A CAMPUS WIDE WASTE ANALYSIS AT CALIFORNIA STATE UNIVERSITY, CHICO

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A Project

Presented

to the Faculty of

California State University, Chico

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In Partial Fulfillment

of the Requirement for the Degree

Master of Arts

in

Geography

Environmental Policy and Planning

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by

Eli L. Gilmore Goodsell

Fall 2011

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DEDICATION

I dedicate this project to the idea of going zero waste. Higher education has the obligation and opportunity to prove that a world without waste is possible. To my friends, family, Hannah and Bowie for understanding my passion for his project and not taking it personally even though I could not give you the attention you all deserve.

ACKNOWLEDGMENTS

I would like to acknowledge the following individuals, whom without; I could have never completed this endeavor. First and foremost my thesis committee, Guy King, LaDona Knigge, and Lori Hoffman, for the advice and direction they provided me throughout my project. The Sustainability Fund Allocation Committee for funding my project. My friend and boss Robyn DiFalco, for the support and expertise she has contributed over the years. Lastly, I would like to send a special thanks to the custodial and grounds staff and supervisors, environmental health and safety staff, and the amazing 65 student volunteers who made the project possible.

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Many waste analyses completed at institutions of higher education focus on material sampling to determine the characterization of their waste. Very few (if any) campuses have collected and sorted all waste generated on campus throughout an average day. Because of the unique waste coming from multiple locations on a campus setting, a more comprehensive analysis is needed to determine waste trends.

The waste analysis and characterization done at California State University, Chico (CSU, Chico) used quantitative methods to compare specific materials found in the waste to the waste stream on campus as a whole. Materials were analyzed from a sample of waste generated over twenty-four hours in buildings and outdoor waste receptacles on campus. All material collected was sorted by location into twenty three separate material

categories. Each waste category was analyzed as well as the top five locations with the most divertible material in their waste stream.

Results of the analysis found that the most prevalent divertible materials in the waste stream were compostable paper, food scraps, paper, and cans and bottles, respectively. These four materials represented sixty-one percent of the weight of waste coming from buildings and outdoor bins on campus.

It is recommended that the composting program at CSU, Chico be expanded in order to capture more compostable paper and food scraps being disposed of on campus. Paper and cans and bottle recycling efforts should also be increased. Education and operations on campus must be improved and expanded to meet these recommendations.

CHAPTER I

INTRODUCTION

Statement of Problem

Over 245 million tons of waste is generated annually in the United States. With the average U.S. citizen creating 4.5 pounds of waste per day, many valuable resources are accumulating in perpetually growing landfills throughout our nation (United States Environmental Protection Agency n.d.). A study conducted by the California Integrated Waste Management Board found that in 1995, 51% of the waste created by California State Agencies was generated on public college campuses. California State University, Chico (CSU, Chico) deposits over 2.8 million pounds of waste in the local landfill annually (California State University, Chico 2009). Considering that the local landfill has less than 30 years until reaching capacity without factoring in population growth, it is imperative that CSU, Chico reduces its large waste contribution (Rodowich 2010). While many resources are recycled and reused on campus, there have been divertible materials identified through informal waste audits conducted by students and staff. A thorough waste audit and characterization needs to be completed in order to identify specific materials that could possibly be diverted from the waste stream.

While waste audits have been conducted and documented by different universities throughout California, the United States and the world, each individual

campus creates a unique stream of waste. Waste audits or characterizations completed by other universities are useful as methodology examples, but their findings do not apply directly to the waste generated at CSU, Chico. In order to understand the waste stream generated at CSU, Chico a specific audit is required.

CSU, Chico adopted the Campus Conservation Committee (CCC) in 2000. This committee was tasked with analyzing waste on campus and making recommendations on how to reduce and manage this waste. While the CCC has performed informal waste characterizations on campus, there has never been a detailed analysis and characterization of waste on campus. Any information on waste has been derived from small sample areas during an inconsistent period of time without adequate accounts of independent or dependant variables. CSU, Chico cannot fully identify and eliminate materials in the waste stream until a thorough waste analysis and characterization is completed. The information that will be gathered by such an analysis is the next step in eliminating unnecessary waste from CSU, Chico's Campus.

This study will be beneficial to CSU, Chico administrators, students, faculty and staff, as well as to other universities worldwide. A concise waste analysis will open the door for the administration of new programs which focus on reducing, recycling and reusing. These programs will benefit those who attend the university for work or school because they will allow them to divert otherwise wasted resources from the landfill. The methodology and graphics used to analyze the waste stream of CSU, Chico will create a model that can be copied and utilized by schools and businesses by adjusting categories to fit their own waste streams. Waste diversion is not only important to individual schools and businesses, but is also crucial in promoting the adoption of waste reduction policies

everywhere. This study hopes to encourage CSU, Chico to follow suit with the University of California system by adopting a Zero Waste goal by 2020 (University of California n.d.).

Purpose Statement

The purpose of this study is to conduct a waste analysis study of the CSU, Chico waste stream using quantitative methods to compare specific materials found in the waste to the waste stream on campus as a whole. The study will analyze the relationship of specific materials to the entire waste stream by weight, volume and location. Additionally, independent variables such as time of year, weather, and location/service of building where waste is generated will be addressed in the findings.

Background

CSU, Chico is located in Chico California, which is ninety miles north of Sacramento in the Northern Sacramento Valley. The population of the City of Chico is 86,900 (City of Chico 2009). The Universities main campus is 119 acres situated next to the downtown area. As of the Fall Semester, 2010, CSU, Chico had 15,989 total students of which 1,300 (8%) were post-baccalaureate students. Full time faculty accounted for 56% (480 faculty) of the instructional staff on campus while the remaining 44% (377 faculty) were part time. With the addition of 954 staff members, there are 17,800 individuals that frequent the CSU, Chico campus. Beyond the students, faculty and staff at CSU, Chico the campus is host to countless visitors throughout the year. The waste stream at CSU, Chico is largely determined the many visitors and more permanent members of campus (California State University, Chico 2011).

CSU, Chico is unique in that waste and recycling on campus is collected by separate programs. While all waste receptacles on campus are services by custodial staff under the Facilities Management and Services Department, all recycling is collected by the Associated Students Recycling Program (ASRP). The ASRP was founded by students in 1996 when a referendum was passed a fee allocating $3.33 from every student each semester to fund the program. Currently, the ASRP has over 2,000 recycling bins on campus and collects nearly 620,000 pounds of recyclable material a year. The program is made up of one full time coordinator and anywhere from 15-20 student staff. Because the contract for recycling services is held by the Associated Students, an essential relationship between the ASRP and CSU, Chico has formed throughout the years (AS Recycling 2009).

