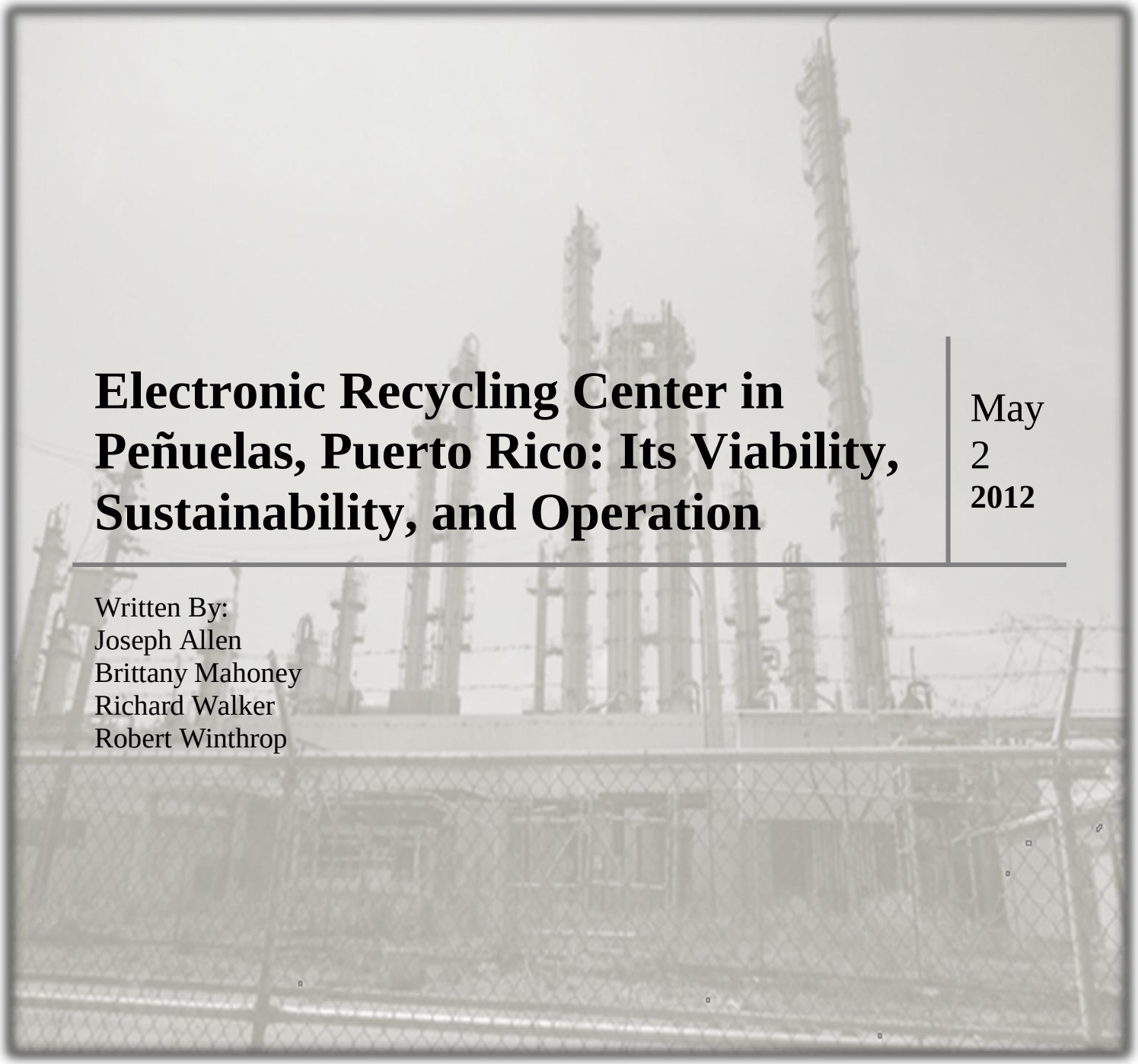

Electronic Recycling Center in Peñuelas, Puerto Rico: Its Viability, Sustainability, and Operation

May 2 **2012**

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Electronic Recycling Center in Peñuelas, Puerto Rico:

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Sponsoring Agency: Desarrollo Integral del Sur, Inc.

Submitted to:

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Abstract

The southern region of Puerto Rico lacks proper electronic waste, e-waste, disposal practices. Desarrollo Integral del Sur, DISUR, wants to utilize brownfield zones in the municipalities of Peñuelas and Guayanilla for an e-waste recycling center. Our project goal was to research the viability of establishing such a facility on one of the existing brownfield sites. Through case studies, interviews, and surveys we determined the technical, financial and educational factors needed to establish a successful e-waste facility in southern Puerto Rico.

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Authorship

This report is the collaborative effort of Joseph Allen, Brittany Mahoney, Richard Walker, and Robert Winthrop. Each section had a primary author, but the entire report was edited by all the members. The formatting was done by Brittany Mahoney and Richard Walker.

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Executive Summary

Technology has become an essential part of society, and many people depend on it in their everyday lives (Azcarraga & Shegerian, 2006). This reliance has a direct correlation with the amount of electronic waste (e-waste) that is released into the solid waste disposal system. There are several management solutions for this e-waste that are used globally, but many regions still use unsafe methods to dispose of their e-waste. The use of landfills and incineration for disposal are practices that harm the environment and the surrounding communities, especially in a fragile coastal ecosystem such as in southern Puerto Rico. It is vital for this region to seek viable solutions to their e-waste disposal problems, focusing on the benefits of proper recycling. A successful e-waste recycling program not only helps limit the damage done to the environment and human health, but it also can provide new jobs for community members.

E-waste is described as "a generic term encompassing various forms of electrical and electronic equipment (EEE) that are old, end-of-life electronic appliances and have ceased to be of any value to their owners" (Bandyopadhyay, 2010, p. 2). When the term recycling is used to describe the disposal of these products, it does not always refer to discarding them. In many cases, these devices are still in working condition and could be used by another consumer. So the resale and reuse of these products accounts for a portion of the recycling system. But for the devices that are no longer in a condition to be used, proper disposal methods must be facilitated. Many forms of e-waste contain harmful materials such as lead, cadmium, and mercury, which pose a threat to health and the environment (Widmer, Oswald-Krapf, Sinha, Schnellmann & Boni, 2005). However many devices also contain useful materials, such as gold or copper, that can be extracted for resale.

The goal of this project was to determine the feasibility of establishing an e-waste recycling center in Peñuelas, Puerto Rico that is equipped to properly handle the unique recycling demands of electronics. To achieve this goal, certain objectives had to be accomplished such as determining how other e-waste recycling centers have been operated successfully. By studying the methods of other facilities, a plan for operation could be developed that will maximize the success of the facility. Determination of the amount of e-waste within a region is needed in order to have a better understanding of what capacity the center should have. The financial and economic needs of an e-waste recycling facility must also be determined, to insure the long-term sustainability of such a center in Peñuelas. The education of community members on the subject of e-waste recycling is also an important objective, because community involvement and participation is essential to maintaining any successful recycling business. After completing the objectives the anticipated outcome of the project was a recommendation for the most efficient way to implement an e-waste recycling system in the southern Puerto Rico region.

To make this possible, we completed extensive background research on successful e-waste recycling centers both locally and worldwide. In order to make recommendations about the implementation of an e-waste recycling center in Peñuelas, we determined what has been successful and unsuccessful in the past. Also, government officials, buyers of recovered materials, and companies involved in the recycling process were interviewed to see how they could contribute to the e-waste recycling process. This provided a good estimate of exactly how much electronic equipment is being used and disposed of in the southern Puerto Rico region.

To gain a better understanding of how to make an e-waste recycling center sustainable and successful, we completed a case study on an e-waste recycling facility in Massachusetts. We interviewed the owner about the economic and operational system for recycling electronic waste.

This provided us with important information about setting up and maintaining an e-waste center for an extended period of time. In order to understand the need for an e-waste recycling facility in southern Puerto Rico, we interviewed professionals to determine the current solid waste management practices. As for the knowledge of community members, we surveyed the people within the community of Ponce, the most populated city on the southern side of the island. This allowed us to gain a better understanding of what they already understood about e-waste and its negative effects. With this information, we were able to develop a plan on how to inform the public about the importance of e-waste recycling.

The information that we gathered was used to help the Puerto Rico based organization, Desarollo Integral del Sur, Inc. (DISUR), inform community members about the prospects of establishing an e-waste facility in southern Puerto Rico. Our report also addressed the viability of establishing an e-waste recycling and processing business, so that DISUR could show interested investors what kind of an economic opportunity there is in such a business.

1.0 Introduction

As the human population of the world increases, the environment is exposed to more stress due to factors which include the formation of solid waste and its improper disposal. According to the Population Bulletin (2008), the global population increased from 6 billion in 1999 to 6.7 billion in 2008, and municipal solid waste production is estimated to have increased 8 percent per year from 2007 to 2011. A significant portion of the solid waste being discarded is electronic waste (e-waste). E-waste is defined as "a generic term encompassing various forms of electrical and electronic equipment (EEE) that are old, end-of-life electronic appliances and have ceased to be of any value to their owners" (Bandyopadhyay, 2010, p. 2). The generation of this type of waste is on the rise due to population increases in the world's population and the dependency that modern society has on electronic technologies. This is an important issue to address because of the negative effects that improper disposal of e-waste can have on the environment, and ultimately on human health. For example, many personal computers in homes today contain over 5 lbs. of lead, which, if improperly disposed of, would end up in landfills, thus seriously polluting the environment (Gross, 2001).

Many places are beginning to develop electronic waste management plans that may prove to be successful. But there are still many areas that have not taken any measures to reduce e-waste build-up, such as southern Puerto Rico. Electronic waste recycling practices in this area of the island are far below acceptable levels, and e-waste is continually dumped into landfills alongside other solid waste. There are many factors contributing to this crisis, including lack of awareness and participation among the local population, lack of enforcement of government policies restricting illegal dumping of electronic waste, and the absence of properly educated

workers. In an ideal situation these factors would be addressed and a successful electronic waste recycling system would be put into operation. However, these steps have not yet been taken in southern Puerto Rico.

Development and execution of electronic waste management systems varies from country to country. A system may be successful in one nation but not another, therefore, it is essential to study existing management systems and tailor each system to the geographical area. Economic and environmental feasibility are two important factors that determine the status of waste management systems in countries. While some local and U.S. federal government regulations do not make recycling of e-waste a priority, other governments have begun to promote effective e-waste recycling. A common technique used by countries is to export the e-waste to other countries for recycling. For example, the U.S. exports 80% of its total e-waste (Gibson and Tierney, 2006). The U.S. also has recycling legislation that creates an effective model to initiate the recycling process. For example, Illinois has a regulation that "allows an income tax credit in the amount of fees paid to a recycler for the acceptance of electronic equipment turned in by the taxpayer" (p. 9). Also, Michigan has implemented legislation that "bans electronic equipment containing CRTs [Cathode Ray Tube] from disposal in landfills" (p. 9). The education of the community members is another extremely important factor, because without participation, these systems would never succeed. Advertising events where personal electronic devices can be dropped off for proper recycling has been used in many regions worldwide (IAER, 2003). These regulations and advertisements are the foundation of an effective waste management system.

It is evident that many steps need to be taken to establish a successful electronic recycling system. The main barrier that is hindering the establishment of such a system is the lack of research on the proper methods for developing it. There are 3,200 acres of a brownfield zone in

southern Puerto Rico that were previously contaminated by petrochemical companies. In conjunction with the EPA Brownfield Pilot Project, Desarollo Integral del SUR, Inc. (DISUR) wants to utilize part of the brownfield zones for building an electronics recycling center, but so far DISUR does not know if and how such a center could be introduced. An important issue that remains unresolved is the financial plan that would ensure a profitable operation. Expenses such as rental of space, payroll for employees, and operational costs must be balanced with sources of income such as sales to buyers of recovered materials and possible government assistance before DISUR can know if an e-waste recycling facility is a viable option for southern Puerto Rico.

The goal of our project was to determine the feasibility of establishing an e-waste recycling center on a brownfield zone in southern Puerto Rico, specifically in Peñuelas. This prospectus includes the number of employees required and what kind of training they would need the financial resources necessary for long-term sustainability, the type of e-waste collection system that would need to be put in place, and the ideal scale of the operation. We also determined what effects an electronics recycling center would have on the local society and environment. We hope that our research and conclusions will aid DISUR in developing a successful e-waste management system. Electronic waste is a global concern, and we know how important it is to dispose of it properly, especially in the delicate natural environment of Puerto Rico.

2.0 Background

The management and disposal of waste has become a troubling issue over the past decade, in particular the management and disposal of electronic waste (e-waste). In this chapter we will discuss the negative effects of e-waste, how it is managed on a global scale by examining effective waste management solutions in other countries, and the importance of managing it in southern Puerto Rico. We will review the impact of dumped e-waste, the process of electronic recycling (e-cycling), and the benefits of e-cycling. The economic and other practical factors in southern Puerto Rico will be assessed in order to determine the potential for an electronic recycling center there.

