COST MODEL FOR DIVERTING CONSTRUCTION AND DEMOLITION WASTE IN NORTH, CENTRAL FLORIDA

By

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A THESIS PRESENTED TO THE GRADUATE SCHOOL
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To my professors, family and friends

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Abstract of Thesis Presented to the Graduate School
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The United States Environmental Protection Agency (EPA) estimates more than 136 million tons of debris is generated annually by building related construction and demolition (C&D) activities (EPA, 2009). Waste is commonly divided into two separate categories: Munipality Solid Waste (MSW) and C&D waste. MSW is the everyday garbage and C&D is waste generated from construction and demolition activities. The environmental benefits of recycling C&D waste may exceed the benefits of landfilling, yet over 6.8 million tons of C&D waste was sent to Florida landfills in 2007. In light of this staggering amount, the State of Florida legislature established a new statewide recycling goal of achieving 75% recycling rate of Municipality Solid Waste (MSW) by the year 2020. This new legislation includes all MSW and some forms of construction and demolition waste, specifically concrete and wood materials. Unfortunately, however, when landfilling is more economically feasible for those responsible for the waste stream, this new mandate may come at a higher price.

Some of the largest barriers of recycling C&D waste lie in financial feasibility, education, lack of C&D resources and available secondary markets. Because of these

barriers, establishing a successful C&D recycling operation can be daunting. This paper will provide a cost analysis for diverting C&D waste. In addition, this paper will make recommendations for local and state governments to order to increase diversion rates in support of the 75% recycling mandate. In order to provide realistic diversion rates, the plan will be based on market conditions and identify those conditions, such as transportation costs, that limit diversion.

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CHAPTER 1
INTRODUCTION

Background of the Problem

The argument between economic optimization and environmental protection has long received attention for construction and demolition waste management services. With the ever-increasing growth in development and the greater need for better environmental standards, the demand for better construction and demolition business practices is on the rise. Within the construction industry, there is a large push for sustainable practices during the pre-construction and construction phases. But what happens after the building is demolished? Where do these materials go? In 2009, Florida generated roughly 7 million tons of construction and demolition (C&D) waste, only 29% of these materials were recycled. Considering most construction materials can be recycled and reused, this number is staggering. Because C&D debris is not federally regulated, it is up to each state to define and instill the regulations and management of C&D debris. Unfortunately, however, many of the state imposed regulations burden those working with the demolition waste stream more than it actually helps. This is due mostly, to the cost demand it places on the waste management companies. In fact, these laws may actually put too much burden on recycling efforts and decrease any desire to work with the materials.

Construction and demolition debris is categorized in four components: building construction and demolition debris, transportation related building and demolition debris; land clearing debris; and disaster debris (FDEP, 2008). This research will only cover building construction and demolition debris. C&D debris is composed largely of the following materials: metals, plastic, wood, concrete/asphalt, brick, roofing, and drywall.

There are a number of factors that must be considered when determining the process of the construction and demolition waste stream. These include: sorting and handling, labor, equipment, transportation, and available markets.

According to the Environmental Protection Agency (EPA) in 2008, there are six main barriers in regards to recycling efforts. These include:

- The cost of collection, sorting and processing is significantly high
- Recycled-content materials have a low value in relation to the cost of virgin-based materials
- The low cost of landfill disposal
- Excessive cost of permit fees for C&D recycling facilities
- Over-regulation of operational procedures at C&D debris facilities
- Limited state purchasing procedures for the use of C&D debris recycled materials (U.S EPA, 2008a).

This research will focus on outlining specifically barriers 1, 2 and 3 from above and evaluate better business strategies to overcome these hurdles.

Purpose of the Research

The research evaluated in this paper will analyze and deconstruct the business practices of the C&D waste stream. This research will analyze current market trends and business models from current Alachua County C&D facilities. In addition, a proposed waste management cost plan will be formulated based on the data collected. Most of the materials recovered from the demolition waste stream are able to be recycled, there is a large market available for financial growth. This available market, in conjunction with the increase in fees for landfill disposal, lends itself to enormous possibilities within the waste stream industry. With an increase in C&D recycling, most states would see a rise in the industry's revenue stream with an increase in labor jobs furthering the nation's economy all the while increasing environmental protection.

The construction industry is in a position to greatly affect the recycling industry from both a financial and environmental perspective. The use of recycled materials has gained some ground in the past two decades due to the help of the United States Green Building Council (USGBC). The USGBC is a non-profit agency aiming to improve and grow sustainable construction practices. The most well known USGBC program is the Leadership in Energy and Environmental Design, otherwise known as LEED. LEED is a rating system to promote the construction of high performance green buildings with a main focus on the use of high efficiency systems and recycled materials. Each recycled material has a direct and indirect overall impact to the built environment. To fully understand this impact, one must look at the overall embodied energy of that material. The Environmental Protection Agency (EPA) defines *embodied energy* as "The amount of energy consumed to produce a product, in this case building materials. This includes the energy needed to mine or harvest natural resources and raw materials, and manufacture and transport finished materials (EPA, 2011). Embodied energy can be assessed only through analyzing its economic and environmental impact.

In light of this growth and educational demand, this research is twofold. (1) to demonstrate the cost benefits of recycling materials vs. landfilling and (2) to outline the direct and indirect environmental impacts of the C&D waste stream.

Scope and Limitations of the Research

The scope of this report focuses on the C&D waste stream of Alachua County, FL and surrounding areas. The environmental factors in this study are limited. The research will be focused on analyzing previous recycling trends and better practices for future recycling in conjunction with the mandated 75% recycling rate instilled by the State of Florida by 2020.

Organization of the Research

Chapter 1 of this research represents the introduction, problem statement, scope and limitation of the research. Chapter 2 represents the literature review, which explores previous research on C&D waste, methods and processes of the C&D waste stream, factors affecting the C&D waste stream, cost benefit, and the market potential for recycled products. Chapter 3 outlines the methodology used for this research. Chapter 4 gives the analysis and results of the research as well as a cost benefit analysis of the research. Chapter 5 gives an overview of the Florida 75% recycling legislation and recommendations for application. Chapter 6 presents the recommendations for future study and lastly, Chapter 7 is conclusion of this research.

CHAPTER 2
LITERATURE REVIEW

The US EPA estimates more than 136 million tons of debris is generated annually by building related construction and demolition activities. One of the biggest problems faced currently by the EPA, United States Environmental Protection Agency, is where exactly to put to all of this debris. C&D waste is not federally regulated, it is up to each individual state to implement stronger regulations against landfilling. In 2007, Florida generated nearly 32 million-tons of MSW out of which 8 tons was C&D waste. In light of this amount, the State of Florida passed legislation entitled *Energy, Climate Change and Economic Security Act of 2008*. The new act established a new statewide recycling goal of achieving 75% recycling rate of Municipality Solid Waste (MSW) by the year 2020. The law encapsulates all MSW including some forms of C&D waste, however, with C&D waste only being recycled at a rate of less than 28%, the new law would increase this amount to 40%.

A wide range of materials (concrete, brick, roofing materials, cardboard, plastic, shingles, etc.) is brought in from the C&D waste stream, and of these materials most are available for re-use and recycling. The National Demolition Association classifies this waste as “benign”, meaning these materials are harmless to the public and the environment. This classification is important because it means most of the building envelope can be recycled and reused (National demolition association, 2004).

These products include:

- Crushed concrete and brick used in road construction, drainage
- Concrete, block, masonry and other clean debris used as borrow pit fill
- Concrete truck washout used to make onsite containing walls and bins
- Reusable building supplies such as lumber and whole bricks
- Remanufacture of wood chips into engineered wood

- Wood fuels used in co-generation plants and industrial boilers
- Horticultural mulches made from natural woody material
- Dyed, decorative mulches made from construction debris wood
- Wood chips used as bulking agent in biosolids, compost, animal bedding
- Planks and other dimensional lumber sawn from whole trees
- Corrugated cardboard containers
- Metals (steel, aluminum other non-ferrous)
- Recovered screened material (RSM) for DEP approved uses
- Processed C&D debris used as daily cover (FDEP, 2001)

Definition

C&D Waste is defined by the U.S Environmental Protection Agency (EPA) as "Construction and demolition (C&D) materials consist of the debris generated during the construction, renovation, and demolition of buildings, roads, and bridges. C&D materials often contain bulky, heavy materials, such as concrete, wood, metals, glass, and salvaged building components." (EPA, 2011) C&D waste is defined differently in each state. Some states include materials and others do not.

According to 403.703, Florida Statutes (F.S.), construction and demolition debris is currently defined as:

> Discarded materials generally considered to be not water-soluble and nonhazardous in nature, including, but not limited to, steel, glass, brick, concrete, asphalt roofing material, pipe, gypsum wallboard, and lumber, from the construction or destruction of a structure as part of a construction or demolition project or from the renovation of a structure, and including rocks, soils, tree remains, trees, and other vegetative matter that normally results from land clearing or land development operations for a construction project, including such debris from construction of structures at a site remote from the construction or demolition project site. Mixing of construction and demolition debris with other types of solid waste will cause it to be classified as other than construction and demolition debris. The term also includes:
>
> (a) Clean cardboard, paper, plastic, wood, and metal scraps from a construction project; (b) Except as provided in s. 403.707(12)(j), unpainted, nontreated wood scraps from facilities manufacturing materials used for construction of structures or their components and unpainted, nontreated wood pallets provided the wood scraps and pallets are separated from

other solid waste where generated and the generator of such wood scraps or pallets implements reasonable practices of the generating industry to minimize the commingling of wood scraps or pallets with other solid waste; and (c) De minims amounts of other nonhazardous wastes that are generated at construction or destruction projects, provided such amounts are consistent with best management practices of the industry.