Students not only played a critical role in the formation of the ASRP, but have been invaluable in numerous waste reduction measures and environmental campaigns at CSU, Chico. Student initiative was beneficial in establishing the Associated Students goal of zero waste by 2015, supporting the signing of the Presidents' Climate Commitment by President Zingg of CSU, Chico, developing a general education sustainability pathway in the curriculum, and a multitude of other environmental victories. CSU, Chico administration and staff has worked hand in hand with the Associated Students to make a number of the student's environmental ambitions a reality on campus.

CHAPTER II

LITERATURE REVIEW

Introduction

The literature reviewed for this project will provide justification for an extensive waste analysis at CSU, Chico. This review will briefly discuss the predicament of waste creation and disposal. The importance of reducing, reusing, and recycling resources found in the waste stream will be emphasized along with a look at the current trends related to these practices. Waste analysis studies play a crucial role in diverting valuable resources from the landfill because they allow for businesses, cities, government agencies, and individuals to determine what is in their waste stream and what materials can be reduced, reused, or recycled. Different waste analysis and characterization methodologies, manuals, and examples will be evaluated in order to determine the amount of material that can be eliminated from the waste stream on campus.

Waste

Garbage is an issue to which nearly everyone can relate. Americans created 2.5 times, or 250 million more tons, of waste in 2007 than in 1960. Some of this increase can be attributed to population growth. However, when accounting for population growth, the average U.S. resident still increased his/her disposal by over 33% (1.5 lbs) of waste per day during this 47-year time frame (United States Environmental Protection

Agency, Office of Solid Waste 2008). While a variety of laws have been passed regulating and restricting what goes into the waste steam, even progressive states such as California still have a vast amount of readily recyclable material ending up in landfills (Californians Against Waste 2011; California Integrated Waste Management Board 2004). Waste has had a controversial history in the United States and will continue to have one until a cost effective, environmentally friendly, and socially acceptable means of resources appropriation is found (Lund 2001; Rodgers 2005; Tammemagi 1999).

Waste Diversion

In order to impede the ever-growing landfills in California, the United States, and the world, waste diversion efforts in terms of reduction, reuse, and recycling must be accomplished. While recycling is a widely recognized component of waste diversion, reduction and reuse is often overlooked (Cooper 1994; California Integrated Waste Management Board 2007; Lund 2001). The analysis of products from a life cycle approach has began to emerge as in international trend. This approach is not limited to looking at a product in terms of its end of life recyclability, but instead compiles the environmental impact the product has in terms of materials mined to produce the product, the manufacturing process , shipment, lifespan , and eventually disposal of the product. This process is very important in determining the true environmental impacts of what consumers purchase (Del Borghi, Gallo, and Del Borghi 2009; Cleary 2009). This thesis project will utilize the lifespan and disposal sections of the life cycle of waste materials found in dumpsters throughout campus at CSU, Chico.

While reduction and reuse are preferred to recycling, by no means should the value of recycling go unrecognized. Recycling not only saves valuable resources from going to the landfill and reduces virgin material from being mined, but recycling also creates more jobs than land-filling or incinerating these resources (Ackerman 2001; California Integrated Waste Management Board 2005). Over 50% of the materials that end up in U.S. landfills could easily be recycled and over 90% of the material is recyclable if the proper recycling infrastructure is in place (United States Environmental Protection Agency, Office of Solid Waste 2008). In order to determine what facilities and operations are needed to reduce waste, quality comprehensive waste analysis and characterization studies must first be conducted to determine what materials make up the waste stream.

Waste Analysis

There have been a number of suggested waste analysis methodologies throughout the world. These methodologies include mechanical and manual sorting techniques, methods that develop a range of material categories into which to sort waste, and both quantitative and qualitative data gathering (Dahlen 2008; Sharma and McBean 2007; Yu 1995). Because most of the methodologies found pertained to the characterization of municipal solid waste, only a small quantity could be adapted for use in a college setting. While mechanical sorting allows for efficient characterization of a large volume of waste, most universities do not have access to this equipment and must rely on manual sorting techniques (University of Oregon Campus Recycling Program 2008). Some methodologies have suggested sorting in to more than 100 separate

categories, but realistic campus waste analyses have focused on having roughly 40 categories to sort waste into (Armijo de Vega, Ojeda Benítez, and Ramírez Barreto 2008; Dahlen 2008). Studies have shown that when comparing quantitative and qualitative data analysis, it has been found that asking users what they throw away does not truly represent what is found in the waste stream when conducting a quantitative waste characterization study Yu 1995). Waste characterization studies have been widely used in municipalities and in the business sector.

Municipalities and businesses have used waste characterization studies to reduce garbage costs and significantly impact the amount of waste that they send to the landfill (Clelland, Dean, and Douglas 2000). However, university waste studies have significant differences when compared to studies of businesses and municipalities because of the unique and ever changing waste stream on college campuses.

Waste characterization manuals have been developed by the University of California, Davis, and the University of Oregon, who are both considered leaders in the development of college waste reduction strategies (University of California, Davis 2009; University of Oregon and Medical University of South Carolina 2010). These manuals are valuable in regards to methodology examples, safety tips, and student volunteer recruitment. Beyond these manuals, the most valuable literature available is waste characterization studies conducted by other universities. These studies not only outline the methodology used and display the results found, but also address any obstacles that were encountered in conducting characterizations.

Consistent themes regarding campus waste studies are that most of the audits done use a portion of the waste on campus instead of sorting all waste and usually one

characterization is conducted which does not account for the weather conditions or time of year (Armijo de Vega, Ojeda Benítez, and Ramírez Barreto 2008; Felder, Petrell, and Duff 2001; Mason, Oberender, and Brooking 2004). One possible reason why most studies are not conducted multiple times throughout the year could be because of the constant change in campus waste and the inconsistency from day to day. Some campus waste studies analyzed the waste stream, determined the location were specific waste items were generated, and linked the use of the location (recreation, food service, student support, etc.) to the waste generated (Armijo de Vega, Ojeda Benítez, and Ramírez Barreto 2008; Felder, Petrell, and Duff 2001).

While many of the studies conducted tended to express their findings with complicated graphs that are difficult to interpret, the solid waste characterization performed at the Campus Mexicali I of Autonomous University of Baja, California is an excellent example of a thorough study accompanied by straightforward intelligible tables and graphs (Armijo de Vega, Ojeda Benítez, and Ramírez Barreto 2008). The methodology used by the Mexicali I University of Baja served as a model for this waste analysis of the CSU, Chico campus.