2.1 Effects of Electronic Waste

Electronic waste has many negative environmental and socioeconomic effects worldwide. As newer and better electronic products are made each year, older models are often retired and not used anymore (Brett, 2009). These constant technology changes have resulted in the improper disposal of e-waste because many users have found it more convenient to dump their e-waste into landfills, rather than storing it at their homes and offices. This improper disposal has resulted in a rise in pollution; some if not many of the materials within e-waste are toxic and can damage the environment, as well as the overall health of the population.

The movement of e-waste is regulated by the Basel Convention because it was deemed dangerous to both humans and the environment (Widmer, Oswald-Krapf, Sinha, Schnellmann & Boni, 2005). These regulations are due to the highly toxic substances that electronics contain, such as cadmium, mercury and lead. It has been estimated that between the years of 1994 and 2003 over 500 million PCs have been “retired.” These “500 million PCs contain approximately

2,872,000 tons of plastics, 718,000 tons of lead, 1363 tons of cadmium and 287 tons of mercury" (p. 437). An average desktop computer is found to contain between five to seven pounds of lead. If this lead is left in a landfill it can leech into the groundwater and contaminate it. In addition to the leeching, if the computers or other e-waste are incinerated, the toxic materials disperse into the atmosphere, which increases the toxicity of air (Gross, 2001). Companies have to be responsible for the proper disposal of their e-waste due to regulations that have been passed by the United States Environmental Protection Agency EPA. These regulations can force a company to spend more money which in turn would cause an increase in the prices of its products.

The appropriate disposal of e-waste can prevent problems in the sending areas, but can still have negative effects on other places around the world where the e-waste is sent for processing. "Environmental protection for health and aesthetic reasons is essentially a luxury of the rich, as mortality is such a great problem in these developing countries, where e-waste is being sent, that the relatively minimal effect of increased pollution would pale in comparison to the problems these areas already face" (Widmer, Oswald-Krapf, Sinha-Khetriwal, Schnellmann, & Boni, 2005, pp.437-438). The problem of e-waste is a growing concern, and it has been recognized by some, but it is often neglected and can lead to many problems locally and globally.

2.2 Global E-Waste Management

Due to the increase of solid waste in recent years, many initiatives worldwide have been created to deal with the management of all kinds of solid waste. In the United States there is no federal mandate for the recycling of e-waste, although many state governments have passed

legislation for controlling e-waste (Gross, 2001). In Massachusetts, a law was passed forbidding the outright disposal of any electrical equipment that contains a cathode ray tube (CRT). The proper disposal of these pieces of equipment now requires a person to take it to one of six facilities in the state that ensure the disposal of CRTs in a proper fashion. While some states are working on bills similar to this one, other states are encouraging the proper disposal of e-waste through voluntary initiatives. States, such as Pennsylvania, offer reimbursements to municipalities that spend money on the proper disposal of e-waste.

In addition to government regulations, there are some companies in the United States that have taken steps towards better e-waste management. Sony has set up drop off points where customers can drop off used Sony products to be recycled free of charge. Waste Management Inc., a provider of integrated environmental solutions, has set up "e-scrap" facilities across the U.S. that recycles used electronics. There are also ways to create products that are easier to recycle. A university in the United Kingdom has been working on developing a type of polymer that changes shape when it experiences increased temperature (Turley, 2008). These polymers will be used as fasteners for electronic products. When the product is being recycled, it can simply be heated up and the casings become undone. This ensures that recyclers are getting everything possible out of the device, and it allows for a quicker, more efficient mode of recycling.

In India, the responsibility of recycling electronics has been placed on the manufacturer of products (Dooley, 2009). Prior to this legislation most of the e-waste recycling and management in India was performed by unskilled laborers. These laborers would often sift through the waste by hand and use improper tools for the extraction of precious, valuable

materials. Though such remedial methods were often times dangerous and inefficient, they turned out to yield a profit, and a small business sector arose based on selling recycled parts. The e-cycling process usually has three stages; the first is decontamination, dismantling and segregation. The second is hammering, shredding and the use of special treatment processes. Finally, the third stage is a chemical, mechanical and thermal recovering process as well as incineration. Depending on the quality of work done in the first two stages the final product can yield a clean and well recycled product or a product still contaminated. Switzerland has proven to be one of the first countries to establish a successful e-waste management program and has continued to excel in this area (Wath, Dutt & Chakrabarti, 2010).

2.3 Process of Electronic Recycling

The actual process of recycling electronic waste is relatively new, even in the most highly developed areas (Flaris, Singh, & Rao, 2009). The process begins with the participation of the community members and ends with the proper disposing of items by a Materials Recovery Facility (MRF). These facilities ensure that materials do not pollute the environment by following a series of equally important steps.

The first step in creating a successful e-waste recycling center in any location is public knowledge of the issue because education leads to increased participation (Glazebrook & Coulon, 1999). E-waste will only be properly recycled if the community participates fully in the effort by properly disposing of their consumer electronic devices (CEDs). In order for the public to properly dispose of their electronic waste, they must have access to adequate facilities. These facilities require advertisements so that citizens will be educated on both the importance of recycling, and how they can participate. Common advertising techniques include television

commercials, newspaper ads, or flyers and signs. The effectiveness of the kinds of advertising used varies with the type of community involved.

The most expensive step in electronic recycling is its collection and transportation. The collection stage usually accounts for about 80% of the total cost of the recycling process (Hainault & Smith, 2000). There are many different methods currently in use worldwide for collecting and transporting e-waste, each with its advantages and disadvantages. Curb side pickup is one of the more direct methods, but also very expensive. By having the waste picked up directly from the consumer's home, participation increases because of the convenience. Another method is having a specified drop off area. This can either be a permanent spot, or in use only during special advertised events. Having a permanent area allows for ease of sorting the waste and also the lowest transportation cost, resulting in being the most cost-effective method. While having a special drop-off event will raise community awareness, it also limits the amount of initial sorting that can be done and requires storage space for the large amount of material collected all at once.

Other methods used for collection of e-waste are the take-back and point-of-purchase methods (IAER, 2003). The take-back method relies on the original equipment manufacturer (OEM) being involved by taking back its products for recycling. The point-of-purchase method is when retailers offer consumers the option to return products directly to where they were purchased. This method requires retailers to advertise this service in order to be successful.

Once waste has been collected, it is then transferred to a local MRF (Kang & Schoenung, 2005). Here, it is sorted into appropriate categories and tested for quality. At this point, the waste is either reused for other products, sold, or dismembered for the use of its parts. This phase of the

recycling process requires the proper facility equipped with appropriate equipment. A properly stocked facility may include a grinder, compactor, forklift, and stations for the disassembling of parts and safety equipment, such as eye protection and a fire extinguisher. Also, basic knowledge of electronics among some of the employees is a necessity. The economic success of the disassembling process is increased by first working on the more valuable products, and finishing with the products that have a lesser worth. If not all of the materials within an electronic product are sold, reused, or broken down, the rest must be disposed of properly.

2.4 Benefits of Electronic Recycling

The benefits of proper e-waste recycling range from environmental to economic impacts (Brett, 2009). Properly disposing of unwanted electronic materials keeps the dangerous substances inside of electronics out of the environment. This can result in preventing many other issues such as health and safety concerns. Improperly recycled contaminants from electronics could eventually make their way into water systems and ground water. If recycled at a high percentage, electronic waste would never make it to the ground water, and the side effects of e-waste would not affect the health of the population.

The economic benefits of electronic recycling are driven by the precious metals that are found within many CEDs (Kang & Schoenung, 2006). Many electronic devices that are being disposed of improperly or collecting dust in someone's garage contain materials such as gold, palladium, copper, or plastics. The collection and resale of these metals and other products are one of the main revenue sources for e-waste recyclers. In many cases, CEDs in the testing stage are found to work properly and can still be used. Often these items are sold off to people who are in the market for used, less expensive electronic devices. This is another good source of revenue

for e-waste recyclers. These devices can also be donated to places such as community centers or schools, where they will be used by people who may not have the opportunity to use them otherwise. When the owners of these recycling centers are making money, it results in rising employment opportunities. The creation of a facility in turn creates new jobs for community members who receive the proper education and knowledge of electronics.

2.5 Electronic Waste Management Strategies

As far as electronic waste management strategies go, it has been consistently proven that the most cost effective way to increase efficiency is by improving disposal systems (Brunner & Feller, 2007). Research has shown that in developing countries there should be a series of steps that, if completed, will eventually lead to a successful e-waste recycling system (Liu, 2009). First, the government has to be involved to improve the policies and enforce mandatory recycling. Second, environmentally friendly industrial parks must be constructed in an area where the recycling of e-waste will have a negligible effect on the natural environment. One of the more important steps is to ensure that employee training meets the required standards, while also protecting their well-being due to risks from hazardous materials in the electronics. The level of technology within the system also has to be of a high quality to ensure that the negative impacts of possible toxic materials are limited. Finally, there has to be an effective monitoring system to ensure the health and safety of the employees within the industry while also focusing on the protection of the environment. These guidelines, if followed closely, have been proven to result in successful waste management facilities.

2.5.1 Case Study of an E-waste facility

In order to understand the process that electronic waste recycling centers use, our team decided to tour All-American Recycling in Ayer, MA, along with its owner, John Bacon. He discussed what steps he took to build a functional facility that is well maintained and uses safe practices. It is necessary to have a mission and a well-developed plan to be successful in the recycling business. Due to the amount of skepticism about proper disposal procedures and environmental concerns, corporations are under a microscope at all times. Therefore, it is necessary to consider all the effects that an e-waste facility may have on the community and the environment. John Bacon discussed the importance of placing the center in an area, such as an industrial park, that does not disturb the surrounding community. Since the company does not smelt any hazardous materials on site, there is no harmful discharge coming from the building. All-American Recycling also has a strict "no landfill" policy, which contributes to their environmentally friendly approach.

Mr. Bacon utilizes his resources and connections with other recycling companies to outsource certain processes. There are particular procedures that are performed at the facility, such as grinding and compacting of plastics and metals. The main role of All-American Recycling is to break down items into smaller parts and then separate the different materials. It is important for the facility to capitalize on all of the commodities in the collected items and sell them to buyers of recovered materials. Commodities include everything from metals to Freon, which is an organic compound found in refrigerators.

Selling the commodities provides a majority of the profit for the company and is a vital factor that drives the recycling industry. Components of items, such as plastic, need to be ground

into a granular form in order to be sold and reused by companies. Computer parts, such as circuit boards, contain precious metals that are sent to companies that specialize in the recovery of these metals. Mr. Bacon sends these parts to a special processor in Fort Devens, MA, that uses robots to dismantle the electronic parts, which negates the possibility of physical harm to workers.

One of the companies that All-American Recycling outsources to is called E-waste Recyclers, LLC, and is located in Jaffrey, NH. Mr. Bacon sends many materials, such as cathode ray tubes (CRTs), to this company because it has the proper equipment to further process them. This company has a machine that separates all hazardous materials out of these tubes, so they can be properly disposed of. There is legislation that is enforced by the EPA that streamlines the management and exportation requirements for CRTs. It is vital for companies to meet all government regulations, but it is also important for one of the main focuses to be on safety. In order to keep workers at the facilities safe, they need to be properly trained in the disposal of e-waste. While prior education is not a requirement, Mr. Bacon described how many of his workers have technological backgrounds, so they are well versed in exactly what components there are in electronic goods. Workers need to be educated on the hazardous materials in electronics, what the valuable and reusable parts of devices are, and how to properly handle them.

There are several unique methods that All-American Recycling uses in its facility. One example is that all of the office equipment comes from reused materials, such as desks, computers, printers and filing cabinets. This proves that the company practices what it preaches. Mr. Bacon also works with many non-profit organizations to foster relationships and build trust with the community. Reusable items, such as computers, are sometimes donated to the local schools by All-American Recycling, which demonstrates that they want to give back to the

community. Mr. Bacon utilizes his ties with the public to hold all-day recycling events at central locations, like local churches. A majority of the waste that All-American Recycling collects is generated from these events.

Another source of waste is gathered from companies that want to recycle old supplies or that have accumulated waste from their business' take-back programs. Collecting these recycled materials is another source of revenue for recycling companies. All-American Recycling also has an eBay room that generates another portion of the company's income. This room contains many reusable and refurbished items that they have collected for testing and pricing. One of the staff members is an eBay "specialist", who appraises recycled items and posts the usable ones on the company's seller page. These sales are a great asset to the company's overall business and are another important strategy that contributes to the success of the recycling operation.

The feasibility of building and maintaining a recycling center can be measured by the availability of resources, possible locations, business opportunities, and worker skill sets. Mr. Bacon described how various facets of the industry are always changing, and it is important for companies to make appropriate changes over time. The recycling industry is an important stimulus to the economy, and the placement and operation of centers can have a great impact on the socioeconomic health of a community. It is important to assess the advantages and disadvantages that a recycling center can have on a community. All-American Recycling represents a good model for the approach that e-waste recycling centers should take to operate and maintain their facilities. They have a well-developed process of dismantling parts and outsourcing specific materials to the appropriate sources. A well-developed plan is what has determined the success of All-American Recycling's operations.

