- Smith, R. (2019, October 17). *Is the Circular Economy Inconvenient?*. Sourceable. Retrieved April 24, 2020, from <https://sourceable.net/is-the-circular-economy-inconvenient/>
- Superfactory (2008) [Shadow board] Retrieved from <https://superfactory.typepad.com/photos/uncategorized/2008/10/16/shadowboard.jpg>

- This is ECO (n.d.). *5 Advertising Campaigns That Make You Want to Recycle*. Retrieved May 7, 2020, from [https://www.thisiseco.co.uk/news\\_and\\_blog/5\\_Advertising\\_Campaigns\\_that\\_make\\_you\\_want\\_to\\_recycle.html](https://www.thisiseco.co.uk/news_and_blog/5_Advertising_Campaigns_that_make_you_want_to_recycle.html)
- Tornio, S. (2018, November 21). *29 Ideas Big and Small to Bring Recycling into the Classroom*. We Are Teachers. Retrieved May 7, 2020, from <https://www.weareteachers.com/21-ideas-big-and-small-to-bring-recycling-into-the-classroom/>
- Union of Concerned Scientists (2009, June 6). *Why Does CO2 get Most of the Attention When There are so Many Other Heat-Trapping Gases?* Retrieved May 7, 2020, from <https://www.ucsusa.org/resources/why-does-co2-get-more-attention-other-gases>
- U.S. Environmental Protection Agency. (2016). *Advancing Sustainable Materials Management: 2016 Recycling Economic Information (REI) Report*. Retrieved May 2, 2020, from [https://www.epa.gov/sites/production/files/2017-05/documents/final\\_2016\\_rei\\_report.pdf](https://www.epa.gov/sites/production/files/2017-05/documents/final_2016_rei_report.pdf)
- U.S. Environmental Protection Agency. (n.d.). *Basic Information about Landfill Gas*. Retrieved May 7, 2020, from <https://www.epa.gov/lmop/basic-information-about-landfill-gas>
- U.S. Environmental Protection Agency. (n.d.). *National Overview: Facts and Figures on Materials, Wastes and Recycling*. Retrieved May 10, 2020, from <https://www.epa.gov/facts-and-figures-about-materials-waste-and-recycling/national-overview-facts-and-figures-materials>
- van Gurp, M. (2011, April 25). *Pollution: Deal with the Consequences*. Osocio. Retrieved May 7, 2020, from <https://osocio.org/message/pollution-deal-with-the-consequences/>
- William Bennett, Emily Chretien, Sophia Gomarlo, Peter Hurly (2017, March 3). *A Proposed Recycling Facility for the Informal Waste Collectors of Oshakati*. [Interactive Qualifying Project, Worcester Polytechnic Institute]. WPI Electronic Project Collections.
- Williams, Hannah. (2011). *Examining the Effects of Recycling Education on the Knowledge, Attitudes, and Behaviors of Elementary School Students*. [Outstanding Senior Seminar Paper, Illinois Wesleyan University]. IWU Digital Commons.

# Appendices

## Appendix A: Survey-related Materials

### A1: Official Survey

English

#### Introduction



#### Recycling at Ciudad del Saber Survey

Responsible Investigators: Xavier Curney, Hoang (John) Do, Ethan Graham, and Katherine Pawlak

- We are a team of four college students from Worcester Polytechnic Institute, USA. You have been asked to participate in our research study that aims at investigating i) the recycling process and ii) the understanding on recycling in Ciudad del Saber.
- You are asked to take the following survey.
- This investigation will result in a proposal to Fundación Ciudad del Saber of suggested improvements to the recycling strategies on campus.
- Although the results of this study may be published, no information that could identify you will be included.
- Questions about this research, research subject's rights, research-related injury, or complaints may be addressed to [gr-cofk-a20@wpi.edu](mailto:gr-cofk-a20@wpi.edu).
- Your consent is being given voluntarily. If you decide to participate in the survey, you are free to withdraw at any

Español (América Latina)

#### Introduction



#### Encuesta del Reciclaje en Ciudad del Saber

Investigadores Responsables: Xavier Curney, Hoang (John) Do, Ethan Graham, y Katherine Pawlak.

- Somos un equipo de cuatro estudiantes universitarios del Instituto Politécnico de Worcester, EE.UU. Se le ha pedido que participe en nuestro estudio de investigación que tiene como objetivo investigar i) el proceso de reciclaje y ii) la comprensión sobre el reciclaje en Ciudad del Saber.
- Se le pedirá que realice la siguiente encuesta.
- Esta investigación dará lugar a una propuesta a la Fundación Ciudad del Saber de las mejoras sugeridas a las estrategias de reciclaje en el campus.
- Aunque los resultados de este estudio pueden ser publicados, no se incluirá ninguna información que pueda identificarle.
- Las preguntas sobre esta investigación, los derechos del sujeto de investigación, las lesiones relacionadas con la investigación o las quejas pueden ser dirigidas a [gr-cofk-a20@wpi.edu](mailto:gr-cofk-a20@wpi.edu).



time without any negative effect on your relations with Fundación Ciudad del Saber or with any other participating institutions.

Thank you for participating in this survey.

There are two sections to this survey:

**General Information Questions:** All participants are asked to respond to the same list of questions.

**Specific Questions:** Each participant will respond to a specific list of questions based on their category.

All multiple choice questions are *required*. There is an option if you do not wish to respond for most questions.

All open-ended questions are *optional*.

Abbreviations:

CAR: Centro de Acopio de Reciclables

CdS: Ciudad del Saber

FAS: Fundación de Acción Social por Panamá

FCdS: Fundación Ciudad del Saber

### General Information Questions

## Section 1 - General Information Questions

Please answer the following questions.

Which range describes your age?

- Under 20 years old
- 20-29 years old
- 30-39 years old
- 40-49 years old
- 50-59 years old
- 60 years or older
- I do not wish to respond

Which of these categories describe you? (choose all that apply)

- FCdS Employee** - A person who works for Fundación Ciudad del Saber
- CdS Resident** - A person who resides in a Ciudad del Saber residential facility for at least one night
- CdS Tenant** - A person who operates or works for a business that leases out space on the CdS campus from FCdS
- CAR/FAS Employee/Volunteer** - A person who works at the recycling center
- Visitor to CAR** - A person who drops their waste off at the recycling center
- Visitor to CdS** - A person who comes to the CdS campus but does not fit into any of the previous categories

Do you recycle at home?

- Yes
- No

Do you recycle in the workspace?

- Yes
- No

- Su consentimiento se está dando voluntariamente. Puede negarse a participar en la encuesta. Si decide participar en la encuesta, puede retirarse en cualquier momento sin ningún efecto negativo en sus relaciones con la Fundación Ciudad del Saber o con cualquier otra institución u organismo participante.

Gracias por participar en esta encuesta.

Hay dos secciones para esta encuesta:

**Preguntas de información general:** Se pide a todos los participantes que respondan a la misma lista de preguntas.

**Preguntas específicas:** Cada participante responderá a una lista específica de preguntas basadas en su categoría.

Todas las preguntas de opción múltiple son necesarias. Hay una opción si no desea responder para la mayoría de las preguntas.

Todas las preguntas abiertas son opcionales.

Las abreviaturas:

CAR: Centro de Acopio de Reciclables

CdS: Ciudad del Saber

FAS: Fundación de Acción Social por Panamá

FCdS: Fundación Ciudad del Saber

### General Information Questions

## Sección 1 - Preguntas de Información General

Por favor responda las siguientes preguntas.

¿Qué rango describe tu edad?

