July 5, 2005

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Enclosed is our report entitled Cafeteria and Construction Waste Management. It was written at Intel during the period of May 14 through July 5, 2005. Preliminary work was completed in Worcester, Massachusetts, prior to our arrival in Costa Rica. Copies of this report are simultaneously being submitted to Professors Gerstenfeld and Vernon-Gerstenfeld for evaluation. Upon faculty review, the original copy of this report will be catalogued in the Gordon Library at Worcester Polytechnic Institute. We appreciate the time that you have devoted to us.

Sincerely,

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Report Submitted to:

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CAFETERIA AND CONSTRUCTION WASTE MANAGEMENT

July 7th 2005

This project report is submitted in partial fulfillment of the degree requirements of Worcester Polytechnic Institute. The views and opinions expressed herein are those of the authors and do not necessarily reflect the positions or opinions of Intel or Worcester Polytechnic Institute.

This report is the product of an education program, and is intended to serve as partial documentation for the evaluation of academic achievement. The report should not be construed as a working document by the reader.

ABSTRACT:

This report, prepared for Intel of Belén, Costa Rica, explored options to reduce the waste volume that is sent to the landfill from the Intel facility. The particular waste streams included cafeteria and construction waste. The following document addresses the necessary background, research methods, findings and recommendations. Through extensive research of construction best practices, physical composting, and investigating of composting systems, we established the best future options for Intel. Segregation is essential for composting to occur. Fifty percent of the waste sent to the landfill is cafeteria waste. Composting could reduce sixty percent of the cafeteria waste. For construction waste, the following document gives a model of best practices to reduce Intel's waste and includes a spreadsheet of the recycling market.

ACKNOWLEDGEMENTS:

We would like to thank the following people for their contribution to this project. Their help was invaluable.

Anibal Alterno
Mario Barquero
Shane Cheatham
Francisco Cespedes
Luis Chinchilla
Erika Diaz
Marco Esquival
Christian Garbanzo
Arthur Gerstenfeld
Randy Helgeson
Susan Vernon-Gerstenfeld

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EXECUTIVE SUMMARY

Costa Rica is a small country located in Central America that has been trying to increase their recycling rate. In the capital city of San Jose, 1,400 tons of waste are being produced daily. Most municipalities do not have the human nor technological abilities to handle the waste effectively. Presently, there are three landfills in the San Jose Metropolitan Area: Rio Azul, La Carpio, and Los Mangos, which are still in operation to date. Although, in 2002, it was predicted that Rio Azul would close in less than four years(http://www.sanjosemetropolitano.org/ModEstudios/GuiaSEAM/ELR_GS_ING_waste.htm). As a result, many companies are investigating other options to prevent waste from being sent to landfills. An alternative to landfill disposal is through recycling.

Intel, a microprocessor producer, is especially interested in improving recycling for their company because of the ISO 14001 standards and regulations. The company is constantly trying to better their waste management and recycling programs. By improving their waste management strategies, Intel hopes to provide more jobs for the community through the recycling company, Servicios Ecológicos, as well as decrease the amount of waste that is being sent to the landfill.

Currently, Intel donates all of their recyclables to Servicios Ecológicos, where the materials are sorted through manually. Servicios Ecológicos donates a percentage of the material to the local schools in the area and sends the rest of the materials that can not be recycled there to companies in Central and North America for a profit. The recycling company has created a program that employs single mothers and their children to work at home and separate materials, which are then left on the curb for pickup. They are focused on helping the community and providing jobs to people that need them. The

main problem they face is that there is a lack of market and technology for them to recycle all of the waste.

We spoke with Sergio Musmanni of CNP+L to assess whether or not there is a market for recycling in Central America. He told us that there was not a current market for recycling within Central America or Costa Rica. A few weeks later, our professors, Arthur and Susan Vernon-Gerstenfeld, asked Sr. Musmanni for information regarding a recycling market and were provided with brochures and magazines with information on Mercado de Residuos Subproductos Industriales (MERSI), a recycling market, created for South and Central America. This market is made up of a database that companies can use to buy or sell materials that they do not need. Aside from searching for a regional market, we thought it was necessary to research companies in the United States that recycle materials that are not able to be recycled in Central America. With this information, we provided Intel with the types of materials each company accepts, where they are located and their contact information. Through this valuable information, Servicios Ecológicos will be able to contact the companies within the United States for information on the newest technologies and procedures for recycling. This will help the company expand and to provide more jobs for the community.

Specifically at Intel, the two areas that can be improved upon are the areas of cafeteria and construction and demolition waste. The company is concerned with these wastes because they are building new facilities and waste will be increasing.

The main problems that Intel is facing are the segregation of waste and keeping records on the materials used during construction. Inside Intel, there is no motivation to have their employees segregate trash, which is especially important for optimal recycling. They do not segregate the construction waste or the inorganic food from the organic food.

Segregating the construction materials is crucial to make the recovery process more time efficient and safer for the recycling contractor. At the moment, the recycling contractor has to climb into the dumpsters and manually recover the materials that can be recycled. We have proposed a solution to this problem by suggesting the use of color-coded dumpsters that are specific to a certain type of material. For example, the green dumpster can be used for wood, the red for metals, etc. Clear signs will be placed on the dumpsters to make sure that each employee knows what material goes into which dumpster. To make sure that segregation is being done, we proposed that a manager be appointed to audit the amount and type of waste being produced. In effect, we provided Intel with a methodology of best practices for reducing construction waste using examples from worldwide construction corporations such as Consigli Construction to help make improvements within the construction waste management area possible. The best practices were based on the waste management hierarchy, focusing on source reduction. When source reduction is practiced, less waste is generated. The waste that is generated can be recycled or reused, which Intel is currently doing. As a last result, materials are sent to landfills.

The other problem we had to take into consideration was focused on segregation of cafeteria food. Segregation in the kitchen as compared to segregation in the eating area is the main focus of our project because that is where most of the waste is being produced. The cafeteria waste alone makes up fifty percent of all the waste from Intel that is being sent to the landfill. To make the cafeteria workers segregate the food for composting, we proposed a specific location for the trash bins with the proper signs of which types of food can be disposed in them. When the organic food is segregated from the inorganic food, Intel will be able to compost most of the waste. The organic food (mostly made of vegetable peels and egg shells) alone makes up fifty percent of the total cafeteria waste, and if composted, Intel will save ninety-two tons of waste per year from being sent to the landfill.

Once the cafeteria waste is segregated, Intel will be able to compost. We conducted composting experiments to make recommendations on the proper ratios of yard to sludge to cafeteria waste that should be used. Through the experiment, we could not obtain the proper data needed to assess the proper carbon to nitrogen ratio because we could not find access to a particular type of thermometer. However, we were able to propose specific composting systems based on the amount and types of materials that are going to be used for composting. These composting systems are the WEMI Model 2000™, the Earth Tub™, and the NaturTech™ composting system.

Training Intel's employees is necessary in order to make these recommendations work. Currently, the mandatory training program only features two slides on environmental health and safety. We proposed that Intel make a separate training course focused on what the construction and cafeteria workers need to do in order to help the company improve the waste management program. This program will make them aware of where they place their garbage and get them familiar with the program and the reasons for its implementation.

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CHAPTER ONE: INTRODUCTION

This report was prepared by members of Worcester Polytechnic Institute Costa Rica Project Center. The relationship of the Center to Intel and the relevance of the topic to Intel are presented in Appendix A.

With an increase in population worldwide, waste is accumulating rapidly. There is too much waste being produced for countries to control. The statistical guide to Europe estimated that between 2004 and 2008 global generation of municipal waste will rise by 31.1 percent (http://epp.eurostat.cec.eu.int/cache/ITY_OFFPUB/KS-CD-04-001/EN/KS-CD-04-001-EN.PDF). Each person produces about 4.3 pounds of waste per day worldwide. In effect, countries around the world are not able to manage the waste efficiently; therefore, it is accumulating in landfills. If waste accumulates at this rate over time, there will be less living space and more land will be needed to sustain this waste.

Each landfill can take up as much as 230 acres, and in the Unites States alone, there are thousands (Freudenrich Ph.D., 2005). The excess waste produced affects sanitary and living conditions. Waste generation causes a loss of materials and energy as well as major environmental problems including climate change and a decrease in the quality of surface and landscapes. Pollutants, such as chlorofluorocarbons (CFCs), which are carcinogenic, can be harmful to human health and can cause harm to the ozone. Hazardous substances, such as asbestos, can be released into the environment through waste generation and can be harmful to human health and even carcinogenic.

The ideal solution is to implement a program to recycle all waste worldwide. However, many individuals choose landfill disposal instead of recycling (Reed Business Information, 2004). Moreover, recycling is a time- and labor-intensive process. The other alternative to landfills is incineration, but that has disadvantages as well. Incinerators have the ability to eliminate seventy-five percent of the waste put into them, but they produce air pollutants, and incinerators are often not permitted by the local community. Pollution has been increasing so rapidly that many individuals and companies choose to recycle.

Costa Rica is currently in the beginning stages of educating individuals and organizations about their increasing waste, and companies, such as Intel, are working to implement recycling programs. Many companies, including Intel, have been active in informing the community of recycling methods. According to Intel, Costa Rica is limited in their recycling abilities because there is a lack of technology and the market for recycling is small.

Currently, Intel recycles sixty-five to seventy percent of its waste; however, planned increases in construction and employee population will likely result in an increase in excess waste (Intel, 2005). Intel is growing rapidly and is building a new facility for assembly and testing of microprocessors. Due to an increase in construction, Intel is producing more construction and demolition waste. Construction waste is responsible for thirty percent of all landfill material in the world (Reed Business Information, 2004). By increasing the population of Intel, not only has construction waste increased, but cafeteria waste has increased as well. Intel wishes to explore the possibility of creating a program to manage their excess waste.

The main problem in reducing construction and demolition and cafeteria waste is that the recyclable materials are not being segregated from the non-recyclable materials. The employees of Intel, Costa Rica are not informed well enough in recycling practices or about the reasons why recycling is beneficial to them as well as to the environment. Segregation of food is an issue in the cafeteria because it is necessary so that composting is possible. The inorganic waste and the used oil have to be segregated from the organic waste. As for construction and demolition waste, there also needs to be segregation in order to recycle.

Our goal was to assist Intel by giving a proposal to reduce the volume of waste that Intel sends to landfill focusing on cafeteria and construction waste. We proposed a composting system, which utilized the organic waste as fertilizer. We also created a methodology for keeping records of the amount and types of materials that are sent to the landfill during construction. This method records the amount of waste that is disposed of after each project to indicate whether or not the project has been efficient in the use of materials. We recommended various options to be implemented by Intel in order to increase the company's waste management efficiency.

CHAPTER TWO: BACKGROUND INFORMATION

Many companies in the world are starting to take charge of their waste management practices due to environmental awareness and, for some, because they participate in the ISO14001 program, an internationally recognized set of standards, (refer to Appendix A for rules and procedures) and are made aware of environmental effects. In order to manage waste efficiently, such as organic and construction and demolition waste, there needs to be an understanding of the types of technologies available and the different recycling options that are available to the companies. Organic waste and construction and demolition waste affects our environment on a global scale. Recycling, the process and technologies for composting, and the current methods of educating individuals to be environmentally aware are essential.

WASTE MANAGEMENT

As the population in the world expands, so does the waste that is being produced. In 2004, the Global Waste Management Market Report estimated that the total amount of waste generated would be 1.84 billion tons, which would be an increase of seven percent from 2003 (http://www.researchandmarkets.com/reportinfo.asp?report_id=72031&t=e&cat_id=13). The main method for disposal is to send the waste to landfills. The outcome from sending waste to landfills throughout the years is a decrease in land area and an unattractive atmosphere. Landfills can also have complications, such as leaks, that can contaminate the ground (http://www.stopwmx.org/liner.html#documentefd). There is less space available for living in the world and are odors due to landfills. Landfills are not ideal for populated areas, because people do not want to live in a place that is taken up by unattractive garbage, smells, and pollution.

WASTE MANAGEMENT IN COSTA RICA

Everyday in the San Jose Metropolitan area, 1,400 tons of waste is produced. Currently, it is the responsibility of the Municipality to handle the waste from residence, commerce, industry and open areas. There is neither waste segregation being done nor being urged. In 2002, sixty percent of all waste was going to landfills. Solid wastes are disposed of in three areas: Rio Azul, La Carpio, and Los Mangos (http://www.sanjosemetropolitano.org/ModEstudios/GuiaSEAM/ELR_GS_ING_Waste.htm, 2002)). In Costa Rica, there are often dumps rather than landfills. Usually, in the dumps, leachate systems are not used and there are no synthetic liners to protect the earth from contamination. Leachate is water that contains pollutants that leaks from disposal sites (wlapwww.gov.bc.ca/wat/wq/reference/glossary.html, 2001). In landfills, waste is safely regulated with liners to prevent leaking of waste water into the environment. Therefore, a number of environmental health risks are associated with the dumps. A major issue with such dumps is that waste pickers are often there.