2.6 Solid Waste Management in Puerto Rico

The majority of solid waste in Puerto Rico is dumped into landfills, which is not a sustainable technique due to the large amount of waste generated by its citizens every year (Authoridad de Desperdicios Solidos, 2010). Although the amount of waste being collected is increasing, there has not been an increase in the area available for dumping. This has resulted in landfills reaching capacity and overflowing, which has negative effects on the environment. Currently, there is solid waste legislation that mandates closure of landfills that are over capacity. The number of legal landfills in Puerto Rico is twenty-two, as shown in Figure 1, but the number is projected to decrease every year as landfills are closed down because of overflow. By the year 2014, the number of operational landfills is predicted to be fourteen, and by the year 2020 the total number of active landfills in Puerto Rico is predicted to be four.

Figure 1: Landfill in Operation in Puerto Rico as of 2010

(Authoridad de Desperdicios Solidos, 2010, p.4)

2.6.1 Current solid-waste management legislation

Puerto Rico has been suffering from waste management problems for many decades (Soto, 2004). Environmental activists and organizations noticed the problems associated with waste management, and they pressured the government and responsible organizations to take more action to protect and preserve of the environment from the negative effects of improper waste management.

According to Authoridad de Desperdicios Solidos (2010), the municipalities and private industries on Puerto Rico generate 11,400 tons of waste per day. Of this amount, all but about 1,540 tons are sent into the islands landfills. This means that 9,860 tons of solid wastes are sent into landfills every day, most of which are already or soon to be at capacity. Figure 2 shows the solid waste flow in Puerto Rico, traveling from consumers to either landfills, Material Recovery Facility (MRF) or exported to foreign countries.

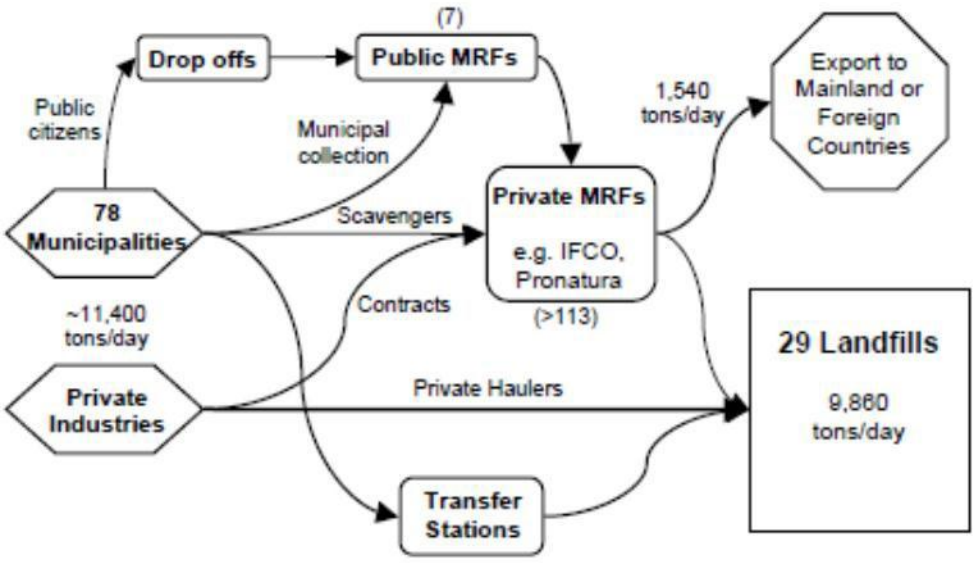

Figure 2: Solid Waste Stream in Puerto Rico

(Chan et al, 2006, p.12)

The government of Puerto Rico responded to the pressure placed on them by passing several acts to curb the negative effects of solid waste (Soto, 2004). These acts focus on the maintenance of landfills and procedures landfills need to follow in order to protect the safety of the workers and the nearby residents.

Landfills in Puerto Rico are required to properly fence the boundaries to the dumping area, which thereby prevents intentional and unintentional trespassing (Soto, 2004). Another requirement for landfills is to have functional truck routes to transport solid waste to and from the facility. Landfills also need to properly cover the waste they collect daily and establish a fire emergency plan that will mitigate the damage from a disaster, as well as protect the workers and nearby citizens.

Unfortunately, despite the legislation put into place by the government, the majority of landfills in Puerto Rico do not adhere to the local and federal environmental regulations (Soto, 2004). According to the Director of the U. S. Environmental Protection Agency, Carl Axel Soderberg, in 2002 only the landfills in Ponce and Humacao followed the established federal regulations. The negligence of most landfills results in unsatisfactory living and working conditions for the workers at the landfill and citizens living nearby. In fact, "many citizens who live near landfills are uncomfortable with their living conditions. Añasco landfill is located adjacent to a community that must live with an unbearable smell and flies" (p. 45).

In addition to legislation that targets landfills, the U.S. government has passed legislation such as the Clean Air Act (1970), the Clean Water Act (1972), and the Resource Recovery Act (1976) to assist with their goal of protecting the environment and ensuring the protection of its citizens (Soto, 2004). The Clean Air Act gives the Environmental Protection Agency (EPA) the

authority to develop and enforce regulations that will protect the general public from airborne contaminants. The Clean Water Act set standards for surface water to ensure its cleanliness and the Resource Recovery Act governs the proper disposal of waste.

The addition of electronic recycling plants can help reduce the amount of solid waste that is dumped into landfills (Beveridge & Diamond, 2012). By increasing the amount of solid waste that is recycled, landfills will be easier to maintain because of the reduced amount of solid waste that will need to be stored, thus making it easier for them to follow the federal and local legislation. However, similar to solid waste management, electronic recycling legislation will be needed in order to promote proper e-waste disposal and provide safety to both workers and citizens.

2.6.2 Recycling Legislation in Puerto Rico

Several municipalities in Puerto Rico have laws regarding the collection and disposal of solid waste (Soto, 2004). Despite the laws in place, they are often not strictly enforced, which results in citizens not abiding by them. The Reduction and Recycling Act states, "The general public, state agencies, and public corporations that generate solid waste are required to properly separate the recyclable materials. In addition to this, any industry, factory, store, commerce, commercial or noncommercial establishment of greater than ten employees must institute a plan of recycling" (Bosman, Milano & Youkana, 2007, p.17). Laws without enforcement serve no purpose. This act should be a catalyst for the creation and use of recycling facilities within Puerto Rico. One example of how this is affecting Puerto Rico is the creation of a new recycling facility in Peñuelas by IFCO Recycling. The recycling facility is projected to create 89 jobs and

will serve as a broker for recycling companies in southern Puerto Rico (Mi Puerto Rico Verde , 2012).

2.6.3 Newly-enacted Electronic Waste Legislation in Puerto Rico

On January 17, 2012, the government of Puerto Rico enacted a landmark electronic-waste law (Beveridge & Diamond, 2012). The law is entitled the Electronic Equipment Recycling and Disposal Law of Puerto Rico and will go into effect May 16, 2012. End-of-life responsibility will be imposed upon manufacturers, importers, and exclusive distributers of electronic equipment and cell phones. One year later, the law will prohibit the disposal of any of these products or cathode ray tubes anywhere other than at a government-authorized collection center. The entities mentioned in this law will need to create a recycling and disposal plan, which will be registered with the Environmental Quality Board. Businesses with more than 11 employees will need to implement an "e-waste take back program", which will be supervised and enforced by the Environmental Quality Board, Solid Waste Management Authority and municipalities.

The new law reinforces what the Puerto Rican government believes in. The constitution of Puerto Rico mandates that the government protect the natural resources, the general welfare of the communities, and its people. The passing of this legislation helps Puerto Rico give more support to its constitution.

2.6.4 Corporate Initiatives in Puerto Rico

Wal-Mart Puerto Rico has an annual recycling challenge called "Tómatelo en Serio" (Wal-Mart, 2010). Wal-Mart has partnered with the Puerto Rico Solid Waste Authority, the Puerto Rico Education Department, Yo Limpio a Puerto Rico, and PepsiCo. Wal-Mart has acted

as the collection center for this challenge. The challenge resulted in 80,000 students from 231 schools bringing in their old electronics to participating Wal-Mart stores. As a result, in 2008, Wal-Mart increased the amount of e-waste collected by fifty-seven percent over the previous year.

In 2010 Wal-Mart partnered with the Autoridad de Desperdicios Solidos (ADS) to collect and recycle 133,750 pounds of televisions at Wal-Mart retail stores (Recogen dos mil, 2011). These retail stores were located in Bayamón, Caguas, and Ponce. These stores collected 1962 televisions. The televisions were then sent to be recycled by a company in the northern part of the island called Reciclaje del Norte.

2.7 Summary

Currently, there are no electronic waste management strategies in place on the southern side of Puerto Rico. If this lack of strategic management continues, then the state of the natural environment and human health will continue to decline. Therefore, the need for a successful system increases in order to limit the amount of e-waste that is produced and not properly recycled. Our project's goal is to help contribute to a solution of the e-waste problem in southern Puerto Rico.

3.0 Methodology

The main goal of this project was to determine the feasibility of establishing an electronic-waste (e-waste) recycling facility in southern Puerto Rico, specifically on a brownfield zone in Peñuelas. In this chapter we discuss the methodology we used to achieve this goal. We determined Puerto Rico's current solid waste management practices, the economic and technical feasibility of operating an e-waste recycling facility, and the current knowledge of community members concerning e-waste. We gathered this information using many different methods such as interviews, case studies, surveys, and direct observations.

3.1 Determine Current E-Waste Management Strategies

We determined the methods of e-waste management currently being used in Puerto Rico before we made any recommendations for improvement. Specifically, we wanted to determine practices at recycling centers and waste management companies. The electronic-waste recycling processes were examined using different investigative methods in order to gain information about how the recycling of electronic waste is currently being handled in southern Puerto Rico.

3.1.1 Interview with Manager of Peñuelas Recycling Center to Determine Operational Procedures

To understand how a recycling center in southern Puerto Rico would be run, we went to the recycling center in the municipality of Peñuelas. We began by introducing ourselves and explaining our project to the facilities manager, Maria Cruz. She was helpful in showing us around the outdoor recycling plant and describing the different procedures that take place. We observed what the facility does with e-waste, and we were able to adopt any practices which may be crucial for the proposed e-waste facility. Also, we were able to directly observe many operations that are common in recycling centers such as separation, disassembly, and

compaction. The interview protocol and minutes for our meeting with Maria Cruz can be found in Appendix B. This meeting was helpful to understand current recycling methods that are in place in Peñuelas, as well as areas that are in need of improvement. This meeting also led us to other contacts such as IFCO, the private recycling company that is contracted by the town to take care of their recycling needs. Maria only spoke Spanish, so David Southgate, our project sponsor's liaison, assisted in translating our questions and her responses about the recycling process in Peñuelas. The information and experience that we gained from these observations enabled us to determine the procedures and equipment necessary to properly run a recycling facility.

3.1.2 Interview with LM Waste to Determine Current E-waste Management Strategies

To determine current e-waste procedures at local waste management companies within Ponce and nearby municipalities, we interviewed the director of LM Waste Service Corp., a waste management company located in Ponce. We contacted the administrative assistant of LM Waste Service Corp. and met with her on March 28, 2012; she set up a conference call with the director of the waste management company. The interview protocol and minutes for this meeting can be found in Appendix C. We collected information regarding the specific municipalities that the company works with, what they do with electronic waste, and their importation and exportation practices. This information was critical for determining the current state of electronic recycling on the island of Puerto Rico.

3.1.3 Interview with Brenda Colon at ADS to Determine Current E-Waste Management Strategies

To determine the current e-waste disposal strategies in Puerto Rico, we held an interview with Brenda Colon of ADS. The interview protocol and minutes of this meeting can be found in

Appendix D. The information that was obtained from interviewing Brenda Colon was vital to our understanding of how the ADS is involved with recycling companies across Puerto Rico. This meeting also gave us information involving the relationship between the recycling companies and retailers, such as Wal-Mart, in terms of partnerships for e-waste recycling.

3.2 Determine Community E-Waste Disposal Habits

We needed determine the current knowledge and practices of e-waste disposal of the people of Puerto Rico living in the southern municipalities. The information we gained for the surveys of community members allowed our group to discover the current knowledge they have about e-waste recycling, the types of electronics they own, and if they desire an e-waste recycling facility. The data collected enabled us to determine what areas of knowledge the community members are lacking awareness in.

3.2.1 Survey of Residents of Southern Puerto Rico to Determine E-Waste Disposal Habits

We walked around the center of Ponce and interviewed twenty-four residents in stores and in public areas. We selected these people at random on the street using a convenience sampling approach. The survey included questions regarding what types of electronic devices the people own, as well as how many. Appendix F contains the questionnaire that was used to survey the locals as well as the results. The information obtained provided us with details about the current e-waste disposal practices of citizens living in the southern region of Puerto Rico and their awareness about the recycling and negative effects of e-waste. We assessed the current knowledge of e-waste disposal and management of the community members in southern Puerto Rico, in order to help us determine a successful approach to an education campaign about e-waste recycling.

3.2.2 Interview with the Advisors for the Mayor of Guayanilla

We interviewed two advisors for the mayor of Guayanailla, Víctor Medina and Pedro Ortiz. The advisors provided information about the recycling habits of the locals. They also provided us with feedback about incentives which could motivate locals to be more proactive about recycling e-waste. Appendix E contains the interview protocol that was used to interview the advisors. We assessed the information to determine successful ways to promote e-waste recycling among the locals.