CHAPTER III

METHODOLOGY

Introduction

The analysis of California State University, Chico's solid waste stream is based on three considerations: (1) an estimate of the daily waste generated on campus, (2) sampling and characterizing waste, (3) securing and evaluating data in terms of waste categories generated on campus. This section will describe how these considerations were implemented and discusses the timeline, safety considerations, equipment needs, budget, and collaborations.

Estimate of Daily Solid Waste Generated

There is currently a daily estimated amount of waste created on for every person on campus which gets reported to the State of California on an annual basis. This average is obtained in relation to pounds per day for employees of the University and pounds per day for employees and students shown on Table 1 (CSU, Chico Campus Conservation Committee 2010).

The averages in Table 1 are based on an estimated weight for all dumpsters smaller than 20 yards that do not get weighed by the waste hauler. Based on this estimate CSU, Chico produces 7,811 lbs of waste per day, or over 2.8 million pounds per year.

Table 1. Daily amount of waste generated—2009 pounds of waste per person per day. Represents the target pounds per person per day required by the State of California. The reported actual pounds is determined by taking the total annual pounds of waste dividing it by the number of employee and/or students and dividing that by 365 days.

	Target Pounds	Actual Pounds
Employees (2,003)	≤14.2 lbs per person	3.9 lbs per person
Employees and Students (17,966)	≤1.2 lbs per person	0.5 lbs per person

The waste characterization performed is based on 1,986 lbs of material coming from buildings and outdoor bins on campus. While this material only accounts for one fourth of the estimated daily waste on campus, it is a good representation of the typical waste created daily. Much of the 2.8 million pounds of waste a year created on campus comes from large projects and special events, which should be audited separately because of their unique waste streams. The most constant stream of waste that can be collected, analyzed, and influenced, is the waste coming from buildings and outdoor bins on campus each day. Because of these factors, this project focuses only on the waste coming from buildings and outdoor bins on campus.

Sampling

The waste characterization and analysis took place using waste created on Tuesday, the fifth of April, 2011. This timing allowed for the examination of waste on a typical busy day in the middle of the semester. The timing was specifically chosen so as not to represent unique days on campus (graduation, move-in, move-out, spring break, etc.) where waste levels may be abnormal. The temperature reached a high of 64º which is within 7º of the average temperature of 71º in Chico that time of year. Zero inches of precipitation was recorded during the sampling day.

By working with the waste hauler for campus the researcher was able to ensure that exactly 24 hours worth of waste was measured in the study. The waste hauler emptied all dumpsters on the morning of April fifth and did not empty any dumpsters for the next 24 hours leading up to the waste audit, which ensured that none of the waste that ended up in dumpsters would leave campus.

By collaborating with custodial and grounds maintenance staff, all outside and inside trash receptacles were emptied 24 hours prior to the characterization in order for the material collected for the study to represent one full day worth of generation. All trash inside buildings on campus was bagged by custodial staff and placed outside each individual building. These bags were collected by the researcher and three volunteers starting at five in the morning on Wednesday, the sixth of April, 2011. Each bag was labeled with a sticker indicating which building it came from and a tally of the number of bags from each building was kept. All bags were brought to a secured sorting location on the outskirts of campus. Grounds maintenance staff collected all outdoor bin locations and brought them to the sorting area by seven in the morning. These bags were labeled and set aside from the bags collected from indoor locations.

Bags were not collected from any auxiliaries on campus including the Associated Students and Continuing Educations. University Housing buildings were not analyzed because they are not considered a university entity and the unique nature of their multifamily waste stream should be analyzed in an audit specific to their locations. The University Farm was not analyzed because of its distance (4.3 miles) from campus and the uniqueness of the waste they produce. It is suggested that the University Farm conduct their own waste audit (or have an audit conducted) to determine what materials

characterize their waste stream. No waste bins belonging to contractors or other third parties on campus were weighed because of the infrequency and unpredictability of this material.

The Gateway Science Museum was not included in this study, because of their focus on servicing the public. Because of the unique function and inconsistency of waste generated, it was decided that waste generated on site would not reflect they typical waste generated on campus and could skew results. No sports fields or public parking areas were included because of the high utilization from the public. High public use of these areas is due to the nature of the sites function or proximity to housing and businesses.

Buildings owned and/or operated by the Associated Students were not analyzed because of the Associated Students position as an auxiliary of the campus. The Associated Students at CSU, Chico already has an aggressive goal of 90% or more waste diversion by 2015 and are completing this goal internally. It should be noted that both University Housing and Associated Students buildings create a large amount of waste that is disposed of in multiple locations throughout campus. While waste from their specific buildings was not collected, much of the material produced by these organizations was sorted and analyzed during this project.

Waste Characterization

Collected bags were separated into piles pertaining to the building or location on campus where it was generated (Appendix A).

All waste was sorted by volunteers and the researcher into 23 categories for each building. The 65 volunteer sorters consisted of interns with the Sustainability

Collaborative and students recruited from environmental classes on campus. A list of the 23 categories can be seen in Figure 1. These categories were determined after considering

Waste Analysis Categories *Subcategories are italicized and weights will be counted towards the category they fall under*	
1. Paper : *white, colored, newspaper, magazines* **2.** Cardboard **3.** Books **4.** Construction/Demolition Material: *wood, cement, etc.* **5.** Scrap Metal/Mixed Metal **6.** Cans and Bottles: *aluminum, tin, clear/amber/green glass, plastics 1 & 2* **7.** Plastics 3,5,7 **8.** Plastic Film **9.** Glass (other): *mirrors, windows, etc.* **10.** Plastic Cups (not Reusable) **11.** Styrofoam **12.** Fiber/Cloth: *clothes, blankets, etc.*	**13.** Food Scraps **14.** Compostable Paper: *napkins, paper plates, paper towels etc.* **15.** Landscaping Material: *leaves, Grass, Branches* **16.** Organic Liquids: *Beverages, rain water* **17.** Hazardous: *cleaners, reactive agents, insecticides, medical waste, other (described)* **18.** Electric Waste: *electronics, cell phones* **19.** Media Storage: *CD's, Tapes, VHS, Floppy Discs, Records* **20.** Light Bulbs **21**. Batteries **22.** Reusable Material **23.** Other/Waste

Figure 1. Waste analysis categories. A listing of the 23 different categories that material generated on campus were sorted into.

categories present in a number of municipal and university solid waste audits and what staff members at CSU, Chico have observed in trash dumpsters around campus (Armijo de Vega, Ojeda Benítez, and Ramírez Barreto 2008; Dahlen, 2008; Felder, Petrell, and Duff 2001; University of California, Davis 2009). The 23 categories are diverse enough to determine policy, education, and procedures to eliminate them from the waste stream, but broad enough to make the sorting process efficient.