- Menores de 20 años
- 20-29 años
- 30-39 años
- 40-49 años
- 50-59 años
- 60 años o más
- No deseo responder

¿Cuál de estas categorías te describe? (elija todos los que correspondan)

- Empleado de FCdS** - Una persona que trabaja para la Fundación Ciudad del Saber
- Residente de CdS** - Una persona que reside en una instalación residencial de Ciudad del Saber durante al menos una noche
- Inquilino de CdS** - Una persona que opera u trabaja para un negocio que alquila espacio en el campus de CdS de FCdS
- CAR/FAS Empleado/Voluntario** - Una persona que trabaja en el centro de reciclaje
- Visitante a CAR** - Una persona que deja sus residuos en el centro de reciclaje
- Visitante a CdS** - Una persona que viene al campus de CdS pero no encaja en ninguna de las categorías anteriores

**Block 3**

Why do you not recycle? (choose all that apply)

- Recycling is time-consuming
- Recycling is unnecessary
- Recycling is expensive
- Recycling is inconvenient
- There are no recycling bins available
- The recycling bins are full
- I do not have enough recyclable materials
- Someone else will separate the recyclable materials from my trash
- I do not know how to recycle
- Other (please specify)
- I do not wish to respond

What are your motivations for recycling? (choose all that apply)

- Recycling is good for the environment
- I feel good when I recycle
- I receive compensation when I recycle
- I am told/made to recycle
- By recycling, I feel that I am donating to Ciudad del Saber
- Other (please specify)
- I do not wish to respond



Who is (are) the most frequent recycler in your household?

- Adult female(s)
- Adult male(s)
- Child(ren)
- Everyone recycles
- No one recycles

Do you think recycling is important?

- Extremely important
- Very important
- Moderately important
- Slightly important
- Not at all important
- I do not wish to respond

Which of these items are or are not accepted at CAR?

|  | Accepted at CAR       | Not Accepted at CAR   | I do not know         | I do not wish to respond |
|--|-----------------------|-----------------------|-----------------------|--------------------------|
| Wood<br>              | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>    |
| Electronic Scraps<br> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>    |

¿Reciclas en su casa?

- Sí
- No

¿Reciclas en el lugar de trabajo?

- Sí
- No

**Block 3**

¿Por qué no reciclas? (elijá todo que se aplican)

- El reciclaje consume mucho tiempo.
- El reciclaje es innecesario
- El reciclaje es costoso
- El reciclaje es inconveniente
- No hay contenedores de reciclaje disponibles
- Los contenedores de reciclaje están llenos
- No tengo suficientes materiales reciclables
- Alguien más separará los materiales reciclables de mi basura
- No sé cómo reciclar
- Otro (especificar)
- No deseo responder

¿Cuáles son sus motivaciones para reciclar? (elijá todos los que correspondan)

- Reciclaje es bueno para el medio ambiente
- Me siento bien cuando reciclo
- Recibo compensación cuando reciclo
- Me dicen/hacen que recicles
- Reciclando, siento que estoy donando a Ciudad del Saber
- Otro (especificar)
- No deseo responder

¿Quién es la persona que más recicla en tu hogar?







- Mujer adulta(s)
- Varón adulto(s)
- Hijo(s)
- Todos reciclamos
- Nadie recicla






¿Crees que el reciclaje es importante?






- Extremadamente importante
- Muy importante
- Moderadamente importante
- Ligeramente importante
- No en absoluto importante
- No quiero responder







¿Cuáles de estos artículos se aceptan o no se aceptan en el CAR?







Accepted in CAR    Not accepted in CAR    No sé    No deseo responder






|   | Accepted at CAR       | Not Accepted at CAR   | I do not know         | I do not wish to respond |
|---|-----------------------|-----------------------|-----------------------|--------------------------|
| Fabric<br>                 | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>    |
| Plastic containers<br>     | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>    |
| Plastic bags/wrappings<br> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>    |
| Batteries<br>              | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>    |
| Organic waste<br>          | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>    |
| Aluminum<br>               | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>    |

|   | Aceptado en CAR       | No aceptado en CAR    | No sé                 | No deseo responder    |
|---|-----------------------|-----------------------|-----------------------|-----------------------|
| Papel<br>            | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Acete<br>            | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Residuo orgánico<br> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Madera<br>           | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Tela<br>             | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

|   | Accepted at CAR       | Not Accepted at CAR   | I do not know         | I do not wish to respond |
|---|-----------------------|-----------------------|-----------------------|--------------------------|
| Oil<br>                  | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>    |
| Shredded paper<br>       | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>    |
| Carboard<br>             | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>    |
| Styrofoam<br>            | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>    |
| Tetra-Pak containers<br> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>    |

|   | Aceptado en CAR       | No aceptado en CAR    | No sé                 | No deseo responder    |
|---|-----------------------|-----------------------|-----------------------|-----------------------|
| Comprobantes<br>               | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Papel en tiras<br>             | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Vidrio<br>                     | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Chatarras<br>Eletrolíticas<br> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Bolas de plástico<br>          | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Copos de papel<br>             | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

|  | Accepted at CAR       | Not Accepted at CAR   | I do not know         | I do not wish to respond |
|--|-----------------------|-----------------------|-----------------------|--------------------------|
| Tissue / Napkin<br> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>    |
| Paper<br>           | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>    |
| Coffee Cups<br>     | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>    |
| Light bulbs<br>     | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>    |
| Glass<br>           | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>    |
| Receipts<br>        | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>    |

|  | Aceptado en CAR       | No aceptado en CAR    | No sé                 | No deseo responder    |
|--|-----------------------|-----------------------|-----------------------|-----------------------|
| Espuma de poliestireno<br>        | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Baterías<br>                      | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Pañuelo de papel / Servilleta<br> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Bombillas<br>                     | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Cartón<br>                        | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

**When you are unsure whether an item is recyclable, what do you usually do?**

- Place item in the trash
- Place the item in the recycling bin
- Ask others where to place the item
- Look up information on the internet where to place the item
- Contact CAR
- other (please specify)
- I do not wish to respond




**Block 4**

**Do you clean recyclable materials before depositing them?**

- Yes
- Sometimes
- No
- I do not wish to respond

**What do you find inconvenient to cleaning recyclable materials before depositing them? (choose all that apply)**

- The task is dirty
- The task is time-consuming
- The task does not make a big difference
- I do not need to clean recyclable materials where I come from
- other (please specify)

|   | Aceptado en CAR       | No aceptado en CAR    | No sé                 | No deseo responder    |
|---|-----------------------|-----------------------|-----------------------|-----------------------|
| Aluminio<br>               | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Tetra-Pak<br>              | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Contenedores Plásticos<br> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

**Cuando no está seguro de si un artículo es reciclable, ¿qué suele hacer?**

- Colóquelo en la basura
- Colóquelo en la papelería de reciclaje
- Pregunte a otros dónde colocarlo
- Buscar en Internet donde colocarlo
- CAR Contacto
- otro (especificar)
- No deseo responder

**Block 4**

- The task is NOT inconvenient
- I do not wish to respond

Which of these incentives would make you want to clean recyclable materials before depositing them? (choose all that apply)

- Receiving money for your clean recyclable materials
- Receiving a certificate for your clean recyclable materials
- Receiving community service hours for your clean recyclable materials
- Being invited to events about recycling
- Learning about recycling
- Other (please specify)
- I do not need an incentive to clean recyclable materials
- I do not want to clean recyclable materials before depositing them
- I do not wish to respond

Do you separate recyclable materials into different categories before depositing them?

- Yes
- Sometimes
- No
- I do not wish to respond

What do you find inconvenient to separating recyclable materials before depositing them? (choose all that apply)

- The task is dirty
- The task is time-consuming
- The task takes up space

- I do not know how to separate them correctly
- The task does not make a big difference
- I do not need to separate recyclable materials where I come from
- Other (please specify)
- The task is NOT inconvenient
- I do not wish to respond

Which of these incentives would make you want to separate recyclable materials before depositing them? (choose all that apply)

- Receiving money for your clean recyclable materials
- Receiving a certificate for your clean recyclable materials
- Receiving community service hours for your clean recyclable materials
- Being invited to events about recycling
- Having more recycling bins
- Learning about recycling
- Other (please specify)
- I do not need an incentive to separate recyclable materials
- I do not want to separate recyclable materials before depositing them
- I do not wish to respond

#### Block 5

Have you seen or heard about recycling programs in Ciudad del Saber?