3.3 Determine Economics of Running an E-Waste Recycling Facility

When starting any business, it is important to consider the initial start-up costs as well as the maintenance costs of the business. The same applies to an electronic waste recycling center. The ability to keep the facility operational for many years is extremely important and relies greatly on the initial planning. We consulted an entrepreneur who was knowledgeable about the necessities of establishing a new business. The information he provided us with was crucial to ensuring the success of the e-waste facility.

3.3.1 Interview Buyer of Recovered Materials, Juan Lugo, for Economic Background Information

David Southgate connected us with a dependable professional named Juan Lugo, an individual who has had a great deal of experience with the resale of used electronic equipment and starting a business. Mr. Lugo does most of his business via websites such as eBay to resell used and unused equipment to buyers in need. An interview protocol and minutes for this meeting can be found in Appendix G. Mr. Lugo provided information about buyers of the materials collected from e-waste. This information was a key part in the chain of recycling electronic devices, and without it the e-waste recycling business could not exist. There are many

precious materials that can be extracted from used electronics, and these buyers have been purchasing e-waste to turn a profit. The information gained from this meeting provided useful information about the economics of running a recycling type business.

3.4 Selection of an appropriate site for an E-Waste Recycling Facility

Since the location of the facility is a key aspect of its viability, it was necessary to determine the best location on one of the 11 brownfield areas in Peñuelas and Guayanilla. DISUR has an ongoing investigation concerning the planning and reuse of the brownfield sites, our team focused on the transportation and communities that surround the sites. More specifically, we assessed the nearby ports, roads and bridges which would allow for the importation and exportation of e-waste. By evaluating this data, our group was able to determine a viable location for the facility.

3.4.1 Tour of Brownfield Zones for Selection of Facility Site

In order to see the actual condition of the proposed sites for an electronic waste recycling facility, we took a tour of the brownfield zones in the area of Peñuelas and Guayanilla. Guiding us through this tour was David Southgate, who is very experienced and knowledgeable about the brownfields. Since he has been living and working in the area for many years, he was able to provide a unique view on the brownfield zones and gave a very informational tour. The notes taken during this tour can be found in Appendix H. Seeing the proposed areas in person gave us a better understanding of what measures are needed to plan for the electronic recycling center.

3.4.2 Tour of Port of Ponce and Peerless Port for Selection of Facility Site

We visited the Port of Ponce and Peerless Port to determine the viability of exporting and/or importing e-waste or components of e-waste in southern Puerto Rico. We observed the facilities at the ports and spoke with Mr. Quiñones, a port director at the Port of Ponce. We gathered information regarding the size of the port, the number of shipments the port receives and sends daily, as well as the types of cargo. This information was critical for determining how an e-waste facility in the area could use the ports for shipments.

4.0 Results and Analysis

In this chapter we present our findings regarding the feasibility of establishing an electronic waste recycling facility in southern Puerto Rico and discuss their significance. We were able to determine the existing factors that affect the viability of maintaining an e-waste facility on the brownfield areas of Peñuelas and Guayanilla. Technical, economic and sociocultural factors were analyzed and utilized to help us draw conclusions and recommend alternative solutions to DISUR, so that they can move ahead with plans of an e-waste recycling facility.

4.1 Waste Management Practices in Southern Puerto Rico

The municipalities in southern Puerto Rico have their own solid waste management systems, and each one has different procedures for handling waste. We assessed several of the communities around the brownfield zones in Peñuelas and Guayanilla to determine their current waste management practices and knowledge. We used this information to determine what waste management problems presently exist in southern Puerto Rico and how they can positively or negatively affect the viability of the operation of an e-waste facility. It is important to note that the information gained from the municipalities of Peñuelas, Guayanilla and Ponce is used as a representation for the rest of southern Puerto Rico due to the similarities in socioeconomic state and culture.

4.1.1 Interviews and Observations at Recycling Programs

The recycling programs in the southern municipalities of Puerto Rico that we visited had a variety of practices for residential and commercial waste management, but overall none of them had proper e-waste disposals methods. Much of the e-waste that is collected is dumped into landfills or sits dormant on the grounds of the recycling centers. For example, at the Peñuelas

recycling distribution center there is an effective program that separates each type of material, such as cardboard, plastic and newspaper, and then crushes or compacts the different materials, which are then collected by IFCO for further recycling. Most electronics, including fridges and stoves, are left sitting in the waste management center or are brought to landfills. The municipality of Peñuelas has a partnership with IFCO Recycling that allows them to use IFCO's equipment, such as a compacter, and IFCO transports the materials to their recycling plant where they are further processed or sold. This collaboration is effective because Peñuelas is paid for the materials, so they are able to afford the upkeep and operation of their recycling program.

In the municipality of Guayanilla, LM Waste Services handles all of the waste management because they won the right through a bidding process. We interviewed the mayor's advisors, Víctor Medina and Pedro Ortiz, who described that many residents are set in their ways, so it might be difficult to encourage community members to recycle their electronics. We informed him about the different modes of collection we have researched and possibly using tax incentives. Pedro and Víctor were very receptive to the idea and thought that the community would be more likely to recycle with a strong campaign and incentives. He also told us that a few years ago tax incentives for residents were implemented if they bought a computer for a dependent and it was successful in the community. One problem in southern Puerto Rico that we heard about during our visit was that there is a high level of theft for precious metals, such as copper. Since these precious metals have high value, scavengers take them from places, such as electrical transformers, to resell them and make a profit. Products are usually resold to privately owned manufacturing companies for further breakdown of materials.

In order to create a successful operation the destination for each type of material for further processing or resale needs to be determined. A properly trained person can determine if a product is reusable or at end-of-life by testing it. If a product is reusable it can be sold through a material exchange, donated or sold on EBay, which is a similar process used by All-American Recycling. Selling refurbished products has proven to be profitable and prevents electronics from ending up in landfills. For end-of-life products, separate materials in designated sections of the facility and use grinders and crushers to process metals and plastics. The raw materials can be sold to buyers of recovered materials, such as IFCO and R4-Enterprises.

Other types of materials, such as CRTs and circuit boards, need specialized processing equipment. Therefore they can be sent to EPA-approved companies, like Ecologic PR, which has the proper equipment to crush CRTs or to export them overseas. There is a need for import and export in order to stimulate the Port of Ponce and create a flow of waste through the facility. There are several Caribbean countries, such as the Dominican Republic, that already collect scrap metal from Puerto Rico, so it might be possible to do an exchange with them and import some of their e-waste.

We have found that there is a lack of e-waste management in southern Puerto Rico, but one organization that continues to be proactive about it is the Autoridad de Desperdicios Solidos (ADS). Figure 3 shows the type of collection boxes that ADS has outside their office to collect batteries and cell phones, which they ship to Nova Terra for no charge.

Figure 3: Cell phone and battery collection outside ADS

ADS has worked with companies, such as Wal-Mart, to hold events annually to collect communities' e-waste. There are two annual events per year and each collects different items due to limitations on funding. In April, ADS collaborates with Sony and Wal-Mart to collect all electronic devices, except televisions, which are collected at a separate annual event. Materials are collected at seven locations around Puerto Rico with only one drop-off point in southern Puerto Rico, Ponce. The electronics are collected and given to companies, such as Nova Terra, which further breakdown and distribute the materials. The television collection event is sponsored by ADS, who partners with Wal-Mart, to collect old televisions at retail stores located in Bayamón, Caguas, and Ponce. The televisions are then sent to be recycled by a company in the northern part of Puerto Rico called Reciclaje del Norte.

Another component that ADS focuses on is the education of communities in Puerto Rico on waste management and recycling. ADS has worked on advertising campaigns, which

consisted of broadcasts on the radio, television and messages on public transportation. There also was an educational campaign developed by the Department of Education, which was based off an environmental curriculum for children in kindergarten through third grade that is still utilized in schools. The educational campaign began in 2006 as a pilot program that started in 10 percent of Puerto Rico's public schools and budgeted for 100 million dollars over 20 years. The main focus was changing environmental science to a core course instead of an elective. The ADS employees informed us that they have been successful in carrying out the recycling message and continue laboring to fulfill it. The educational campaign continues to grow through the school system in Puerto Rico and has an impact on the younger generation.

The mode of collection of the electronics and educational campaigns are two key assets that contribute to the feasibility of an electronic waste facility. Another source that discusses creating an educational campaign, facilitating all-day collection events and other procedures for an e-waste center is a guide called Best Management Practices for Electronic Waste, which can be found in Appendix I. The guide is intended to assist communities in overcoming problems with e-waste by giving step by step instructions for decision-making and implementation of new procedures. It provides other valuable information, such as insurance and contracting professionals, which would be very beneficial to an organization setting up an e-waste facility.

4.1.2. Survey of Community Members

Beyond looking into e-waste management programs, we surveyed twenty-four residents of Ponce to assess their knowledge about electronic waste and what types of electronics they own. The surveyed residents do not represent the whole population in the area, but the data we collected proved to be suggestive and interesting.

We have learned that because each type of electronic equipment needs to be processed differently, it is important to determine what types of electronics the residents of an area own. Figure 4 shows that eighteen cell phones, sixteen flat screen televisions, nine tube televisions, five desktop computers and four laptop computers were owned by the residents who took the survey.

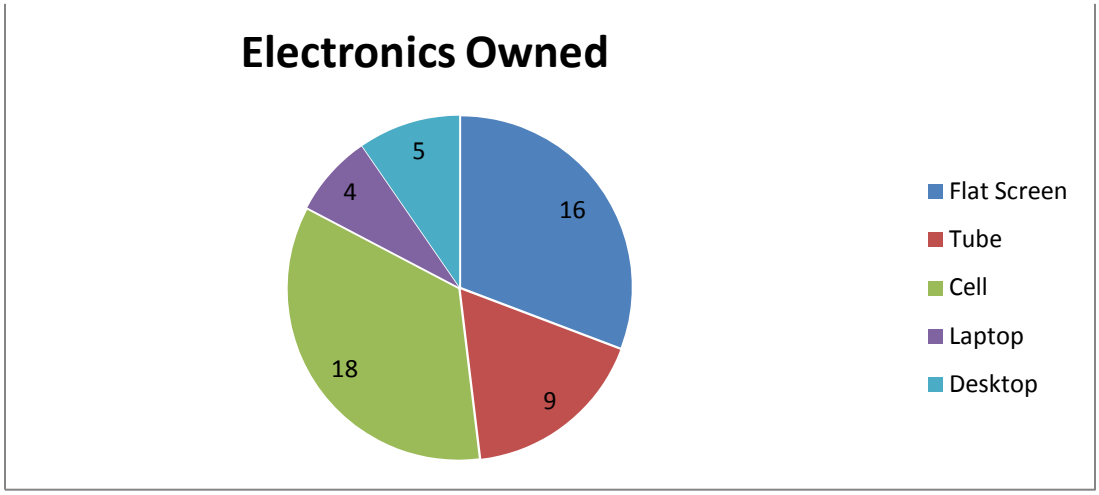

Figure 4: Electronic equipment owned by a sample of 24 Ponce residents (n=52)

The level of community awareness about e-waste is an important consideration for the viability of establishing an e-waste facility. The community members need to have a good understanding of what the proper disposal of e-waste is and what the negative effects of improper disposal are so they are motivated to recycle their electronics. The questionnaires that we distributed provided us with information about the community's e-waste disposal habits and their opinions about recycling. Of the twenty-four people surveyed twenty said they agreed, three were neutral and two strongly disagreed that they are aware of the negative effects of e-waste on the environment and community.

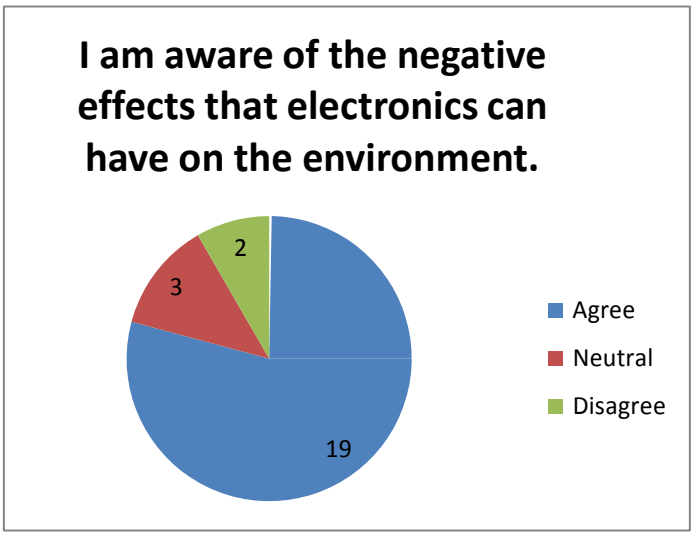

Figure 5: Ponce residents' awareness of the effects electronics have on the environment (n=24)

The survey results as shown in Figure 5 demonstrate that majority of the respondents agree that they are aware of the negative effects that electronics can have on the environment. We also asked the respondents if they were aware of proper disposal methods for electronic waste and whether they actually used these methods.