There are a number of factors that are responsible for the lack of recycling in Costa Rica. According to the Plan Nacional de Manejo de Desechos, there is incomplete legislation, improper management of solid waste and lack of institutional policies for the recovery of recyclables (http://www.unep.or.jp/ietc/ESTdir/Pub/MSW/RO/Latin_A/Topic_e.asp). Most Costa Ricans have not yet developed the habit of separating their waste, and in addition, there is not a system in place to handle the waste if it were to be segregated. In the province of

Heredia, where Intel is located, a private company, Waste Professional Processor (WPP), is responsible for receiving and processing the waste produced.

COMPOSTING

Organic waste is produced wherever there are human beings, and, in industrialized countries, the amount produced is increasing rapidly. Organic waste consists of food waste, agricultural waste, and human and animal waste. Organic waste can often be hazardous when disposed of in landfills because of the leachate that forms when it is broken down by micro-organisms. Leachates, which include nitrates and heavy metals, are materials that are unsuitable for composting. They can leak during heavy rain or during a surplus of moisture. Leachates contain bacteria and rotting matter and can create a serious problem if they leak into the water system. Organic waste in landfills can also generate methane, which can be a potentially harmful greenhouse gas if released into the air (http://www.itdg.org/docs/technical_information_service/recycling_organic_waste.pdf).

Composting has become an effective way to manage organic wastes that would usually be sent to the landfills. It is an alternative that helps prevent the growth of landfills and helps improve the appearance of the surrounding natural environment. It consists of food scraps that can be combined with sludge, paper, and yard clippings to create nutrient-rich food for the environment.

There are two types of composting: aerobic and anaerobic. Aerobic composting needs oxygen to function properly, while anaerobic does not. Both of these types of composting contain different types of bacteria that help to breakdown organic waste.

Anaerobic composting, known as digestion, is mainly used to decompose untreated wastewater, which cannot be treated by aerobic processes (Bourgault et al, 2005). Anaerobic composting breaks down organic waste without having to control the temperature or moisture content. Though no maintenance is needed for this type of composting, it can take months for the process to be complete, while aerobic composting can take as little as a week. Moreover, the bacteria found in anaerobic compost produce toxic gases such as methane, hydrogen sulfides, and ammonia (Bourgault et al, 2005). The most common form of composting is the aerobic, or thermophilic composting, due to the thermophiles that breakdown the waste. Thermophiles are microorganisms that develop the most at high temperatures (www.uri.edu/ce/ceec/food/factsheets/glossary.html, 2000). In the aerobic composting process, particular levels of heat and moisture must always be maintained for optimal results. Thermophiles work best in a 60°C environment and require a certain carbon to nitrogen ratio (also called C: N ratio) of 30:1 to flourish. If the aerobic composting is properly maintained, the process should be complete in about a week (Bourgault et al, 2005). The high heat that is produced during aerobic composting kills the pathogens, which is the reason why companies can sell this type of compost without regulatory action to anyone for home or industrial use (Bourgault et al, 2005). The total benefits of aerobic composting make it an ideal option for composting at Intel, Costa Rica.

Composting Systems

There are various composting systems available. Systems are chosen based on composition and quantity of the material as well as the cost efficiency. The two main types of composting systems are in-vessel systems and windrow systems.

In-Vessel System

In-vessel systems are automated systems enclosed in a container (NRAES, 1992). They can be either vertical or horizontal. The in-vessel systems greatly range in technology and advancements. They allow for more control of the in-vessel system and reduce the amount of land needed for composting. The in-vessel systems also offer protection from pests that might infest compost as well as reducing, if not eliminating odor. The operating cost for in-vessel systems is low. Unfortunately, though, the capital cost is very high.

Windrow System

Windrow systems are simple piles of waste that decompose and produce a significant amount of composting. The effectiveness of windrow systems is based on the mixture's porosity. The right amount of porosity is essential so the pile will not have too much odor or heat and moisture loss. Oxygen is provided through the rotation of the compost. Depending on density, the size of the composting system will be 90-360 centimeters high and 300-610 centimeters wide (NRAES, 1992). Windrow systems will compost for approximately ten to fourteen weeks. There are a few disadvantages to the system. Leachates can be produced, leak into the groundwater and contaminate it. Also, rodents often infest the compost. Although the windrow system has a lower capital cost, it requires land and labor so the operating cost is much higher.

CONSTRUCTION AND DEMOLITION WASTE

Construction and demolition (C & D) waste is composed of unnecessary or useless materials created from construction, renovation, and demolition. According to the Solid Waste Association of North America, C & D waste can be broken up into five categories; roadwork, excavated, building demolition, construction and renovation, and site clearance (American City & County, 1994). Roadwork waste includes asphalt, paving material, concrete, and earth fill. Excavated waste consists of earth, sand, soil, and stones. Building waste incorporates concrete, steel, plumbing fixtures, mixed rubble, and timber. Construction and renovation wastes include wood, shingles, roofing, ducts, pipes, insulation, dry wall and carpets. Finally, site clearance waste consists of tree stumps, earth, and brush.

Unfortunately, many materials become C & D waste because it is easier to dispose of the material than it is to recycle it (American City & County, 1994). C & D waste is difficult to segregate in a cost and time efficient manner. If the waste is not segregated, it is challenging to recycle and, for that reason, it is put into landfills.

C & D waste takes up fifteen to thirty percent of municipal waste in the United States (http://www.cecer.army.mil/td/tips/product/details.cfm?ID=120&TOP=1). What does not get recycled, goes into landfills. In 2001, there were 1,858 operating landfills in the United States alone (http://www.epa.gov/epaoswer/non-hw/muncpl/pubs/msw2001.pdf). C & D waste keeps accumulating and the area for landfills keeps decreasing.

REDUCE, REUSE, RECYCLE

According to the United States Environmental Protection Agency, the amount of waste produced by each individual has nearly doubled over the past thirty-five years. It is commonly accepted that the most effective way to stop this trend would be to prevent waste in the first place, which is known as source reduction. Source reduction is the designing, manufacturing, purchasing of or using materials in ways that will reduce the amount of toxicity or waste being created. Reusing items is another way to stop waste at the source because it also avoids putting the item in a disposal system. When source reduction and reuse are not an option, recycling is the next best step to take. This method is known as the principle of the three R's: Reduce, Reuse, Recycle.

The reduction takes place before the materials have been identified as waste. It is a preventative measure to reduce the amount of waste that will be produced. The method of reducing saves materials as well as energy, and removes the need to dispose of materials because it will not be created. Once a product has been manufactured, the decisions made to improve the environmental impacts cannot be changed (Bullock, 1995). Source reduction saves natural resources, reduces waste toxicity, and reduces the cost over time. Moreover, by doing so, it benefits the community, businesses, and consumers. Many communities in the United States have "pay-as-you-throw" programs, in which the people of the community pay for each trash bag they put out for disposal opposed to a flat fee. If the members of the community were to use the method of reduction, they would have less trash and therefore lower trash bills. In the business community, reduction would also save money. By reducing supplies, the business would be able to manufacture its product with less packaging, therefore using fewer materials. When a business saves money, it allows them to sell their product for less and that allows the consumers to save money as well. If Intel is able to reduce at their source, they will save money for themselves and that allows the consumer to save money as well. After the product has been manufactured, the method of reducing cannot be applied, and therefore, one might try to reuse the product.

Reuse means that a material or product is used more than once for any purpose (www.earth911.org). Reuse consists of taking what is deemed unusable and, without significant processing, creating a usable material. A study by Minneapolis-based URS Corporation concluded that nearly half of all construction waste that currently goes into landfills could be reused through onsite grinding and recycling (Johnson, 2003). For example, after wood is taken out of the structure, it can be broken down and used for landscaping mulch. If an individual or organization is unable to reuse a product, they can choose to process it in order to recycle the item.

Recycling is a series of treatments for used materials in order to use them again and save resources. Individuals and organizations implement this process in order to reduce their waste disposal. Recycling turns used materials, which would otherwise be put into landfills or incinerators, into new resources and products. This process carries environmental, financial and social benefits. For example, steel is one of the most recycled materials in the world. Steel's mechanical properties allow it to take different forms. A steel I-beam that may have held a building together can be recycled into a cans.

Recycling is a continually growing trend in the construction and demolition industry due to tougher regulation of landfills as well as possible future financial benefits. Landfill fees continue to rise, giving companies incentives to find alternatives (Reed Business Information, 2004). Whether or not a company will make a profit, break even or lose money, due to recycling, has a large impact on the recycling programs, in which they will participate. According to the Construction Industry Federation, once companies learn to segregate and recycle waste they will become more cost efficient (San Diego Business Journal, 1992).

Non-Recyclable Waste Disposal

If a material cannot be reused or recycled, then as a last resort, it could be incinerated to prepare for final disposal. Incinerators are the main alternative to landfills due to their ability to destroy nearly seventy-five percent of the waste put into the incinerators. During the incineration process, waste is heated to an extremely high temperature until it is burnt to ashes. There are incineration plants whose sole purpose is to eliminate waste and there are co-incineration plants whose main purpose is to use waste as fuel to generate energy. While incineration will inevitably eliminate waste, it can have adverse affects on both the environment and human health. For example, pollutants emitted in the air result in acid rain and possible climate changes (Ares and Bolton, 2002).

While incineration reduces the amount of waste, the ashes of the waste will eventually still end up in a landfill. The majority of construction and demolition waste is put in two types of landfills: municipal or those specifically made for C & D waste. In 1998, there were nearly 8,000 landfills, but that number decreased to less than 2,000 by 2001 (http://www.epa.gov/epaoswer/non-hw/muncpl/pubs/msw2001.pdf). A 1994-1995 waste study found there to be 1,800 U.S landfills that are willing to take C & D waste, but the number has decreased in the last decade (Reed Business Information, 2004). This means the need for recycling of C & D waste is only increasing.

RECYCLING METHODS

There are several options that a company has in order to have a successful waste management program. First, the organization could be aware of what is being disposed. By looking through the waste, a company can see what materials it did not use and the company can be more efficient purchasing materials. Some companies have started to have the subcontractor order the needed materials. If the organization is paying for all the materials, the subcontractors are free to purchase excess materials, but if it is coming out of their budget they are more inclined to only buy what is necessary. Therefore, the waste is reduced.

Several companies replace dumpsters with fences, either wire or mesh. This way the company can view what is being disposed of and make sure the workers are following the proper regulations. The company can have designated areas or containers for different types of waste so that they do not have to sort through it later. C & D waste can be divided into items that are recyclable and items that are not. Inert waste can be segregated and reused or recycled into fill material. Land waste can be reduced, reused, or recycled into mulch or compost. This separation can save the organization time and facilitate recycling (http://www.bae.ncsu.edu/programs/extension/publicat/wqwm/ag473_19.html).

The next step could be to re-use as many of the materials as possible. A great deal of construction waste can be re-used. Many materials can be reused by the company who produced them or can be given to another company or community who could benefit from them. Table 1 shows different ways that materials can be reused.

Table 1: Material Reuse

Material	Reuse
Insulation	• Can be used in attics • More rigid insulation can be placed under concrete floors
Somewhat damaged finished products	• Can be donated to non-profit organizations • Can often receive a tax reduction for the donation
Clean carpet	• Can be used in another complex
Vinyl flooring	• Can be used in another complex
Masonry	• Can be used as inert fill and put under driveways and sidewalks
Concrete	• Can be used as inert fill and put under driveways and sidewalks
Bricks	• Can be used as inert fill and put under driveways and sidewalks
Drywall	• Filler pieces

*information provided by: http://www.bae.ncsu.edu/programs/extension/publicat/wqwm/ag473_19.html

Materials that cannot be reused may be recycled. Many materials can be transformed into other useful materials. Table 2 shows the different ways various materials can be recycled.