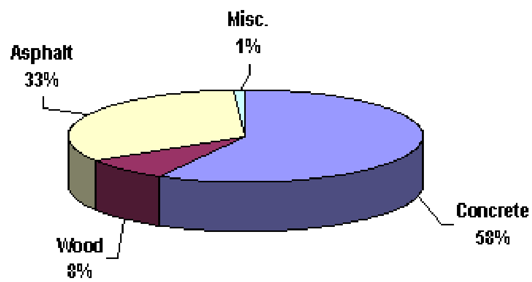

Figure 2-1. 1998 Composition of C&D Debris Recovered in Florida

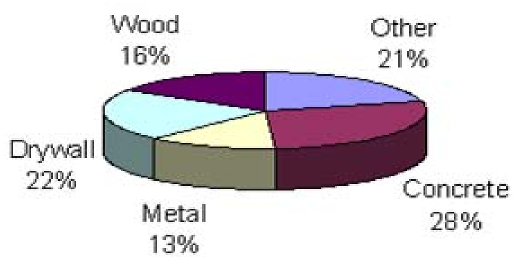

Figure 2-2. Composition of Commercial Construction Waste by Volume (Commercial Construction Site in Gainesville)

Alachua County, Florida Waste Management History

In 1972, there were four operating landfills within Alachua County. By 1982, three of these four landfills were closed down due to the passing of the federal Clean Water Act and the creation of the EPA. In 1987, the first major recycling program was implemented within Alachua County in order to divert materials out of the landfills. In 1998, the Leveda Brown transfer station was constructed and began operations. In

2010, Alachua County proposed to build a Resource Recovery Park in order to increase recycling within the county as well as encourage community growth.

Waste Management Systems

With the growth in popularity of using recycled over virgin materials, there has also been a growth in the desire for better waste management systems. In the past, waste management systems were defined as the process by which most C&D material was hauled from the jobsite and deposited into a landfill. As the landfills grew and a desire to be more 'green', lawmakers and industry executives saw a need to drive materials out of the landfill and into recycling centers for reuse. The 'green' initiative within the built environment encapsulates waste prevention, material reuse and recycling, energy recovery from waste, saving primary sources and diversion from landfills. When alternative methods are used in different fields of application, the economic aspects, technical quality objectives and environmental issues all need to be address and balanced (Sloot, Vandecasteele 2010). Not only are recycled materials better for the environment, but also there is a large potential to develop an un-tapped financial market. Unfortunately, prior waste stream services were not set up for this market model. As the industry grows, and the built environment continues to grow as well, the need for more economically diverse systems will grow as well. In addition, should the number of C&D landfills decline, which means fewer disposal options, greater hauling distances, and increased fuel consumption and vehicle emissions (Napier, 2011), the cost basis for these systems will need to be discussed.

On most common job sites, the contractor is responsible for contracting the disposal of construction demolition materials; the means, methods, techniques, sequences and procedures. Many times, the layout of waste management is set before the contractor is brought on board. This may vary if the project is set to be a LEED, Leadership in Energy and Environmental Design, certified building or not. If the building is going to be LEED certified, the waste management plan may focus around the diversion of all on site materials in order to maximize the number of credits focused on waste diversion. Another long-term option is to construct the building with deconstruction in mind which will impact the waste stream at a later time.

Some owners require the contractor to sign a “C&D waste management plan.” The waste management plan maybe contractually set prior to the beginning of construction (Napier, 2011). This plan may include items such as:

- Name of individual(s) responsible for waste prevention and management.
- Actions that will be taken to reduce solid waste generation.
- Description of the regular meetings to address waste management.
- Description of the specific approaches to be used in recycling/reuse.
- Waste characterization; estimated material types and quantities.
- Name of landfill and the estimated costs, assuming no salvage or recycling.
- Identification of local and regional reuse programs.
- List of specific waste materials to be salvaged and recycled.
- Estimated percentage of waste diverted by this Plan.
- Recycling facilities to be used.
- Identification of materials that cannot be recycled or reused.
- Description of the means by which any materials to be recycled or salvaged will be protected from contamination.
- Description of the means of collection and transportation of the recycled and salvaged materials.
- Anticipated net cost or savings

Depending on the relationship between the contractor and owner, the owner would pay a contracted price to have these materials picked up, and transported to either a landfill for sorting and dumping or a transfer station. Once taken off the job site, the materials no longer belong to the owner. Typically these materials are transported using freight on board (FOB) shipping arrangements, meaning the party who directly paid for shipping now owns these materials. Should any profit be made from the shipped materials it is paid directly to the shipper?

A will planned integrated waste management plan may also look to salvaging materials as much as possible; incorporate the waste management into the scheduling and planning of the building; consider on site concrete and asphalt recycling; utilizing timber and metal recycling in most if not all cases. Unfortunately it is often difficult to coordinate these activities within the construction design or schedule.

Project Leadership

In 1990, for the Journal of Resource Management and Technology, now known as the Journal for Solid Waste and Technology, Reza Motemeni and Thomas Falcone analyzed this very topic in their study *The Application of Martin Fishbein's Theory of Reasoned Action in Solid Waste Management and Recycling (Motemeni, Falcone 1990).* Martin Fishbein's Theory of Reasoned Action suggests that a person's behavioral intention depends on the person's attitude about the behavior and subjective norms (*Motemeni, Falcone 1990)*. In short, if a person intends to do a behavior then it is likely that the person will do it. Motemeni and Falcone utilized this theory under the terms of solid waste management. They found certain factors contributed to a population's willingness to participate in recycling and those who will not participate. Motemeni and Falcone used Fishbein's theory of linking attitudes to beliefs and beliefs to intentions or behaviors in order to formulate a starting off point to strengthen the solid waste management structure (Motemeni, Falcone 1990).

Integrated Waste Management

Previous waste management models in the 1970s and 1980s were based largely around the economics of waste management. Instead of focusing on economic, social and environmental impacts, previous systems focused greatly on landfilling debris. Landfilling saved money with no cost impact. The thought of integrated waste management and sustainable management were not methods being utilized until the 1990s (Morriseey, Browne, 2003). It was during this time, in conjunction with the growth in popularity in 'green' movement, that new methods began to take rise. The Integrated Solid Waste Management (ISWM) model was introduced in the late 1990s. ISWM works towards pushing reliance away from the landfill towards a wider range of waste management techniques, including environmental, economical and social aspects (Seadon, 2006). More recently, these ISWM models stretch as far to include social outreach, education and community promotion.

The most current way of structuring waste management is to include cost benefit analysis and life cycle costing analysis. Cost Benefit analysis, with regards to waste management, is a way of analyzing each aspect of the system and making economic decisions based off this information. Life cycle costing analysis (LCC) is a tool that studies the performance aspects and comparative maintenance and salvage impacts throughout the product's life from production, use and final disposal (Morriseey, Browne, 2003). LCC is a common tool found throughout construction in regards to the building, and/or materials. McDougall's book, *Integrated Solid Waste Management: A Life Cycle Cost Inventory,* he links the concepts of ISWM and life cycle cost. The two methods combine waste streams, waste collection, treatment and disposal methods, with the objective or achieving environmental benefits, economic optimization and social acceptability (McDougall et al. 2001).

In Morissey and Browne's *Waste Management models and their application to sustainable waste management,* they named two main weaknesses in any waste model. One, the lack of involvement of stakeholders, government or local authorities and secondly, no model integrates all three, environmental, economical and social, aspects of waste management together (Morrissey, Browne 2004). He states

> "Successful implementation of the strategy will not just be based on economic criteria, or diversion rats from landfill, but also on stakeholder inclusion, intergenerational equity and the satisfaction of social needs." (Morrissey, et al. 2004)

Supply Chain Management Approach

A study conducted in Brazil in 2008 by da Rocha and Sattler, utilized the supply chain management to approach to further understand the flow of construction and demolition waste. Supply chain management (SCM) is a term used to define the management and flow of materials from beginning to end. For the purpose of this study, SCM will define an integrated process starting from demolition to transportation, transportation to sorting, sorting to market, and market to end client. There are three main players in the SCM: demolition contractor, CDW transporter and the final client. By using SCM, it focuses on the whole operation of waste management, giving a more clear perspective on where major improvements may occur.

De Rocha and Sattler (2008) found ten majors factors that contributed to their study, these include:

1) Deconstruction cost, 2) Periods for demolition activities and deadlines 3) Retail price of reused products 4) Inconsistence of quality of demolition products 5) Clients perception of demolition products 6) Regulations and taxes for CDW 7) Information flow problems in the supply chain of reused components 8) Informality and trust in the supply

chain of reused components 9) Inconsistence of quantity and compatibility of reused products available 10) Excess of stock points in the supply chain of reused components.

It is essential when analyzing the data of waste to understand how each factor may constraint or enhance the reuse and recycling of materials. In order for the system to work, each factor must equally interact with one another. De Rocha and Sattler found certain factors had greater impact than others; for example, factor 4 'inconsistence of quality of demolition products' and factor 5 'negative perception of demolition products by clients', had a stronger impact than factor 7 'information flow problems in SCM' (de Rocha, Sattler, 2008). The study of supply chain management was primarily conducted to analyze the major factors regarding reuse and recycling products in order to increase productivity. In general, there was a preponderance of economical and social aspects such as labor costs for deconstruction activities and the retail price of reused components, compared to legal aspects (de Rocha, Sattler, 2008).

Materials

Each material of the Construction and Demolition waste stream is handled and processed differently. The composition of the C&D waste stream is dependent on various factors such as: type of structure, location of the project, materials used, process of demolition, construction waste management plan, etc. Each state has different mandates for what constitutes the materials in the C&D waste stream. According to a 1998 study conducted by the Florida Department of Environmental Protection, the waste stream is primarily concrete at 58% asphalt at 33%, and wood at 8% (FDEP, 1998). This research will only consider eight MSW C&D waste classifications. MSW waste can be further broken down into the following categories:

- METALS. These products include aluminum cans, ducts, siding, re-bar, pipe, sheet metal, wire/cable, fasteners, metal buckets, mesh, strapping, trim, nails, electrical switches, brass, flashing and gutters. Metals have the highest market value for recycling.

- CONCRETE (MASSONRY AND RUBBLE). This category includes all concrete waste products including rubble including walls, foundations, slabs, concrete pavements, mortar, plaster rock, stone, tiles, etc.

- PLASTICS. Plastic wrap, mesh strapping, PVS, HDPE, or ABS pipe, buckets, sheeting, bags and laminates

- ROOFING MATERIALS. Any waste materials from demolition or renovation from roof. Such as asphalt or asbestos shingles, roofing compound, tar paper, roofing tar, and roof tiles.

- WOOD. Any product that is a bi-product, direct or indirectly derived from wood. This includes: dimensional lumber, cabinets, composites, shipping skids, siding, veneer, plywood, oriented strand board, wood pallets or any other object constructed out of wood.

- DRYWALL. Any panel made of gypsum plaster. Usually it is pressed between two thick sheets of paper. One of the hardest material to recycle.

- CARDBOARD. Packaging waste generated in the construction remodeling or repairs of structures, including paper or cardboard products.

- GLASS. Windows mirrors and lights.

After the C&D waste is taken off site, it can by reused, recycled or landfilled. The equipment used for C&D waste is outlined below.