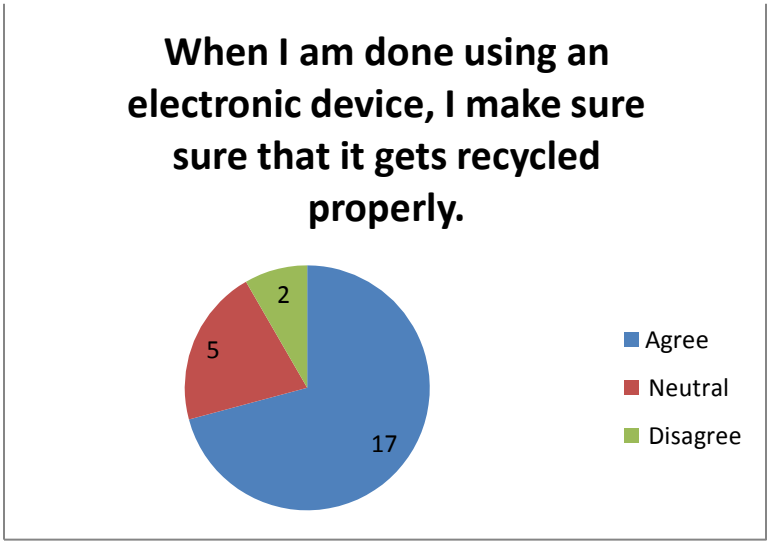

Figure 6: Proper recycling practices by respondents in Ponce (n=24)

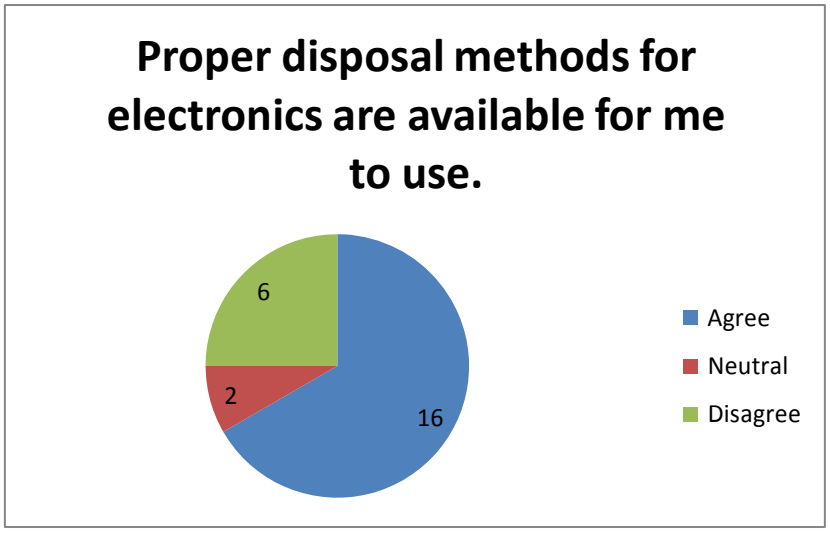

Figure 7: Opinions about whether proper disposal methods for electronics are available in Ponce (n=24)

Figures 6 and 7 show that the majority of the respondents surveyed agreed that the proper disposal of electronics is practiced and available to them. Figure 8 shows that most respondents also felt that e-waste recycling opportunities were properly advertised in their home area.

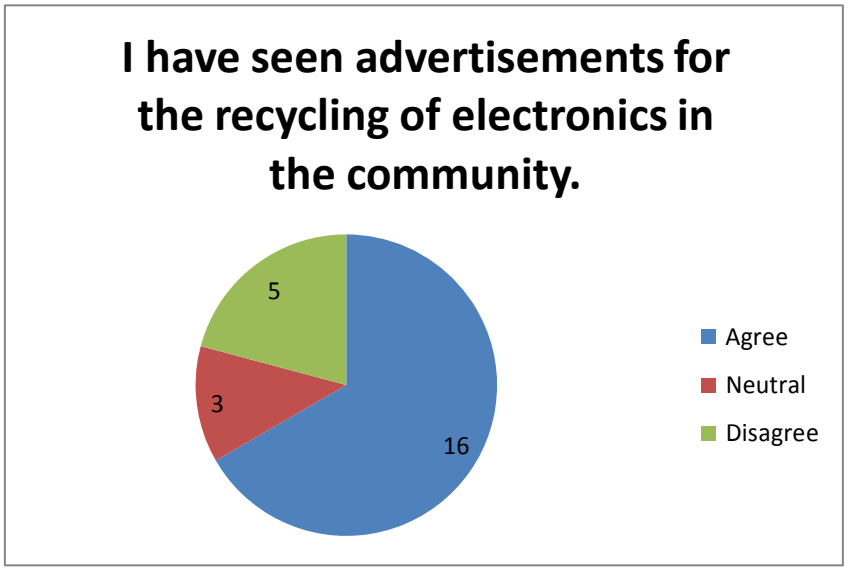

Figure 8: Presence of advertisements for e-waste recycling in Ponce (n=24)

Since community support is an important factor in the viability of an e-waste facility center, we wanted to determine the community's desire for an electronic waste recycling facility near Ponce. Figure 9 shows that our survey respondents strongly support the idea of an e-waste recycling center in the Ponce area. Twenty-two of the respondents strongly agreed that there should be an e-waste facility near Ponce, while only two persons disagreed with that idea.

Figure 9: Desire for a facility near Ponce (n=24)

4.1.3 Analysis

From the data obtained pertaining to the recycling programs in the southern municipalities, we found that there is no official recycling procedure for e-waste. The existing waste collection programs collect the e-waste, but the equipment is not broken down and therefore e-waste ends up in containers that are sent to landfills instead of being sent to facilities that can properly recycle this type of waste.

Figure 10: Unbroken down E-waste in a container at a recycling facility

The data collected from the sample of community members suggest that the community members have a general knowledge about the effects of electronic waste on the environment. Eighty-three percent of the respondents agreed that they generally know about the effects of e-waste. In regards to other questions on the survey, sixty-seven percent of the respondents claim that they are aware of the correct ways to recycle e-waste and the same percentage believes that they dispose of their e-waste correctly. However, these data do not conform to our observations at recycling plants in the Ponce area, where e-waste was not being recycled properly but was ending up in landfills instead, which is evident in Figure 10. This contradiction implies that community members are not properly informed about the final destination of their e-waste, and/or they do not know what the correct procedures are for disposing of e-waste.

One of the more important findings is that ninety-two percent of the surveyed people would like to have an e-waste facility in their area, which helps to support the viability of establishing such a facility in southern Puerto Rico. While all of these data are valuable, it represents a small sample of the population in southern Puerto Rico. However, the information

still provided us with insights on the opinions of community members near the proposed site for the facility, who would be most affected by the creation of an e-waste recycling center.

We found that while e-waste is being collected by waste management programs in southern Puerto Rico, there is no procedure for the breakdown of the e-waste into its recyclable components and properly disposing of toxic materials. Even though ADS holds annual events to collect e-waste, the municipalities themselves do not have proper practices to collect and dispose of e-waste.

4.2 Potential Business Opportunities

To be successful an e-waste facility must be economically sound and be able to be sustainable. Therefore we needed to determine what business opportunities would be available related to electronic recycling. Through interviews, surveys, and observations we were able to identify how possible business opportunities might affect the overall viability of an e-waste facility in southern Puerto Rico.

4.2.1 Interviews with Business Managers

We interviewed Juan Lugo, an entrepreneur who buys and sells used medical devices, and he provided us with information on how to make an e-waste recycling facility profitable. He emphasized that the facility would need to add value to the electronic waste in order to make the facility profitable. In other words, the e-waste had to be broken down or transformed into a commodity that other individuals or companies would want to use and buy. In addition to adding value to e-waste, the facility would need to do this in a cost effective manner.

Juan Lugo also informed us that some companies in Puerto Rico utilize stainless steel, wood, cardboard, and rubber to make products. E-waste contains these raw materials, so by breaking down the e-waste and extracting these raw materials, they could be sold to potential buyers. He put particular emphasis on glass, because of its high value as a commodity because it is used to make spandex. If a recycled electronic device contains a large amount of glass, then its value would be dramatically increased. Currently there are no facilities in Puerto Rico that recycle glass because it is a very expensive process. However, glass can be exported to other places, such as the US and Asia, for breakdown and processing.

Another strategy that would help an e-waste recycling facility to be successful is through promotion and networking. Potential buyers of e-waste and their components need to know of the facility, so they can be contacted for business partnerships. Since the electronic waste disposal law of Puerto Rico will be enacted in May 2012, there will be many companies that will have e-waste that needs to be recycled. Another method that can be used to collect or sell is through a website called Puerto Rico Materials Exchange, which has a list of buyers and sellers and what they want to sell or buy. Mr. Lugo mentioned it would be beneficial for a newly formed company to advertise itself using public media, such as the radio and local newspapers.

4.2.2 Observations of Brownfield Areas and the Port of Ponce

There are 11 brownfield areas, which can be seen in Figure 11, in the EPA planning stage and several zones are potential sites for an e-waste recycling facility. According to the data we received from DISUR, one of these sites would be the proposed location for an e-waste recycling center.

Figure 11: Proposed area for the e-waste recycling facility

(David Southgate, personal communication, April 4, 2012)

The brownfield zones are located in former industrial areas, and each zone has varying proximity to residential areas. The transportation of materials to and from the brownfield zone and potential recycling center is a crucial factor in determining the most suitable location for a facility. Transportation by land needs to be taken into consideration as well as the proximity to the ports in the southern region for sea transportation opportunities.

There are two ports of interest to our project: Port of Ponce and Peerless Port. As seen in Figure 12, the Port of Ponce has adequate infrastructure to handle the import and export of the raw materials obtained from breaking down e-waste, but the waterways are only approximately fifty feet deep. The shallow depth of the port is not suitable for Post Panamax ships, which might hinder exporting or importing large shipments of materials.

Figure 12: Crane at Port of Ponce used to unload/load cargo ships

In contrast to the Port of Ponce, the depth in the Peerless Port is greater, which would allow the port to host larger cargo ships. However, this port does not have sufficient equipment to unload cargo ships easily. Due to the lack of equipment, the Peerless Port is currently not being used to its full potential.

Potential transportation between the e-waste facility and the ports would be mainly via roadways, some of which must cross bridges. Figure 13 shows that bridge 83, which is under construction, connects the area where the ports are to the main road. The other two bridges are small and narrow with a low weight limit. These bridges as they are now are not suitable for frequent use by large trucks and would limit the transportation of materials to and from the ports to the proposed site of the recycling facility.

Figure 13: Bridges that would be utilized in the operation of an e-waste facility

4.2.3 Socioeconomic Conditions

There are nine rural neighborhoods and approximately 10,900 persons living near the proposed area for the e-waste recycling facility. The area has a high unemployment rate of twenty percent and a high poverty rate of fifty-seven percent. This means that approximately 2000 persons are currently unemployed. As seen in Figure 14, there is an eighty-six percent literacy rate in Peñuelas area as of year 2000.

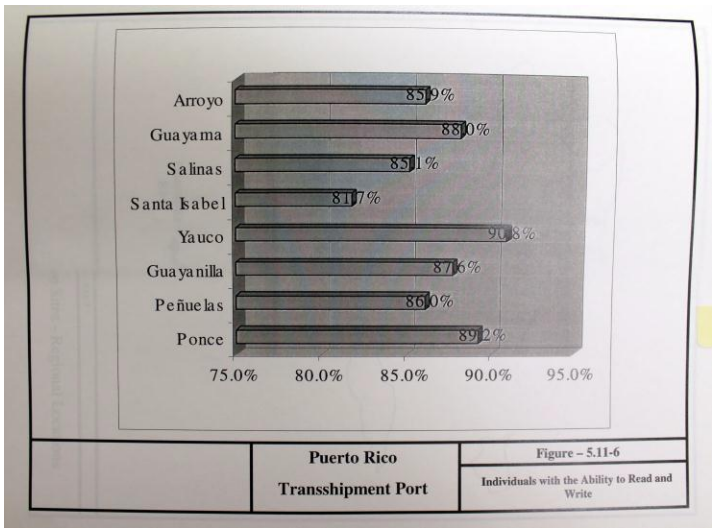

Figure 14: Literacy Rate Southern Puerto Rico- 2000

(Juan Feliciano, personal communication, April 17, 2012)

From our background research we know that basic training is needed to work in a recycling facility, but such technical training could be successfully given to someone without a high school diploma. Given the levels of unemployment and poverty in this area, there is a real need for economic development. The establishment of an e-waste recycling facility would encourage business investment and eventually generate new jobs for the area's residents.

4.2.4 Analysis

From our research it is apparent that profitability, transportation, and community involvement will be crucial to the development of an e-waste facility. The facility will need to breakdown the e-waste into different components, which are then sold to potential buyers in order to turn a profit. Value can be added by breaking down the e-waste into different components, which are then sold to potential buyers. If the e-waste is still functional, it can be sold again, sometimes after some repair or modification, thus maximizing the use of the product. There is a market for stainless steel, wood, cardboard, and rubber in Puerto Rico. If the e-waste contains these materials, then it increases the value of the e-waste.