Table 2: Materials That Can Be Recycled

Material	Recycled Into
Wood	• Mulch • Animal Bedding • Compost • Boiler fuel
Drywall	• Gypsum board can be ground and recycled into new drywall
Cardboard	• Used again as cardboard, usually boxes (e.g. cereal, tissue, etc.)
Vinyl	• Window frames • Electrical boxes • Cooling tower fill • Floor mats • Pool liners
Some Metals	• Scrap metal yards will take them
Concrete, Bricks, Tiles	• Ground and used as aggregate
Glass	• Fiberglass • Sand replacement for paving material
Asphalt shingles	• Paving • Pothole repair
Some Plastics	• Used again as plastic (e.g. toys, pipes)

*information provided by: http://www.bae.ncsu.edu/programs/extension/publicat/wqwm/ag473_19.html

After the organization recycles, they can publicize their environmental friendliness to the local community and businesses. Not only can the company achieve a good reputation, but they can also be a role model. In effect, other people will follow suit and organize recycling programs as well (http://www.smartgrowth.org/library/resident_const_waste.html).

The organization can donate many materials that are still of usable quality to the community and to other businesses, which creates good community relations. For example, the company can donate lumber and other building materials to the community.

EDUCATION

One of the most important aspects of recycling is education. It is necessary for people to learn how waste can affect the environment and the importance of recycling. Schools can educate students using the three R's program; reduce, reuse, recycle.
The Solid Waste Authority of the United States has a program that includes classroom presentations and tours of recycling and landfill facilities (www. waynetwplandfill.com).

The first Recycling Awareness Week started in Oregon in 1986 to raise public awareness of recycling. Along with many other states Oregon promotes recycling and buying recycled materials. Recycle Awareness week is usually held mid November, close to November 15, which is National America Recycles Day. America Recycles Day began in 1997 in order to encourage Americans to recycle and to buy recycled products. The goal of the day is to build awareness and the importance of recycle (http://www.americarecyclesday.org/Press/press.html). The U.S. EPA, as well as other organizations, offer awards and scholarships for individuals who choose to recycle.

Intel Costa Rica has been educating the community of Belén on recycling. They have developed an Environment, Health and Safety (EHS) community awareness program in which they hope to get other companies and organizations involved to improve the community even further. They have developed an EHS handbook which is distributed in schools and discusses the environment (Intel, 2005). Intel is involved in creating environmental awareness in the community, but in order to make the programs work, there must be incentives. In the future, they hope to create a program with C & D waste, which we will explore through our project.

In the C & D industry, the on-site workers should know how materials will be segregated, where materials should go and how often the materials will be collected and delivered to the appropriate facilities (http://www.metrokc.gov). It is necessary to involve sub-contractors so they will know where the on-site recycling is and how it works. Education plays a large role in preventing waste and practicing recycling in this industry.

CHAPTER THREE: METHODOLOGY

The goal of this project was to assist Intel, Costa Rica to reduce the volume of waste being sent to the landfill. We developed a methodology made up of the best practices in the construction industry to improve their construction and demolition waste management. As for the cafeteria waste, we proposed a composting system that would suite the needs for handling the cafeteria, sludge, and yard waste. In order to accomplish this, we had to:

- Assess the volume of construction and demolition waste and cafeteria waste that is generated
- Define the problems that Intel faces with recycling the cafeteria and construction and demolition waste
- Perform a composting experiment with Intel's cafeteria waste
- Take careful observations of the composting experiment
- Research best practices in the construction and demolition field for material efficiency use
- Research different types of composting systems and procedure

CAFETERIA WASTE ANALYSIS

The first step in designing a plan to reduce the amount of waste Intel Costa Rica sends to landfills was to examine the company's current methods and standards. Upon our arrival, we toured the facility in order to better understand the company's practices. We toured the two cafeterias located in CR2 and CR3 to observe the system as well as problems associated with segregating waste. In addition, we interviewed the cafeteria manager, Marco Esquival to obtain information on the amount and type of food waste generated at the facility. All of our interviews were informal and were conducted on-site in pairs so that one person could conduct the interview while the other took notes on what was being said.

It was important to obtain information on the quantity of waste generated in the cafeteria so we could compare and evaluate the appropriately sized composting systems. The cafeteria subcontractor, Sodexho, weighs the excess food that has been prepared after each meal. Using the records over the first ten days of the month of June, we calculated the amount of money they would save if they were to send the leftovers to the compost.

With the data Sodexho gave us, we added the weight of the leftover food over the course of the ten days. Then, we found the average amount of waste produced per day, multiplied it by thirty and then multiplied that product by twelve to find the average for the whole year. We also reviewed their records for the past five months and took the average weight of the waste that was created during the preparation of the meals, which consisted mostly of vegetable peels and egg shells. We considered this an accurate sample because the information we received spanned almost half a year. With the data from the leftovers and the food from cooking, we were able to determine the total savings of disposal that Intel will make if they decide to compost.

We then interviewed Christian Garbanzo, from Doctor Verde, the contracted company that handles both the wastewater sludge as well as the yard waste. He provided us with the records on the amounts of sludge and yard waste produced every week. Doctor Verde is currently using the sludge and the yard waste for composting all over the Intel site. We used the records provided to us to determine the size of the composting system. We determined what size the composting system should be by the total volume of waste that is created by the sludge, cafeteria waste, and yard waste per day.

COMPOSTING EXPERIMENT

In order to determine the best carbon to nitrogen ratio of food, yard and sludge waste we conducted a small scale composting experiment. The major problem our group faced was the lack of segregation in the cafeteria waste. In composting, only organic cafeteria waste can be used. At Intel, inorganic waste such as plastic and paper packaging are put into the same containers as the organic waste. For us to conduct our experiment, it was necessary to sift through the waste by hand in order to yield a more ideal composting situation. The sludge and yard waste were provided fresh by the landscaping contractor company, Doctor Verde. After our preliminary research, we had concerns about the environmental constraints involved in using sludge waste in composting systems. Fortunately, Intel conducts regular laboratory testing on the wastewater sludge to meet local as well as ISO14001 standards. ISO14001 standards are explained in Appendix A.

Currently, the company puts all sludge waste into the ground to fill holes in their facility. We followed the procedure developed by another WPI project team, who did a project for McNeil in Puerto Rico in 2005. We created five different mixtures and observed which one decomposed at the fastest rate. Based on our preliminary research, we expected the bucket with the most food waste to decompose the fastest. We used ten gallon buckets with holes in the bottom for drainage. Each bucket contained six parts by volume as shown below in Table 3.

Table 3: Compost Ratios (Parts by Volume)

*Yard waste is composed of grass clippings, leaves, and branches collected from the Intel site

	Sludge	*Food*	*Yard**
Bucket 1	6	0	0
Bucket 2	2	2	2
Bucket 3	1	1	4
Bucket 4	0	3	3
Bucket 5	1	3	2

The buckets were covered and located outside away from the facilities at Intel. Buckets one and four were used as control buckets, containing six parts sludge and half food/half yard waste respectively. The other three buckets differed in ratios to provide a range of options to see which condition provided the best ratio for composting. We made observations daily and turning of the compost was done weekly. Unfortunately, we were unable to find out if the composting reached its optimal level because the proper thermometer was unavailable.

ANALYSIS OF COMPOSTING SYSTEMS

As discussed in our background, composting systems are either windrow or in-vessel. We discovered there are numerous composting systems available. To begin, we developed two criteria for the system that should be used by Intel; the system should be in-vessel and should be small in size. We developed these criteria after our composting experiments had been performed. In our composting experiment, we found that a windrow system would not operate efficiently at Intel. The first day we started our composting experiment, we left the buckets uncovered and noticed the next day that the compost had dried. After seeing this, we made the decision to cover the buckets with plastic sheets to hold the moisture in, which is ideal for aerobic composting.

Next, we took into consideration the quantity of waste produced at Intel. Many industrial systems are equipped to handle over fifty tons of waste per day with as much as

500 tons being processed in the largest systems. Intel is a large company. However, the amount of waste generated per day is in the range of one to five tons.

We compiled a list of possible systems that met our criteria and investigated them more in depth. We investigated three specific systems. They were the Earth Tub, NaturTech, and Wright Model 600. First, we calculated the initial investment to buy the machine. We then determined the amount of waste that would be composted opposed to being sent to landfills

CONSTRUCTION WASTE ANALYSIS

As stated earlier in our methodology, designing a plan to reduce waste required us to examine the current methods and standards of waste generation at Intel. We began by touring the area that will be the construction site. Next, we interviewed two project managers, Shane Cheatham, who is the project manager on Intel's side, and Fernando Melo, who is the project manager on the contractor's side. Unfortunately, our waste analysis was not able to be completed because there was a lack of records. For example, Intel had no records on the amount of materials they used in prior projects, nor records of the cost for the materials used. There was also no record of the amount of material used per unit of area or the amount of waste produced from each project, which was crucial to construct a material efficiency indicator. In addition, we were not able to investigate the current construction waste because the site is in the preliminary stages of being cleared for construction and no one could provide information on the size of the building that is to be constructed, such as the cubic area. We only found estimates which differed from person to person.

CONSTRUCTION BEST PRACTICES

More companies worldwide are practicing new construction and demolition waste management techniques due to the increase in tipping fees at landfill facilities. We compiled a list of various agencies and companies that are regarded as leaders in the construction industry. The companies were regarded as leaders due to the recognition they have received through various awards (refer to Appendix G). In addition, we researched different state and country agencies. We contacted the companies, who provided us with information regarding the manners in which they dispose of waste. We researched the models that they follow to achieve high recycling rates in a cost efficient manner. In turn, we developed a model for Intel to follow to achieve similar results.

We investigated Intel's current construction waste management practices through interviews to compare to the model we developed. This was necessary to find out what Intel would need to get from their current practices to what has been deemed best practices. It was important that we did not increase cost significantly in order to increase recycling rates. The model of best practices we created was based on the waste management hierarchy (see Data Analysis and Results), which mainly utilizes the method of source reduction. Source reduction is often associated with increased labor cost.

RECYCLING CENTER

Servicios Ecológicos is the recycling contractor for Intel. We held an informal interview with Pedro Zolano, an employee of Servicios Ecológicos. He was able to tell us what materials have been recycled during past construction projects for Intel. Unfortunately, he was not able to provide us with records of the materials recycled. We assumed he is knowledgeable in the information he provided because we were told by

Erika Diaz to speak with him. He was also able to provide information associated with problems concerning the current waste management practices, which are mostly due to the lack of resources of his company.

In order to investigate the existence of a market for the material Intel would recycle, we contacted CNP+L, a non-profit organization. We spoke to Sergio Musmanni, the head of CNP+ L Company in Costa Rica to find out if they had knowledge or contacts for a market for construction waste. To locate potential markets elsewhere, we researched recycling companies within the United States using the recycling database, RecyclingMarket.Net.

CHAPTER FOUR: DATA RESULTS AND ANALYSIS

After conducting waste analysis in cafeteria and construction waste, we analyzed the data and researched various methods associated with waste management in the previously mentioned areas. The following chapter reflects the information we gathered.

CAFETERIA DATA

At Intel, garbage is collected daily. The company is currently paying approximately 1,010,000 colones ($2,000) per month to dispose of their garbage for all the Intel Costa Rica facilities. This fee includes renting the dumpsters and paying the contractor to dispose of the garbage in the dumpsters (see Table 4). They pay 5,700 colones ($10[1]) for each ton of garbage removal. In the month of May alone, the cost for disposal of the cafeteria waste was 379,758 colones. Of the 29.950 kg from the total disposal (Table 4), the cafeteria produced 12.940 kg (Table 7).

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[1] We used the current exchange rate at about 475 colones to the dollar in order to convert colones in to United States currency (June 25, 29005).

Table 4: Total Cost of Disposal for Waste for all Intel Facilities in the Month of May

Service	*Cost*	*Quantity*	*Total Cost (colones)*	*Total Cost (dollars)*
Rental Fee for Compactor	122,000	2	244,000	513.68
Rental Fee for Dumpster 18m^3	28,000	4	112,000	235.79
Rental Fee for Dumpster 3.4m^3	5,000	0	0	0
Trips to the Compactor/Opening it	23,000	21	483,000	1,106.84
Trips to the Dumpster 3.4m^3	120,000	0	0	0
Final Disposal	5,700 per ton	29.950 tons	170,715	359.40

Total Cost (colones)	***1,009,715***
Total Cost (dollars)	***2,215.71***

Figure 1, shown below, shows data of the number of trips that WPP, the waste disposal contractor, made to each facility to empty the trash bins each month. With more construction increasing due to the addition of new assembly and test buildings, so is the total amount of waste and the number of trips that have to be made, which means that Intel will be paying more for the disposal of garbage if they do not find an alternative for disposing their waste. With an increase in the number of pickups, the cost rises as well.