- Yes, frequently
- Yes, occasionally
- Yes, rarely

¿Limpias los materiales reciclables antes de depositarlos?

- Sí
- A veces
- No
- No deseo responder

¿Qué le parece inconveniente para limpiar materiales reciclables antes de depositarlos? (elija todos los que correspondan)

- La tarea está sucia
- La tarea consume mucho tiempo
- La tarea no marca una gran diferencia
- No necesito limpiar materiales reciclables de donde vengo
- Otro (especificar)
- La tarea NO es inconveniente
- No deseo responder

¿Cuál de estos incentivos le haría querer limpiar materiales reciclables antes de depositarlos? (elija todos los que correspondan)

- Recepción de dinero por sus materiales reciclables limpios
- Recepción de un certificado para sus materiales reciclables limpios
- Recepción de horas de servicio comunitario para sus materiales reciclables limpios
- Ser invitado a eventos sobre reciclaje
- Aprender sobre reciclaje
- Otros (especificar)

- No necesito un incentivo para limpiar materiales reciclables
- No quiero limpiar materiales reciclables antes de depositarlos
- No deseo responder

¿Separa los materiales reciclables en diferentes categorías antes de depositarlos?

- Sí
- A veces
- No
- No quiero responder

¿Qué le parece inconveniente para separar materiales reciclables antes de depositarlos? (elija todos los que correspondan)

- La tarea es sucia
- La tarea requiere mucho tiempo
- La tarea ocupa espacio
- No sé cómo separarlos correctamente
- La tarea no hace una gran diferencia
- No necesito separar los materiales reciclables de donde vengo
- Otro (especifique)
- La tarea NO es inconveniente
- No quiero responder

¿Cuál de estos incentivos haría que desea separar los materiales reciclables antes de depositarlos? (elija todos los que correspondan)

- Recibir dinero para sus materiales reciclables limpios

- No, I have not
- I do not wish to respond

**Would you be interested in learning more about recycling?**

- Definitely yes
- Probably yes
- Probably not
- Definitely not
- I do not wish to respond

**What would you specifically want to learn more about? (choose all that apply)**

- Types of recyclable materials
- Recommended recycling practices
- The impact of recycling
- The process of recycling
- The shortcomings of recycling
- Common misconceptions about recycling
- Recycling volunteering in Ciudad del Saber
- Other (please specify)
- I do not wish to respond

**Would you be interested in participating in a Recycling Fair in Ciudad del Saber?**

- Definitely yes
- Probably yes
- Probably not

- Definitely not
- I do not wish to respond

**How would you want to help with recycling in Ciudad del Saber? (choose all that apply)**

- Clean recyclable materials before depositing them
- Separate recyclable material before depositing them
- Work/Volunteer for CAR/FAS
- Donate money
- Educate the Ciudad del Saber community on recycling
- Participate in online recycling awareness campaigns
- Other (please specify)
- I am not interested in helping with recycling
- I do not wish to respond

**Specific Question**

**Section 2 - Specific Questions**

The following questions are specific to  $\{q://QID/ChoiceGroup/SelectedChoices\}$ .  
Only a few questions left!

**Which category would describe the business you operate/work for in Ciudad del Saber? (choose all that apply)**

- International/Non-Profit/Non-Governmental Organization
- Education

- Recibir un certificado para sus materiales reciclables limpios
- Recibir horas de servicio comunitario para sus materiales reciclables limpios
- Ser invitado a eventos sobre reciclaje
- Tener más papeleras de reciclaje
- Aprender sobre el reciclaje
- Otro (especifique)
- No necesito un incentivo para separar los materiales reciclables
- No quiero separar los materiales reciclables antes de depositarlos
- No quiero responder

**Block 5**

**¿Has visto u oído hablar de programas de reciclaje en Ciudad del Saber?**

- Sí, con frecuencia
- Sí, ocasionalmente
- Sí, rara vez
- No
- No quiero responder

**¿Le interesaría aprender más sobre reciclaje?**

- Definitivamente sí
- Probablemente sí
- Probablemente no
- Definitivamente no
- No quiero responder

**¿Sobre qué querrías aprender específicamente? (elija todos los que correspondan)**

- Tipos de materiales reciclables
- Prácticas recomendadas de reciclaje
- El impacto del reciclaje
- El proceso de reciclaje
- Las deficiencias del reciclaje
- Conceptos erróneos comunes sobre el reciclaje
- Voluntariado para reciclar en Ciudad del Saber
- Otro (especifique)
- No quiero responder

**¿Le interesaría participar en una Feria de Reciclaje en Ciudad del Saber?**

- Definitivamente sí
- Probablemente sí
- Probablemente no
- Definitivamente no
- No quiero responder

**¿Cómo quisieras ayudar con el reciclaje en Ciudad del Saber? (elija todos los que correspondan)**

- Limpie los materiales reciclables antes de depositarlos
- Separe el material reciclable antes de depositarlos
- Trabajo/Voluntario para CAR/FAS
- Donar dinero

- Research and Development (R&D)
- other (please specify)
- I do not wish to respond

Does the business you operate/work for in Ciudad del Saber currently have a recycling program/facility in place?

- Yes
- No
- I do not know
- I do not wish to respond

How useful would the following be to help your business recycle more?

|   | Extremely useful      | Very useful           | Moderately useful     | Slightly useful       | Not at all useful     | I do not wish to respond |
|---|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|--------------------------|
| Onsite assistance and training  | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>    |
| Free recycling container  | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>    |
| Free education materials on how to and where to recycle (e.g. pamphlets, magnets, etc.) | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>    |

Why do you work/volunteer for CAR/FAS?

Do you think recycling is important for Ciudad del Saber?

- Yes
- No
- I do not wish to respond

Do you have another job beside the one at CAR/FAS?

- Yes
- No
- I do not work for CAR/FAS
- I do not wish to respond

What is the purpose of your visit to Ciudad del Saber?

How did you hear about CAR/FAS? (choose all that apply)

- FAS Website
- CdS Website
- Facebook
- Instagram
- Twitter

- Educar a la comunidad de Ciudad del Saber sobre el reciclaje
- Participar en campañas de concienciación sobre el reciclaje en línea
- Otro (especifique)
- No estoy interesado en ayudar con el reciclaje
- No quiero responder

### Specific Question

### Sección 2 - Preguntas Específicas

Las siguientes preguntas son específicas para \$ {q://QIDI/ChoiceGroup/SelectedChoices}. ¡Sólo quedan unas pocas preguntas!

¿En qué categoría describiría el negocio para el que opera/trabaja en Ciudad del Saber? (elijá todos los que correspondan)

- Organización Internacional/Sin Fines de Lucro/No Gubernamental
- Educación
- Investigación y Desarrollo (I&D)
- Otro (especifique)
- No quiero responder

¿El negocio para el que opera/trabaja en Ciudad del Saber tiene actualmente un programa/instalación de reciclaje?

- Sí
- No
- No sé

No deseo responder

¿Qué utilidad tendría lo siguiente para ayudar a su negocio a reciclar más?

|   | Extremadamente útil   | Muy útil              | Moderadamente útil    | Ligeramente útil      | Nada útil             | No quiero responder   |
|---|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| Asistencia y formación in situ  | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Contenedor de reciclaje gratuito  | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Materiales educativos gratuitos sobre cómo y dónde reciclar (por ejemplo, folletos, imanes, etc.) | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

¿Por qué trabajas/voluntarios para CAM/FAS?

¿Cree que el reciclaje es importante para Ciudad del Saber?