C&D Waste Equipment:

- JAW. Primary Crusher for C&D waste: reduces large size rocks by placing the rock into compression. The rock remains here until it is small enough to pass through the bottom of the jaw.

- IMPACT. Uses impact to crush the material as opposed to pressure

- CONE. Reduces large rock into smaller rocks, gravel or rock dust by utilizing a gyrating spindle. Large pieces are broken once, and fall to a lower position, then broken again. The cone crusher is suitable for crushing a variety of mid-hard rocks.

- GRINDER. Designed to break material into smaller pieces. After grinding, the state of the solid is changed.
- SHREDDER. A machine used for reducing the size of all kinds of material. Materials shredded: rubber, cardboard, wood, metals and plastic
- CONVEYOR SYSTEM. Move materials from one place to another. The main purpose of the conveyor system is to sort through C&D materials.
- LANDFILL COMPACTOR. Large bulldozer used to handle all material that comes into the landfill
- TROMMEL. A screened cylinder used to separate materials by size
- STAR SCREENS. Separates fine materials from the larger ones
- FERROUS METAL MAGNETS. Separates one material from another

Transportation

Transportation has an enormous impact on the control of C&D waste management. It also acts as one of the larger barrier within the waste management system. Because of the location of landfills and the distance from the job site to the landfill or transfer station, transportation can account for a large portion of the cost and embodied energy of a material. Because of the social implications of landfills, most are located on the perimeter of cities. Therefore, driving to and from the dumping site may often include a 30-minute haul each way. Considering bins on a jobsite can be dumped up to a 3/week, this transportation cost can be significant

In 2009, Mohamed Hameed, a master's student at the University of Florida, studied the impact of transportation on cost, energy, and particulate emissions for recycled concrete aggregate. According to the EPA, particulate emissions refers to an emissions factor as a representative value that attempts to relate the quantity of a pollutant released to the atmosphere with an activity associated with the release of that pollutant (EPA, 2009). Part of his study was to analyze the environmental and cost impacts for using recycled concrete versus the virgin aggregate form. His findings showed that when using an on site concrete crusher, it both reduces the transportation costs as well as cuts down tremendously on transportation, thus reducing the environmental impact. He states, "The portable crusher emitted lower amounts of particulate emissions whereas purchasing virgin aggregate produced the greatest amount. Therefore, using a portable crusher onsite emits the least amounts of particulates into the atmosphere." Hameed also found, when distance increased from the recycling plant to the job site, virgin aggregate becomes a more favorable option in terms of cost, energy consumption, and particulate emissions (Hameed, 2009).

When composing the research for this study, one of the main barriers found within all aspects of the waste industry was the transportation cost. When a hauler has to transport waste a long distance (rule of thumb for long distance is any distance over 50 miles), the trucking costs rise greatly. Unless the job is a LEED certified job or the distance is mandated by the owner, it is unbeneficial for the hauler to transport waste a great distance in order to recycle.

Available Markets for Recycled Products

One of the largest factors when considering whether or not to recycle a product is the available end market. Is there a profit to be made off this material? Is there an available market? Markets are dependent on trends and susceptible to economic fluctuation thus changing regularly. The available markets for each material, is different. Certain materials hold a high re-sell value, while others hold no value and have no available market. These markets are ever changing and consistently wavering. One material may hold a higher value dependent on the economy, location of that material, quality of material, etc. For the most part, materials are dependent on demand. Here are three examples of available end markets for C&D recycled materials. This study will further expand on these markets and the availability within North, Central Florida.

Concrete makes up the largest percentage of material in the C&D waste stream. It also has a large availability for market potential of the recycled aggregate. Some potential ways of using recycled concrete are as follows: aggregate base concrete, ready-mix concrete, pipe bedding, and landscape materials (CMRA, 2010).

Metal is considered the most valuable of the C&D debris because it holds the highest resell value. In addition, the availability of metal recyclers is readily available throughout the state of Florida. According the Steel Recycling Institute, more steel is recycled than aluminum, paper, glass and plastic combined (Steel Recycling Institute, 2011).

Finally, drywall is available for recycling as new drywall, portland cement, land agricultural application and compost (CMRA, 2010). Drywall is one of the hardest materials for recycling and thus, the end markets and recycling centers are not as readily available.

Sorting and Handling Processes

When it comes to handling construction and demolition waste, there is not one consistent method. Each demolition contractor and/or waste supervisor handles waste a different way and the materials found in the waste stream can prove to be complicated and diverse. The typical components of the C&D waste stream are: wood, drywall, metal, plastics, roofing, rubble, brick and glass. Most of these construction and demolition materials are able to be recycled, yet most counties are only recycling roughly 6-15% of materials, and landfilling the remainder. See appendix A for C&D recycling rates.

Similar to the methods mentioned previously, the sorting and handling of the waste stream, are planned as independent operations. However, they are all closely linked. The planning required for a fluid system to work requires a balance between each independent system. For example, when materials are removed for the site, there must be a connection between the demolition of the materials and the transfer of those materials for transportation. Each of the methods above utilizes a cause and effect relationship. During the integrated waste management plans such factors as onsite or offsite sorting, transportation distances and costs, material value, and environmental factors all need to be balanced and economically feasible.

Many factors influence the waste stream sorting process. These factors include: materials found in the waste stream, client's order, recyclability of materials, labor, equipment, time, space and end market of the materials. In most cases, the waste sorting begins on site. This may be handled in two separate ways: 1) Sort on site with various C&D bins per particular item. This may include one bin for concrete, one for drywall, one for metals, etc. 2) Sort off site at landfill or transfer station. This research will focus on analyzing both methods of sorting.

Sorting on site results in the best out come versus sorting at the transfer station or landfill. By sorting on site, there is more of a guarantee that the most of the materials will make it through to the recycling stage instead of landfilling. It also allows for less labor, equipment and transportation costs. In addition, sorting on site gives more control to the on site contractor. There are, however, managerial issues when it comes to sorting on site. Contractors must be willing to continually educate their labor to have knowledge of the waste stream. Project managers, who supervise their waste stream daily, have the best outcome in terms of recycling the materials. This may be conducted through daily ‘tool box talks’, a common construction term that refers to daily or weekly meetings that include all workers on a construction site, on waste and setting up a construction waste management protocol before construction or demolition begins. This protocol outlines where each demolished material should be placed and how the waste is handled. There is one main problem, however, with recycling on site. If the project space is small, there will not be enough room on site to hold various material waste bins.

Figure 2-3.	On Site Sorting

On the other hand, many on site choose to have materials sorted off site at landfills or transfer stations. This may because of a lack of space on site, lack of appropriate project management or lack of knowledge regarding the demolition waste stream. In a typical non-automated landfill, the process off site requires the use of 1-3 labor workers per waste bin, at a rate of $9.50/hour for approximately for 4 hours. As seen in Figure 2-4 below, once the materials have sorted, they can either transfer them off to the proper recycling center or landfill the materials. If the materials are placed in the landfill, there is a tipping fee applied to the client. A tipping fee is a fee that is paid, generally per cubic/yard, in order to dump materials into the landfill. If the materials are able to be diverted, they will be sorted according to material and sent to the appropriate recycling center or transfer station. A transfer station is used for holding and separating materials prior to sending out to the landfill, incinerator or recycling site. Depending on the available market of that material, the hauler will either pay to have the material recycled or it the materials will be bought from the recycler. In general, the most popular material for purchasing is metal. Items such as concrete and asphalt provide no cost benefit to recycle; and drywall requires purchasing in order to be recycled. The available markets for recyclable materials will be discussed later on in this research.

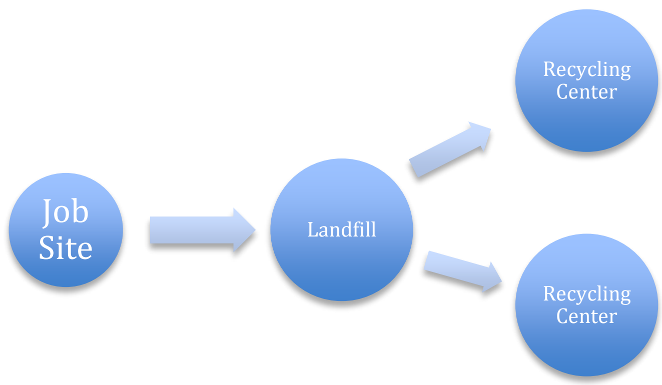

Figure 2-4. Off Site Sorting

State Regulations

Since the federal government does not regulate C&D waste, it is up to the local and state governments to implement legislation. Legislation on the waste streams various from state to state. Some states such as Massachusetts, Washington and California have been quick to implement rules and regulations while others have been slow to catch up. There are a range of options available for the C&D market, including: open market for C&D debris collection, permits for roll-off box haulers, franchise, non-exclusive commercial franchises, separate C&D debris franchises, rebate portion of franchise fee if recycling occurs (FDEP, 2001). In 2008, the state of Florida established a 75% reduction in waste for 2020; this 75% legislation includes all MSW and some C&D waste, i.e. concrete and wood, the parameters of the C&D regulations will be discussed further in chapter 5 of this research. In order to meet this deadline, most counties in Florida have quickly begun work on waste management plans. However, except for a handful of counties noted in the Appendix there seems to be a vast gap between the goal and the current state of the industry as a whole.

Massachusetts C&D Efforts

The state of Massachusetts has grown to be one of the top leaders in recycling of construction and demolition waste. In order to recycle more waste, the state has set some of the strictest landfills restrictions yet. In 2006, Massachusetts began a ban on C&D materials, more specifically, the State banned the following materials: pavement, brick, asphalt, concrete, cardboard, metal and wood. And most recently, they are working towards a ban on clean gypsum board, one of the hardest materials to recycling. This ban will begin in July of 2011 (American Recycler, 2011). In order to provide assistance to those who must comply with the waste ban, the state of Massachusetts set up various online resources, found at http://www.mass.gov/dep/recycle/reduce/managing.htm. Before the ban takes place, the state of Massachusetts will make sure they have the appropriate recycling infrastructure in order to support the incoming materials.

California C&D Efforts

Along with Massachusetts, the state of California has been one of the most successful states in waste management. Through it's Green Roads campaign, the Department of Resources Recycling and Recovery is promoting the use of RAC, rubberized asphalt concrete (American Recycler, 2011). The RAC is made with a combination of asphalt and crumb rubber that is made from ground up waste tires. RAC also saves money because it takes half the thickness of traditional pavement, which requires less material and less time to install. In addition to RAC, California's Green Roads campaign is also utilizing TDA, tire-derived aggregate. TDA is made from shredded scrap tires and is used in a wide range of construction projects such as wall backfill, lightweight embankment fill, landslide stabilization, vibration mitigation, and various landfill applications (Calrecycle.org, 2011).