Glass was found to be another valuable commodity that is present in e-waste because it can be used to make spandex. However, there are no facilities in Puerto Rico that can process glass. If the facility were to benefit from procured glass, the glass could be exported to another country. Since this is the fate of all recycled glass in Puerto Rico, there is a significant business opportunity for a company to take on the collection of this glass within island, and even consider investing in the technology necessary to process it into a new product.

To maximize the efficiency of the export of some components of e-waste, suitable transportation between ports and the facility will be needed. Roadways and bridges that connect the ports to the "mainland" could prove to be a serious limitation for the facility if there is only one route to and from the ports. Dependency on a single roadway could hinder operations if the roadway or bridge were damaged. The risk of the roadways to and from the port being damaged is relatively high due to their proximity to the sea. During hurricane season, which is about 6 months of the year, potential heavy rains may damage or destroy certain routes.

The brownfield zones have great potential for the site of an electronic was recycling facility because it isn't suitable for residential living and is close to the ports, which is vital for exportation. A labor force will be needed to operate the facility. Due to the high unemployment rate in the area proposed for the e-waste facility, there is a demand for jobs, and the facility would be able to draw eager employees from a relatively large pool. From our background research we learned that the skill set for the workers at an e-waste facility requires basic training. After the assessment of the potential business opportunities in southern Puerto Rico, we have found that the socioeconomic conditions, geographical assets and industrial opportunities could support the establishment of an e-waste recycling facility in Peñuelas.

5.0 Conclusions and Recommendations

Based on the results of our research, we have developed conclusions and recommendations for DISUR to consider in moving forward with the idea of creating an e-waste recycling facility in the Peñuelas brownfield zone. Our conclusions and recommendations are broken down into specific topics that we believe are crucial for the establishment of a successful e-waste facility. Due to the qualitative nature of most of our data, our recommendations are subjective, and may differ from the opinions of others. However, we hope that DISUR will consider our recommendations and take the appropriate measures needed to complete their brownfield zone development project.

5.1 Current E-Waste Management in Puerto Rico

Electronic waste management is almost non-existent in Puerto Rico, with the exception of a few companies in northern Puerto Rico. Recycling centers in southern Puerto Rico collect e-waste, but the e-waste is not broken down on site or sent to an e-waste facility to be broken down and processed. Community members are uninformed as to what is happening to their e-waste. The absence of an e-waste facility in southern Puerto Rico provides a business opportunity. The high levels of unemployment along with other socioeconomic conditions in the region can be combined with competence and an entrepreneurial spirit to develop a successful e-waste facility.

5.1.1 Recycling Centers of Southern Puerto Rico

Recycling centers in southern Puerto Rico utilize partnerships and contract recyclers, which are more cost-effective, but they handle e-waste inadequately. The majority of the e-waste collected by the recycling centers in the south ends up dumped in landfills or remains dormant on

site. The need for an e-waste facility in the south is supported by the lack of proper e-waste management by southern recycling centers and the infrequency of collection events. There is a need for a substantial amount of materials to be collected in order to maintain the facility. Therefore, it is important to have a solid plan for the collection of products from residential and commercial districts. The most effective means of collection we have found is an all-day collection event. Another possible method of collection could be a dumpster in a major city, such as Ponce, where electronics can be deposited year-round. However, some electronics can be very valuable so it is important to provide protection, such as security camera and lock, and frequent pick-ups to avoid theft.

5.1.2 Education & Support of Community Members

Citizens of southern Puerto Rico lack adequate knowledge regarding proper disposal of electronic waste. The citizens have electronic waste, and they are aware of the negative effects of improper disposal of their e-waste. The majority believes they properly dispose of their e-waste and there are facilities which properly handle their e-waste, but in actuality neither is being done. Despite the locals' beliefs that the recycling of e-waste is sufficiently advertised, their lack of awareness points to a gap in knowledge regarding e-waste disposal.

5.1.3 Business Opportunities

Profitability, transportation, and community involvement are vital to the development of an e-waste facility. The breakdown of e-waste into a commodity that is valuable to another person or business provides opportunities for profit. Additionally, it is favorable to reuse or resell electronics that are still in working condition because it keeps them out of the waste stream and is a more sustainable practice. Companies in Puerto Rico utilize recycled stainless steel, wood,

cardboard, and rubber to make products. If these components are properly extracted in the breakdown process from electronics, the materials can be sold and reused for revenue. The collection and recycling costs can be offset by the salvage value, so it is important to have a strong business plan that maximizes cost-benefits.

There are several brownfield areas that can be considered as potential sites for the development of the e-waste facility. A successful site will need close proximity to appropriate transportation channels between the local communities, the facility and the ports. It is preferable that the site is not located directly next to communities to avoid disturbance from noise.

Lastly, the development of an e-waste facility could help alleviate the poor socioeconomic conditions in the local area. There will be a demand for jobs at the facility, and the demand could be easily met because of the high rates of unemployment and poverty in the local area. The jobs at the facility do not require extensive technical knowledge, and with training new employees will be able to successfully work in the facility.

5.2 Recommendations

We will provide recommendations regarding the feasibility of an e-waste facility in Peñuelas, Puerto Rico. These recommendations were derived from the conclusions we have outlined above.

5.2.1 Selection of Facility Site and Size of Operation

We recommend that the site of the e-waste recycling facility be located on the brownfield zone whose owner is willing to make the best deal financially. Since many of the sites are similar in terms of building potential and close in proximity, the space with the most cost efficient price

should be chosen. We also recommend that the facility employ 20 workers initially, having 1 or 2 be experienced in the field of electronics and their inspection or disassembly. The training for the employees should be based on health and safety regulations and should occur initially and annually after the first year. We recommend contracting an e-waste recycler from northern Puerto Rico to assist with set up of the operation. It is preferred that there is partnership with another municipality, such as Guayanilla, to share resources in order to minimize costs and maximize profit. More specific guidelines for selection of a contractor can be found in Appendix I.

5.2.2 Education of Community

We feel that one of the most important obstacles that must be overcome in terms of electronic recycling is the education of community members. For this reason we recommend that an educational campaign is launched to target the younger generations. The campaign should include educational fliers in local transportation, advertisements on local TV and radio, and recycling facility tours. Since ADS has had success with their educational campaigns concerning recycling in the past, we recommend that there is collaboration with ADS and the Department of Education. The campaign should initially focus on general awareness of e-waste and its negative effects and then once there is a facility established, focus on advertising the services available to residents.

5.2.3 Methods of Collection

We suggest that collection events be held every three months, four annually, in different municipalities in southern Puerto Rico. These collection events should be held at a central

location, such as a church or school, to encourage community members to participate. There needs to be an adequate number of public service announcements, via TV, radio or flyers, to inform communities about the event. Setting up all-day events requires significant planning, but will provide large quantities of electronics in a short amount of time. We recommend that there is a re-evaluation of the frequency of these events after the first year. Depending on the amount collected, it might be beneficial to have less all-day events per year. Since ADS holds annual collection events with Wal-Mart, developing a partnership with them is also a viable option.

We also recommend that a dumpster be placed in a high traffic area and be available for continuous drop off. This dumpster should have proper protection to prevent theft such as a lock and security cameras. We suggest that pick-ups should occur every two months initially and then be reassessed after several months of a trial period. Appendix I describes steps to setting up all-day events and permanent collection centers, which will serve as a useful resource when designing plans for an e-waste facility.

The facility's operators should get into contact with managers of companies in southern Puerto Rico to inquire about possible electronics recycling. With the new electronic recycling and disposal law act going into effect in May, retailers who sell electronics will be required to recycle returned electronics. Similarly, universities and other local organizations should be contacted because they also have large amounts of electronics and need a place to have them recycled.

To deal with the transportation involved, we recommend that a box truck be purchased by the facility, to adequately transport the materials collected to and from the recycling center. Also,

improvements to the areas roads and bridges should be strongly encouraged, which could be done by appealing to the local government agencies.

5.2.4 Procedures for Processing and Distribution

In order to create a successful and profitable operation, we recommend the electronics first go through a testing procedure, "plug-and-play" system, to check if they work. For products that are deemed to be in good working condition by the employees, we recommend that they are refurbished to be resold or donated. We recommend that machines, including a compactor and shredder, are purchased so products that are end-of-life can be broken down and sold as commodities. The raw materials including plastics and metals should be sold off to buyers of recovered materials, such as IFCO and R-4 Enterprises, while the more harmful materials, including CRTs and circuit boards, require a specific breakdown process. These harmful materials should be sent to EPA-approved companies where their proper disposal can be guaranteed.

If products need to be shipped to or from another country for whatever reason, we recommend that the Port of Ponce be used because of its crane system. But since this port has relatively shallow waters, we must also recommend that no ship bigger than Panamax be used for transportation.

5.2.5 Other Factors to Create a Successful Facility

All of the aspects mentioned previously are important considerations, but there are also some lingering problems in Puerto Rico that need to be addressed. Since there is a lack of glass

recycling in Puerto Rico we suggest that this is address in the facility because there is an opportunity to capitalize on this market.

Due to the amount of poverty found in southern Puerto Rico, it is important to note that e-waste will not be turned in if the population is charged for doing so. To encourage participation in e-waste recycling, we recommend that tax incentives or rebates should be created so that the population is more likely to turn in their end-of-life electronics. Therefore, it is advisable to encourage the government to create tax breaks, since they will be enacting the previously mentioned legislation concerning e-waste in May.

5.3 Concluding Remarks

After thorough consideration of all the variables related to establishing an e-waste management facility in southern Puerto Rico, we think that it is feasible to create an e-waste recycling center on the brownfield areas in Peñuelas. By doing so, there will be significant economic benefits, while also producing environmental, social and educational benefits.

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Bernstad, A., Jansen, J. L. J., & Aspegren, H. (2011). Property-close source separation of hazardous waste and waste electrical and electronic equipment- A Swedish case study. *Waste Management, 31*(4), 743-753.

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-This IQP will be used by our group because it focuses on the importance of educating the community about the issue. This is something that our group thinks is important.

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050107-160303). Retrieved from the Worcester Polytechnic Institute Electronic projects Collection: http://www.wpi.edu/Pubs/E-project/Available/E-project-050107-160303/unrestricted/FirstBank.pdf

-This report focuses on the current recycling practices on Puerto Rico, so it is very relevant to our group's interests. We will be able to use a lot of their information but will have to delve into the specifics of electronic waste more.

Brett H., R. (2009). E-waste: An assessment of global production and environmental impacts. *Science of the Total Environment, 408*(2), 183-191. doi:10.1016/j.scitotenv.2009.09.044

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-Using previous research to help our report be as accurate as possible is very important. This report does a great job of laying out basic necessities for operating a successful e-waste recycling facility.

Chan, K. L., Eckelman, M., Percy, S., & Zhou, X. (2006). *A characterization of the recycling sector in puerto rico*. Unpublished manuscript, Industial Ecology, Retrieved from http://is4ie.org/resources/Documents/2006 Recycling Sector.pdf

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DISUR b. (2012). - Desarrollo Integral del Sur, Inc.- Goals. Retrieved 1/25/2012, from http://www.disur.org/en/disurs-general-goals-socioeconomic-development-south-puerto-rico

-This page contains information on the goals and objectives of DISUR.

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-This site contains the basic information about DISUR.

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E-waste concerns grow. (2011). *Mechanical Engineering,* 133(12), 10.

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EPA. (2000). Electronics reuse and recycling. *EPA WasteWise,* 1-20. doi:EPA530-N-00-007

-This government update describes the benefits of electronic reuse and recycling. It also describes the steps that the government is taking to manage electronic waste and give incentives to citizens and manufacturers to recycle.

Flaris, V., Singh, G., & Rao, A. R. (2009). Recycling electronic waste. *Plastics Engineering*, *65*(5), 10-15. Retrieved from http://search.proquest.com/docview/213877786?accountid=29120

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Hileman, B. (2002). Electronic waste. *Chemical & Engineering News, 80*(26), 15-18.

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-This shows some of the things being done during the manufacturing of electronics. It helps us when looking into more sustainable materials.

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Vernekar, S.S. & Wadhwa, P., (2008) E-waste Management. *ASBM Journal of Management* 1.1: 102-117

-This journal article sheds light on the vast number of electronics being dumped. It also looks into the likely hood of recycling such materials.

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-This article was helpful to us because it explained the dangerous materials that many electronics contain.

Appendix A: Sponsor Description

Sponsor Description: DISUR

Founded in 2006, Desarrollo Integral del Sur, or DISUR, Inc. (2012c) is a non-profit corporation whose strategic intention is to promote and maximize the competitiveness and sustainable development of the southern region of Puerto Rico. It realizes this intent by combining efforts and resources from the public, private, and academic sectors, as well as from the area residents and communities. The purpose of DISUR is clearly stated in their mission statement, vision, and values.

Mission Statement:

DISUR's (2012d) mission states that it should be: "A broad-based organization model for regional planning and the sustainable socioeconomic development of South Puerto Rico through the alignment of sectors, innovation, job creation and retention of well-paid employees and the worldwide commercialization of competitive products and services" (p. 1).