- Sí
- No
- No quiero responder

- Other online sources
- Newspaper Article/Advertisement
- Radio
- TV
- Passing by
- Word-of-mouth
- Other
- I do not wish to respond

**Do you separate waste based on the different colors of the bins in Ciudad del Saber?**

- Always
- Most of the time
- About half the time
- Sometimes
- Never
- Not Applicable/I do not wish to respond

**Which day(s) of the week do you usually bring recyclable materials to CAR? (choose all that apply)**

- Monday
- Tuesday
- Wednesday
- Thursday
- Friday
- I do not wish to respond

**Which day(s) of the week would be the most convenient for you to bring recyclable materials to CAR? (choose all that apply)**

- Monday
- Tuesday
- Wednesday
- Thursday
- Friday
- Saturday
- Sunday
- I do not wish to respond

Powered by Quattrics

**¿Tienes otro trabajo al lado del CAM/FAS?**

- Sí
- No
- No trabajo para CAM/FAS
- No quiero responder

**¿Cuál es el propósito de tu visita a Ciudad del Saber?**

**¿Cómo se enteró de CAM/FAS? (elija todos los que correspondan)**

- Sitio web de FAS
- Sitio web de CdS
- Facebook
- Instagram
- Twitter
- Otras fuentes en línea
- Artículo/Anuncio del Periódico
- Radio
- TV
- Pasando por
- Boca a Boca
- Otro
- No quiero responder

**¿Separa los residuos en función de los diferentes colores de los contenedores de Ciudad del Saber?**

- Siempre
- La mayoría de las veces
- Alrededor de la mitad del tiempo
- A veces
- Nunca
- No Corresponde/No quiero responder

**¿Qué día(s) de la semana suele llevar materiales reciclables a CAM? (elija todos los que correspondan)**

- Lunes
- Martes
- Miércoles
- Jueves
- Viernes
- No quiero responder

**¿Qué día(s) de la semana sería el más conveniente para usted para llevar materiales reciclables a CAM? (elija todos los que correspondan)**

- Lunes
- Martes
- Miércoles
- Jueves
- Viernes
- Sábado

- Domingo
- No quiero responder

Con tecnología de Quattrics



A2: Instagram Graphics for Survey Distribution



### **A3: A Message for Survey Distribution via Slack**

- English Version:

We are a team of four college students from Worcester Polytechnic Institute, USA. You have been asked to participate in our research study that aims at investigating i) the recycling process and ii) the understanding on recycling in Ciudad del Saber. This investigation will result in a proposal to Fundación Ciudad del Saber of suggested improvements to the recycling strategies on campus. Questions about this research may be addressed to [gr-cofk-a20@wpi.edu](mailto:gr-cofk-a20@wpi.edu). Thank you for participating in this survey.

- Spanish Version:

Somos un equipo de cuatro estudiantes universitarios del Instituto Politécnico de Worcester, EE.UU. Se le ha pedido que participe en nuestro estudio de investigación que tiene como objetivo investigar i) el proceso de reciclaje y ii) la comprensión sobre el reciclaje en Ciudad del Saber. Esta investigación dará lugar a una propuesta a la Fundación Ciudad del Saber de las mejoras sugeridas a las estrategias de reciclaje en el campus. Las preguntas sobre esta investigación pueden ser dirigidas a [gr-cofk-a20@wpi.edu](mailto:gr-cofk-a20@wpi.edu). Gracias por participar en esta encuesta.

# Appendix B: Delegated Interview Materials

## B1: Delegated Interview Protocol

Name(s) of Interviewer(s): \_\_\_\_\_

Date of Interview: \_\_\_\_\_ Time of Interview: \_\_\_\_\_

Hello! We are a team of students from Worcester Polytechnic Institute, USA. We are conducting a research to understand the recycling processes in Ciudad del Saber as well as in Panama in general. As part of our investigation, you have been asked to participate in an interview. This interview will be recorded due to language comprehension issues. The recording will be deleted once we have gathered the information for our questions. This investigation will result in a proposal to Fundación Ciudad del Saber of suggested improvements to the recycling strategies on campus. Although the results of this study may be published, no information that could identify you will be included. Questions about this research, research subject's rights, research-related injury, or complaints may be addressed to [gr-cofk-a20@wpi.edu](mailto:gr-cofk-a20@wpi.edu). Your consent is being given voluntarily. If you decide to participate in the interview, you are free to withdraw at any time without any negative effect on your relations with Fundación Ciudad del Saber or with any other participating institutions or agencies. Thank you for your participation! Do you have any questions for us before we begin?

Do you give your consent to participate in this interview? *(Receive verbal confirmation/denial)*

Do you give your consent to us recording this interview? *(Receive verbal confirmation/denial)*

Our main goal with this interview is to gain knowledge on where processes at the recycling center can be made more efficient. We believe recycling is vital in order to lead a sustainable future. Let's get started with the questions!

*Note: the interviewer will use phrases such as "Tell me more", "Could you give me an example?", "Could you explain that?" as prompts to solicit more detailed information when needed.*

1. To get started, let's introduce ourselves. In your introduction, please tell us who you are, and your job at the recycling center.
2. Which parts of the current process at the center do you think are functioning well?
3. Which parts of the current process at the center do you think can be improved?
4. What are some of the challenges you face in this job?
5. Which aspect of your job do you think could be improved?
6. What are some sources of contamination you notice while accepting recyclable materials?
  - a. Are there any sources of contamination that are very common?
7. What are your expectations for the people who bring recyclables to the recycling center?

## B2: Delegated Interview Note 1

### Protocolo de Entrevistas para Empleados de FAS

Nombre(s) del (de los) Entrevistador(s): Luis Angel Ceballos  
Fecha de la entrevista: 15/9/20  
Hora de la entrevista: 2:43 p.m.

¡Hola!

Somos un equipo de estudiantes universitarios del Instituto Politécnico de Worcester, EE.UU. Estamos llevando a cabo una investigación para entender los procesos de reciclaje en Ciudad del Saber, así como en Panamá en general. Como parte de nuestra investigación, se le ha pedido que participe en una entrevista. Esta entrevista será grabada debido a problemas de comprensión del lenguaje. La grabación se eliminará una vez que hayamos recopilado la información para nuestras preguntas. Esta entrevista no implica ningún riesgo para usted. Esta investigación dará lugar a una propuesta a la Fundación Ciudad del Saber de las mejoras sugeridas a las estrategias de reciclaje en el campus. Aunque los resultados de este estudio pueden ser publicados, no se incluirá ninguna información que pueda identificarle. Las preguntas sobre esta investigación, los derechos del sujeto de investigación, las lesiones relacionadas con la investigación o las quejas pueden ser dirigidas a [gr-cofk-a20@wpi.edu](mailto:gr-cofk-a20@wpi.edu). Su consentimiento se está dando voluntariamente. Usted puede negarse a participar en la entrevista. Si decide participar en la entrevista, puede retirarse en cualquier momento sin ningún efecto negativo en sus relaciones con la Fundación Ciudad del Saber o con cualquier otra institución u organismo participante.

¡Gracias por su participación!

¿Tiene alguna pregunta para nosotros antes de empezar?

*¿Da su consentimiento para participar en esta entrevista? (Recibir confirmación/negación verbal)*

Si  No

*¿Nos da su consentimiento para que grabemos esta entrevista? (Recibir confirmación/negación verbal)*

Si  No

Nuestro principal objetivo con esta entrevista es adquirir conocimientos sobre dónde se pueden hacer más eficientes los procesos en el centro de reciclaje. Creemos que el reciclaje es vital para liderar un futuro sostenible. ¡Empecemos con las preguntas!

*Nota: el entrevistador usará frases como "Cuéntame más", "¿Podrías darme un ejemplo?", "¿Podrías explicar eso?" como indicaciones para solicitar información más detallada cuando sea necesario.*

1. Para empezar, vamos a presentarnos. En su introducción, por favor díganos quién es usted, y su trabajo en el Centro de Acopio de Reciclables.