European C&D Efforts

In June of 2010, the European Union conducted a study titled "Management of construction and demolition waste in the EU" for a stakeholders workshop in Brussels. The study consisted of two different tasks. One, to establish a common definition of C&D waste, specify waste management options and assist EUROSTAT in establishing a framework to calculate recycling target. The second task was to describe the current situation in the EU and identify drivers and barriers towards the 70% target. The study found the main barriers to be: economic, cultural and technical. Economical being that there is a high availability and low cost of virgin materials; cultural meaning there is a misconception of the quality of recycled products and finally, technical in so far as there is ineffective sorting and cross contamination of the waste flow.

Alachua County, Florida

For this research, we will focus on the waste stream of Alachua County. In July 2010, Alachua County Public Works released a white paper on Alachua County waste titled "Alachua county, solid waste management issues" (Alachua County, 2010). This paper analyzes the main problems with waste management in Alachua County and the steps that need to be taken in order to rectify it. It states problems within the "free market” of waste and problems with waste being taken out of state for landfilling. In light of these problems, the county began steps on building a Resource Recovery Park. The Resource Recovery Park will allow all materials to flow through this transfer station and then re-sold for recycling or reuse. In order to increase economic activity in the county of Alachua, all materials will remain within the county lines as well as increase the number of local jobs available.

Recycling vs. Landfill Disposal

A main section of this research is focused on the environmental aspects of waste management. There have been many studies done in the past regarding the environmental aspects of how to handle waste. Do we attempt a reduction in the production of new materials? Is the recycling of all products feasible? So far, there is no right or wrong answer on how to handle waste. As landfills begin to close down throughout the country, what happens to all this debris? There is an underlining fear that landfills are the root of many problems with the environment; some of this is true and some of this is false. This research will outline the pros and cons of recycling vs. landfilling.

Landfills are categorized as a Class I, II, or III landfill. Class I and II landfills are defined by the amount of debris the receive daily; class I receive an average of 20 tons or more of solid waste per day, and a class II receive an average of less than 20 tons of solid waste per day. According to the Florida Department of Environmental Protection, Class III landfills are FDEP permitted sites that are generally not required to have a liners. They can only receive yard trash, construction and demolition debris, waste tires, asbestos, carpet, cardboard, paper, glass, plastic, furniture other than appliances, or other materials approved by the FDEP (FDEP, 1999). Processing at Class III landfills is typically limited to sorting and grinding C&D debris such as wood and concrete.

Class I landfills are those which receive an average of 20 tons or more of solid waste per day. Class II landfills are those which receive an average of less than 20 tons of solid waste per day. Class I and Class II landfills receive general, non-hazardous household, commercial, industrial, and agricultural wastes, subject to the restrictions of Rules 62-701.300 and 62-701.520, F.A.C. Class III landfills are those which receive only yard debris, construction and demolition debris, waste tires, asbestos, carpet, cardboard, paper, glass, plastic, furniture other than appliances, or other materials approved by the Department which are not expected to produce leachate which poses a threat to public health or the environment. Class III landfills shall not accept putrescible household waste.

There are 83 active landfills in Florida and 75 C&D disposal sites (FDEP, 2010). According the Florida Department of Environmental Protection, there are a number of rules that apply to landfill owners; these include: permits for owning and operating a landfill, landfill liner requirements, type of waste you are allowed to have on your site, distance you are required to have from landfill to the end of the landfill site, etc.

Every day, Americans produce roughly 4.5 pounds of waste per person with an increase of 110 million tons of garage each year (Ridley 2001). Most of this waste will either end up in the landfill, recycled or incinerated.

The USGBC's Role in Waste Management

The United States Green Building Council (USGBC) established LEED (the Leadership in Energy and Environmental Design) in 1998. LEED was created in order to facilitate a points based system that would grade buildings on their sustainable practices and implementations. The LEED system has grown over the years and recently, incorporated points accrued for buildings that implement a Construction Waste Management Plan, use local, recycled materials and divert a certain percentage of their own demolished and waste materials. These credits may be found under Materials and Resources category and are classified as credits 2.1 and 2.2, or MRc2.1 and 2.2. A detailed description of these points is listed below.

Listed under the category, Materials and Resources, MRc2 has a total amount of 3 points, under Credit 2.1: 'Construction Waste Management, Divert 50% from disposal, points available: 1'**.** The Intent of the points is to divert construction, demolition and land clearing debris from landfill disposal, redirect recyclable material back to the manufacturing process and redirect reusable materials to appropriate sites. The requirements include: develop and implement a waste management plan, quantifying material diversion goals, and recycle and/or salvage at least 50% of construction, demolition and land clearing waste. Calculations can be done by weight or volume but must be consistent throughout. The other credit 2.2: 'Construction Waste Management: Divert 75% from disposal, points available: 1 point in addition to credit 2.1'. The intent is to divert construction and demolition debris from disposal in landfills and incinerators, redirect recyclable recovered resources back to the manufacturing process and redirect reusable materials to appropriate sites. The requirements are as follows: recycle and/or salvage an additional 25% beyond MR Credit 2.1 (75% total) of non-hazardous construction and demolition debris, excavated soil and land-clearing debris do not contribute to this credit. Calculations can be done by weight or volume, but must be consistent throughout. Credit MRc2: Exemplary Performance: Divert 95% from disposal (Innovation in Design credit), points available: 1 point in addition to credit 2.1 and 2.2. Under this credit, project teams may earn and Innovation in Design credit for exemplary performance by diverting 9% or more total construction waste. Credit: Regional Priority Credits, points Available: 0. The intent is to incentivize the achievement of credits that address geographically specific environmental priorities. The RPCs are not new credits, but credits that the local regional sections and the USGBC designate as particularly important for that area. The requirement are as follows, currently, Credit 2.1 and 2.2 are currently not recognized in the State of Florida as part of the regional priority credits.

As mentioned previously, a construction waste management plan is used as a guide and resource for those working on the job site. It also outlines how the job will handle the waste incurred throughout the length of the project. In some cases, this includes on site sorting and requires a project manager who is willing to enforce USGBC's LEED practices and understands the demands of working on a LEED job. This can be a large barrier for many involved in construction.

CHAPTER 3
RESEARCH METHODOLOGY

Overview

The purpose of this study was to analyze the C&D waste management system for Northern Central Florida. The main source of information used was the data collected from industry representatives throughout the area. The primary objective was to compare and analyze cost, transportation and management of materials within the C&D waste stream. This information was then used to create a cost analysis and strategies to increase diversion within the C&D industry.

The methodology of this research was divided into three different parts. Part one, was to provide documentation analyzing and defining the costs associated with construction waste diversion including transportation and labor costs. Part two, was to outline a cost analysis of landfilling versus diverting C&D waste. And lastly, part three was to review, and analyze Florida's 75% recycling mandate by 2020.

Part one was created through research of prior and current waste management systems. This section of the report was used as a base model for previous systems and where improvements may take place when moving forward towards better costs benefits and larger recycling rates.

Part two of this report was the creation of a cost analysis matrix for waste management systems. The cost analysis outlines the costs of recycling versus landfilling C&D materials as well as provides alternative strategies for cost benefits as well as steps to improve recycling rates. In order to receive the most current and accurate information, a number of local businesses were interviewed. These include: C&D contractors, recycling facilities, waste management industries, Florida Department of Environmental Protection, local non profit agencies and transfer station operators. There were many factors taken into consideration when designing the model. These include

- Prior and Current Waste Management Systems: This factor will look how the waste stream is handled from beginning to the end market.
- Transportation: The transportation factor for waste management systems is a one of the most important factors and yet the hardest to pin down. Transportation is an ever-changing industry and many assumptions had to be made. In addition, many factors had to be taken into consideration. These included: distance, trucking fees, labor, and energy emissions.
- Equipment: the equipment need on and off site to handle the materials. This equipment is dependent on another variable, availability in the location needed. For example, Alachua County lacks a drywall machine, therefore, drywall is transported to another county down south for recycling.
- Materials: these materials included: concrete, asphalt, cardboard, plastic, drywall, metals and roofing materials.
- Available Markets: the available markets for re sell and recycling.
- Landfill: Even though most C&D materials are available for recycling and re-use, a small percentage is actually recycled, the rest is sent to the landfill. This factor analyzes why materials are landfilled and not recycled.

Part three is an analysis of the new Florida legislation on 75% recycling rates. This analysis was provided in order to further understand the appropriate recycling demands of each county, not just a statewide mandate. This analysis was conducted through research on population, total C&D waste and total recycling rates of C&D waste per each Florida County. This section also includes recommendations for more realistic recycling rates based on these findings.

Cost Analysis

Before interviewing any businesses for this research, a number of factors were taken into consideration. The business must have some direct correlation with the recycling of C&D materials and handle these materials on a consistent and daily basis. Each interviewee must be familiar with the C&D industry and the market for available materials. The set of questions asked varied from business to business in order to get a realistic understanding of how the business operated daily. For example, if the interviewee worked as an operator for a C&D contractor, the question would be “how to determine whether or not a material is landfilled or diverted?” For someone in the recycling business, the question would be “what are the available markets for that particular material?”

After gathering all of the data from the interviews, a system was set in place to analyze and deconstruct the information. The system evaluated the barriers and potential catalysts for greater cost implementation within the construction and demolition Industry.

Assumptions and Limitations

Because of consistent market conditions throughout the low-automated C&D industry, it is assumed that C&D waste facilities have similar cost trends. Low automated C&D facilities that primarily use manual labor for sorting with the support of heavy equipment operators (i.e. frontend loaders). For example, only a certain amount of C&D contractors were interviewed for this research, in the so far as to say that each C&D contractors utilizes similar tipping fees, labor and equipment fees, etc.

The main limitation for this research is location, the data gathered was for North Central Florida; however, it is applicable for other counties, state wide. Another limitation is the basis for handling and processing waste. One facility might vary from another, thus, varying the appropriate cost business plan.