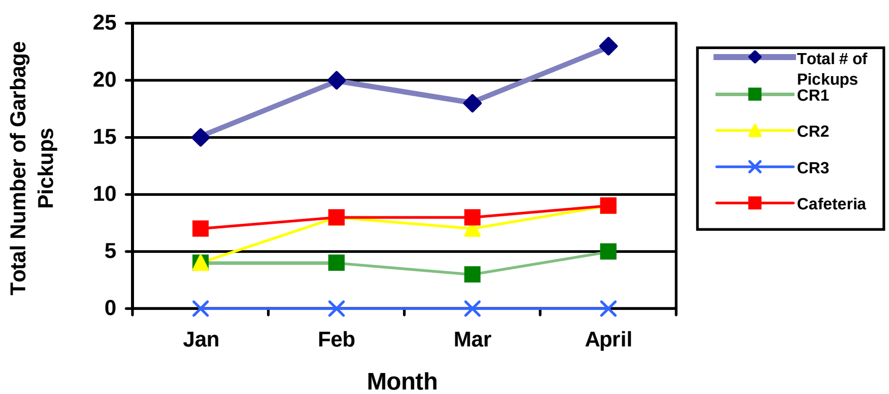

Figure 1: Total Number of Pickups per month

This Figure shows the number of times garbage that was collected from each building within the facility. CR1, CR2, and CR3 are the names of these buildings. The main cafeteria is located in CR3, where all the leftovers from the cafeteria in CR2 are sent. For the exact numbers in this graph, refer to appendix D.

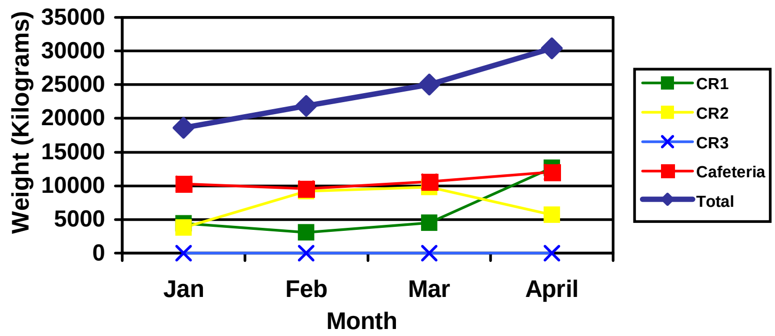

Figure 2: Weight (kg) of Waste per Month

Figure 2 gives information on the amount of weight of trash that was picked up at each facility at Intel. The figure shows that the total weight of garbage is increasing each month due to construction and the increase in workers at Intel. For the exact numbers presented in this figure, refer to appendix D.

In order to find out the exact cost per month for only the disposal of garbage, we converted the units of kilograms into tons, where: 1 ton = 907.1847399 kg

Table 5 shows the weight converted to tons. This unit conversion was necessary to calculate the cost of disposal, which is measured in colones per ton. We used the weight in tons and multiplied it by 5,700 colones to get the total cost of disposal for every month at each building in the Intel Facility. The cost does not include the renting fees or the other types of services.

Table 5: Weight (Tons) of Waste Collected per Month

	Jan	*Feb*	*March*	*April*
CR1	4.9	3.4	5.0	14.0
CR2	4.2	10.1	10.8	6.3
CR3	0	0	0	0
Cafeteria	11.4	10.5	11.7	13.2
Contractor	0	0	0	0
Total	**20.5**	**24.0**	**27.5**	**33.5**

The areas in Table 5 are highlighted to emphasize the amount of cafeteria waste. It makes up about half of the total garbage that is sent to the landfills. Table 6 emphasizes the large amount of money that is spent on disposing of the cafeteria waste alone.

Table 6: Cost of Disposal per Month

¢57000/ton				
	Jan	*Feb*	*March*	*April*
CR1	27,930	19,380	28,500	79,800
CR2	23,940	57,570	59,850	35,910
CR3	0	0	0	0
Cafeteria	64,980	59,850	66,690	75,240
Contractor	0	0	0	0
Total	**116,850**	**136,800**	**155,040**	**190,950**
($12/ton)				
CR1	58.80	40.80	60.00	168.00
CR2	50.40	121.20	129.60	75.00
CR3	0	0	0	0
Cafeteria	136.80	126.00	140.40	158.40
Contractor	0	0	0	0
Total	**246.00**	**288.00**	**330.00**	**401.40**

According to Figure 2 on page thirty-one, which depicts the weight of garbage per month, waste from the cafeteria is the majority of waste collected in the months of January through April. It makes up approximately forty-five percent of the total waste sent to the landfill. There are forty-seven tons of cafeteria waste and 106 tons of waste overall. The average cost per month for the disposal of cafeteria waste is 66,690 colones or $117.

Every day the leftover foods from the cafeterias are retrieved and weighed in order to measure the amount of excess food that was made. It is then sent to the garbage and then taken to the landfill. Taking data over the course of ten days, we found that the average amount of cafeteria waste produced per day is 36.74 kilograms. This means that approximately 1,102.2 kilograms of waste is produced per month and 13,226.4 kilograms is produced per year. If the 13,226.4 kilograms of leftover food were composted instead of being sent to the landfill, Intel would save approximately 83,104 colones per year. The calculations are shown below.

Amount of leftover food waste produced

36.74 kg/day x 30 day/month = 1,102.2 kg/month x 12 month/year = **13,226.4 kg/year**

13,336.4 kg = **14.5796 tons**

As indicated earlier, it costs 5,700 colones per ton to dispose of the garbage. Therefore, **5700 x 14.5796 tons = 83,100 colones** (rounded to the nearest hundred) will be saved **every year** if the 14.6 tons of food is composted. In dollars, 83,100 colones ÷ 475 colones/dollar = **$175/year** saved in the disposal of leftover food. This is approximately 1/10 of the total cafeteria waste, not including the waste generated while cooking. This can make a big difference in terms of the weight of trash not being sent to the landfill. There would be 14.6 tons of waste that would be prevented from going to landfills. If Intel can save this much garbage from being sent to the landfill, in a few years, they would have saved a great deal of space that would have been consumed. In the month of May alone, twenty-one trips were made from the compactor, measuring $15m^3$, for disposal.

The above calculations do not take into account the large amount of food waste that is produced while preparing the food. The majority of the waste that is produced while cooking consists of vegetables and egg shells. We received data from the past five months of the total weight of the vegetables and egg shells generated while preparing the food. All of the vegetables and egg shells can be used for composting, resulting in less waste going to landfills, which allows Intel to save on disposal costs.

As for the garbage produced while preparing the food, vegetable peels make up most of the weight. Some of the vegetable peels that produce a bulk of the waste are from lettuce, carrots, potatoes, yuccas, watermelons, papayas, and bananas. The data we have averages the weight of the vegetables and egg shells to make up fifty percent of the total cafeteria garbage that is disposed (see appendix C). This is about 77.64 tons of waste per year through cooking waste.

Amount of food waste produced while preparing food

12.940 tons/month x 50 percent = 6.47 tons of vegetable waste/month

6.47 tons x 12 months = 77.64 tons/year

77.64 tons/year x 5700 colones/ton = **442,548colones/year saved**

Adding this to the leftover food savings, Intel will save **525,652 colones** ($1,107) per year. **Ninety-two tons** of cafeteria food will be saved from going to the landfill. This is a food waste reduction of **sixty percent.**

Intel's cafeteria throws all of the garbage into the compactor. Table 7, shown below, shows the cost of using the compactor and the weight of the waste produced (final disposal) in the month of May. Besides food, other garbage that is disposed of, in the compactor, includes Styrofoam cups and food packaging, but neither the Styrofoam nor the packaging makes up a significant amount of weight.

Intel Disposal Costs for the Month of May

Table 7: Cafeteria Compactor Costs

Type of Service	*Quantity*	*Price*	*Total Cost*
Transportation	8	23,000 ($48)	184,000 ($384)
Renting compactor 15m^3	1	122,000 ($257)	122,000 ($257)
Final Disposal	**12.940 tons**	**5,700 ($12) Per ton**	**73,758**
		Total Cost	***379,758 ($800)***

Looking at Table 7, the cost for transportation and renting the compactor at the cafeteria, but not including the weight for disposal, is 306,000 colones or $641. The price of renting the compactor is going to be a constant factor and will not change. On the other hand, the number of trips made to dispose of the trash can be reduced. If we assume that approximately $641 is spent per month on transportation and rental fees alone, the annual cost would be $7,692.

If Intel were to send that sixty percent of organic waste produced by their cafeteria to be composted, we can assume that half the number of trips will need to be made for garbage disposal. This would bring the number of trips down to four per month, which means, once per week (Table 8). This means that with the transportation reduction fee, the annual cost is $5,388. Taking the current price for transportation and subtracting the price of the reduced cost, the total savings in transportation is $2,304.

Table 8: Reduction of Trips Made for Disposal Costs

Type of Service	*Quantity*	*Price*	*Total Cost*
Transportation	4	$48	$192
Renting compactor 15m^3	1	$257	$257
Total Cost (month)			**$449**

Total Savings in the Cafeteria

Savings in weight disposal + Savings in transportation = \$1,107 + \$2,304 = \$3,411

The total amount of money that Intel will save in disposal fees alone if they composted all of the organic waste is \$3,411. This is taking the savings of reducing food weight added to the savings of reducing the number of trips made to the site.

COMPOSTING EXPERIMENT RESULTS

Currently, Intel is using the wastewater sludge and yard waste to fill and fertilize the grounds. However, they are sending the cafeteria waste, which is a large part of their waste, to landfills. To reduce the landfill disposal, the company should emplace a composting system for the cafeteria waste as well as the sludge and yard waste.

We conducted our composting experiment for three weeks and found that insufficient composting was the reason for us not being able to determine the carbon to nitrogen ratio. While we were not successful in finding the ratio, we were able to learn about the problems of composting. The buckets were uncovered the first day and they became dried out and did not hold in the moisture necessary for composting. We covered the buckets for the rest of the experiment. In general, the grass and food waste composted quickly. The food waste, with the exception of eggshells, could not be seen three days after we began the experiment. However, the leaves compost very slowly, and have not yet finished composting in the third week.

We expected the first bucket, which contained six parts wastewater sludge, to have a bad odor. However, the buckets (four and five) with the most food proved to have the worst odor. In addition, we found that the bucket filled solely with sludge did not contain many maggots, flies or any other pests, while buckets four and five contained the most pests.

In Costa Rica, the rainy season is from May to November. During this time, a substantial amount of rain falls nearly every day. We had concerns over the accuracy of our composting because of the weather conditions. We would make observations on our compost everyday, frequently having to replace the covers on the buckets because the rain would cause them to come off. By the time we checked the compost in the morning, the sun had dried out the compost containing a large ratio of brown leaves. The other buckets containing more sludge and food waste remained moist. We mixed the waste in each bucket once a week to keep sufficient airflow in the compost for optimal metabolic activity of the aerobic bacteria that need air to break down food.

When the waste in a composting system reaches sixty degrees Celsius, the aerobic microorganisms break down the waste and optimal composting occurs. Unfortunately, we were not able to determine if any of our buckets reached the optimal temperature for composting because we did not have access to an adequate thermometer. We needed a thermometer that recorded temperatures of sixty degrees Celsius and we were not provided with a thermometer in time to use it in the experiments.

While we did not determine the carbon to nitrogen ratio, we did obtain an important finding. We determined that a windrow system would not operate sufficiently at Intel. In addition to the problems associated with rain, we believe that the dry season creates additional problems. Intel Costa Rica lacks proper irrigation systems to keep the compost moist in the dry season, and, therefore, an in-vessel system is the best choice.

SPECIFIC COMPOSTING SYSTEMS

With the results we obtained for the composting experiment as well as the cafeteria waste analysis, we were able to research appropriately sized in-vessel systems. As mentioned in our methodology, we compiled a list of possible systems. We chose to further investigate three systems which we believe to be the most effective for Intel's needs.

WEMI Model 2000

The WEMI Model 2000 was created by Wright Environmental Management, Inc®. It is a rectangular shape between twenty and twenty-four feet long, nine feet high and eight feet wide. It handles waste that accumulates at a rate of one ton per day. A hydraulic bucket takes the material to the top where it goes through a mixer. The bio-filter is located at the top of the system. The system requires a four inch thick concrete base that is thirty-five feet long and twenty feet wide as well as 460 voltage and a half inch water line. The company would provide a three day training period to educate the workers. The system requires the labor of one person for two to three hours a day. A few workers, a plumber and an electrician are needed to install the system. It costs $170,000 without shipping (http://www.wrightenvironmental.com, 2005).