Values:

As stated by DISUR, Inc. (2012d) the organization's values are:

- Commitment to Puerto Rico, the Southern Region and its future generations;
- Pro-active attitude, collaboration and integration of willing partners;
- Responsibility and integrity in our actions;
- Empowerment of constituents;
- Continuous and sustained learning;
- Consensus and action

(p. 3).

Structure of the Organization:

DISUR (2012a) is an organization run by a Board of Directors and led by a president, vice president, secretary and treasurer. The organization's staff consists of an executive director, Carlos Maldonado Piris, a project manager and communications expert, David Southgate, a

Public Relations and Communications Director, Frances M. Pomar Diez, two community relations and charette coordinators, Frances M. Pomar Diez and María Mercedes Rivera Grau, and an administrative assistant, Evelyn Rodríguez Gómez. Most organizational funding comes from donations. The annual budget would be directly related to funding the organization receives and the projects being worked on.

The organization is composed of five different sectors: public, private, public state, public federal and academic (DISUR, 2012a). The public sector is made up of small municipalities located in the southern region of Puerto Rico. These municipalities are as follows; Adjuntas, Arroyo, Coamo, Guánica, Guayama, Guayanilla, Jayuya, Juana Diaz, Patillas, Peñuelas, Ponce, Salinas, Santa Isabel, Villalba and Yauco. DISUR works closely with these communities to ensure the growth and prosperity of southern Puerto Rico. The private sector is comprised of 37 companies, including Jet Blue Airways and Food International Export Corporation, which work with DISUR in many different ways for each to achieve their goals.

DISUR (2012a) has a partnership with these five government agencies: Compañía de Comercio y Exportación, Consejo de Desarrollo Ocupacional y Recursos Humanos, Porta Caribe, PRIDCO and Puerto de las Américas. The agencies all promote the attributes of southern Puerto Rico. Some advertise to attract vacationers, while others look for investments in ports and industry in the area. In addition to the public state sector, the organization also is a companion to the public federal sector. DISUR was selected by the EPA as a brownfield area-wide planning pilot program recipient. There were 23 different organizations chosen to work on this issue, DISUR being the only one located in Puerto Rico. Using the grant money that they receive for this project, they work together with some of the organizations listed above to research the possibility of using these contaminated areas in a positive way in the future. Together, these

organizations are working to collect the necessary data that will eventually help make these polluted areas useful in the future (Rodriguez & Grau, 2011).

DISUR's (2012a) involvement in the academic sector involves working with the following twelve institutions: Catholic University of PR, Turabo University, InterAmerican University-Ponce and Guayama Campuses, Ponce School of Medicine, University of Puerto Rico-Ponce Campus, Ponce Paramedical College, North Point International Institute, University of the East, University System Ana G. Mendez, Metropolitan University, Columbia University Center and John Dewee College. DISUR cooperates with these schools to perform research and look for viable options for the further advancement of southern Puerto Rico. All of the five sectors work with DISUR to develop and improve the socioeconomic conditions of the southern region of Puerto Rico.

Appendix B: Interview Protocol and Minutes for Meeting with Peñuelas Recycling Center

The DISUR team has decided to conduct an interview with the manager of a recycling center in Peñuelas, Puerto Rico. We believe that they will be able to provide us with useful information about how much if any electronic waste is received. This waste may not be properly recycled, and we feel it is important to get a good estimate of how many electronic items and of what types are being improperly disposed of.

We will begin by introducing ourselves as students who will be traveling to Puerto Rico for a research project. We will explain that we are working with DISUR on a project funded by the EPA, to assess the feasibility of creating an electronic recycling center on a brownfield zone in southern Puerto Rico. We want to carry out this interview in a semi-standardized fashion, allowing for the wording and questions to be somewhat flexible.

Questions:

- How much e-waste would you estimate you see in your landfill in a standard year?
    - Are you able to save any for resale or recycling?
- What are the restrictions on what you can accept in your landfill?
    - Do you charge money for people to dispose of electronics?
- What are your general procedures when you receive end-of-life electronics?
- What can you tell us about the physical process of breaking down of materials?
    - What skills are required?
    - Can it be dangerous?
- Do you properly dispose of the waste yourself?
    - Or do you ship it somewhere else for that?
- What can you tell us about how you make your business successful?
    - What are the most important aspects of the business that make you money?
- What contacts do you have for selling recovered materials?

Interview and tour with Maria Cruz at the Municipality of Peñuelas Recycling Center March 26th, 2012

-The team of about 17 employees separate plastic, newspaper and cardboard. Then use machines to compact the materials into a form than can be transported. They also collect fridges, stoves, etc. but they end up in the landfill.

-Once per week, the company picks up at companies and schools, also known as "urbanization".

-The municipality works with the recycling company, IFCO Recycling in Caguas. The compacters and many of the containers belonged to this company and when there is a certain amount of each material, the company takes the materials for free and pays the municipality.

-The municipality ends up breaking even with the cost of maintenance/ paying employees and the profit from IFCO Recycling.

-Public works also use machines to chop up vegetation. The chopped materials can be kept by the owner or reused somewhere else (i.e. farm).

-We discussed the possibility of using the site for several municipalities (i.e. Peñuelas and Guayanilla) jointly.

*Brittany gave Maria her email to receive information on how much waste the municipality collects. Maria also gave the team educational material that is given to community members and the contact information for William Vasquez at IFCO Recycling (T. 756-653-4300)

Appendix C: Interview Protocol and Minutes for LM Waste.

The DISUR team has decided to conduct an interview of LM Waste in Ponce, Puerto Rico. We believe that they will be able to provide us with useful information recycling and buyers of recovered material. Since they do recycling for some of the southern municipalities we feel this will be very helpful.

We will begin by introducing ourselves as students who will be traveling to Puerto Rico for a research project. We will explain that we are working with DISUR on a project funded by the EPA, to assess the feasibility of creating an electronic recycling center on a brownfield zone in southern Puerto Rico. We want to carry out this interview in a semi-standardized fashion, allowing for the wording and questions to be somewhat flexible.

- What municipalities and companies do you serve?
- What types of materials do you process?
    - What type of methods do you use to process them?
- What do you do if a company wants to recycle e-waste?

LM Waste meeting with Ninotchka
March 28th, 2012

-Conference call with head of LM recycling

-They serve: Coamo, Yauco, Ponce, Juana Diaz, Peñuelas, Guayama and Guayanilla (Primary Plant)

-About a year ago they partnered with an e-waste facility if a company wanted to.

-The facility is Novaterra of Arecibo. They simply separate the electronics and send it to Novaterra.

-We will get contact information from Ninashka

-LM does not import waste they only export.

-There is no glass recycling in Puerto Rico so it is really not recycled. It is not cost effective.

-LM receives cardboard, Newspaper and plastics for recycling. If they get metal they export it.

-There are very few end buyers in Puerto Rico

-Most needs to be exported they use US brokers and they sometimes buy the materials and sell it as well.

-Some Puerto Rico brokers are: International Fibers (IFCO), Plastics in Isabella and Mixer in -Selinas that does metal.

-Wal-Mart partners with ADS for recycling events.

Contacts

ADS- Sistema Reciclaje del Gabierno 787-765-7575- Brenda Colon Director of Recycling

Appendix D: Interview Protocol and Minutes for ADS Recycling Practices:

The DISUR team has decided to conduct an interview with appropriate employees of Wal-Mart regarding their policies on discarding of electronic waste. We want to better understand the electronic waste recycling strategies of a major distributor of electronics in Puerto Rico.

We will begin by introducing ourselves as students who have traveled to Puerto Rico a university research project. We will explain that we are working with DISUR on a project funded by the EPA to assess the feasibility of creating an electronic recycling center on a brownfield zone in southern Puerto Rico. We want to carry out this interview in a semi-standardized fashion, allowing for the wording and questions to be somewhat flexible.

Questions:

- What can you tell us about the number of electronic devices that you distribute throughout Puerto Rico in a given year?
- What is the history of Wal-Mart's electronic waste recycling strategies in Puerto Rico?
    - Currently, how much e-waste does Wal-Mart collect to be recycled per year?
- Do you collect very harmful items such as cathode ray tubes and florescent light bulbs?
    - If you do collect them, what do you do with them?
- Are there any buyers of recovered materials that you work with on the island of Puerto Rico?
    - If so, could you possibly tell us how to get in contact with them?
    - If not, where do you send your recovered materials and how are they shipped there?

ADS Meeting with Brenda Colon

April 11th, 2012

-They work with Sony and Wal-Mart to collect electronics

-They collected TV and Wal-Mart and Sony paid for the process

-They have a collection April 28th at 6-7 locations they will take most electronics but not TVs

-This has no cost so the electronics are just given to e-cycing, REPR, and Novaterra

-Reciclaje del Norte exports to US

-There is a presentation on the April 17th to all the companies about the new e-waste law

-They think a facility would and be very good

-There is a procedure to follow to obtain the endorsement of ADS and the need of a good business plan

-They collect cell phones and batteries and send them to Novaterra (no money is exchanged)

-They send the Plastics and aluminum to IFCO (787-653-4300 tous@ifcopr.com)

-Landfill is a private service that works with guyanabo and Carolina recycling plants

-Wal-Mart Brunee Torres- bruni.torres@wal-mart.com

-Vanesa Pieruchi Nova Terra vpierischi@novaterra.com

-Brenda is going to send waste statistics of Puerto Rico

-The Wal-mart take back program is expensive

-The best way to advertise is TV broadcast

-Use the company to promote it, Newspaper is expensive

-Education: The Solid Waste Management Authority have worked with advertising campaigns. One of these was broadcast on radio and television. In addition, we used public transport to spread the recycling message. On the other hand, developed by the Department of Education an environmental curriculum for children in kindergarten through third grade, which is currently used in schools. In addition, we join various educational partnerships to bring the recycling message. I understand we have been successful in carrying our message and continue laboring every day to continue fulfilling our mission.

Appendix E: Interview Protocol and Minutes for Meeting with Guayanilla Government Officials

The DISUR team has decided to conduct an interview with appropriate employees of Guaynilla regarding their policies on discarding of electronic waste. We want to better understand the electronic waste recycling strategies of a municipality in southern Puerto Rico.

We will begin by introducing ourselves as students who have traveled to Puerto Rico a university research project. We will explain that we are working with DISUR on a project funded by the EPA to assess the feasibility of creating an electronic recycling center on a brownfield zone in southern Puerto Rico. We want to carry out this interview in a semi-standardized fashion, allowing for the wording and questions to be somewhat flexible.

- What recycling facilities does the town of Guayanilla currently work with?
    - Are there any strategies in place to recycle electronics?
- How would citizens respond to a recycling center in the community?
- Are there any educational campaigns in place to advertise recycling?
- How do you think a private e-waste recycling facility would function in this area?

Meeting with Víctor Medina and Pedro Ortiz, assistants of the Mayor of Guayanilla:

March 26th, 2012

-Recycling of Guayanilla was owned by ADS, but there was an open auction and LM Recycling Services now owns the recycling sector.

-We discussed how it might be difficult to start an e-waste facility in the south because the population is less dense and the community is only accustomed to recycling paper, glass, etc.

-We discussed how the recycling facility would need to utilize the selling of other materials (plastic, wood and metals) in electronic devices.

-ADS might have information on the volume of E-waste collected.

-There is possibility for importing from other Caribbean islands, but there are no trade routes to Ponce Port.

-We discussed the problem about the security element because there are have been many problems with scavengers stealing scrap metal and precious metals, such as copper, from electrical lines.

-They suggested that we should go to big companies (Walmart) and see how many electronics they have sold. There has never been a study on how many electronics are owned in PR.

-We all discussed tax incentives, the interviewees thought it would be a great idea. Pedro described that there is a rule for residents to get tax credits for buying computers for their dependents.

- Some useful websites might be fdc.gov (US dept of trade) and jp.gobierllapr.comno.pr (PR planning board).

Appendix F: Survey of Community Members and Results

Survey:

The DISUR team has decided to conduct surveys of the community members in southern Puerto Puerto Rico, to better understand how e-waste is being handled. More specifically, we will interview community members in the city of Ponce. We believe that the information gathered from these surveys will show the current knowledge that most community members have on e-waste. We will ask questions about what types of electronics the community members own in order to gauge the amount of e-waste they are producing.

We will begin by introducing ourselves in Spanish as a student group working with DISUR on electronic waste. We will then briefly describe what research we have been doing, and ask the person to take a minute out of there day to fill out a short survey for us.

Electronic Waste Survey

Date: _____

What technology do you own (circle one):

Flat screen TV Tube TV Cell phone Laptop Computer Desktop computer

For each of the following statements, please indicate whether you:

Strongly Agree (1); Somewhat Agree (2); Neutral (3); Somewhat Disagree (4); Strongly Disagree (5).

	1 Strongly Agree	2 Somewhat Agree	3 Neutral	4 Somewhat Disagree	5 Strongly Disagree
Proper disposal methods for electronics are available for me to use.					
I am aware of the negative effects that electronics can have on the environment.					
I have seen advertisements for the recycling of electronics in the community.					
When I am done using an electronic device, I make sure that it gets recycled properly.					
I would like for there to be a successful e-waste recycling system in my area.					