Three sorting tables (see Figure 2) were setup to help optimize space and efficiency for sorting the 298 bags collected. Each category had easy to read signage with

Figure 2. Picture of sorting table. One of the three sorting stations setup for the audit. Each station had bins that were sized to accommodate the amount of material found in each category.

pictures to ensure the accuracy of sorting by volunteers. An example of signage can be seen in Appendix B. The researcher was present at all times (other than restroom breaks) in order to answer any questions by volunteers. If the researcher was not present, there was a specific bin that volunteers could place questionable materials into and they would be sorted once a proper category was identified. Once the sorting of one building was completed all 23 categories were weighed, a volume of the material was measured, and the data recorded. See Appendix C for building records table. Weight and volume measurement procedures will be discussed in the data recording section of this document.

The waste analysis category of reusable material was difficult to classify because individual interpretations of what can or cannot be reused differ. Research was done to find if any large reuse organizations (Salvation Army, Habitat for Humanity, and the ARC thrift store) had a scientific or regulated method of determining what could be reused/resold. It was found that none of the contacted organizations have a formal process for determining reusability and that the decisions are made by individual workers and managers within the individual organizations. Therefore, it was decided that all potentially reusable items found during the waste analysis would be voted on. Votes for a material were only conducted when seven or more people were present at the sorting area. If the majority of people voted that it was a reusable item, the vote and location was recorded and the item was placed in the reuse category. If the majority of people voted that the item was not reusable, the item was disposed of and recorded in the waste category. Because the determination of reusable items is subjective, it was determined to be the best method to allow the important category of reuse to be included in the findings.

The results for all 23 waste analysis categories will be discussed in the results section of this report.

Data Recording and Analysis

Once all waste was sorted, weighed and volume recorded in relation to the category from which it belonged (in terms of location and waste category), the data were analyzed by weight and volume.

Weight

1. Each of the 23 categories of waste was compared by weight to the total sample sorted from campus. CP = (CW/TW) x 100. This provides the University with a general view of its waste steam and what types of waste are more prevalent than others.

2. Each of the 23 categories of waste was compared by weight in regards to which building or location it came from in comparison with the total weight of waste sorted from campus. CP = (CW in specific L / TW in specific L) x 100. With this information, the University can determine which buildings may need more waste education or recycling infrastructure.

3. Each building was compared by the total divertible material gathered, in order to determine which buildings should be focused on first. The five buildings with the most divertible material were analyzed further.

Volume

1. Each of the 23 categories of waste was compared by volume to the total sample sorted from campus. CP = (CV/TV) x 100. This provides the University with a general view of its waste steam and what types of waste are more prevalent than others.

2. Each of the 23 categories of waste was compared by volume in regards to which building or location it came from in comparison with the total weight of waste sorted from campus. CP = (CV in specific L / TV in specific L) x 100. With this information, the University is able to determine which buildings may need more waste education or recycling infrastructure.

The equations used in the above analysis are based on:

CP as percent of category waste

CW as total weight of specific waste category

TW as total weight of sample

CV as total volume of specific waste category

TV as total volume of sample

L as a specific location or building on campus

Timeline

- ❑ Summer 2010
  - Contacted collaborators and secured permission to conduct study from administrators.
- ❑ Fall 2010
  - Wrote proposal and receive funding from the Sustainability Fund Allocation Committee for equipment and supplies.
  - Found site to conduct audit.
- ❑ Spring 2011
  - January through April
    - ♦ Recruited 65 student volunteers through AS Sustainability and class talks/extra credit from professors.
  - March
    - ♦ Was in contact with custodial supervisors to work out any issues with their staff collecting and setting out trash bags.

- Contacted the waste hauler for CSU, Chico to ensure they are aware of the study and could alter their pickup days/times.
- Ordered large bins from the waste hauler for study.
- Purchased all the equipment and bins needed for the study.

- April
  - Conducted audit from the sixth of April until the eighth of April.

- Summer/Fall 2011
  - Analyzed data collected during the study and made recommendations in regards to divertible material.
  - Presented findings at California Higher Education Sustainability Conference.

Safety Procedures

Specific procedures were in place during the audit to ensure the safety of those collecting the bags and sorting the material. Nitrile gloves, filter masks, painter suits, shoe covers, and safety glasses were provided to all volunteers. All bags were opened with utility knives and the contents were dumped onto tables because of safety issues pertaining to sharps and hazardous materials. By dumping the bag on the table, sorters could view the entire contents of the bag, instead of reaching their hands into a bag without seeing the items inside. All potentially hazardous or unsafe materials were immediately identified and turned into the researcher who recorded it and arranged for proper disposal. All volunteers received training in regards to safe sorting and material handling procedures.

Equipment

All collection and sorting of solid waste was done by the researcher and volunteers. The following equipment was used:

- *Bins* – different sized bins were used for sorting different material into**.**
- *Dumpsters* – five dumpsters were provided by the local waste hauler for the waste audit area. Two 3yrd dumpsters were provided for compost, two 3yrd dumpsters were provided for paper, and one 40yrd dumpster was provided for waste. All of the 3yrd dumpsters were emptied on an on-call basis, the 40yrd dumpster did not have to be emptied for all three days of the audit.
- *Floor scale* – a floor scale was used to weigh all sorted material.
- *Tarp*- a 30x50 foot tarp was laid down to ensure that the sorting area was left clean at the end of the event.
- *Gas* – 15 gallons of gas was purchased and stored in gas cans. The gas was used to refuel the generator as needed.
- *Generator* – a generator powered a large floor scale, water cooler, and radio. A generator was rented that was low in emissions and quiet when in use.
- *Stake-bed Truck* – a large truck was used for picking up trash bags from outside of buildings and transporting equipment and supplies.
- *Measuring Sticks* – wooden dowels were marked to measure the volume of specific bins. Each dowel was marked in 5-gallon increments in correlation to the bin they were used to measure. The 5-gallon increments marks were determined by filling individual type of bins (large toters, small toters, brute round bins, square blue bins,

buckets) with 5 gallons of water at a time, placing the dowel into the bin and marking the water line on the dowel. See Figure 3 for dowel measuring stick.

- *Radio* – used to provide entertainment during the 8-10 hours a day spent sorting.
- *Records Binder* – a binder was used to keep and organize paperwork in regards to volunteer information, data collected, and procedural notes.
- *Safety Supplies* – nitrile gloves, filter masks, painter suits, shoe covers, and safety glasses were provided to all volunteers. Gloves and closed toed shoes were required, while all other safety precautions were optional. See Figure 4 for an example of some of the safety supplies used during the audit.
- *Tables* – five 4x8 foot tables were used in the waste audit area.
- *Tent* – a 20x50 foot tent was used for the audit. This provided shade and shelter for volunteers during the audit.
- *Trash Bags* – three boxes of heavy duty trash bags were available for lining bins. Less than one box was used because the bags collected on campus were reused after their contents were sorted.
- *Utility Knives* – utility knives were used to open bags before dumping the contents on the table.
- *Water Cooler* – a water cooler filled with five-gallon water jugs was kept on site to ensure all volunteers would be properly hydrated throughout the day.
- *Writing Utensils* – Pens and pencils were kept on site to record data and make procedural notes.