Suis Angel, Ayudante General  
Cargar cajas, Clasificar  
Empaquetar  
Toda

2. ¿Qué partes del proceso actual en el centro crees que funcionan bien?

Nada. Todo hay que mejorarlo

3. ¿Qué partes del proceso actual en el centro crees que se pueden mejorar?

- Recepción de materiales: Entregan con material clasificado y limpio  
- Punto Exterior: Entregan más clasificado, todo está todo  
- Retiro de material: De ir en muchos en venir a buscar el material  
- Clasificación: Para clasificar papel hay que buscar cajas y una demora

4. ¿Cuáles son algunos de los desafíos a los que se enfrenta en este trabajo?

Siempre pesa. Hay cosas con muchas peso

5. ¿Qué aspecto de tu trabajo crees que podría mejorarse?

Cargar material

6. ¿Cuáles son algunas fuentes notables de contaminación? Que observa cuando está aceptando o clasificando el material reciclable

Basura  
Botella con líquido  
Residuos de comida

a. ¿Hay alguna fuente de contaminación que sea muy común?

Botella que tienen comida

7. ¿Cuáles son sus expectativas para las personas que traen materiales reciclables al centro de reciclaje?

traer material limpio y seco  
Clasificación de casa

## B3: Delegated Interview Note 2

### Protocolo de Entrevistas para Empleados de FAS

Nombre(s) del (de los) Entrevistador(s): Samuel Meison  
Fecha de la entrevista: 15/9/20  
Hora de la entrevista: 2:34 p.m.

¡Hola!

Somos un equipo de estudiantes universitarios del Instituto Politécnico de Worcester, EE.UU. Estamos llevando a cabo una investigación para entender los procesos de reciclaje en Ciudad del Saber, así como en Panamá en general. Como parte de nuestra investigación, se le ha pedido que participe en una entrevista. Esta entrevista será grabada debido a problemas de comprensión del lenguaje. La grabación se eliminará una vez que hayamos recopilado la información para nuestras preguntas. Esta entrevista no implica ningún riesgo para usted. Esta investigación dará lugar a una propuesta a la Fundación Ciudad del Saber de las mejoras sugeridas a las estrategias de reciclaje en el campus. Aunque los resultados de este estudio pueden ser publicados, no se incluirá ninguna información que pueda identificarle. Las preguntas sobre esta investigación, los derechos del sujeto de investigación, las lesiones relacionadas con la investigación o las quejas pueden ser dirigidas a [gr-cofk-a20@wpi.edu](mailto:gr-cofk-a20@wpi.edu). Su consentimiento se está dando voluntariamente. Usted puede negarse a participar en la entrevista. Si decide participar en la entrevista, puede retirarse en cualquier momento sin ningún efecto negativo en sus relaciones con la Fundación Ciudad del Saber o con cualquier otra institución u organismo participante.

¡Gracias por su participación!

¿Tiene alguna pregunta para nosotros antes de empezar?

¿Da su consentimiento para participar en esta entrevista? (Recibir confirmación/negación verbal)

Si

No

¿Nos da su consentimiento para que grabemos esta entrevista? (Recibir confirmación/negación verbal)

Si

No

Nuestro principal objetivo con esta entrevista es adquirir conocimientos sobre dónde se pueden hacer más eficientes los procesos en el centro de reciclaje. Creemos que el reciclaje es vital para liderar un futuro sostenible. ¡Empecemos con las preguntas!

*Nota: el entrevistador usará frases como "Cuéntame más", "¿Podrías darme un ejemplo?", "¿Podrías explicar eso?" como indicaciones para solicitar información más detallada cuando sea necesario.*



1. Para empezar, vamos a presentarnos. En su introducción, por favor díganos quién es usted, y su trabajo en el Centro de Acopio de Reciclables.

*Samuel, estudiante general, facer de todo*

2. ¿Qué partes del proceso actual en el centro crees que funcionan bien?

*Recepcion y Clasificacion*

3. ¿Qué partes del proceso actual en el centro crees que se pueden mejorar?

*Retiro de los materiales*

4. ¿Cuáles son algunos de los desafíos a los que se enfrenta en este trabajo?

*el espacio para acomodar el material y como acomodar mejor el material*

5. ¿Qué aspecto de tu trabajo crees que podría mejorarse?

*Area de carga y descarga -> demasiado trabajo manual  
mucho peso de los materiales*

6. ¿Cuáles son algunas fuentes notables de contaminación? Que observa cuando está aceptando o clasificando el material reciclable

*Basura*

---

---

---

a. ¿Hay alguna fuente de contaminación que sea muy común?

*Alimentos, bolsas plásticas*  
*Basura orgánica como hierba*

---

---

---

7. ¿Cuáles son sus expectativas para las personas que traen materiales reciclables al centro de reciclaje?

*Clasificación más específica y limpia*

---

---

---

## B4: Delegated Interview Note 3

### Protocolo de Entrevistas para Empleados de FAS

Nombre(s) del (de los) Entrevistador(s): Rebato Castillo  
Fecha de la entrevista: 15/9/20  
Hora de la entrevista: 2:58 p.m.

¡Hola!

Somos un equipo de estudiantes universitarios del Instituto Politécnico de Worcester, EE.UU. Estamos llevando a cabo una investigación para entender los procesos de reciclaje en Ciudad del Saber, así como en Panamá en general. Como parte de nuestra investigación, se le ha pedido que participe en una entrevista. Esta entrevista será grabada debido a problemas de comprensión del lenguaje. La grabación se eliminará una vez que hayamos recopilado la información para nuestras preguntas. Esta entrevista no implica ningún riesgo para usted. Esta investigación dará lugar a una propuesta a la Fundación Ciudad del Saber de las mejoras sugeridas a las estrategias de reciclaje en el campus. Aunque los resultados de este estudio pueden ser publicados, no se incluirá ninguna información que pueda identificarle. Las preguntas sobre esta investigación, los derechos del sujeto de investigación, las lesiones relacionadas con la investigación o las quejas pueden ser dirigidas a [gr-cofk-a20@wpi.edu](mailto:gr-cofk-a20@wpi.edu). Su consentimiento se está dando voluntariamente. Usted puede negarse a participar en la entrevista. Si decide participar en la entrevista, puede retirarse en cualquier momento sin ningún efecto negativo en sus relaciones con la Fundación Ciudad del Saber o con cualquier otra institución u organismo participante.

¡Gracias por su participación!

¿Tiene alguna pregunta para nosotros antes de empezar?

¿Da su consentimiento para participar en esta entrevista? (Recibir confirmación/negación verbal)

Sí  No

¿Nos da su consentimiento para que grabemos esta entrevista? (Recibir confirmación/negación verbal)

Sí  No

Nuestro principal objetivo con esta entrevista es adquirir conocimientos sobre dónde se pueden hacer más eficientes los procesos en el centro de reciclaje. Creemos que el reciclaje es vital para liderar un futuro sostenible. ¡Empecemos con las preguntas!

*Nota: el entrevistador usará frases como "Cuéntame más", "¿Podrías darme un ejemplo?", "¿Podrías explicar eso?" como indicaciones para solicitar información más detallada cuando sea necesario.*

1. Para empezar, vamos a presentarnos. En su introducción, por favor díganos quién es usted, y su trabajo en el Centro de Acopio de Reciclables.

Roberto Castillo, antes trabajaba de chofer después  
pase a compactar los diferentes materiales en el Centro  
Prerentemente trabajo en el proyecto de Inmonapet  
para hacer bloques de pet para casa

2. ¿Qué partes del proceso actual en el centro crees que funcionan bien?

Hay más organización, hay diferente cubículo, como se clasifica  
después más simple con mesa  
Se coloca los cosas mejor en los cubículos

3. ¿Qué partes del proceso actual en el centro crees que se pueden mejorar?