CHAPTER 4
RESULTS

Cost Analysis

This study began as exploration into effective management and implementation of waste diversion and recycling systems in North Central Florida. The goal was to determine the hurdles to diversion and recycling on a county by county basis. Effectiveness of the management plans was based on the following factors: cost benefit of recycling versus landfilling and the systematic flow of the waste stream. This study analyzed past and recent waste systems, materials, transportation, available markets, sorting and handling of waste, state regulations and the possible environmental impact of recycling versus landfilling. In order to receive the most current and accurate information, interviews were conducted with those directly effected by the waste management industry. The research began with field visits and Technical Advisory Group (TAG) meetings. Further information was conducted by in person as well as phone interviews and emails. This section elaborates on the results of these interviews and further analyzes the problems within waste stream management. The objective of this research is to bring light to issues surrounding waste management and apply this information to cost benefit strategies. In addition, this research will provide a plan to increase recycling awareness within North Central Florida.

Waste Management Systems

As mentioned in Chapter 2, there are various waste management systems currently being used in the industry. The main systems used are: integrated waste management, cost benefit and life cycle costing analysis and supply chain management. Unfortunately, none of these systems cover the entire basis of waste management. One of the main points of conflict within any waste management system is the final product. Some of the available markets for C&D waste are not yet economically feasible due to either transportation, technology, or costs versus virgin products.. Therefore, why pay more for recycled materials when virgin materials are less more economical? Considering this important factor, it is essential to set up a management system that is financially feasible.

A common waste stream flow is composed of the following elements: building deconstruction on site, waste bins hold the C&D waste until transported to the landfill/transfer station, transportation picks up the waste bins and brings them to the sorting site (this is generally no more than 50 miles), the waste is then sorted and either landfilled or transported again to a recycling location. For this study, the median haul price for an on site bin is $225. This price includes transportation of the bin and its waste to and from the sorting site. The waste hauler's profit above does not account for depreciation on trucks, overhead, fixed or variable operational costs, and permits required to run the truck on city roads. In the next sections, we will discuss profit made from the selling or landfilling of these materials sorted from the demolition waste stream.

Materials

The materials analyzed in this research are the following: metals, concrete, asphalt, cardboard, wood, plastic, drywall and roofing materials. Each material is handled differently once sorted form the waste stream. For example, metals have a high rate of recycling because there are a larger amount of end markets; while drywall is harder to recycle because it is neither as cost effective nor as readily available the virgin aggregate counter part. In many cases, the available markets for recycled materials are long distance or over seas, which in turn increases the price for recycling. This section will present two different cost estimates. The first cost estimate is based on the price for the recycling of C&D materials straight from the job site. The second cost estimate is based on the market value of the materials once they are recycled and ready for re-sell.

The cost model presented in this section is a comparison of diverting waste from the landfill versus disposal into the landfill of 5 common C&D waste materials. The model assumes off site sorting. The numbers calculated in the model are based off a 100 ton or 400 cubic yard project. The cost model is based on a formula that utilizes the following factors:

- Weight and/or volume of waste from the job site
- Number of Loads needed to transfer the waste to and from the sorting site. This number is calculated by the amount of waste on the job site divided by the size of the waste bin. In this model, a 20 cubic yard can is used.
- Pull Charge: amount charged by the waste company to pull the bin off site, and dump of the waste.
- Value of Goods Sold: monetary amount received for any waste that may be sold to recycling facilities
- Diversion Charge: price recycling facilities may charge for acceptance of the waste
- Tipping Fee: Amount charge by the landfill to place waste into the landfill.

Table 4-1 outlines the formula used throughout this section.

Metals

In the C&D waste stream metals consist of are ferrous (i.e., steel products) and non-ferrous (i.e., aluminum) metal products including aluminum cans, ducts and siding, re-bar, pipe, sheet metal, wire/cable, fasteners, metal buckets, mesh, strapping, trim, nails, mercury from electrical switches, brass, flashing and gutters. A 2001 study conducted for the Florida Department of Environmental Protection (FDEP) found metals form the C&D waste stream in commercial construction account for 13% in Alachua

County. Within Alachua County, there are two major metal recyclers: CMC Recycling and KT recycling.

Table 4-1. Cost Model Inputs for diverting vs. landfill disposal

	Description	Amount
A	Cubic Yards: amount of material found in the waste stream based on a 400 cubic yard jobs which equals roughly 100 tons	# of cubic yards
B	Tons: converted from cubic yards[1]	# of tons
C	# Loads (based on the number of cubic yards mentioned in column1 and the size of the waste can.)	Column A/20 yard can
D	Pull Charge (Set by waste hauler)	$
E	Haul Subtotal 1	Column C*Column D= $
F	Value of Goods Sold (Price set by the recycling facility)	$
G	Diversion Charge (Price set by the recycling facility)	$
H	Value Subtotal 2 (Diversion)	Column B* Column F or G= -/+$
I	Landfill Tipping Fee (per cubic yard)	$
J	Value of Subtotal 3 (Landfill)	Column A * Column I = $
K	Total Cost for Diverting Materials	Subtotal 1 + Subtotal 2= -/+$
L	Total Cost for Landfill Disposal	Subtotal 1 + Subtotal 3= -/+$

Table 4-2 presents an example of diverting versus disposal of metal. The amount of cubic yards and tonnage is based off a percentage of waste found on a 100 ton project.

As shown in table 4-2, there is a cost benefit to diverting metals versus landfill disposal because there is a value to the waste. In 2008, the scrap recycling industry generated $86 billion and supported 85,000 jobs. In addition, the United States exported $28.6 billion—roughly 44 million metric tons—of scrap commodities (West, 2008). All metal recovered from the waste stream has the ability to be recycled and

[1] *All cubic yards to tons conversion factors may be found here: http://www.calrecycle.ca.gov/LGCentral/Library/DSG/ICandD.htm

reused. In some cases, the metal is resold to an available market within driving range of the nearest sorting site. In others, the metals are shipped overseas for re-use. Like most recycled products, the selling and buying price fluctuates with the current market. In a bad economy, the purchasing price may be low, however, metal will not be considered a "buyer's market" because there is always an available market for metal.

Table 4-2. Cost Model for Metals

	Description	Quantity
A	Cubic Yards	54
B	Tons	6
C	# Loads	2.7
D	Pull Charge	$225
E	Haul Subtotal 1	$607.50
F	Value of Goods Sold (per ton)	$220
G	Diversion Charge	$0
H	Value of Subtotal 2 (column F or G*B)	$1,320
I	Landfill Tipping Fee (cubic yard)	$7
J	Value of Subtotal 3 (column A*I)	$378
K	Total Cost of Diverting Materials (E-H)	+$729
L	Total Cost of Landfill Disposal (E+J)	$985.50

Concrete/Asphalt

Recycling concrete has grown in popularity over the past few years. Mainly because recycled concrete can be used in various ways, the most important of which is aggregate. The FDEP states concrete accounts for 28% of the total composition of commercial construction waste. According to the Construction Recycling Materials Association, concrete should be recycled for various reason, some of which include:

- Concrete is currently being used in concrete and asphalt products with better performance over comparable virgin aggregates.
- Provides for superior compaction and constructability.
- Weighs 10-15% less than virgin concrete (CMRA, 2011).

With any recycled material, there are various barriers. The largest barrier found in this research is the lack of economic viability for recycling concrete. For the landfill owner, diverting concrete to a recycler ends up costing the owner money to have the material taken off site and transported to the recycling site. In order to bypass the barrier of transportation costs, the waste hauler must consider on site vs. off site sorting. If the concrete is sorted and handled on site, then the only transportation requirement is distributing it to the recycling center. If this concrete is sorted at the landfill site, the waste hauler should transport from the construction site to the landfill site and then back to the recycling location.

As seen in Table 4-3 below, even though there is no value to the concrete waste, diverting the material from the landfill is still the more economical cost alternative. This is due mainly to the tipping fee charge per cubic yards.

Table 4-3. Cost Model for Concrete

	Description	Quantity
A	Cubic Yards	117
B	Tons	50
C	# Loads	6
D	Pull Charge	$225
E	Haul Subtotal 1	$675
F	Value of Goods Sold (per ton)	$0
G	Diversion Charge	$0
H	Value of Subtotal 2 (column F or G*B)	$0
I	Landfill Tipping Fee	$7
J	Value of Subtotal 3 (column A*I)	$819
K	Total Cost of Diverting Materials (E+H)	$1360
L	Total Cost of Landfill Disposal (E+J)	$1,494

For the recycler, there is not always an end market for recycled concrete. There are many reasons for this barrier, but the largest being the economic recession seen since the dip in construction in 2005. Buildings are being demolished therefore concrete is being recycled, however, there is a lack of new construction which means a lot of un-used recycled concrete.

Once this concrete is purchased, it belongs to the recycler. This material is then recycled and transported off site. Because of high trucking fees, concrete is generally transported no further than 50 miles outside the city limits. In short, this means, there must be an available end market within the city limits in order for recycling concrete to be cost effective for the recycling business.

Miscellaneous materials: cardboard/plastic/roofing materials

Recycling cardboard is similar to recycling metals in so far as the recycling programs are consistent and in high demand. Cardboard represents 11-30% of the construction and demolition waste stream (Recycle C&D debris www.recyclecddebris.com, 2011). Recycling cardboard does not face as many barriers as other C&D materials because of the ease of recycling, low cost and available markets. It is the benefit of the builders to recycle cardboard as it is sorted on the job site because it provides more job space as well as a price per ton for cardboard.

Plastic within the C&D waste stream may often times come in various materials. Some of these include plastic sheeting, brackets, caulk, etc. Plastic falls under the miscellaneous category and does not account for a large percentage of the C&D waste stream. It may also be hard to recycle plastic in a thorough manner because many of the recovered items contain plastic resins (FDEP, 2001). In residential construction, the amount of plastic recovered is 6%, which is much higher than that for commercial construction. For this research, the cost of commercial C&D plastic recycling will be used.

Approximately 11 million tons of waste asphalt roofing shingles are generated in the U.S. per year. Re-roofing jobs account for 10 million tons, with another 1 million from manufacturing scrap (calrecycle.com, 2011). The most common material used for roofing is asphalt in the form of asphalt shingles. The end result of recycling asphalt roofing is the manufacturing of new asphalt shingles. These crushed shingles can be used with hot mix asphalt concrete in roadway application. As well as use in rural roads, to cover pot holes, ruts, etc. Although there are many applications for shingle recycling, it is not a common practice found throughout the United States. According to the FDEP, Roofing shingles account for 6% of the waste stream. Therefore with a lack of available recycling opportunities, this 6% goes straight into the waste stream.

Table 4.4 is a model for mixed materials found in the waste stream. There is a diversion charge of $15 associated with mixed materials. Often times recycling facilities that accept plastic and cardboard will charge a fee for these items. This will be included in the cost of diversion.