Figure 3. Picture of volume measuring dowels. Examples of measuring dowels used to calculate the volume of materials.

Budget

Funding for the audit was secured through the Sustainability Fund Allocation Committee (SFAC) at CSU, Chico. The funding proposal for $1,700 was approved and $1,457.26 was spent on the audit. For a detailed description of the budget see Figure 5.

Figure 4. Picture of volunteer in safety gear. A typical happy material sorter in the proper safety gear (including gloves, goggles, and painter suit)

Other resources for the audit were donated, including; bins, dumpsters, use of the scale, and use of trucks, water cooler, and tables.

Collaboration

Collaboration between students, faculty, staff, administration, the Associated Students at CSU, Chico, and local businesses were crucial in making this project a success.

SFAC Allocation:	$1,700
Actual Description	**Amount**
Tent (rental/set up) CAF: 94056 - FMS	$325.00
Suits, gloves, masks, knife, shoe covers	$137.00
est. CA sales tax on pant suits	*$5.88*
Stickers, tarp, markers, tape, dowels (x20)	$170.35
Generator Rental - Expected Cost	*$325.00*
Color Posters (x69) + Lamination	$134.00
Specialty Dumpster Signs	$5.88
tape and gloves	$107.18
Sunscreen, scale, batteriess	$80.11
Generator Rental - Beyond expected cost	$0.50
Gas for generator	$26.02
gloves for waste audit	$21.63
remainder of generator cost (put back into	-$81.39
	$200.00
Actual Spent	**$1,457.16**
Remaining	**$242.84**
Percentage of total allocated	**85.72%**

Figure 5. Budget. Represents a breakdown of the budget for the waste audit.

Source: DiFalco, R. 2011. SFAC budget table for campus wide waste analysis [internal document]. Chico, CA: California State University, Chico, Sustainability Fund Allocation Committee. Reprinted with permission.

Students were relied upon to provide most of the physical sorting for the audit. Sixty-five students assisted in sorting materials during the three days of the audit, for a combined total of 135 sorting hours (not including the 27 hours of sorting and training work by the researcher from April 6th to April 8th). Most students were required to

participate through their internship with the Associated Students Sustainability Program, but others volunteered their time or received extra credit from a professor on campus.

Faculty members were identified early in the process and were contacted to encourage students in their classes to participate in the audit. The faculty who offered extra credit in their classes had the most students sign up to do sorting.

Staff on campus played an integral role in the success of this project. The researcher collaborated with custodial staff and grounds staff in order to get bags placed in the proper locations, facilities reservation staff to secure a location and the tent, university police to provide extra security for the sorting area at night, and environmental health and safety staff to ensure proper safety procedures and equipment was in place.

It was of the utmost importance to get approval for this project by administrators on campus. The researcher met early on with the Vice President of Business and Finance to seek support for the project. The project endorsement by administrators helped secure a location for the audit and went a long way in gaining cooperation from other groups on campus.

The Associated Students at CSU, Chico funded the project through an SFAC grant (discussed in budget section of document) and donated equipment and supplies for the audit. Associated Students Recycling vehicles were used to collect the bagged waste on campus and to transport equipment and supplies to the audit site.

The waste hauler, an equipment rental business, and a local special event tent provider were all off campus parties involved in the audit. Communication with the waste hauler was important to ensure accuracy of the time waste was picked up on campus, as well as the donation of dumpsters and bins for the event. An equipment rental place as

used for renting the generator, while the tent provider setup and tore down the tent used at the audit site.

CHAPTER IV

RESULTS, DISCUSSION AND RECOMMENDATIONS

Introduction

Results are presented in all 23 different waste categories. They will be discussed in terms of weight, volume, and location. Since weight is the current measurement of waste reported to the State, most results will be discussed in regards to this measurement. Volume will be used when volume to weight results differ greatly, or when volume measurements are relevant to recommendations made. Recommendations on what CSU, Chico can do to reduce the divertible material in their waste stream are made at the end of the discussion of each waste audit category. While these recommendations may not pertain to other universities regarding their particular waste streams, it is the researchers hope that they will provide a starting point for CSU, Chico to become a leader in their waste reduction efforts.

Waste Analysis by Materials

Each of the 23 waste audit categories will be discussed along with recommendations on how to reduce its presence in the waste stream. Figures 6 and 7 present the overall composition of material collected by both weight and volume respectively. Figures delineating a materials origination will be included for the five