En cada parte se debe mejorar para que sea más rápida  
Entrega de materiales para clasificarlos limpios

4. ¿Cuáles son algunos de los desafíos a los que se enfrenta en este trabajo?

Corte por pedidas de vidrio quebrados, y eso conteniendo  
Un compañero le dio una picadura que se creó que  
pasó por algo de la basura que llega.

5. ¿Qué aspecto de tu trabajo crees que podría mejorarse?

La compactación: el material debe venir sin tapa y después  
trabaja el plástico en materiales más limpio

6. ¿Cuáles son algunas fuentes notables de contaminación? Que observa cuando está aceptando o clasificando el material reciclable

Grupos de tetrapack con gusos y material en sacos de hojín  
Bata sucia  
Pampas

a. ¿Hay alguna fuente de contaminación que sea muy común?

Tetrapack sucios

7. ¿Cuáles son sus expectativas para las personas que traen materiales reciclables al centro de reciclaje?

Esta cantidad de materiales se clasifican  
Algunos si clasifican y otros no clasifican  
En el punto de Acopio lo dejan tirado

## Appendix C: Direct Interview and Observation Materials

### C1: Direct Interview Questions

1. Please describe the paperwork process. Who is/are involved in such tasks?
2. How do you weigh the materials? When in the overall process does this happen?
3. Is there any step of the process that you do not do, or that you do not know how to do?  
Who does those tasks?
4. Who operates the baler? How is it usually used?
5. Which tasks are you most familiar with/fluent in? Which task are you least familiar with/fluent in? Please explain.
6. What tools or processes do you think could be provided or improved in order to make your job easier?
7. What are your expectations for the people who bring recyclables to the recycling center?
8. Do you know if the people who usually come to the center live in CdS or off-campus?
9. Do the visitors usually stay around when they drop off the materials? Do they come to the center to meet and catch up with each other?
10. Do you know if the visitors drop off the materials on their way to another place, or to only drop off the materials and then return home?
11. Have you taught a recycling workshop before? Why or why not?
12. How was your training process when you first started?
13. Currently, are the materials collected by the pickup service better/well-classified than the usual donations?
14. What is the pickup process? When do the buyers usually come? Is there a schedule?
15. How often do you take a break? Is there a schedule? Is it spread out throughout the day?

## **C2: Color Code**

**Measurement** - data generated from the process used to evaluate quality of the product

**Personnel** - anyone involved in process

**Machines** - any equipment required for the job

**Environment** - conditions like culture, time, and location

**Materials** - raw materials used to produce product

**Methods** - how the process is performed and what specific requirements are required

### C3: Coded Katherine's Note (September 17)

A member of FAS works as a **Driver**, where they are in charge of picking up recycled materials on campus 3 times a week from tenants.

**Classifier**, a job where one classifies materials. As soon as the classifier finishes classifying they weigh the recyclables.

Materials donated by companies are **weighed before**, so that the percentage of what can be recycled is known.

Compacting is a more specialized task, and a person with a disability focuses on compacting for **CAR**. When he's not here someone else will compact, which takes away from their usual duties.

After cardboard and plastic is classified into color and types, it gets compacted.

Mostly plastic is classified, and usually only when cardboard is overflowing

Plastic classification needs to be improved, as it needs to be classified and sorted more once it gets to the recycling center, such as taking off tops of bottles

Paper can't really be improved, as it would be difficult for donors to properly classify.

If the workers at the recycling center didn't have to focus on the plastic so much they could focus on the paper more. Which would be good as paper is more lucrative than plastic.

There is just too much Plastic, and it overwhelms the FAS members.

The center keeps receiving more and more donations from residents which is **mainly plastic and glass**.

The easiest job in the center is weighing and putting it in its cubby.

Classifying at the source is a possible improvement.

A **jack lift/pallet jack** could be used for weighing materials

Dividing tasks: Since everyone does a little bit of everything it would help if there were specific tasks because **people often don't finish the tasks they start**. For paper: paper would not accumulate as much if someone is in charge of it.

Rotating roles might be a good solution in theory. However, **older women can not lift heavy weights like the younger workers** so rotating wouldn't be good

In the paper process, **staples don't get removed, but Paperclips do**.

White paper gets separated as it can be used with **less processing than colored paper**.

How would the classifying for plastic bottles work? **They come mixed in one bag and need to have their tops taken off**

**The FAS workers are trying to get people to classify waste**. All the workers would have to do is weigh their recyclables and put them in their cubby

The current FAS workers need to be assertive. **This is because they need to learn how to refuse peoples contaminated and unclean recyclables**.

What are the common contaminations? What kind of paper would they not recycle? With paper if the donors **shred the paper before it comes** then the FAS workers will have to throw it out because the paper is too mixed. Sometimes **office paper comes mixed with food containers** and it is dirty/needs to be thrown away.

Plastics: **contamination is people not rinsing it, stuffed with stuff**

With tin cans it is **common that people don't finish it or leave liquid in them. People don't rinse them** which means the recycling center is unable to use them.

Glass: **nobody leaves the liquid in the glass and so it comes the least contaminated**.

Cardboard: **sometimes it comes wet. People will try to recycle pizza boxes/scraps of food stuck on it**



Tetrapak: milk typically, donors will put cap back on and the carton sits somewhere with drink leftover and gets gross

Big trash bins- the contaminated material gets thrown in there

Do people come to the center for the sole purpose of coming to the center or are they on their way to something?

-it is a combination of both people coming just for recycling or working at cds

-is there a fixed schedule for when the buyer comes? It's not on a schedule, when its full they call them. Alessa thinks it should be on more of a schedule

How often are there breaks? Whenever they get tired, walk around for a quick minute

When its open less breaks

Scheduled lunch break? All of them eat 12-12:30

Have any of them taught a recycling workshop before? No.

We dont have the opportunity to bc there's not enough time during the work week

Training: Woman in charge of supervising the team: 2 weeks go through each task. Not many new employees. The people person lady also does some training

How often is the baler used? Roberto does it everyday and grey shirt guy does it different times of the week when hes not out collecting on campus

Supervisor and project coordinator also teach the volunteers

Volunteers are given a specific task

Is there a way they decide which cage they store material in or is it just whichever is empty? Not all the cubbies are the same size, so some items overflow much.

Classified in the front and unclassified in the back

Cardboard always go directly in front of the door bc it has so much volume

Do they think moving or rearranging would be good? And they said the big bags are in the back and it would be easier for them to be up in the front (the sacks I believe)

Cages: recommend standard size, they are currently all different sizes

Pick up service:

The amount they pay per 6 bags

Plastics 1 and 2

Pet mixed

Aluminum cans and tin cans

Office space:

Worker is always out working as opposed to coordinating

Scale is next to the fire extinguisher

Unclassified section white board:

Daily task board

Worker space for belongings

Lockers and changing rooms

#### C4: Coded John's Note (September 17)

Remove staples, remove tapes from papers from big company

Sit in a chair, there are some bins around them, unsorted in front of them, remove contamination, then put in the bin

Sit in front of the cages, swivel chair

First person: Driver

- Pick up 3 times a week from the campus tenants
- Also classifier

Both weigh the materials

The male do more heavy lifting (weighing)

How to weigh? → as soon as finished classifying

The only recyclables weighed before being classified, are from the tenants

Any steps they don't do?

Compacting (more specialized, only 2 employees doing it)

Only cardboard and plastics

After the color and type is classified

No liquid

Function well:

- What they think work well and what could be improved?
- Improved: the plastic (takes a lot of classifying, removing the cap)
- Improved: reception

Paper: it's a pain, people don't know how to classify

If they don't have to focus on classifying so much, they can focus on classifying the paper more

Receiving more residential recyclables

Plastics have high volume

Wants more tenants to recycle

Tenant (paper) vs resident (bottles)

More campaign for paper

Familiarity:

Easiest: weighing, putting away into cages (last steps)

Straining: picking up and lifting, moving the materials

Improve: for weighing: jack pallet could help. Currently use a flatbed cart

Task division: If there's specific task for a person can help. They have to lend a hand to people and cannot finish their current task

If the roles rotate: they say rotating can't work coz there are older women working

Stools for workers to rest when they have to stand the whole day

The workers have other difficulties.