Table 4-4. Cost Model for Mixed Materials

	Description	Quantity
A	Cubic Yards	88
B	Tons	22
C	# Loads	4
D	Pull Charge	$225
E	Haul Subtotal 1	$900.00
F	Value of Goods Sold	$0
G	Diversion Charge	$15
H	Value of Subtotal 2 (column F or G*B)	$330
I	Landfill Tipping Fee	$7
J	Value of Subtotal 3 (column A*I)	$616
K	Total Cost of Diverting Materials (E+H)	$1,230.00
L	Total Cost of Landfill Disposal (E+J)	$1,516.00

As shown in Table 4-4, with the increase in the diversion charge, the cost of diverting materials from the landfill is higher than disposing of the materials into the landfill. Without the disposal charge, the amount to diverting the materials would decrease by $330.

Wood

Wood accounts roughly 16% of the commercial C&D waste stream and accounts for even higher percentage from the commercial waste stream, roughly 52% (FDEP, 2001). Because wood is highly recyclable and has a large amount of end markets, recycling wood products is cost beneficial. There are two main options for recycling of wood: fuel and engineered wood. Other options include grinding down wood for mulch, wood chips, compost, etc. It is important when deconstructing wood to pay attention to the care given to the wood, especially if it is treated wood. This has a large effect on the recycling of the product.

Table 4-5 shows the cost model for diverting versus landfill disposal of wood. Although wood is a common recycled product, it holds no value. Therefore, this material does not increase or decrease the cost of diverting the material.

Table 4-5. Cost Model for Wood

	Description	Quantity
A	Cubic Yards	67
B	Tons	6
C	# Loads	3
D	Pull Charge	$225
E	Haul Subtotal 1	$675.00
F	Value of Goods Sold	$0
G	Diversion Charge	$0
H	Value of Subtotal 2 (column F or G*B)	$0
I	Landfill Tipping Fee	$7
J	Value of Subtotal 3 (column A*I)	$469
K	Total Cost of Diverting Materials (E+H)	$675.00
L	Total Cost of Landfill Disposal (E+J)	$1,144.00

As seen in Table 4-5, the diversion of wood from the landfill is a cost benefit. This is due to the price of the tipping fee as well as the lack of cost for diversion. Because wood has a high heating value, it can be used as boiler fuel and is commonly done so at pulp and paper mills as well as sugar refineries. A higher price is given to wood that has minimal soil and other foreign objects, and a low moisture content (FDEP, 2001). Other recycling options included engineered wood and mulch. Engineered wood includes fiberboard, oriented strand board and particleboard. In order to form a cohesive product, wood chips are compressed using various methods and adhesives. Another option for wood recycling and probably the most common and easiest form of recycling is mulch. Mulch is used in various lawn and agricultural applications.

Drywall

Drywall is one of the biggest problems faced today by the construction and demolition industry. Gypsum drywall is a common mineral composted of hydrated calcium sulfate. The United States Geological Survey (USGS) determined that the United States produced 22 millions tons of drywall in 2008, valued at $165 million (Olsen, 2008). Furthermore, 40 tons of drywall are disposed in landfills worldwide everyday. Unfortunately, the recycling programs available for drywall are limited. In most cases, transporting drywall to and from the recycling center can be a detrimental profit loss. With a lack of options, landfilling this material is often times the only viable one.

In the FDEP's 2001 composition study, drywall accounted for 22% of the total C&D waste stream. Some of the recycling options for drywall include: new drywall, agricultural amendment, Portland cement manufacture, animal bedding and compost amendment (FDEP, 2001). The National Association of Homebuilders suggests that individual contractors can crush drywall on site and land apply as part of the landscaping (FDEP, 2001). Unfortunately, however, these available re-use applications are again, limited and found only in certain parts throughout the United States. A major place for drywall re-sell is with peanut farmers who use 1000 lbs of natural recycled drywall/acre.

As of January 2011, there was no available drywall-recycling center within North Central Florida. The closest center is GEL Corporation, located 100 miles south of Alachua County. Because of this addition transportation cost, the waste haulers increase the price of the bin for diversion of the waste. In this case, the bin increase went from $225/bin to $400/bin. As presented in Table 4-6 below, the cost to landfill drywall is less due to the increase in the haul cost which is a direct result of an increase in transportation fees. Note, column F (the price for landfill disposal) use the average bin cost of $225 not the haul cost in column E which is used only for long distance material transports.

Table 4-6. Cost Model for Drywall

	Description	Quantity
A	Cubic Yards	92
B	Tons	7
C	# Loads	5
D	Pull Charge	$400
E	Haul Subtotal 1	$2,000.00
F	Value of Goods Sold	$0
G	Diversion Charge	$28
H	Value of Subtotal 2 (column F or G*B)	$168
I	Landfill Tipping Fee	$7
J	Value of Subtotal 3 (column A*I)	$644
K	Total Cost of Diverting Materials (E+H)	$2,168.00
L	Total Cost of Landfill Disposal (E+J)	$1,769.00

Table 4-6 shows how greatly transportation costs affect the total outcome of waste transportation. The increase in bin fee is a direct result of the transportation costs the waste hauler will encounter to transport the material. Because of this cost, it is more economically effective to landfill these materials.

The understanding of the cost analysis of recycling materials is two fold; one, construction recycling is based on the supply and demand of the recycled product in a particular area and two, the buying of recycled materials is based on the knowledge and education of those who have the ability to purchase these materials. In short, a rise in recycled materials will only be seen with a rise in demand for these materials and this rise will not come if those who handle the construction market are still utilizing virgin materials. This research is specifically analyzing the waste stream in North Central Florida; however, the market varies from region to region. Miami, FL., for example, is finding innovative ways to use the recycled materials. For example, they are using recycled concrete aggregate for horse track racing. It is up to those involved in the market to find creative and new ways to utilize these materials.

The only consistent profitable recycling material is metal. Metal is always in high demand and will consistently deliver a profit. However, if there is a low amount of metal in the waste stream for a particular job, then the total cost for recycling materials in North, Central Florida is not cost beneficial to the waste stream. Landfilling the materials can result in an almost double profit for those who handle the waste. In addition, this chart does not include the cost for long distance recycling hauls, I.E. drywall recycling. In short, what are the benefits then for those to recycle these materials than to landfill? Is it economically ethical to enforce the 75% legislation on construction waste haulers when it is to their cost detriment to recycle?

C&D Calculator

Figure 4-1 shows a detailed calculation of a 100-ton job located in Alachua County. This calculator utilizes the same formulas as the tables above in order to generate pricing for diverting versus landfilling the same waste. The job is based off a 100 ton job based in Alachua County, utilizing all local recycling facilities, a local landfill operation, a local waste hauler and an off site sorting operation.

Job:
Location:
Contractor:
Cost of Recycling

A	B	C	D	E	F	G	H	I	J	K	L
Material	Cubic Yards	Conversion Factor based on weight	Tons	Container Size (volume per load-cubic yards)	# Loads (Column A/Column D)	Pull Charge	Subtotal (Col E * Col F)	Tip Fee (tons)	Value of Goods Sold Per Ton	Subtotal 2	Total Cost
Metals	54	0.1125	6.08	20	2.7	$ 225.00	$607.50	$ -	$ 220.00	$ 1,336.50	($729.00)
Concrete	117	0.43	50.31	20	5.85	$ 225.00	$1,316.25	$ -	$ -	$ -	$1,316.25
Drywall	92	0.071	6.53	20	4.6	$ 400.00	$1,840.00	$ (28.00)		$ (182.90)	$2,022.90
Wood	67	0.0845	5.66	20	3.35	$ 225.00	$753.75	$ -		$ -	$753.75
Other: Roofing materials, cardboard,	88	0.24	21.12	20	4.4	$ 225.00	$990.00	$ 15.00	$ -	$ 316.80	$673.20
Totals							$ 5,507.50			$ 1,470.40	$4,037.10

Cost of Disposal

Material	Container Size (volume per load-cubic yards)	# Loads	Pull Charge	Subtotal 1	Total Cubic Yards	Weight per cubic yard	Tons	Tip Fee (cubic yards)	Subtotal 2	Total Cost
Mixed C&D Debris	20	20	$ 225.00	$ 4,500.00	418	0.24	100.32	$ 7.00	$ 2,926.00	$ 7,426.00

Savings or Cost of Recycling

Cost of Disposal	Cost of Reycicing	Total Savings
$ 7,426.00	$ 4,037.10	$ 3,388.90

Figure 4-1. C&D Calculator

The C&D calculator was created in order to generate information regarding the diversion of debris versus landfilling the debris. As the table shows, metals generate the highest profit therefore counter acting many of the costs associated with recycling. In order for the diversion of waste to be more economically feasible, there must local recycling facilities available to utilize the waste and there must be local end markets for the recycled materials. Without these two factors, diverting the waste from the landfill comes at a higher cost for those who own the waste.

Transportation

As seen in the research throughout this study, transportation often accounts for a large portion of the cost associated with recycling. Not only does transportation include the distance traveled from job site to dumping or transfer station, but it also accounts for the distance traveled to the recycling centers and back. Often times, this distance is outside of the city limit radius. In order to offset these costs, the hauler must increase their dumping fee for certain materials. In bad economic times, this increase in fines can deter those away from paying the extra transportation costs, instead opting for landfilling. For example, with a material such as drywall when the distance is over 100 miles to the nearest recycling center, it is more cost effective to pay the dumping fee of $7/yard as seen in Table 4-6.

When interviewing those involved in the trucking industry, one of the largest problems faced is the regulations and permitting process imposed on those involved with transporting waste. Often times, the fees to run a waste hauler on the city roads are over $1000/truck/year. If one company has over 5 trucks, these costs can exceed $5000. This does not include costs for depreciation or driving labor. In addition to the permit costs, the paperwork involved can add up to a number of hours of employee time as well as the hiring of an outside consulting fee. In total, permitting alone can cost a waste company over $8,000.

Another issue facing the trucking industry today is the issue of overall environmental impacts. As stated throughout this study, most landfills and transfer stations are located outside of the city limits; meaning driving to and from job sites can be of lengthy distances. When considering the environmental impacts of recycling and landfilling materials, it is essential to analyze the overarching embodied energy of a material. Embodied energy is defined as the commercial energy (fossil fuels, nuclear, etc) that was used in the work to make any product, bring it to market, and dispose of it. Embodied energy is an accounting methodology which aims to find the sum total of the energy necessary for an entire product lifecycle. Unfortunately, the transfer of materials from the job site to the recycling facility may often times be such long distances that it negates any environmental attributes.