The WEMI Model 2000 is a highly advanced composting system with many advantages. However, it is extremely expensive. The system itself costs $170,000 without shipping or the other necessary requirements. This system would not be cost-efficient for Intel.

NaturTech System

The NaturTech Composting system ranges from a capacity of 40 cubic yards to a capacity of 110 cubic yards holding from 20-55 tons of waste. Its retention rate ranges from fifteen to twenty days composting between 1.25 and 3.67 tons per day of waste. The NaturTech system uses enclosed roll-off or intermodal containers. It uses a centralized mixer and has self-cleaning as well as odor control. The NaturTech system costs approximately $125,000(www.composter.com/, 1996).

Intel produces an average of 0.826 tons of waste that can be composted per day so this system has a good capacity. However, it is very expensive.

The Earth Tub

The Earth Tub™ was created by Green Mountain Technologies® for on-site composting whether it is continuous or in batches. The insulated Earth Tub™ composts 40-200 pounds per day of food, sludge and yard waste as well as some wood chips and shredded papers. The waste is loaded through a hatchway in the cover into the three cubic yard container where it goes through a mechanical auger system which fully mixes the compost. The compost material is then discharged through a side door. The system requires some manual labor to rotate the cover at least twice a week. It is a clean system with aeration and odor control. The system uses a blower to send air through the compost and bio-filter. The composting takes between three and four weeks and the curing takes between twenty and forty days to stabilize. Each Earth Tub™ costs $8,495. Although the Earth Tub is relatively inexpensive, it unfortunately has a very small capacity. Eight tubs would be needed. The Earth Tub does require manual rotation of the cover twice a week for each system. However, it costs significantly less than other systems. For these reasons, we recommend the Earth Tub system (http://www.gmt-organic.com/EarthTub/et-info.htm, 2004).

Even though it will cost Intel approximately $64,000 to invest in the earth tubs, with a saving about $3,400 per year on disposal fees in the cafeteria alone (It will take over 21 years to pay off), they have to make their priorities clear. The question they have to ask is if they want to reduce the amount of food being sent to the landfill in spite of the cost or if they would rather save money and not invest in the composting system.

CONSTRUCTION AND DEMOLITION

Intel is currently constructing an additional building, named CR4. New construction generates a tremendous amount of additional waste and Intel would like to reduce the impact through the development of a new construction waste management plan. In addition, they would like to develop a material efficiency indicator which would allow them to track there waste generation. The following section will provide information on Intel's current waste management plan as well as a formal recommendation to implement a new waste management plan.

Co-Mingled Recycling

We found that Intel is primarily practicing co-mingled recycling. As shown in Figure 3 (Next page)   Co-mingled recycling allows workers to put all recyclable materials into one dumpster. The recycling contractor, then, goes thru the dumpsters and segregates the materials. In many cases, the employees of the recycling contractor do not thoroughly sort through the dumpsters and some materials that are easily recycled go to waste. Therefore, the effectiveness of co-mingled recycling varies, from as little as fifteen percent to as high as ninety-three percent. The capability to recycle and the facility's ability to handle specific materials results in the variation in percentages. In addition, not all construction waste can be put into a single dumpster. For example, in Seattle, it is a violation of the city's municipal code to put more than ten percent of non-recyclable construction waste by volume into a co-mingled recycling container. Often, the only materials that are able to go into a co-mingled container are the ones that the recycling contractor has the ability to handle at their own facility. The benefit of practicing co-mingled recycling is that it saves space. Sites that are limited in area are not able to have multiple dumpsters on-site. Therefore, source segregation is not an option.

Figure 3: Co-Mingled Recycling at Intel

Intel’s Current Practices

At Intel, space is not a problem, but they practice limited source segregation. They have separate dumpsters at their facilities for plastics and cardboards, similar to the one shown in Figure 4.

Figure 4: Segregated Dumpster

However, the segregated containers are not always utilized. The recycling contractors are required to go into the containers everyday in order to segregate the recyclable items that are picked up daily. The recyclable containers are brought to two centers, Santana or Moravia, where they are segregated again. In some cases, the waste is not segregated well enough, and recyclable items are sent to the local landfill. During the construction process at Intel, the materials named in Table 9 are currently being recycled or reused.

Table 9: Materials Currently Recycled at Intel

Material	Handling Method	Action Planned
Cardboard	Recycled (unless contaminated)	Sold to cardboard manufacturer
Plastic	Recycled	Processed at Recycling Center
PBC Pipes	Recycled	
Steel Pipes	Recycled	Sent to Guatemala to be processed
Paper	Recycled	Sold to paper manufacturer
Bubble Wrap	Recycled	Processed at Recycling Center
Styrofoam	Recycled	Made into coolers
Wood	Reused	Given to people in the community
Steel < 2ft in length	Reused	
Steel > 2ft in length	Recycled	Sent to Guatemala to be processed
Nails	Reused	

All other materials generated from construction are sent to the landfill. This includes the materials that are ordered in excess for the site. According to the subcontractor's project manager, when building the main skeletal structure, the concrete and formwork create a lot of excess waste. Formwork is defined as the structure of boards that make up a form for pouring concrete in construction. It is customary to order an extra three percent of concrete, three percent of rebar, and seven percent of debris so that if mistakes are made during construction, additional materials are already on-site. All of the previously mentioned over-order will become waste.

Source-Segregated Recycling

Source segregated recycling requires workers to put select recyclable materials in different containers. For example, when metal is generated, it will go into a specific segregated dumpster and then go directly to the recycling center. Source segregated recycling usually costs less than co-mingled recycling even with the additional labor costs. In addition, it also generally yields a ninety percent recycling rate or higher. Source segregation requires recycling containers to be clearly labeled with acceptable and unacceptable materials.

While source segregation is not practiced on the construction sites at Intel, it is used in the office areas. In every cubicle, there is a general waste container as well as a blue recycling container. Intel has specialized containers in the general areas of the office area as well. The specialized containers have three compartments, metal, paper, and plastics. Each compartment is clearly labeled with a hole shaped to the specific product. For example, the paper compartment is long and thin, while the plastic and metal compartments are circular as shown in Figure 5.

Figure 5: Disposal Containers in the Office Area at Intel

Best Practices for Construction Recycling

After reviewing case studies of companies that have excellent reputations in construction and demolition waste management, we contacted the companies to find out what they were doing to achieve high recycling rates and have been recognized through various awards. Our main contacts included Simons Construction of the United Kingdom and Consigli Construction of Massachusetts (refer to Appendix G). Through the information we acquired, we were able to compile information on the best practices for construction and demolition waste management and create a model based on the best practices.

CONSTRUCTION AND DEMOLITION WASTE MANAGEMENT MODEL

The following model, which we created, is based on the information provided from the various agencies and companies listed in Appendix G which was compiled during the research of best practices of construction and demolition waste management. Many of the best practices are basic.

The management of construction and demolition waste (C&D waste) should follow the waste management hierarchy, as show in Figure 6, beginning with source reduction and ending with landfills as a last resort.

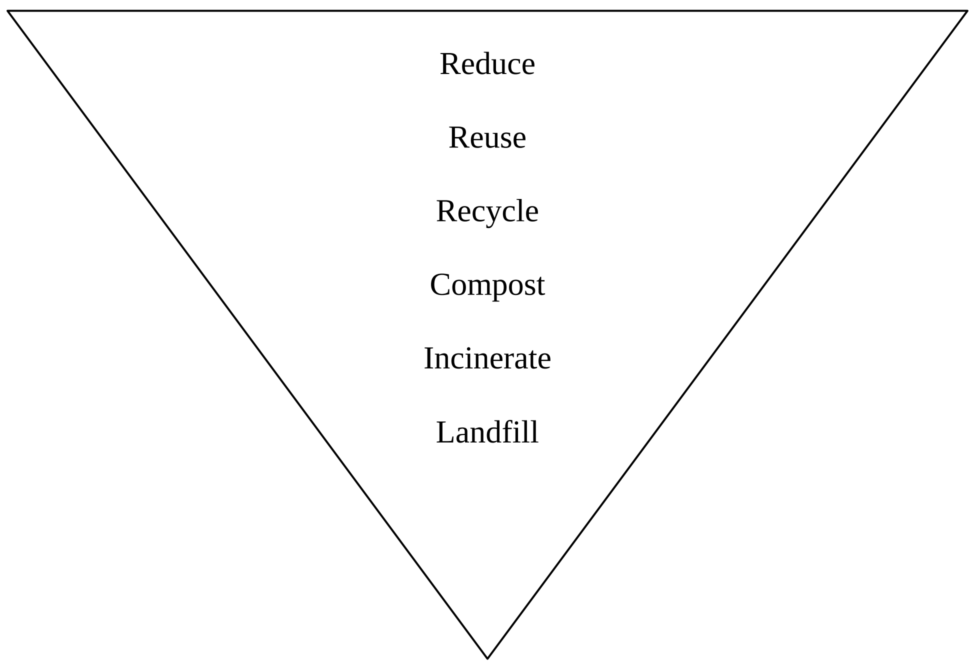

Figure 6: Waste Management Hierarchy (Consigli Construction)

Prevent Waste Generation

A successful program requires that the entire project team be involved; which includes owners, architects, contractors, subcontractors and waste haulers. It is important for all parties involved to know their clearly defined and stated specific roles. The plan we established states waste prevention begins prior to construction, even prior to plans being drawn up. The architect can design to prevent waste. Examples include designing with standard sizes for building materials and designing pre-cast concrete members. When standard sizes for building materials are used, it is not necessary to make cuts. Therefore, less waste is generated. If pre-cast concrete members are used, it would no longer be necessary to over-order concrete. The architect may also consider designing a space that is flexible and has the ability to change with the company's needs.

Establish Management Plan

Next, the company should establish project specific waste management goals as well as a plan to implement them. A sample waste management plan, from the State of Washington Department of General Administration, is provided in appendix H. An effective plan should state the specific source reduction, reuse, and recycling goals. The management plan will identify the targeted waste types, detail the procedures for managing waste, and identify the recycling and disposal facilities. Also, the company should also appoint a site manager or use an existing manager to be responsible for implementing as well as ensure the waste management plan is being followed. The waste manager will promote the plan and reward good performance.

The bid of the project is a crucial stage in reaching the company's goals in waste management. The bid package phase occurs after the drawings are complete, and contractors develop prices for building the structure. This stage is critical because it turns the waste management goals and guidelines into enforceable contractual regulations. All of the mentioned regulations should be written into the contracts with all subcontractors involved in the construction process. If the rules and regulations are not followed, then a consequence should be put in place. For example, the company could implement financial penalties for any breaches of contract. The company can determine what the appropriate consequence would be.

Education and Communication

It is imperative that everyone involved in the construction process know the rules and regulations of the site and they should be required to attend a training course before their first day of work. Intel has two Environmental, Health and Safety programs in place, which emphasize recycling. Unfortunately, the programs are not made mandatory. As a result, we found that few employees attend. In the mandatory training program, employees will learn what and how the materials will be segregated, why they are being segregated, and what participation Intel expects from each employee. The training program will include all subcontracted employees as well.

Communication throughout the implementation of the plan is imperative. Waste prevention and recycling should be discussed regularly in the Environmental, Health and Safety department. As each new subcontractor comes on site, they will be presented with the waste management plan and shown the recycling areas by the manager in charge of the plan. The subcontractor and his crew will be expected to follow all rules and regulations provided by Intel.

Material Purchasing

After the plans have been drawn up and materials need to be purchased, there are a number of ways to prevent waste generation. Begin with making use of tight estimating, as all materials ordered beyond the project's need will inevitably become waste. This is shown through the simple formula:

Accurate Quantities + Over Order= Building + Waste.

A lot of excess waste is generated through packaging of materials. If products are chosen wisely, with minimal to no packaging, there will be a reduction in waste because all packaging will become waste. If a supplier is willing to coordinate with material buy back or take back any excess materials can be put back on the market, rather than sent to landfills. Also, if the materials are delivered on returnable pallets or containers there will be less waste being brought on-site. If materials are delivered as close to when they will be used as possible, this will result in less risk of materials being damaged while on site. Careful storage of materials will not only reduce accidental damage to the materials, but it will reduce accidental injury to workers as well. There will be fewer tripping hazards and less falling materials. Purchasing materials in such a manner will result in less materials going to waste and less need to over-order materials.