For paper classifying: staples are not removed, only big metals like paper clips. If there's writing, goes into color? tape, separate according to color/white Reuse the boxes they come in to contain the sorted paper

For plastics bottles: all mixed. So they have to separate color, types, and take the cap off.

People are used to bringing in mixed things

They (members of FAS) should feel more confident in telling people NO

Contamination:

- Paper: if it's shredded paper, and newspaper is mixed with white/color, cannot be used. Sometime papers get food on it, liquid
- Plastics: don't rinse it, come with liquid, stuff with things inside
- Tin/Aluminum: soda can, liquid in it, straws in the can, napkin in the can, tin can: don't rinse, sardine in thingy
- Glass: liquid, but usually booze GLASS IS USUALLY CLEAN
- Cardboard: wet, pizza boxes, grease, food scrap
- Tetra pak: unrinse

There's a big trash bin for all the trash. Open top bin, Originally a company collects.

Visitor: both work on campus and just for dropping off

They call the company to pick up

Take a short stretch break whenever they get tired. All eat at 12-1230.

They have not taught the workshops

There's not enough time to do that. (main reason)

There may not be enough things to do (artisanal)

Could be because people dont know how

The supervisor taught them (2 weeks), go through the tasks and teach them how to do it. There's another one that also helps with teaching. They (peeps being interviewed) also teach the volunteers. But also whoever is there teaches the volunteers.

Baler: Usually, almost everyday, another person 3 times a week when not picking up recycle.

There's a board at the end of the center.

There is a cart for moving the materials

Volunteers are given a specific task

How they organize the cages? -> By the size of the cage and the materials. Usually unclassified on the left, classified on the right

Cardboard is always a lot, in front of the door

Classified Tetra pak is left side, right next to the door

If rearranging would be good? - they think it works fine

Shorten distance? - the big bags are all the way at the right, may be better to move closer

Since people put stuff in big bags now, relocate to nearer to the door would be better

The cages have different quality and sizes

Pick up truck is right in front of the normal drop off spot

People want it to reopen

Only 6 cars can fit in the lane

Need to schedule pick up time

Or move the pick up zone to the back

Pick up trash morning

The area behind: things to classify, metals, kind of exit, maybe reorganize, find a use. There's a lot of space (sheltered, but not walled)

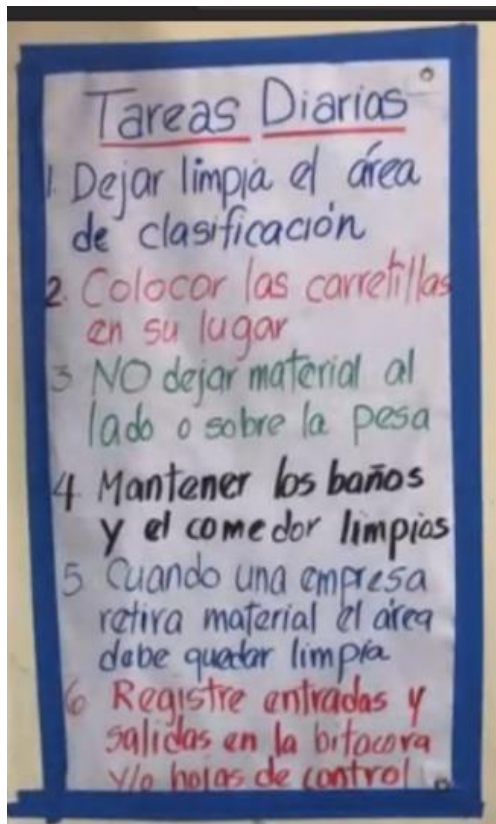
Plastics

Office : coordinate pickup, answer call, the person is on the floor working

The team writes down the weight. The driver has a registry of the pickup. The weighing notebook next to the scale

The scale, next to the door, right side. The second one is broken, not fixed yet. May buy a new one

Whiteboards: daily task



Work schedule (who comes in which day). Overtime weekend to tidy up

Taped out calendar

Team supervisor and coordinator update the boards (location is hidden)

The lockers/belonging storage, near the office. Changing room, bathroom, showers are there too. is away frm the task board

There's one un used board

Bins are placed in random places

Forklift in maintenance. Has to be scheduled. Sometimes they cant show up

Handwash station outside, left pavement, near leftmost door,

One big investment a year

Some safety signs around on walls, some on doors,

There is a stand for individual buying jars, cans, etc.

There's a board of not recyclable

New covid signages for across cds campus

Some signs are old

## C5: Coded Xavier's Note (September 17)

Companies do not separate recyclables, especially paper

-Workers have to separate manually

-paper most tedious

-colored paper has to be bleached

-very dark colored paper gets thrown out

a driver (picks up 3 times a week from tenants)

-also classifies and weighs out material

-weighing and putting away material in its section is the easiest

-the two young guys do most of the lifting, less able people do other jobs

-everyone does a little of everything

After classification is finished they weigh it, the only material that is weighed before classification is stuff sent by companies

Compacting (plastic (and cardboard if there is too much)) is done by another employee

-done after plastic is classified and if it has nothing inside of it

Plastic takes a lot of time

Reception of material is a hassle currently and impedes sales

Paper is rough but people don't know how to classify it so it would be hard to be improved

If people sorted their drop offs they could focus more on paper because paper is quite profitable

Some schools will sell the recyclables themselves

-The schools that do recycle with FAS will bring in mostly paper and cardboard

They use flatbed carts to move recyclables but need some way to jack them up to easier dump the materials?

Since everyone does everything, if tasks had roles for specific people it may help with efficiency as they move from task to task often leaving the previous task unfinished which causes build up

Role rotation? Would not possibly work as some people would be unable to fully do every task

Many people who work at the center are not in the greatest of places so everyone may be somewhat pressed.

Staples are not removed from paper but larger pieces of metal are, then it is sorted by color

-The boxes the paper comes in is reused for classification

-The paper arrives in boxes usually

Materials usually come in as a hodgepodge of mixed recyclables

Currently some of the workers feel somewhat uncomfortable with telling people no when they try to bring in mixed recyclables

Contaminants

With paper if they shred it before it comes, some people shred mixed paper together

-if the paper is shredded with food or some other type of stuff it is unusable

Plastic is unrinsed or comes with food waste

-also if the plastic is stuffed with other stuff

With tin cans its common for people to not finish their drink

-they are also unrinsed

-sometimes a straw or napkin will be stuffed in as well

Glass bottles are usually alcohol and are usually the least contaminated

Cardboard will sometimes come wet

-pizza boxes are often recycled when they are still filthy

Tetrapak are often left unrinsed

Unclean and contaminated recyclables are thrown in the trash

-trash is picked up a couple of times a week

Some people come solely for recycling, and some people come because they work on campus

-The people who come for recycling usually come out of their way on a day off, mostly moms come after they have dropped their kids off

The recyclable pick up is not on a schedule, just when it is full they will have them pick up recyclables

They take a break whenever they get tired, not a schedule

-When they are open and a lot of people are coming they will usually not take many breaks

-take a lunch break at 12 to 12:30

They have not done a training workshop before

-There is not a lot of time to do a workshop

-Not a lot of things to be done for a workshop

Women in charge of supervising taught them for two weeks

New employees are very infrequent as there is not enough money

The supervisor and project coordinator are also in charge of teaching the volunteers

-other employees also teach them and help whenever needed

-the volunteers are given a specific task

The baler was used everyday

The material is put in a cubby depending on how much space is available

The cardboard is mostly placed in the cubby in front of the door

-from cardboard on is classified and the other side is unclassified

Would reorganizing be more efficient?