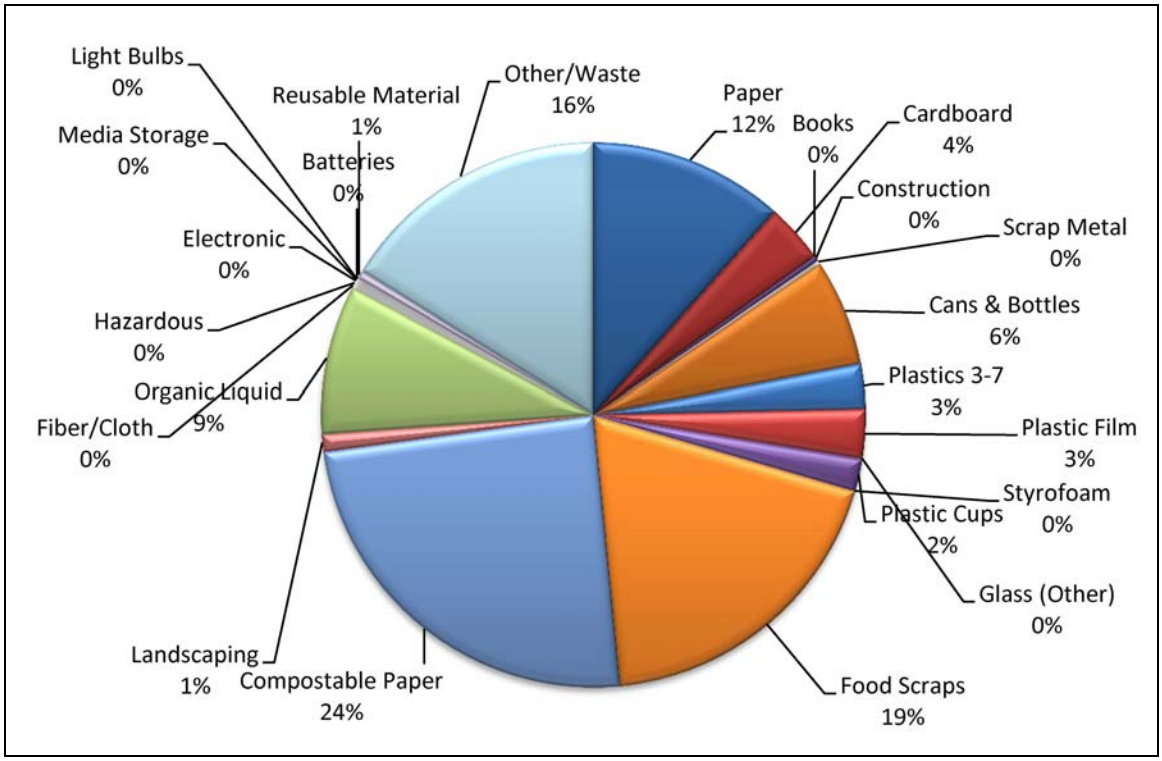

Figure 6. Material breakdown by weight. Illustrates what percentage of the total material each of the 23 categories represents in terms of weight.

most prevalent divertible categories. Twenty-two of the 23 categories were present in the waste stream since no books were found in the study. If any other category (besides books) is represented as 0% of the waste stream, it means that the material found was less than 1% overall. See Appendix D for a table of materials found by weight and their representation in the waste stream.

Compostable Paper – 24% Weight (W)
29% Volume (V)

Compostable paper products were the highest percentage of any material found (by W and V) in the waste stream. This category included items such as compostable plates, napkins, cups, and paper towels. While compostable food service

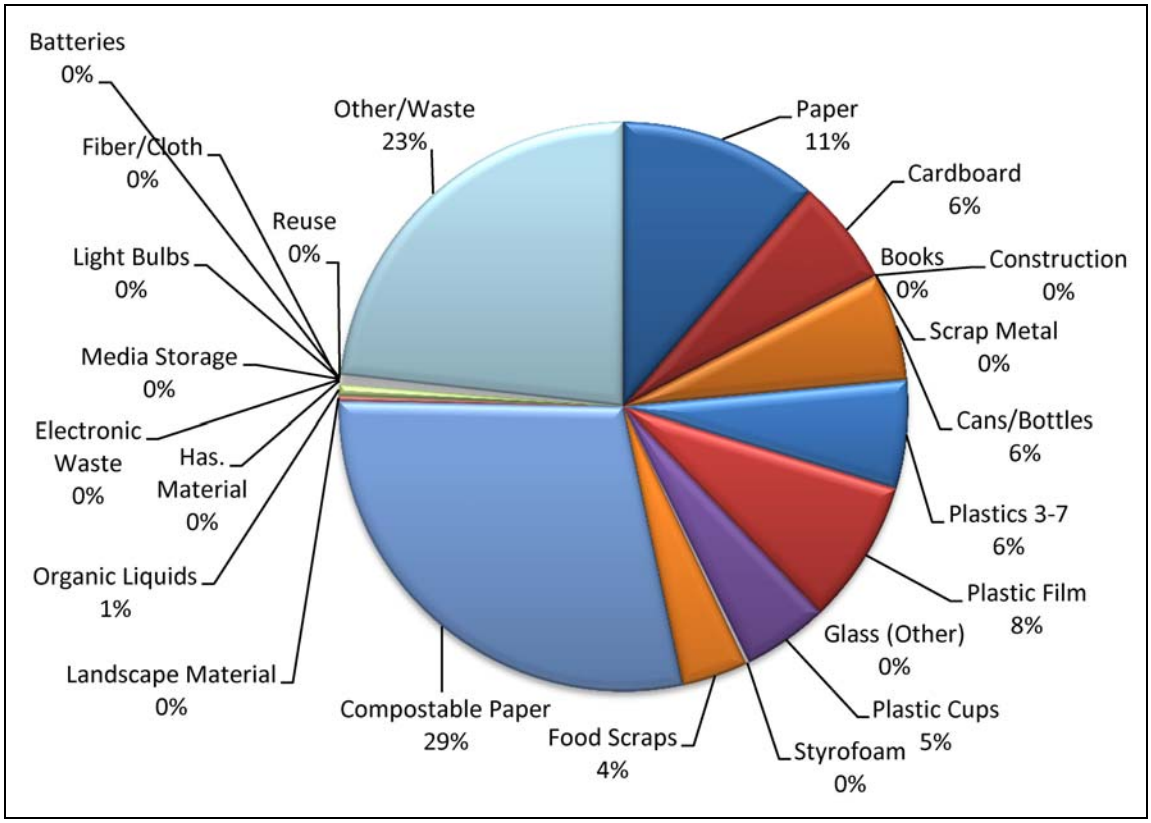

Figure 7. Material breakdown by volume. Illustrates what percentage of the total material each of the 23 categories represents in terms of volume

items were found in the waste stream, paper towels were by far the most prevalent material in this category. For material weight by building, see Figure 8.

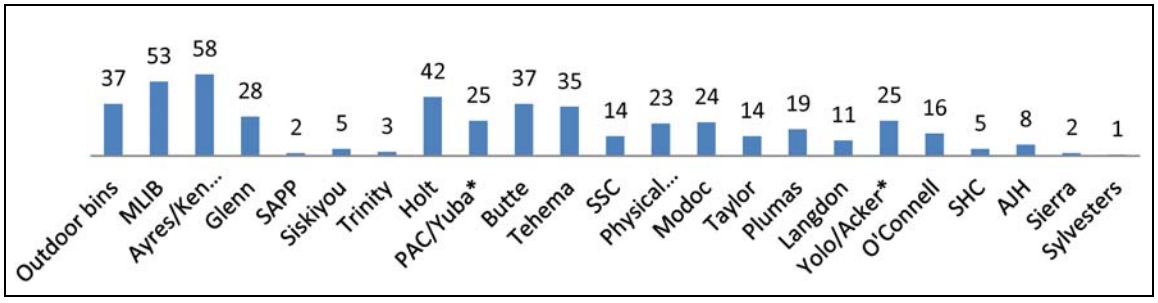

Figure 8. Compostable paper (pounds) per building. Illustrates the areas of campus where compostable paper was found in the waste stream and how many pounds were found in each location.

Recommendations

- Develop and implement a program to compost paper towels in bathrooms throughout campus.
- Increase awareness of collection sites for compostable food service items on campus.
- Implement an education campaign to reduce the amount of paper towels used by individuals on campus.

Food Scraps – 19% W, 4%V

While the volume of food scraps found in the waste stream was minimal, the weight of this material is significant. Since compliance with State mandated diversion goals are based on weights, this category of waste is important to reduce. Most items found in this category consisted of partially eaten meals and snacks. For material weight by building, see Figure 9.