Available Markets

The lack of available markets is one of the largest downfalls of the construction and demolition industry. Considering almost all C&D materials have the ability to be recycled and re-used, it is shocking to know that roughly only 29% of these materials are actually recycled and 71% are landfilled (FDEP, 2010). When interviewing those involved with landfilling, the overall consensus was that they would much rather recycle than landfill, however, if there is no cost benefit, landfilling is the only option.

With the shortage in available markets, it is highly essential to highlight those materials that do offer a strong available market. These markets open up opportunities for economic and social development within counties. Unfortunately, the lack of available markets comes from many factors, one of which is a lack of recycling education, specifically within the building industry. Those involved with construction may have interest in recycling impacts for environmental reasons, but the education of recycling is not thorough. The greater impact of using recycled materials goes further than simply environmental. The social and economic factors are substantial. Financially, opening up recycling markets will increase the economic flow within a community as well as create many local labor jobs. Using local recycled materials helps generate local commerce as well as prevents those recycled materials from leaving city lines and being shipped to another state or internationally. Of course, the use of the use of materials is determined by the state of the economy as well. Opportunities for cities to encourage the use of recycled materials comes from local and state governments, as will be discussed in the upcoming section.

Sorting and Handling

The way materials are sorted and handled can ultimately have a great affect on the cost benefit of each material. As mentioned in the previous section, transportation has a large financial impact on the cost of each material. Not only is cost impacted through transportation, but also the environmental impacts of transporting waste are enormous. Because of these two factors, it is essential for those working with the waste stream to understand the benefits of how these materials are sorted and handled. In recent years, there has been a greater availability of on site sorting systems. These can include: on site separate bins for each material, on site recycling equipment, as well as a more efficient transfer system at the recycling and landfill stations.

On Site Sorting

One of the most economical ways to reduce in costs is to sort on site. Before a construction project even begins, the general contractor in charge of the project must instill a construction waste plan. This construction waste plan must be able to educate and inform all workers how to handle the waste. This may include separate bins on site for each material. Specifically bins for recyclable materials such as: concrete/asphalt, metals, cardboard and miscellaneous. These bins can then be sent directly the recycling facilities without having to be transported from the job site – to the sorting station – then back to the recycling center. This offers up a large reduction in sorting labor, which is roughly $9/hour/worker, as well as a reduction in transportation costs. It does, however, require the on site project manager to conduct weekly meetings to educate on how to use the bins and the importance of not mixing each material.

This may come at a cost for the on site equipment, however, with a larger project such as a roadway, etc., this equipment could save the project money over time by being able to directly recycling on site and either re-use on the same project or directly sell from the site. The most common on site equipment is for concrete and asphalt, which may be crushed down into road base aggregate.

And finally, the most long-term efficient way of handling waste is an integrated waste system. In Alachua County alone, there are two large landfill operators and various recycling and transfer facilities. Because of the high amount of volume, waste is constantly being transferred from one station to another. An ideal system would include the ability to sort material, recycle and landfill material on one site. As seen in Massachusetts, the C&D facilities include all the appropriate equipment in one location. This type of sorting allows for an efficient waste flow and cuts costs in transportation, labor and time.

State and Local Regulations

There are a number of options the state and local governments could implement in order to increase recycling of C&D waste as well as facilitate better business practices among the Construction and Demolition Industry. One of the largest problems seen throughout this research is the lack of any fluidity among the businesses involved with the C&D waste stream. For one, there seems to be a lack of communication among various businesses. And secondly, there are very few state or local incentives set in place in order to promote the recycling industry.

Some Options for Local Government Improvement Include:

Local ordinance mandate recycling of C&D debris: Local governments can require all recycling of C&D debris. The county can place an ordinance, which would require waste haulers to recycle a majority of C&D debris. This has been successful in counties such as Sarasota County, FL. and Alameda County, CA (FDEP, 2001). This would involve an available market or business that would be willing to accept all materials at a feasible cost to the project owner, contractor, or hauler.

Require builders to recycle on site: On site recycling has proven to decease transportation cost and facilitate in the sorting and handling of C&D waste. This would also require builders to create a C&D construction waste management plan prior to the start of building. The City of Portland, OR. Requires 75% on-site recycling in all construction projects, valued above $50,000 (portlandonline.com, 2011). This would require the integrated waste management plan to be considered during the design phase of the project so available opportunities are designated for the materials.

Increase education and awareness on C&D recycling: Often times the lack of recycling efforts and using recyclable materials comes from a lack of education. Hold city forums and educate those involved with the C&D waste stream. This includes city officials, builders, contractors, architects, etc.

Some Options for State Government Improvement Include:

Increase Grants for those wanting to open a recycling program: Because there is often a lack of available recycling equipment in each county, the State should offer grants to pay for proper equipment. This would decrease transportation costs, carbon emissions and increase local recycling efforts which would in turn, create economic development by creating local labor jobs.

Increase funding to local recycling companies: An increase in funding to local recycling companies would allow these companies to facilitate operation even in a slow economic cycle. Florida currently has a program set in place to provide low interest loans to small start up recycling companies (FDEP, 2011). This program could be further expanded upon and modified to include expansion of C&D equipment and availability of businesses.

Provide rewards and incentives to those who recycle 100% C&D waste: The recycling of C&D waste can often times place a hard economic factor on a company. In order to offset the increase in cost, the state could offer incentives such as tax exceptions for recycling a certain amount/year; publicize construction companies that recycle and reduce waste, etc.

Increase Tipping Fees: It is more financially feasible to landfill certain materials than to recycle. An increase in tipping fees may offset this cost. An increase in tipping fees, however, can fluctuate with the economy. In a bad economy, low tipping fees allow for a competitive market among landfill owners. Increase in tipping fees without ensuring available markets would not solve the problem. Without these markets the more viable option may be to ship materials to more cost effective landfills thereby creating more environmental damage.

CHAPTER 5
FLORIDA'S 75% RECYCLING MANDATE BY 2020

In 2008, the State of Florida signed into law a 75% recycling mandate by 2020. According to the letter sent the Governor of Florida in 2010, 'As much as 12% of the 2020 recycling goal could be met by processing C&D debris at a 75% rate through materials recovery facilities, all at relatively low cost and with an income source in recovered materials' (FDEP, 2010). The new law calls for all forms of Municipal Solid Waste (MSW) to be recycled and some materials found in the Construction and Demolition (C&D) waste stream.

Construction and Demolition (C&D) materials: what counts towards the goal:

- Concrete from residential/commercial building used for: road base, pipe bedding, drain fields, septic tanks, landfill cell drainage & stabilization and artificial reefs
- Wood and Land Clearing Debris sent to a processed fuel/biomass facility
- Wood and Land clearing debris used for: mulch, compost and final cover

The 75% recycling law is a statewide goal to be met by 2020. Because the goal is statewide and not county-by-county, there are various problems associated with the mandate. Most notably, the law does not take into account the various factors that contribute to a successful recycling program. Some of these factors include: availability of recycling facilities, availability of end markets for the recycled materials, education on C&D recycling, the construction market for each county, population and the economic feasibility of recycling. If an individual county is lacking in any of these factors, the 75% recycling goal is not feasible. In order to realistically meet the recycling goal, the legislation must be altered to establish a realistic diversion rate per county.

For example, the larger counties in Florida will continuously have higher recycling rates. This is because more new construction is occurring and those involved with construction in these counties are increasingly recycling more materials. As discussed in the above research, these recycling rates are higher due to availability of facilities, market value for recycled materials, new construction, and culture surrounding recycling. For this research, we researched the correlation between population, amount of C&D waste and the amount of recycled C&D waste.

Table 5-1. 2008 Florida C&D Waste Generated per County

County	Population	C&D waste	C&D recycled	Percentage %
Miami-Dade	2,477,289	421,702	48,268	11
Hillsborough	1,200,541	277,555	9,627	3
Escambia	313,480	117,048	7,857	7
Lake	288,379	89,948	1,724	2
Clay	185,168	29,336	0	0
St. Johns	181,180	102,974	34,328	33
Okeechobee	40,003	11,240	0	0
Desoto	34,387	4,655	0	0
Wakulla	30,717	5,572	0	0
Liberty	8,158	722	0	0

The study looked at all of the Florida counties and compared the population with the amount of C&D waste being processed in 2008. Miami-Dade County, the largest populated county in Florida, produced over 400,000 tons of waste and recycled 11% of this waste. The same year, Hillsborough County with over a million residents produced over 200,000 tons of waste and recycled only 3%. According to the same FDEP records, Liberty County, the smallest County in Florida with just over 8,000 residents, produced 722 tons of C&D waste and had a 0% recycling rate. In order for Liberty County to meet the 75% goal by 2020, the County would have to see an increase of

8.3% for the next 9 years to meet this goal. For a County with currently no significant amount of recycling taking place, this would be an unrealistic goal. See Appendix A for the FDEP's 2009 data on Florida C&D waste.

Recycling Barriers*:* In order to understand why the mandate is not feasible, it is important to understand the barriers to greater recycling efforts. The most notable recycling hindrances are as follows:

- *Sorting of waste*: lack of available equipment within the county limits. This includes facilities with appropriate recycling equipment as well as the ability to recycle on a job site
- *Transportation*: trucking costs to move waste from the job site to the appropriate recycling facilities. Specifically if the recycling facility is outside city limits
- *End Markets*: recycled materials are a market driven commodity; meaning if there is a lack of construction happening within a county, there will not be a need for recycled products.

In order for the State of Florida to see an increase in recycling rates, some changes must be made. If recycling comes at a cost for those who handle the waste, there must be an economic incentive for those who handle the waste. In addition, the State needs to find better ways of supporting and educating those who handle the waste on the 75% recycling goal. And finally, the recycling law must be modified to provide realistic diversion rates for each county.

CHAPTER 6
RECOMMENDATIONS

Throughout this research, there were many consistent problems found within the C&D waste stream. Some affected the economic factors, while others effected social and environmental. For this section, we will focus on the economic problems and certain strategies that may be implemented in order to increase cost benefit within the C&D waste stream. These economic problems include:

- Lack of available end markets
- Lack of availability for proper C&D equipment
- Inconsistency of material distribution and communication within the waste industry
- Lack of financial funding available to start up and small C&D businesses
- Lack of knowledge regarding the re-use of materials

Acknowledging these problems is first step in fixing the waste stream management, learning how to address and fix these problems is the second step. This chapter utilized all available information previously discussed including research, interviews, and analysis.