Site Arrangements

In order for a plan to be successful, organization of the site is necessary. If potential sources of waste are identified. Then, dumpsters can be put in locations that are easily accessible for the waste to be disposed of. For example, the area where materials are cut, there will be a lot of scraps generated from making the cuts. Another area is the site's office where mixed general waste is common. The container type, size, and location are important to making the program successful. It would not be beneficial to have a small dumpster while doing the framework because during this time a lot of steel waste is generated. There are a number of ways to prevent contamination of segregated containers. If the disposal company allows, the dumpsters can be color coded to ensure segregation of waste and should be clearly defined with large signs. Signage is important to ensure proper segregation; posting pictures of what is recyclable in the containers would prevent contamination. An option for dumpster segregation is shown below.

Table 10: Dumpster Segregation Option

Waste Stream Category	Example Waste Products	Color Bin
Quarry Products	Waste concrete, demolished concrete, concrete blocks, bricks, sand, gravel, soil	Orange
Metal	Reinforcing and structural steel, metal framing, metal roofing, flashings	Blue
Paper Products	Newspapers/magazines, ordinary paper, fax paper, phone books, cardboard, paper, packing	Yellow
Plasterboard	-----------	Brown
Timber Products	Plywood timber, particleboard	Green
Plastic	-----------	Gray
General Refuse	Glass. Small amounts of building rubble, dirt	Red
Contaminated Refuse	Paint cans, glue containers, solvent containers, sealant tubes, food scraps	Black

If the site keeps segregated dumpsters in the same place for the duration of the project: the workers can become accustomed to where they are. Also, segregated waste dumpsters should be put behind the mixed or general waste dumpsters. Therefore, if waste accidentally gets put in the wrong dumpster it would go into the mixed dumpster because it is closer which will prevent the segregated dumpsters from becoming contaminated. In addition, the mixed dumpsters should be emptied regularly. If they are not emptied regularly the overflow could be put in the segregated containers, resulting in contamination. The dumpsters that are put on site are dependent on what waste is being generated at any given time. If the company is putting up steel framework, then there would not be a specific dumpster for wood, as there would be for steel. If possible it would be beneficial to also have a small forklift truck mounted near a dumpster in individual work areas to pick up a particular type of waste. The forklift would allow for large amounts of the same material to be put into the container with ease.

Material Efficiency Indicator

The effectiveness of the plan should be reviewed through regular waste checks. The check plan should be clearly defined within the waste management plan. With strong records of all waste rising, movement, and treatment, the wastage will be easily identified and it will highlight the significant waste products. It will allow the company to see trends and to make any corrective actions for the waste management plan. The information that is tracked should include number and size of each bin, waste type of each container, total tonnage generated, tonnage recycled, recycled waste generation, and reuse/recycling initiatives, as shown in Table 11.

Table 11: Waste Check Data Collection Sheet

Recycling and Waste Management Record						
Delivery Date	Bin Size	Waste Type	Pick Up Date	Total Tonnage Taken Away	% Recycled	Comments

Waste should be tracked monthly and the cumulative data from the entire project should be analyzed. The cumulative data can then be compared to case studies from past projects within Intel as well as projects that other companies have performed.

According to Consigli Construction of Massachusetts, the average new construction project yields 3.9 pounds of waste per square foot of building area, for example, a 50,000 square foot building will produce 100 tons of waste. According to Simons Construction of the United Kingdom, on one particular project where they carried out the best practices mentioned they had tremendous success in reduction of waste. The company was able to get waste down to 13.5 cubic meters per £100,000 of construction value, compared to an industry average of 47 cubic meters per £100,000 of construction value. The company then recycled sixty-eight percent of the waste that was produced. This is equivalent to reducing the waste to landfill by ninety percent (compared to an average project). In addition, according to Barry Smith of Simons Construction, as a minimum the company reduces waste by twenty percent, recycle fifty percent of the waste arising by weight, which reduces waste to landfill by sixty percent.

Benefits of Performing Best Practices

After Consigli completed a 65,000 sq ft addition and a 60,000 sq ft renovation on the Clark Distribution Center using a similar waste management plan to the one being recommended, they had a waste reduction of ninety-seven percent, which saved them 49,043 dollars in disposal fees. According to Consigli, the financial considerations include increased cost due to increased jobsite labor and administration, decreased cost due to lower tipping fees, better haul rates and greater efficiency/productivity over time. They say the bottom line impact is neutral impact financially with the possibility to save slightly. In addition to saving money on disposal cost, construction waste management creates environmental benefits. It saves natural resources, for example, trees, oil and minerals. Construction waste management can also help the economy, through creating more jobs, for example, at the recycling facility. In addition, construction waste management programs are a strong reflection of a company's corporate social responsibility.

RESEARCHING A RECYCLING MARKET FOR SERVICIOS ECOLOGICOS

Upon visiting the recycling facility, we were able to witness the labor intensive process they use. At the facility, they sell paper and cardboard to local companies and they process more than forty types of plastics that are then sold in the United States. The company currently does not have the capability to handle construction waste adequately. The inadequacy is, in part, due to the lack of technology available. In addition, there is a lack of market for such products in Costa Rica and the contractor lacks the knowledge of a market in the United States. In turn, this added an additional aspect to our project.

After initially contacting CNP+L for information on whether or not a recycling market existed, we found that the only contact they had was Holcim, a local company who will haul and process construction concrete. Farther into our project, our professors, Arthur and Susan Vernon-Gerstenfeld, spoke to Sergio Musmanni, a manager at CNP+L, and asked if they had any information on a current recycling market. CNP+L provided our professors with information on a recycling market in Central and South America, which they gave to us before our final presentation to Intel. This market is called Mercado de Residuos Subproductos Industriales (MERSI). MERSI is an inter-institutional effort between la Cámara de Industrias de Costa Rica and CNP+L to aid companies in recycling. MERSI provides companies with information on reusing materials as well as recycling them. They make a recycling database available for all companies to send information on the types of materials that they need to dispose of and how much is produced in a certain amount of time. When this information is placed in the database, other companies that are looking for these certain materials will be able to purchase them through the market. For example, if Intel had a lot of metal waste, they would simply fill out a form on the database telling what type of material it is and how much they are producing. Once this information is entered in to the database, companies that are looking for metal will be contacted and they would have the option of purchasing it from Intel. This market will be successful if numerous companies are able to participate.

Other than in Central America, we thought it necessary to look for a recycling market elsewhere. We turned to the United States because of the newer technologies that are being used there. Using RecyclingMarket.Net, an enormous recycling database, were able to find a market used in the United States that has contact information for numerous companies that have the desired recycling capabilities. After sorting through the database to find the companies that handle materials relevant to the recycling contractors needs, we compiled a list that we have provided to the company (appendix I).

CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS

After analyzing the data presented to us and doing extensive research, we were able to make recommendations for Intel to reduce the volume of waste that is sent to landfills. The recommendations include the reduction of both cafeteria and construction waste.

CAFERTERIA AND COMPOSTING WASTE MANAGEMENT

For the composting part of the project, we can make recommendations to Intel Costa Rica based on our research and experimentation. In order to successfully compost waste, the cafeteria must first segregate the organic waste from inorganic waste. In CR2, the company should utilize a segregated trashcan that contained two parts. One part would have a round hole for plastic recyclables and the other part would be for regular trash. It could be placed next to the tray shelf where the regular trashcan is currently located. In CR3, segregated recyclable and non-recyclable trashcans should be utilized as well so people do not have to walk across the room to segregate the waste. Also in the kitchen, the workers need to segregate organic waste from the inorganic waste. This can be achieved by placing a two part trashcan in the kitchen so the workers can easily segregate the food waste as they are preparing the food and as they are disposing the excess food. The trashcan should be located in the vegetable cutting area. There should be a three part trashcan located next to the conveyor belt in the kitchen as well so that when the trays come into the kitchen, the waste can be segregated into organic waste, inorganic waste, and recyclables. Also, regulations should be emplaced so the workers are obligated to segregate the waste. Once the food is segregated, it can be put into the composting system along with the sludge and the yard waste.

An in-vessel would be essential if Intel is to purchase a composting system. Due to weather conditions in Costa Rica, a windrow system would not be valuable to the company. The company has many options for possible composting systems. All of the systems have their particular advantages and disadvantages. We investigated many of the systems and narrowed Intel's best options down to three systems, the NaturTech system, the Earth Tub, and the WEMI Model 2000. Through further evaluation, we determined that the Earth Tub system would be most beneficial for Intel. Multiple tubs would be needed for the amount of waste Intel produces and the price is low in comparison with the other systems. It also requires some labor and has odor control.

CONSTRUCTION AND DEMOLITION WASTE MANAGEMENT

After developing a construction and demolition waste management model based on the industries' best practices, and comparing it to Intel's current construction and demolition waste management practices, we were able to make several improvement recommendations. The model provides a methodology for Intel to follow in order to reduce the amount of waste that is sent to the landfill. The model is composed of general guidelines that Intel will require the subcontractors to implement. In addition, while the model appears to be basic, we found through our analysis of Intel's current practices, that such methods are not being utilized.

Currently, during the mandatory class that every employee must complete on the rules and regulations of the facility, there are only two slides on environmental awareness. We would recommend that the environmental courses that have been established at Intel be mandatory for all Intel employees as well as subcontracted employees. Education is the first step in making any waste management program successful. If the employees understand the importance of the program, they will do their part in recycling. In addition, the company could provide additional motivation to encourage employees to be enthusiastic. Perhaps there could be a system of rewards in place for the group that is achieving the highest recycling rate or the lowest waste disposal rate. In turn, we hope that this leads to a larger community effect. Moreover, if the employees of Intel are environmentally aware at work, they may carry those practices home with them.

In order to have a successful program, it is necessary for Intel to employ a waste manager, opposed to giving additional responsibility to the project manager. The waste manager's job would be to ensure that all rules and regulations of the site are being followed by all employees. They would establish the waste management goals as well as be responsible for implementing a waste management plan. The waste management plan would follow the best practices discussed in the data analysis and results section. In addition, the waste manager would also be responsible to conduct all of the waste checks. Intel is not currently keeping accurate records of the waste generated and the waste checks will provide the necessary data to provide the information to create a material efficiency indicator. The material efficiency indicator will give Intel the knowledge of whether or not their waste management plan is effective. The effectiveness will be shown through the amount of materials bought and the amount that is being sent to landfills. If the amount of waste being sent to landfills is higher in comparison to previous projects built by Intel, the waste management plan can be altered.

The more materials that Intel is able to recycle, the more the local community will benefit. The recycling center, Servicios Ecológicos, currently has fifty employees. The employees hand-sort through plastics, paper and cardboard. The company also aids single-mothers and their children by providing at home jobs for them. The families are paid to sort through bags of materials every week and then put it out on the curb for it to be collected. Therefore, if Servicios Ecológicos can handle more materials, more families can be utilized.

Servicios Ecológicos is able to process plastics, which are then sold in the United States. All of the other materials are sold or shipped to different countries to be processed. The main problem that the recycling center faces is that it does not know where to send the construction materials. We are providing a spreadsheet of contact information (see appendix I) of companies within the United States that accept specific construction and demolition waste materials for recycling. With this valuable information, Servicios Ecológicos will be able to create a recycling market and expand there local recycling capabilities. In turn, more jobs will be created for the citizens of Belen.

In conclusion, currently, Intel is recycling between sixty-five and seventy percent of the waste generated at the Intel facility. However, if the company follows the proposed waste management model, we expect that the recycling rate will increase to ninety percent. As mentioned in our data analysis and results, source segregation typically yields a ninety percent recycling rate. A twenty percent increase in recycling would result in tremendous savings for Intel and a better environment. The savings will be from less money being spent on disposal fees.

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APPENDIX A

MISSION OF INTEL CORPORATION AND INTEL COSTA RICA

ABOUT INTEL

Intel was founded in 1968 with the mission to "be the preeminent building block supplier to the internet economy" (Intel, 2005). The company is located in a free trade zone. They supply computer industries with chips, boards, systems, and software building blocks used to make computers, servers, and networking and communications products. In 1971, Intel introduced the world's first microprocessor, which controls the central processing of data in personal computers, servers, workstations, and other devices. The main products that the company makes are microchips (microprocessors), chipsets, and motherboards. Intel earns revenues from all over the world. In 2003, twenty-seven percent of the revenues came from America, twenty-four percent from Europe, forty percent from Asia-Pacific, and nine percent from Japan. Through their networking, Intel has become the world's largest chipmaker, a leading manufacturer of computers and networking and communication products. Today, the company employs 78,000 people in 249 facilities and offices worldwide (Intel, 2005).