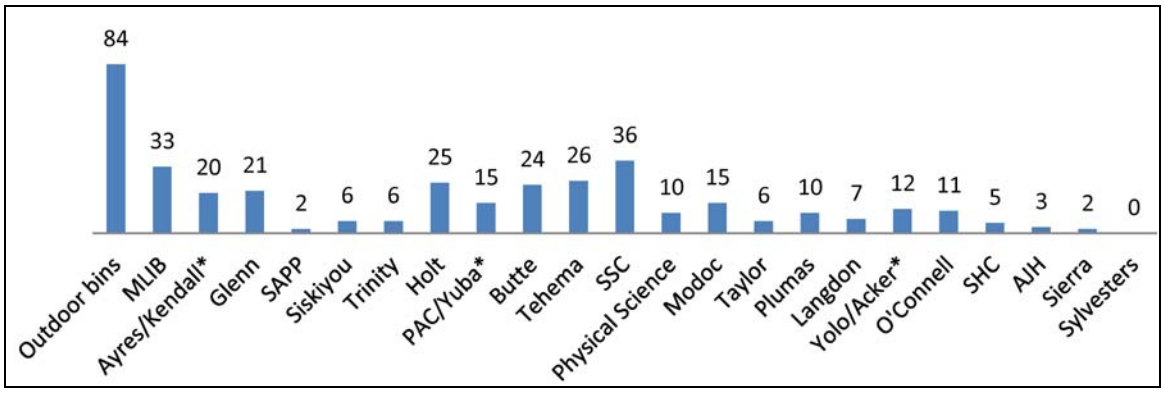

Figure 9. Food scraps (pounds) per building. Illustrates the areas of campus where food scraps were found in the waste stream and how many pounds were found in each location.

Recommendations

- Develop a composting program across campus, not just in dining halls and food service areas. This could be coupled with the paper towel composting program, where food scraps could be brought to bathrooms to be composted.
- Increase awareness of collection sites for compostable food scraps on campus.
- Implement an education campaign to reduce food waste.

Other Waste – 16% W, 23%V

Items found in the waste stream that could not be recycled, composted or reused, included: rigid plastic packaging material, chip and other snack bags, hygiene products, cigarette butts, plastics with no recycling code, dog feces, Styrofoam food service ware and other items that did not fit into the other 22 categories.

Recommendations

- Enact procurement policies to reduce the amount of non-recyclable items and packaging materials that arrive on campus.
- Educate campus populations on what is and is not recyclable and compostable.
- Promote reduction of single use items and an increase in reusable items.

Paper – 12% W, 11%V

Paper products found included office paper, newspapers, paper bags, paper packaging material, and paper posters. Paper is extremely recyclable and significant infrastructure to recycle this material is already in place. For material weight by building, see Figure 10.

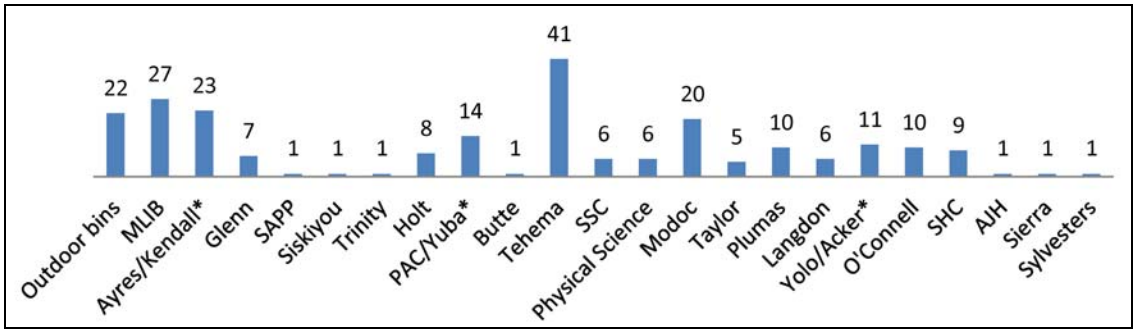

Figure 10. Paper (pounds) per building. Illustrates the areas of campus where paper was found in the waste stream and how many pounds were found in each location.

Recommendations.

- Decrease locations with only trash receptacles, either by increase paper collection bins, or removing excess trash bins. This included classroom locations.
- Provide outdoor paper recycling receptacles.
- Educate the campus community about paper recycling and bin locations.

Organic Liquids – 9% W, 1% V

The majority of organic liquids came from beverages containers that were not fully empty. Most liquids consisted of carbonated beverages and water. For material weight by building, see Figure 11.

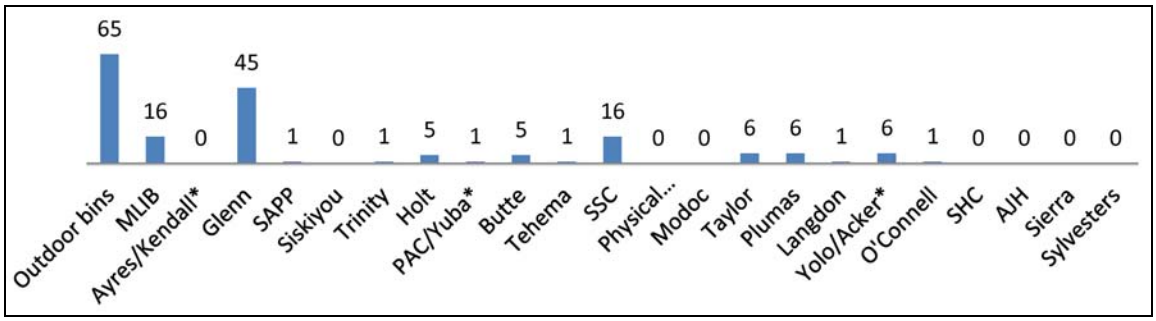

Figure 11. Organic liquid (pounds) per building. Illustrates the areas of campus where organic liquids were found in the waste stream and how many pounds were found in each location.

Recommendations

- Provide education on the amount of drinkable liquids wasted on campus.

Cans and Bottles – 6% W, 6% V

This category consisted of aluminum cans, bi-metal cans, glass bottles, and plastic bottles #1 and #2. There are programs in place to recycle these materials and an infrastructure of bins on campus. Because of the high value (monetarily and material recyclability) of these materials, extra effort should go into keeping them out of the landfill. For material weight by building, see Figure 12.