The big bags are in a weird spot, but most of the stuff has a decent flow to it currently that works

The classification cages may need a remodeling as they are all different sizes

-a big task however though

-could be a recommendation for when they move buildings

A man that saw the gates were opened appeared and wanted to know if he could drop off, and understood the drive through-like way setup

-the current drive through can hold about 6 cars but Alessa wants to make it bigger

The drop off trucks will have to be scheduled now or move where they drop off their recyclables

Metal or big bulky items will be put in the patio area, also a catch all area

For the recyclable pickup service, they are required to sort plastics and cans so plastics (type 1 and 2) and cans (aluminum and tin) are mixed recyclables still

-When they come to CAR they are asked to sort by how the recyclables will be sold

Only about 1 person does most of the paperwork, but others will fill out small amounts of paperwork



Scale at the front of the drop off area

They have a forklift, but it is not often that they have access to one

One big buy a year for FAS/CAR

There is also budget for improving efficiency and

they are unable to fully take advantage of tools available

## **C6: Virtual Tour 1 Note (September 11)**

What is the reopening plan?

U turn, classify, maybe rotational schedule, Oct 5th

Why do the workers prioritize sorting glass and plastics?

FAS told them priority. They don't really have a written list. They may be overwhelmed and start working on those.

Who has been running the craft workshops at the center? Are these workshops free?

FAS runs them. They're free since the product isn't great. Not a lot of people come to those. They may do it together with the volunteer event. Children join their parents for the craftwork.

Is there any sort of hierarchy on what to sort/work on or is it just sort/work on what you can as things come in?

There were in the past but the workers would get overwhelmed by plastic and then focus on that and ignore the recycling priority.

What is the difference between Usarios (offices/tenants) and Entregas Voluntarios (donations)?

Usarios: the offices, the tenants, those that FAS collect

EV: people who come to the center and give their materials, some companies (outside of CdS)

Is it possible for us to get creative in reselling glass?

There's a local market that can sell stuff

Glass and precious plastic material is a possibility

FAS employees already have a lot of work. Need a partner that manages the plastic component (potentially mutual benefits). There are a lot of coworking and incubator spaces in CdS, so can reach out to a startup.

Why is glass' value zero?

Before, there was a facility, now it moved to Costa Rica. Now, the glass collectors have to transport the glass to costa rica, and the cost is too high so no one buys glass anymore. Rehab center breaks down the glass and ship it. Minimal profit, mainly for job.

Is the paper shredded before or after receiving?

The two staff members are classifying backlogged materials

-----

### **Tour of CAR**

Entrance: parking lot, U turn

Compactor at the end of the lot



The sacks are against the long side of the wall

the signages are placed on the wall

What are those tables/bins on wheels on the outside? → classification table. They were garden beds, now reused as classifying tables. On wheels right now. The empty tables are used to direct human flow rn

Beforehand, tapes were put around to guide traffic

Only some signages visible

The bags are clipped on the side,

Inside: left side (has to be classified, mainly paper)

Closed off area (has the cage, the sacks, the stepping platforms) Won't open anytime soon

Papers are delivered in boxes

FAS picks up at houses now, customers have to pay (about 60 households)

Paper for most of the space

Glasses (one small cage)

Shredded paper one cage

Plastic more on the right, then electronic, then metal, then plastic, the blank space for relab

Currently making the shredder. Built by a mechanics working w FAS. Grant given by an organization on campus to fund the project (transform plastic to inovaPET, building blocks). With a professor from a local university. Relab is on a smaller scale. Maybe pre-made machines from europe. The product has to be approved before used

Compactor near the entrance, far away from the plastics

Air vents on the wall for ventilation

Decent lighting

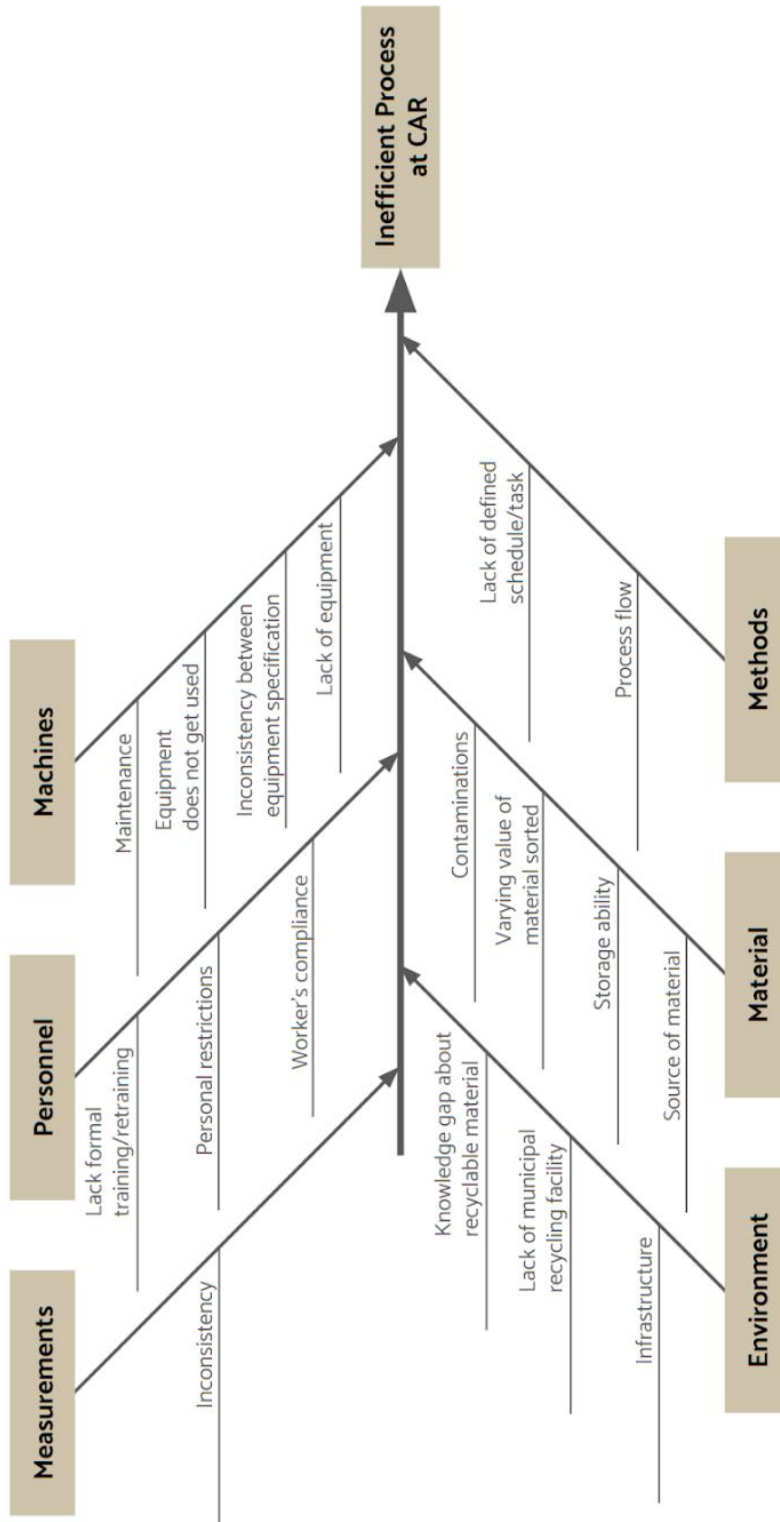
Paper is the hardest to classify

Yellow lines on the ground, overflowing from their spaces

Some arrows visible on the ground, yet too small

Space may not be enough outside

# Appendix D: Cause-and-Effect Diagram



# Appendix E: Proposed Layout 2 (Counter-clockwise)