Intel's Values:

Intel takes pride in their company and there are certain values that they wish to uphold. These values are discipline, results orientation, risk taking, great place to work, customer orientation, and quality (Intel, 2005).

Intel's Objectives:

Intel has set goals for itself and applies objectives to improve their work. In order to be one of the top companies, they try to execute the following objectives. These objectives are to extend silicon leadership and manufacturing capability, deliver architectural innovation for platforms, and pursue opportunities worldwide (Intel, 2005).

INTEL COSTA RICA

Intel Costa Rica, located in the city of Belén, began their manufacturing operations in 1998. Intel was the first assembly line and test facility in Latin America. Before, the manufacturing process for microprocessors, known as the assembly and test, took place in Costa Rica, but is not in operation anymore as of this past year. At Intel Costa Rica, the production of Intel Pentium 4 and Pentium Xenon microchips takes place, but they are tested elsewhere. The company distributes finished products to Europe, Asia, Latin America, and the United States (Intel, 2005).

INTEL AND THE COMMUNITY

One of Intel Costa Rica's main areas of focus is to be a responsible corporate neighbor. They want to be proactive within the community by developing programs to interact with them. These existing programs are focused around education, environmental awareness, technological awareness, and improving the quality of life.

As a part of their recycling program, Intel Costa Rica donates their construction and demolition waste to the community. The company created an informal model called the Intel Computer Clubhouse to educate children who lack education in technology. Through this model, they hope to increase the children's confidence and to help them acquire problem solving skills. Massachusetts Institute of Technology Media Lab in conjunction with the Museum of Science developed this model supported by Intel.

INTEL AND EDUCATION

The mission of Intel in education is to help improve primary schools, high schools, and universities in areas of science, such as technology and engineering.

Objectives of Intel Costa Rica towards Education are:

-To support education institutions

-To develop the future work force of the country

-To focus on the number of graduates in the fields of engineering, technology, electronics, and computations

-To promote education in the fields of science, engineering and computer science

-To promote interest in the students in these fields of study

Intel has developed programs and projects with education organizations to accomplish these objectives. They offer the teachers training programs, seminars, and education qualification. They also promote scholarships and science fairs for students.

Every year, Intel works with the National Science Fair Commission Science and Technology in Costa Rica to encourage the students to be interested in math, science, and technology. They do this by holding twenty regional and one annual National Science and Technology Fair for elementary and high school students. They also support training for over two hundred teachers and sponsor the two finalists of the fair to participate in the Intel International Science and Engineering Fair. Intel Costa Rica also works closely with the two universities in Costa Rica to better their skills in engineering. They work with the faculty and train them for the skills that will be needed in these areas of study in the future.

INTEL AND THE ENVIRONMENT

According to Intel, they practice eliminating wastes in a safe way. Nearly seventy percent of all waste is recycled (Intel, 2005). There is a government agreement between the United States and Costa Rica to have chemical wastes exported to the United States periodically. Moreover, Intel implemented a program to control, recover, and recycle coolants to avoid ozone depletion. By participating in the ISO 14001's voluntary waste management program, Intel's standards are recognized worldwide. They are a part of the program to meet the ISO 14001's standards of the environmental management system.

ENVIRONMENTAL STANDARDS

The International Organization for Standardization 14001, or ISO 14001, is a voluntary international standard that some companies partake in; there are no legal requirements to participate in the ISO program. It sets certain environmental standards for companies that wish to apply an environmental management system (EMS). Standards that the EMS regulates are environmental policy, planning, implementation and operation, inspection and corrective action, and management review (http://www.ibm.com/ibm/environment/iso14001/iso14001.shtml). Companies are expected to maintain and improve their waste management strategies constantly, in order to be consistent in managing their waste. The ISO environmental standards help to show that companies are committed to obeying environmental policies and contributing to reducing pollution. Moreover, the ISO helps to make sure that the company is following environmental laws and regulations properly. The company can also get another company’s opinion on their waste management procedures. (http://www.iso14000-iso14001-environmental-management.com/iso14001.htm).

APPENDIX B

TRAINING PROGRAM OUTLINE

CAFETERIA WASTE

Taught to all cafeteria workers and people involved in composting

Why is it important to segregate waste and recycle?
    Give benefits for Intel
    Give benefits for each person
Segregation in the cafeteria
    What types of food is good for composting
    How to dispose of each type of food (show specific trashcans with signs)
    What packaging materials can be recycled and where? (show the bins in the back of the cafeteria and stress how important it is to place the materials in the correct bins – ex. It saves the recycling contractor time)
How to prepare the food for composting

CONSTRUCTION AND DEMOLITION

Taught all construction workers

Intel's Goals of decreasing the amount of waste being sent to the landfill
What are the current problems preventing them from recycling more?
Segregating Construction Materials
    Train the employees on what materials go into which colored bin (show pictures)
Whose job is it to make sure that the materials are being separated properly?
Why is segregating important
Keep records of material use so that you can measure reductions

APPENDIX C

Table 12: AMOUNT OF WASTE PRODUCED AT EACH INTEL BUILDING OVER PAST FIVE MONTHS (JANUARY-MAY)

	Jan	Tons (Natural/Veg Waste)	Feb	Tons (Natural/Veg Waste)	Mar	Tons (Natural/Veg Waste)	Apr	Tons (Natural/Veg Waste)	May	Tons (Natural/Veg Waste)
Trips										
CR1	4		4		3		5		4	
CR3	0		0		0		0		0	
Cafeteria	7		8		8		8		8	
CR2	4		8		7		9		9	
Contractors	0		0		0		0		0	
Sprung									0	
Galvez & Vollo										
Total	15		20		18		23		21	
Kilograms										
CR1	4,460		3,110.00		4,550.00		12,660.00		6,340.00	
CR3	0		0.00		0.00		0.00		0.00	
Cafeteria	10,305	5,200	9,550.00	5,000.00	10,630.00	5,100.00	12,010.00	6,000.00	12,940.00	6,500.00
CR2	3,830.00		9,200.00		9,810.00		5,700.00		10,670.00	
Contractors	0.00		0.00		0.00		0.00		0.00	
Sprung (cubic meters)										
Galvez & Vollo										
Total	18,686.00		21,880.00		24,880.00		30,370.00		29,860.00	

APPENDIX D

DISPOSAL COST

Table 13: Open Dumpster Costs CR2

Type of Service	*Quantity*	*Price*	*Total Cost (colones)*
Transportation	8	23,000	184,000
Final Disposal	8.430 kg	5,700	48,051
		Total Cost (colones)	**232,051**

Table 14: Additional Dumpster

Type of Service	*Quantity*	*Price*	*Total Cost (colones)*
Transportation	1	23,000	23,000
Final Disposal	2.240 kg	5,700	12,768
		Total Cost (colones)	**35,768**

Table 15: Intel CR1 Compactor

Type of Service	*Quantity*	*Price*	*Total Cost (colones)*
Transportation	4	23,000	92,000
Rental fee	1	122,000	122,000
Final Disposal	6.340 kg	5,700	36,138
		Total Cost (colones)	**250,138**

APPENDIX E

MATERIAL RECYCLING DATA

Table 16: Recyclable waste in kilograms from Intel corresponding to the month of April 2005

Recycled Material	***Kilogram of Waste***
Cardboard	23,090
Various Plastics	12,402
All classes of Platforms	10,751 (average of 13 kilos each)
Word	2,300
1 Gallon Plastic Containers	202.50 (0.15 grams each *reusable and non reusable)
5 Gallon Plastic Containers	102.35
Crushed Paper	420
Office Paper	667
Sponge	181
Cartridges	27.75
Styrofoam	180
Total Traditional Garbage	50, 323.60
Total Untraditional Garbage*	12,779.50
Total amount of Garbage	**63,103.10**

* Untraditional garbage collected from different storage centers (CR1, CR2, CR3, and chemical warehouse) surplus of construction, scrap iron, amongst others

Removed materials from storing centers from employees, sproom and cafeteria parking lot:

Paper: 203 kg
Plastics: 122 kg
Cardboard: 105 kg

Total amount of waste recovered from the cafeteria and sproom building parking lots: **430 kilos**

Removed materials from construction areas: tubes, iron scrap, pipes, amongst others: **10,000 kilos**

Table 17: Recyclable waste in kilograms from Intel corresponding to the month of May 2005

Recycled Material	***Kilograms of Waste***
Cardboard	22,106
Various Plastics	14,295
All classes of Platforms	10,842 (average of 13 kilos each)
Word	9,050 (0.15 grams each *reusable and non reusable)
1 Gallon Plastic Containers	169.50
5 Gallon Plastic Containers	64.40
Crushed Paper	675
Office Paper	873
Sponge	105
Cartridges	55.50
Styrofoam	120
Total Traditional Garbage	58,355.40
Total Untraditional Garbage*	10,940.50
Total amount of Garbage	**82.215.90**

* Untraditional garbage collected from different storage centers (CR1, CR2, CR3, and chemical warehouse) surplus of construction, scrap iron, amongst others

Removed materials from storing centers from employees, sproom and cafeteria parking lot:

Paper: 203 kg
Plastics: 122 kg
Cardboard: 105 kg

Total amount of waste recovered from the cafeteria and sproom building parking lots: **588 kilos**

Removed materials from construction areas: tubes, iron scrap, pipes, amongst others: **12,920 kilos**

APPENDIX F

GARBAGE COLLECTION DATA

Table 18: Number of Times Garbage was Collected Per Month

	Jan	*Feb*	*March*	*April*
CR1	4	4	3	5
CR2	4	8	7	9
CR3	0	0	0	0
Cafeteria	7	8	8	9
Contractors	0	0	0	0
TOTAL	**15**	**20**	**18**	**23**

Table 19: Kilograms of Waste Collected Per Month

	Jan	*Feb*	*March*	*April*
CR1	4460	3110	4550	12660
CR2	3830	9200	9810	5700
CR3	0	0	0	0
Cafeteria	10305	9550	10630	12010
Contractors	0	0	0	0
Total	**18595**	**21860**	**24990**	**30370**

APPENDIX G

COMPANIES AND AGENCIES USED TO DEVELOP MODEL

Consigli Construction of Massachusetts

-2004 Environmental Merit Award

-2004 EPA WasteWise Award

-2004 Building Design & Construction Award

-2004 Mass Preservation Awards

-OSHA Blue Safety Partnership

Simons Construction of the United Kingdom

-Winner of the Green Apple Award, the annual international campaign to recognize, reward and promote environmental best practice around the world, 2001-2004

-Winner of the Linconshire Environmental Award, 2001 & 2003

The Australian Government Department of the Environment and Heritage

Welsh School of Architecture

Washington State Department of General Administration

Public Works and Public Services Canada

APPENDIX H

SAMPLE WASTE MANAGEMENT SPECIFICATIONS

The following is a model that was found during the research of construction waste management best practices. It was written by Washington State Department of General Administration.

SUSTAINABLE JOB-SITE OPERATIONS

WASTE REDUCTION PLAN

PART 1 GENERAL

1.1 SUMMARY

A. Section includes:

1. Description of a Job-Site Waste Management Plan
2. Waste Management Requirements

1.2 JOB-SITE WASTE REDUCTION

A. Goals:

1. Owner has set a waste minimization goal for the project, within the limits of the construction schedule, contract sum, and available materials, equipment, products and services.
    a. These goals are consistent with the 1997 “Statement on Voluntary Measures to Reduce, Recover, and Reuse Building Construction-site Waste” released by the American Institute of Architects and the Associated General Contractors of America, Federal Executive Order 13101, and EPA Comprehensive Procurement Guidelines (CPG). The EPA CPG established preferred product standards and have been adopted by the State of Washington in RCW 43.19A.020.
2. Minimize the amount of CDL (construction, demolition and land clearing) waste generated. The project goal is to recycle, salvage or reuse at least 50% [or 75%] of the wastes generated.
3. Divert waste created through CDL processes from disposal through reuse (salvage) and recycling.
4. Use recycled or salvaged building materials.

1.3 DEFINITIONS

A. Waste: For the purpose of this section, the term applies to all excess materials, including materials that can be recycled, unless otherwise indicated.

B. Construction, Demolition and Land clearing Waste (CDL): Includes all non-hazardous solid wastes resulting from construction, remodeling, alterations, repair, demolition and land clearing.