Encuesta de residuos electrónicos en su municipio/comunidad

Fecha: _____

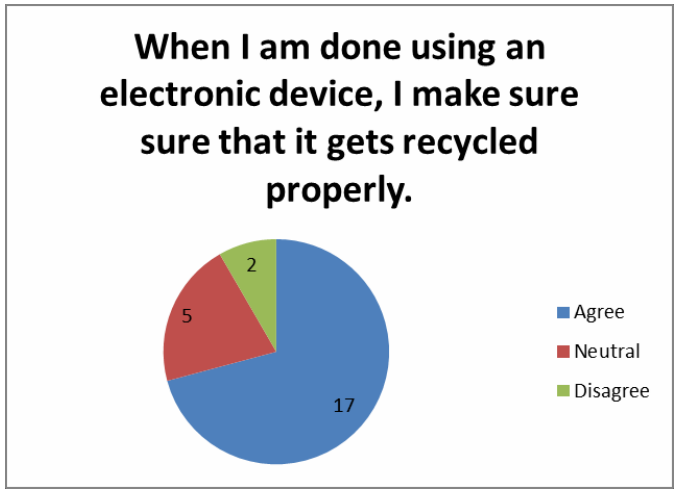
¿Qué tecnología que es de su propiedad (**por favor circule todas las que apliquen):**

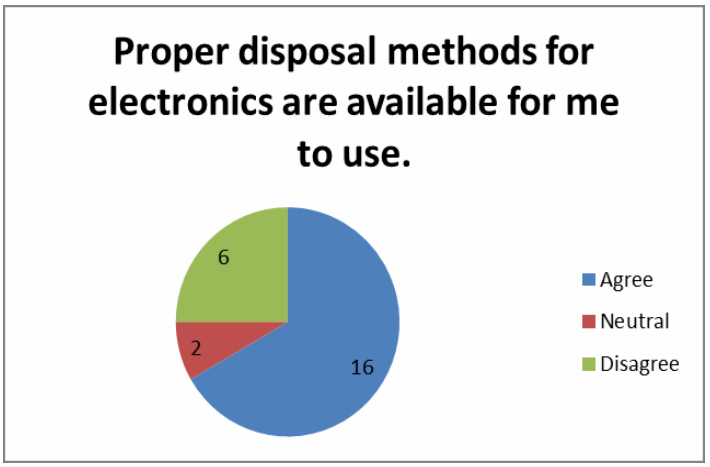
TV de Plasma/LCD TV de tubo Teléfono Celular
Computadora portátil Computadora Personal

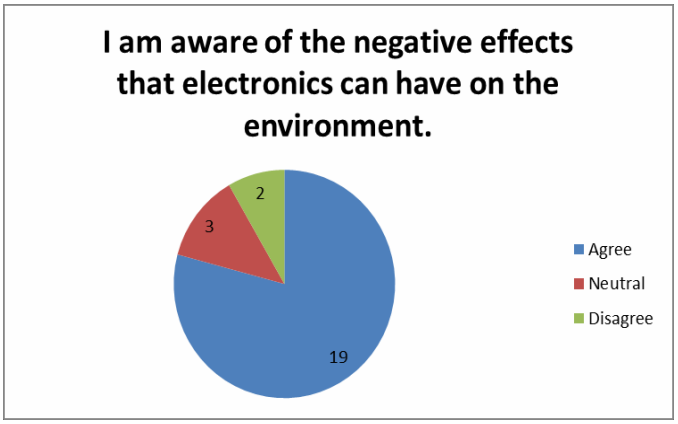
Para cada una de las siguientes afirmaciones**, por favor** indique si usted esta**:**

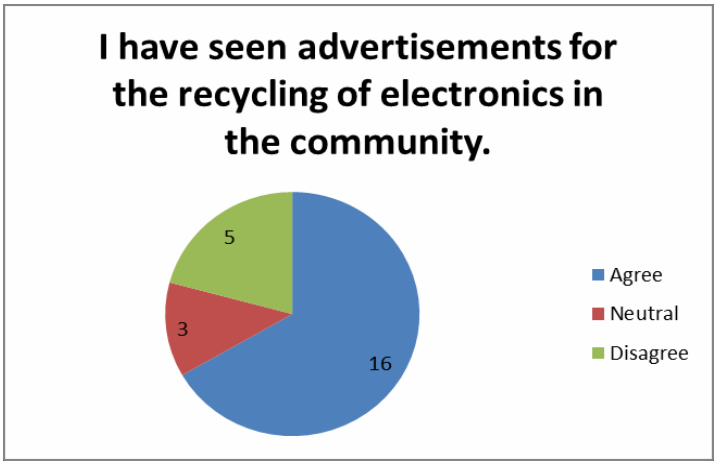
otalmente de acuerdo (1); Menos de acuerdo (2); Neutral (3); Algo en desacuerdo (4); Totalmente en desacuerdo (5).

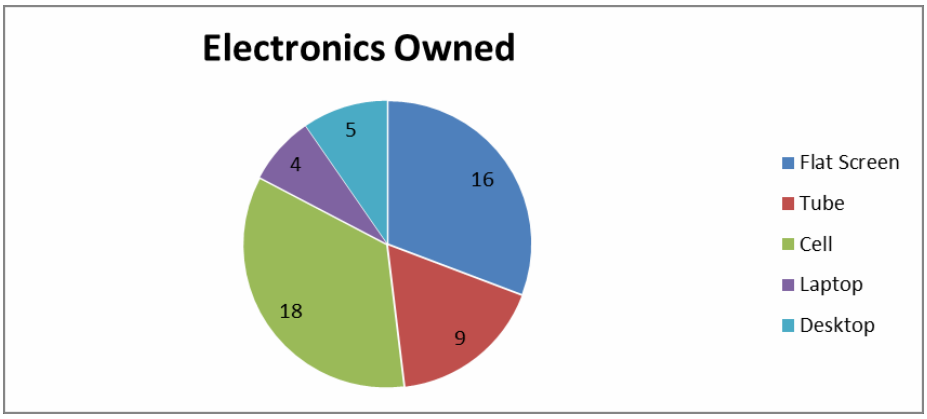
	1 Totalmente de acuerdo	2 Algo de Acuerdo	3 Neutral	4 Algo en desacuerdo	5 Totalmente en desacuerdo
Los métodos de disposición apropiados y responsables para desecho de equipos electrónicos están disponibles en mi municipio / comunidad.					
Soy consciente de los efectos negativos que el desperdicio electrónico puede tener sobre el medio ambiente.					
He visto anuncios publicitarios para el reciclaje de equipo electrónico en mi municipio / comunidad.					
Cuando descarto un dispositivo electrónico, me aseguro que es reciclado correctamente.					
Me gustaría que exista un de sistema de reciclaje de equipo electronico en mi municipio / comunidad.					


When I am done using an electronic device, I make sure sure that it gets recycled properly.
2
5
17
Agree
Neutral
Disagree


Proper disposal methods for electronics are available for me to use.
6
2
16
Agree
Neutral
Disagree


I am aware of the negative effects that electronics can have on the environment.
2
3
19
Agree
Neutral
Disagree


I have seen advertisements for the recycling of electronics in the community.
5
3
16
Agree
Neutral
Disagree


Electronics Owned
5
4
16
18
9
Flat Screen
Tube
Cell
Laptop
Desktop

Appendix G: Interview Protocol and Minutes for Meeting with Juan Lugo, Buyer of Recovered Materials:

The DISUR team has decided to conduct an interview with a man experienced with the resale of electronic products. We believe that they will be able to provide us with useful information about the best methods to turn a profit when dealing with reusable electronic devices. Juan Lugo specifically dealt with medical equipment parts, but we think that the information he can give us will still be helpful in terms of buyers of recovered materials.

We will begin by introducing ourselves as students who will be traveling to Puerto Rico for a research project. We will explain that we are working with DISUR on a project funded by the EPA, to assess the feasibility of creating an electronic recycling center on a brownfield zone in southern Puerto Rico. We want to carry out this interview in a semi-standardized fashion, allowing for the wording and questions to be somewhat flexible.

Questions:

- What can you tell us about the process you went through to resell a used device?
    - Did you use online sources such as EBay?
- How would you contact people interested in purchasing such products?
- In order to turn a continuous profit, how many products would you have to sell in a month?
- What can you tell us about any employees you had working for you or partners you worked with?
- How much recovered materials do you normally purchase a year?
- What types of materials do you collect?
- What do you do with these materials after they have been purchased?
- Which products/materials are the more expensive ones for you to buy?
- What are some practices that will make a recycling center successful?
- What are the most efficient ways of sending the materials?

DISUR Student Team: Visit to Eli Lily

March 29, 2012

-We visited a closed down pharmaceutical manufacturing center in Carolina.
-The property was valued at approx. $104 million in 2008.
-Mr. Lugo plans to divide the property into 5 major parts:
    a. Medicinal Packaging
    b. R&D for oversea companies
    c. Fitness & Wellness center
    d. Distribution Center
    e. Digitization Center
-The brackets in the pipes in the building cost $600 a piece. If he sold all the brackets in the building, he would make more than the cost of the property.
Fitness Center Info:
- The center has the potential to serve 1600 employees within the industrial park.
- Companies would utilize the center to improve the health condition of their staff, thus lowering their insurance costs.
Digitization Center Info:
-Mr. Lugo wants to start a business where he digitized medical records.
-42 US states have laws records cannot have a digital copy alone.
- 5% records in the US are digitized, compared to 90% in Singapore.
-Government new legislation states new records need to be digitized.
Recycling Business Info:
-Mr. Lugo gives computers to R4, an e-cycling company, and get $0.05/pound.
-10 million feet of Industrial Areas are wasted; could be reused.
-He charged $1300/day to recover e-waste from some companies. It included:
- 4 persons labor force
- 8 hours of work
- Transportation from the company to his site.
- He would then auction it, and share ½ the profit with the company.
-There are 3 main things needed to have a successful business, you need:
- To create savings
- Add value
- Be more efficient
-The business needs to be PROFITABLE
-Mr. Lugo's facility does not recycle, more like reuse. He creates a database so that people can buy others unused parts.
-Mr. Lugo stressed that networking is very important. You need good contacts.
-Spandex is made from glass; Asia takes glass from PR and uses it to make spandex.
-Plaza del Caribe has recycling dumpster for computers/e-waste, we need to look into that.
End Users (Potential Buyers of recycled materials) Info:
-Companies that make stainless steel tanks, furniture, rubber tires, and cardboard boxes.
Promotion & Education Info:
-Target AM radio to educate Older people, FM for younger people.
-Use regional papers; they are cheap, and freely distributed.

Appendix H: Tour of Brownfield Zones with David Southgate and Notes

The DISUR team has decided to take a tour of the brownfield zones in Peñuelas and Guayanilla. We wanted to better understand the proposed area of the e-waste recycling center and want to learn as much about the zones as possible.

The trip began with David Southgate driving us around from Guayanilla to Peñuelas, while stopping to give us information concerning the proposed sites.

Tour of Brownfield Zones with David Southgate:

March 26th, 2012

-Traveled from East to West to visit brownfield zones.

-First area was used to grow sugar crane in the 1940s and there are also high levels of arsenic in the soil.

-The Oxichem and Caribe (14 acres each) were owned by Corico. This land has the possibility for dismantling of infrastructure or reuse after remediation.

- Several of the brownfields still aren't approved by the EPA because the identity and history of the land needs to be discovered.

-In order to receive federal money, the municipality can't own it, but a non-corporation company can.

-Empire Gas is a company that provides natural gas to several places in Puerto Rico.

-There was a salt flat, where there were several [solid waste] lagoons.

-The Marati Warehouse is owned by the Department of Education. It is a cement building that might contain pesticides and there is a possibility that LM Waste Services is looking into buying it.

-There were several communities and commercial areas very close to the brownfield zones. In the hills there is a large agricultural area and an industrial dumping site (owned by Integrated Waste Management).

-Echo Electrica wants to run a pipe to provide gas through the island, project is called Via Verde, and the community is extremely against it.

-Transportation isn't very efficient because the main bridge is very narrow and the other bridge is only one land because it's under construction. This creates a "bottleneck" effect.

-We saw land, called berms, which are flat ground that solid waste management companies covered. The solid waste management lagoons still need to be remediated.

-Port of Ponce and Peerless port are both free trade zones, but only Port of Ponce has cranes that can move containers.

Appendix I: Summary of Contractor's Report to the Board: Best Management Practices for Electronic Waste.

The Contractor's Report to the Board regarding the best management practices for electronic waste is a helpful report that serves as a guide to create plans for an electronic waste management facility. It provides outlines for communities that lack e-waste recycling by giving step-by-step recommendations for strategies and implementations needed to have a successful e-waste recycling center. The report describes pros and cons for collection events, such as permanent collection sites and all-day events, and gives detailed descriptions about selection of a recycling contractor and advantages of partnerships with other municipalities. Overall, this report is very informative and outlines the need for an electronic waste facility and how to operate it successfully.

Please refer to the electronic copy of *Contractor's Report to the Board: Best Management Practices for Electronic Waste*, 2004.

http://www.calrecycle.ca.gov/Publications/electronics/63004005.pdf