How to handle a lack of available end markets: With the recent economic downturn, most of those involved with the waste stream are left with a serious lack of available end markets. Questions begin to be asked: What do we do with all this waste? If landfilling is a bad environmental and economic proposal, then what's the best option? Unfortunately, the options are limited, however, there are certain steps a business may do in order to maximize waste diversion and increase financial feasibility. These include:

Identify the material with the greatest cost benefit. Once these materials enter the waste stream, immediately sort them out on site and transport them to the appropriate recycling center. For example, instead of transporting tin from the job site, then to the sorting site, then sort the material; re-load the tin onto the waste hauler and transfer to the recycling center. Not only does this system increase your transportation costs, but it also increases your labor and time costs.

Identify the best transportation route. Throughout this research, one of the largest complaints from waste haulers is the time and money it takes to transport materials back and forth from job site to transfer station and back. Make sure the trucks are utilizing all routes possible in order to decrease these costs.

Lack of availability of proper C&D equipment: In order to properly and sufficiently handle the C&D waste stream, the correct equipment must be available. This equipment must be able to handle the amount of C&D waste and generate a fluid stream. C&D equipment is like any other piece of equipment; it requires money up front for purchasing and funds for upkeep and maintenance. Most times, those handling the waste stream are small companies and do not have the available funds to purchase the best equipment. In addition, this equipment may be scattered throughout multiple different companies for one county. The waste is then being transferred from one station to another when it should be processed in one facility.

Inconsistency of material distribution and communication within the waste industry: The most shocking revelation found in this study was the lack of communication between those involved with the waste industry. And often times, this communication happened through word of mouth or an agreement with a 'shake of the hands'. Unfortunately, by exchanging information this way, companies are only setting themselves up at a disadvantage. It doesn't allow for a free and open exchange of communication, whether that is positive or negative. Here are the strategies to generate information exchange:

- Encourage and promote the use of open communication among employees involved with the waste industry.
- Follow daily websites that promote this communication. Some of these sites are listed below:
  www.wastemap.org
  http://www.dep.state.fl.us/waste/rbac/pages/market.htm
  http://swix.ws/
- Prohibit the use of "word of mouth" or "shake of the hands" agreements. Unfortunately, these types of agreements in the long run, only hinder a business from growing and prospering. Most of these agreements are done as favors and do not economically stimulate the business.

Lack of financial funding available to start up and small C&D businesses: This has been discussed many times throughout this research. Unfortunately, the lack of financial funding rests in the hands of state and local government. However, it is also the responsibility of the business to seek out these available options. Locate and communicate your needs with the local officials; seek out environmental grants; contact the state government in search of environmental or social grants. Most of these requite some time and planning but the pay off can be large. For example, as mentioned in this research, there is a lack of drywall recycling centers. Contact the local and state governments to seek out grants to help purchase the equipment needed. Having a local drywall recycling would cut down on transportation costs, thus providing more cost benefit to recycling as well as reduce carbon emissions.

Lack of knowledge regarding the re-use of materials. Although recycling has been around for decades now, it is still consider an "on the rise" movement. Most involved in construction are only recently becoming accustomed to “green standards”. Because of this, it is taking time for all to get on board with recycling instead of landfilling. This applies to builders, architects and local authorities. This lack of knowledge and understanding of recycling will, over time, lead to bad environmental and economical consequences. In many cases, it is unclear whose job this education actually belongs to. Is it the job of the recycling business to educate those on their services? Is it the job of the builder to have a social and environmental responsibility? In order to increase recycling, which will in turn have a great economic effect; it is the responsibility of all involved in the waste stream to educate.

CHAPTER 7
CONCLUSION

The problems the solid waste industry faces today are much larger than simply how to sort debris and where to distribute it. These problems are physical, social, economical, and educational. Most involved with C&D waste, would state they would much rather recycle materials than landfill them, however, this option is not always economically viable. With the large governmental push for recycling efforts, there must be greater incentives for those involved with C&D waste to actually meet this requirement. Unfortunately, however, these incentives do not exist, and in fact, it is quite the opposite. In order to own a landfill or handle C&D waste, there are a number of hoops one must jump through. These include, but our not limited to, trucking and transportation fees, landfill fees and landfill fines, landfill environmental requirements, permits, etc.

In addition to governmental regulations, those involved with C&D waste must deal with social and physical problems. Because most cities do not want landfills within the city line, they are located miles from where the actual construction takes place. This means transportation to and from the construction site to the landfill or transfer station is a long distance, which ultimately increases the transportation costs for those who haul the waste. Because most C&D companies work on a set fee, these transportation costs come at the expense of the hauler. Furthermore, because of a lack of education surrounding the waste stream, these barriers go unnoticed.

The most detrimental problem the construction and demolition industry faces today is economical. As stated throughout this body of research, the single most important contributing factor to the detriment of the waste stream is the lack of available end markets for recycled materials. This lack of end markets provides no financial incentives or economic advantages over landfilling these materials, especially if it comes at the cost of the waste company.

Florida's 75% recycling mandate is a good example of government interest in larger recycling efforts; however, the legislation does not help or protect those who handle the waste. In order to meet the 75% recycling, the waste must be diverted from the landfill. If there are no local opportunities for recycling efforts, the waste will be transported to another county where there are larger opportunities for diversion. This will result in a larger distance. This larger distance will force a higher transportation cost. This larger transportation cost will then increase the charge towards those who generate the waste, i.e. contractors, and owners. In an economic time when people are hungry for construction work, who can afford to pay a higher cost? In addition, these higher distances have a negative environmental effect, which is the sole purpose of recycling, to preserve our natural environment.

Perhaps the greatest success for the waste industry will come from a commitment from all involved in construction to implement greater environmental standards on buildings. With the ever-increasing growth in population, the waste stream will continue to rise.   Those involved in all steps in construction; owner, builders, architects, etc.; must respond aggressively to the outside economic and environmental demands of society. It is no longer acceptable to continue building with virgin materials. It is no longer acceptable to continue demolishing buildings with landfilling as an option. If the demand for utilizing recycled materials grows, so will the economic incentives to no longer landfill. This is the cyclical nature of supply and demand.

APPENDIX
FLORIDA C&D WASTE DATA

Table A-1. 2009 Florida C&D Waste Data

County	Population	Building Permits	C&D waste	C&D recycled	%
Miami-Dade	2,477,289	1,395	502,919	127,777	25
Broward	1,758,494	1,049	505,476	89074	18
Palm Beach	1,294,654	1,431	544,778	162,626	30
Hillsborough	1,200,541	3,745	219,752	6,355	3
Orange	1,114,979	1,929	690,485	222,823	32
Pinellas	938,461	1,135	356,549	142,395	49
Duval	904,971	2,694	626,516	303,107	48
Lee	623,725	944	267,766	109,564	41
Polk	585,733	1,135	139,136	1,206	1
Brevard	556,213	995	384,753	177,589	46
Volusia	510,750	666	193,871	48,217	25
Pasco	438,668	1,801	309,477	159,563	52
Seminole	426,413	665	56,367	23,300	41
Sarasota	393,608	536	220,624	82,240	37
Collier	332,854	944	140,593	59,049	42
Marion	329,418	394	68,282	1,440	2
Manatee	317,699	1,227	115,188	9,857	9
Escambia	313,480	594	140,353	0	0
Lake	288,379	814	137,503	4,032	3
St. Lucie	276,585	264	86,819	62,663	72
Leon	274,892	666	81,166	63,954	79
Osceola	273,709	1,079	74,480	18,722	25
Alachua	252,709	519	106,773	44,818	42
Okaloosa	197,597	410	94,104	0	0
Clay	185,168	532	58,034	456	1
St. Johns	181,180	1,142	58,034	456	1
Bay	169,307	352	85,597	870	1
Charlotte	165,781	296	32,998	17,567	54
Hernado	164,907	194	22,456	1,804	8
Santa Rosa	144,136	448	8,545	0	0
Martin	143,868	120	24,577	8,752	36
Citrus	142,043	484	15,505	5,159	33
Indian River	141,667	327	33,346	1,540	5
Highlands	100,207	114	10,779	2,084	19
Flagler	95,512	168	29,939	9	0
Sumter	93,034	2,253	21,349	10,890	51
Monroe	76,081	116	17,077	3,238	19
Putnam	74,989	36	11,365	342	3

Table A-1. continued

County	Population	Building Permits	C&D waste	C&D recycled	%
Nassau	71,915	252	62,780	3,946	6
Columbia	66,121	99	18,009	0	0
Walton	57,784	231	94,000	0	0
Jackson	52,639	78	4,369	0	0
Gadseden	50,611	108	853	117	14
Hendry	41,216	54	8,567	29	0
Suwannee	40,927	53	3,207	0	0
Levy	40,817	83	19,195	0	0
Okeechobee	40,003	39	8,894	0	0
Desoto	34,387	109	2,900	0	0
Wakulla	30,717	95	2,568	0	0
Braford	29,059	24	1,360	159	12
Hardee	27,909	25	2,501	0	0
Baker	25,890	46	1,085	3	0
Washington	24,779	38	298	0	0
Taylor	23,199	17	1,161	0	0
Madison	20,152	32	222	0	0
Holmes	19,757	23	448	4	1
Gilchrist	17,256	10	1,111	0	0
Gulf	16,923	36	4,733	22	0
Union	15,974	17	1,135	11	1
Dixie	15,963	19	2,793	0	0
Hamilton	14,779	13	389	0	0
Jefferson	14,553	26	2,135	60	3
Calhoun	14,310	28	2,401	0	0
Franklin	12,331	23	5,975	175	3
Glades	11,323	27	1,335	0	0
Lafayette	8,287	10	6,062	0	0
Liberty	8,158	14	400	0	0

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BIOGRAPHICAL SKETCH

Tricia Ketchey was born and raised in Tampa, Florida in 1982. Upon graduating from high school, she studied fine arts at the University of the South in Sewanee, TN. After college graduation, Tricia moved to New York where she worked in the publishing industry as a photo editor, from there she moved to Nashville, Tennessee where she first started working on interior design and construction. Always having a love for nature and the outdoors, it is no wonder she found a passion for sustainable construction practices. After working 3 years, she decided to improve upon her education and go back to school in her home state of Florida at the ME Rinker, Sr., School of Building Construction.. It was during this time that she began working for her professor on researching C&D recycling and pushing for greater recycling efforts in the State of Florida.