C. Proper Disposal: As defined by the jurisdiction receiving the waste.

D. Hazardous Waste: As defined by the jurisdiction receiving the waste.

E. Recycling: The process of sorting, cleaning, treating, and reconstituting materials for the purpose of using the material in the manufacture of a new product. Can be conducted on-site (as in the grinding of concrete and reuse on-site).

F. Recycling Facility: An operation that can legally accept materials for the purpose of processing the materials into an altered form for the manufacture of a new product. Recycling facilities have their own specifications for accepting materials.

G. Reuse: Making use of a material without altering its form.

H. Salvage: Recovery of materials for on-site reuse or donation to a third party.

I. Source-Separated Materials: Materials that are sorted at the site for the purpose of reuse or recycling.

J. Co-mingled Materials: Mixed recyclable CDL material that has not been source-separated. Some facilities will separate co-mingled materials off-site for recycling.

1.6 REFERENCES

A. Construction Recycling Directory lists area haulers and processors available for recycling CDL materials in King County http://www.metrokc.gov/greenworks

B. Contractors Guide: Save money and resources through job-site recycling and waste prevention provides information on how-to recycle and prevent waste on the job available online at http://www.metrokc.gov/greenworks

PART 2 PRODUCTS

2.1 MATERIALS

A. Recycled-content, salvaged, rapidly renewable or otherwise resource-efficient products are specified in appropriate sections.

PART 3 EXECUTION

3.1 DEMOLITION

A. Recycle the items listed below (on or off-site).

1. Acoustical ceiling tiles
2. Asphalt
3. Asphalt shingles
4. Cardboard packaging
5. Carpet and carpet pad
6. Concrete
7. Drywall
8. Fluorescent lights and ballast
9. Land clearing debris (vegetation, stumpage, dirt)
10. Metals
11. Paint (through hazardous waste outlets)
12. Wood
13. Plastic film (sheeting, shrink wrap, packaging)
14. Window glass
15. Wood
16. Job-shack wastes, including office paper, pop cans and bottles, and office cardboard.

3.2 NEW CONSTRUCTION

A. Recycle the items listed below (on or off-site).

1. Acoustical ceiling tiles
2. Asphalt
3. Asphalt shingles
4. Cardboard packaging
5. Carpet and carpet pad

6. Concrete
7. Drywall
8. Fluorescent lights and ballast
9. Land clearing debris (vegetation, stumpage, dirt)
10. Metals
11. Paint (through hazardous waste outlets)
12. Wood
13. Plastic film (sheeting, shrink wrap, packaging)
14. Window glass
15. Wood
16. Job-shack wastes, including office paper, pop cans and bottles, and office cardboard.

B. Include in supply agreements a waste reduction provision specifying a preference for reduced, returnable, and/or recyclable packaging.

C. Use detailed material estimates to reduce risk of unplanned and potentially wasteful cuts.

D. Store materials properly to avoid moisture or other damage to materials. Materials that become wet or damp due to improper storage shall be replaced at contractor's expense.

E. Use safety meetings, signage, and subcontractor agreements to communicate the goals of the waste reduction plan.

F. As part of regular clean up, schedule visual inspections of dumpsters and recycling bins to identify potential contamination of materials.

APPENDIX I

RECYCLING MARKET CONTACT INFORMATION

Type of Material	Company	Location	Web Page	Phone	Fax
Concrete	Commercial Paving and Recycling	Maine	http://www.cpcrs.com/info.php?sx=MzU4MS4wODI=	207-883-3325	207-883-1121
	Environmental Resource Return Corp	New Hampshire	http://www.errco.com/resident%20info%20sheet.pdf	603-679-2626	603-679-2526
	Mercer Group International, Inc.	New Jersey	http://www.mpeinc.com/	215-295-6681	215-295-6683
	Resource Management Technology/UNESCO	New Jersey			
Construction and Demolition Debris	Arc-Asset Recovery Contracting	Illinois	http://www.arcdemo.com/	847-674-8653	847-674-0932
	Powell Center for Construction & Environment	Florida	http://www.cce.ufl.edu/past/deconstruction/reuse.html	352-392-7502	
	Gerchman, Brickner, & Bratton, Inc.	Virginia	http://www.gbbinc.com/services/index.asp?service_id=7	800-573-5801	703-698-1306
	Commercial Paving & Recycling Company	Maine	http://www.cpcrs.com/	207-883-3325	207-883-1121
	Complete Resources Company	Ohio	http://www.complete-resources.com/	614-253-6415 ext 223	614-251-1635
	Environmental Resource Return Corp	New Hampshire	http://www.errco.com/resident%20info%20sheet.pdf	603-679-2626	603-679-2526
	Frank Lurch Demolition Company	New Jersey		732-988-8814	
	Gramercy Group, Inc.	New York	http://planetzig.com/gramercy/homepage.html	516-876-0020	
	Intercoastal Salvage, Inc.	Texas		956-831-8661	
	Intercon	Texas	http://www.constructionwork.com/contractor3262378_intercon_environmentalcom.html	817-477-9995	817-477-9996
	Marcor Remediation, Inc.	Maryland	http://www.marcor.com/home_index.cfm	800-547-0128	
	Trisource Contracting	Maryland		410-549-7705	
Glass (all Grades)	Commercial Paving & Recycling Company	Maine	http://www.cpcrs.com/	207-883-3325	207-883-1121
	Environmental Resource Return Corp	New Hampshire	http://www.errco.com/resident%20info%20sheet.pdf	603-679-2626	603-679-2526
High Density Polyethylene	Arcadia Recycling	Wisconsin		608-323-3385	
	Marco Color Laboratories Inc.	California		310-527-4333	310-527-4334
	Green Resource Center	California	http://www.greenresourcecenter.org/	510-845-0472	510-845-9503
Mixed Waste Paper	Channeled Resources Inc.	Illinois	http://www.channeledresources.com/	800-887-6866	312-733-1628
	Commercial Metals Company	Texas	http://www.commercialmetals.com/employment/cmfcu_reps.asp	214-689-4319	
	Marcal Paper Mills, Inc.	New Jersey	http://www.fiberclaycouncil.org/marcal/	201-703-6404	201-703-6234
	Searcy Recycling Center	Arizona	http://www.cityofsearcy.org/sanitation/recycle.htm	501-279-1079	

	World Resource Recovery Inc	Ohio		216-486-6446	
	Waste Parchment Inc.	Ohio		800-282-2454	
Paper (all Grades)	American Fiber Resources	Michigan	http://www.afrholdco.com/		
	Arc Unlimited	Louisiana		318-364-7215	
	Arcadia Recycling	Wisconsin		608-323-3385	
	Arcata Community Recycling Center	California	http://www.arcatarecycling.org/	707-822-4542	707-822-1672
	Arch Industries	Ontario	http://www.textileweb.com/storefronts/arch.html	416-741-7247	416-741-7400
	Capital Environmental Resource Inc	Alberta	http://www.solidwaste.com/storefronts/cap.html	403-578-3299	403-578-3313
	Central Kentucky Fiber Resources, LLC	Kentucky	http://www.centralkyfiber.com/	877-542-7227	859-225-1238
	Channeled Resources Inc.	Illinois	http://www.channeledresources.com/	800-887-6866	312-733-1628
	CNY Resource Recovery, Inc.	New York	http://www.communitysite.com/cnyscrapmetal/	315-471-0254	
	D.C. Intercel	Maryland		410-355-5800	410-355-3075
	Fairchild Waste Control	Michigan		989-735-0400	
	Fibresource, Inc.	Arkansas	http://www.fibresource.com/	800-241-9765	
	Marcells Paper & Metal Inc.	Illinois	http://marcellspaper.com/contactus.html	773-265-1200	773-265-1220
	Northeast Recovery Association	New Hampshire	http://www.recyclewithus.org/	603-798-5777	603-798-5744
	Rhode Island Resource Recovery	Rhode Island	http://www.rirrc.org	401-942-1430	401-946-5174
	SPARC	Oregon	http://www.sparc-steppingstone.org/	541-476-8214	
	Waste Parchment Inc.	Ohio		800-282-2454	
Plastic (all Grades)	Gateway Resources Inc.	Manitoba	http://www.gatewayresourcesinc.com/	204-325-7304	204-325-1958
	Intercontinental Export, Import, Inc.	Maryland	http://www.ieiplastics.com/	410-674-5600	410-674-5700
	Jarco Inc.	Ohio	http://home.fuse.net/jarco/index2.html	513-624-6000	513-624-6400
	Marco Color Laboratories Inc.	California		310-527-4333	310-527-4334
	Northeast Recovery Association	New Hampshire	http://www.recyclewithus.org/	603-798-5777	603-798-5744
	Rubber Research Elastomerics Inc.	Minnesota		612-572-1056	612-572-2357
	Shuman Plastics (Resource Recovery Service)	New York	http://www.shuman-plastics.com/resource.html	716-685-2121	716-685-3236
Plastic Drums	Marco Color Laboratories Inc.	California		310-527-4333	310-527-4334
Rubber (all Grades)	Commercial Paving & Recycling Company	Maine	http://www.cpcrs.com/	207-883-3325	207-883-1121
	Gateway Resources Inc.	Manitoba	http://www.gatewayresourcesinc.com/	204-325-7304	204-325-1958

	Intertex World Resources, Ltd.	Ohio	http://www.intertexworld.com/beta/hsrmb.htm	330-665-5533	330-962-6610
	Jarco Inc.	Ohio	http://home.fuse.net/jarco/index2.html	513-624-6000	513-624-6400
	Lancaster Colony Commercial Products	Ohio	http://www.lccpinc.com/	800-292-7260	614-263-2857
	Rubber Research Elastomerics Inc.	Minnesota		612-572-1056	612-572-2357
	TRC Industries, Inc.	Ohio	http://www.trc-silmix.com/	330-688-4816	330-688-6561
Rubber (Buffings)	Commercial Paving & Recycling Company	Maine	http://www.cpcrs.com/	207-883-3325	207-883-1121
Rubber (Crumbs)	Dura Underconstructions Ltd	Quebec	http://www.duracushion.com/	514-737-6561	514-342-7940
Shingles	Commercial Paving & Recycling Company	Maine	http://www.cpcrs.com/	207-883-3325	207-883-1121
	Environmental Resource Return Corp	New Hampshire	http://www.errco.com/resident%20info%20sheet.pdf	603-679-2626	603-679-2526
Special Metals	Aeroco Metals Inc	Michigan		313-841-0177	
	American Iron & Metal Company Inc.	Quebec		514-494-2000	514-494-3008
	Consolidated Scrap Resources, Inc.	Pennsylvania	http://www.consolidatedscrap.com/	717-233-7927	717-233-3567
	HC Stark Inc.	Massachusetts	http://www.hcstarck.com/index.php?page_id=5	201-438-9000	201-438-0891
	Hercules Safety Equiptment	Texas		713-462-2666	
	Marcells Paper & Metal Inc.	Illinois	http://marcellspaper.com/contactus.html	773-265-1200	773-265-1220
	NSSI Sources & Services, Inc	Texas	http://www.nssihouston.com/services.html	713-641-0391	713-641-6153
Spaciality Grades	Channeled Resources Inc.	Illinois	http://www.channeledresources.com/	800-887-6866	312-733-1628
	CNY Resource Recovery, Inc.	New York	http://www.communitysite.com/cnyscrapmetal/	315-471-0254	
	Waste Parchment Inc.	Ohio		800-282-2454	
Stainless/High Temperature	Aeroco Metals Inc	Michigan		313-841-0177	
	AMG Resources Midwest Corporation	Iowa		515-955-6474	515-955-3120
	BRC Company, Inc.	Virginia	http://www.brcscrapmetals.com/index.htm	804-385-6050	804-385-8887
	Circosta Iron and Metal Inc.	California		415-282-8568	415-641-7804
	CNY Resource Recovery, Inc.	New York	http://www.communitysite.com/cnyscrapmetal/	315-471-0254	
	Consolidated Scrap Resources	Pennsylavania	http://www.consolidatedscrap.com/	717-233-7927	717-233-3567
	Mercer Group International, Inc.	New Jersey	http://www.mpeinc.com/	215-295-6681	215-295-6683
	Mercer Wrecking Corp	New Jersey	http://www.constructionexecutive.com/	609-631-8230	

NSSI Sources & Services, Inc	Texas	http://www.nssihouston.com/services.html	713-641-0391	713-641-6153
Omnisource Corporation	Georgia	http://www.omnisource.com/home.htm	678-352-4556	678-352-4560
Porter Brothers Bismark-Mandan Division	North Dakota		701-223-0339	
Remelt Sources Inc.	Ohio	Remelt Sources Inc.	216-289-4555	216-289-0939