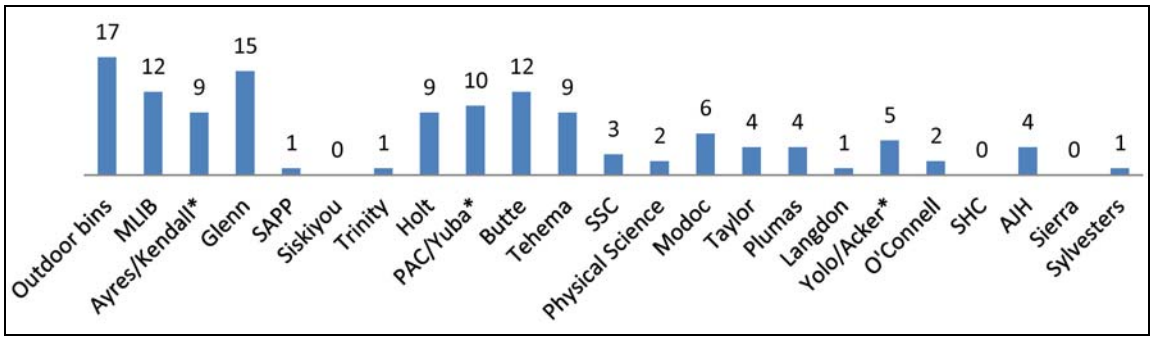

Figure 12. Cans and bottles (pounds) per building. Illustrates the areas of campus where cans and bottles were found in the waste stream and how many pounds were found in each location.

Recommendations

- Increase cans and bottle recycling receptacles throughout campus. Ideally every publicly located (hallways, outdoors, near restrooms, in classrooms) waste bin on campus would have a cans and bottle recycling bin located next to it.
- Increase education on where current recycling bins are and the importance (economic and environmental) of recycling this material.

Cardboard – 4% W, 6% V

Cardboard products consisted of shipping boxes and small amounts of packaging containers (used to package snacks and other small items). For material weight by building, see Figure 13.

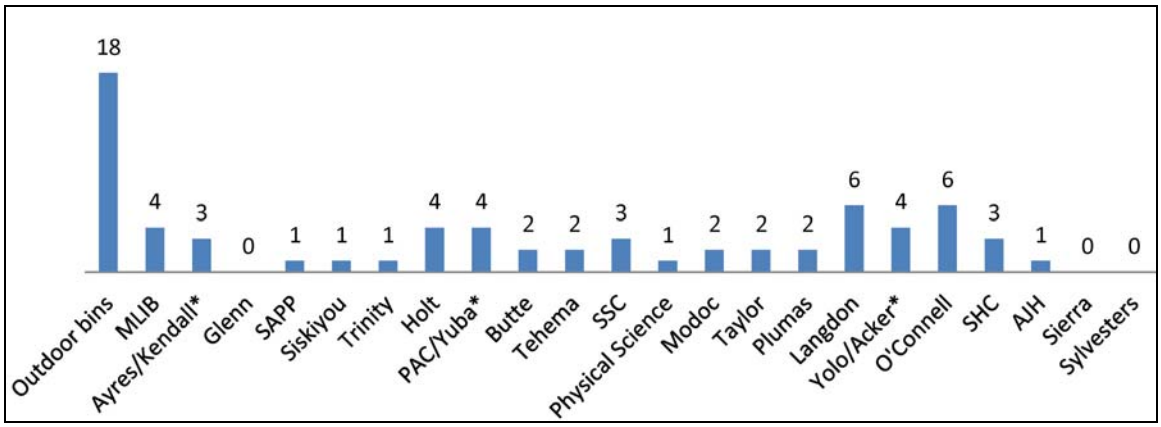

Figure 13. Cardboard (pounds) per building. Illustrates the areas of campus where cardboard was found in the waste stream and how many pounds were found in each location.

Recommendations

- Ensure that all large dumpsters on campus have cardboard bins located next to them.
- Provide education regarding the proper way of disposing cardboard containers on campus.

Plastic Film – 3% W, 8% V

This category consisted of plastic bags. Sizes varied from small sandwich bags, medium grocery bags, to larger trash bags. No bags that were full of trash were counted in this category, but empty trash bags were found and counted. While this material does not have significant weight, it accounts for 8% of the total volume of waste

coming from campus buildings and outdoor bins. If this material can be diverted from waste receptacles, it can make a considerable impact of the volume of waste on campus.

Recommendations

- Plastic bags can currently be placed in mixed paper bins to be recycled at CSU, Chico. A greater effort should be made to educate the campus community of this service.
- Bins exclusively for plastic film recycling should be provided for locations on campus that regularly dispose of large quantities of plastic film.

Plastics 3,5,7 – 3% W, 6% V

Plastics numbered 3,5, or 7 consist of items such as, yogurt cups, condiment containers, plastic piping, food storage containers, and molded plastics. These plastics are harder to recycle in the Chico area and they were separated from the other plastics (1,2,4,6) because of this.

Recommendations

- Reduce the amount of 3,5, and 7 plastic coming onto campus by purchasing practices and education campaigns.

Plastic Cups – 2% W, 5% V

No matter the plastic number (1-7), plastic cups were separated from other plastics because of their lack of currently recyclability in the area. While recycling trends may change in the future, the researcher deemed it best to keep the material separate at this point and time.

Recommendations

- Educate the campus community on the difficulties of recycling plastic cups.
- Promote the purchase and use of reusable cups on campus.
- Provide cups that can be composted on campus in food service areas.

Landscaping Material – 1% W, 0% V

Landscaping materials found included grass, branches/sticks, soil, and rocks.

Recommendations

- Provide training and follow up for grounds staff in regards to the proper disposal of landscaping materials.

Glass (Other) – 0% W, 0%V

Glass (Other) consisted of any glass found that was not of California Redemption Value. While a few small pieces of scrap glass was discovered, it was an insignificant part of the waste stream.

Styrofoam – 0% W, 0%V

Only five pieces of block Styrofoam were found during the audit and six gallons worth of Styrofoam peanuts. The small amount of Styrofoam found is insignificant in terms of weight and volume.

Books – 0% W, 0% V

No books were found during the waste audit. This is the only category in which no material was found.

Construction Materials –0% W, 0%V

Construction material found consisted of some broken porcelain, a two pieces of treated wood, and some miscellanies nuts and bolts. Construction material coming from buildings and outdoor trash receptacles does not need to be addressed at this time.

Scrap Metal – 0% W, 0%V

There were only five small pieces of scrap metal found during the audit. The small amount does not warrant any action regarding scrap metal coming from buildings and outdoor trash receptacles.

Electronic Waste – 0% W, 0%V

Materials found with electronic components included a microphone, earphones, a light switch, one keyboard, a calculator, and a mouse to a computer. While the weight and volume of this material was insignificant in terms of total waste on campus, the heavy metals and toxins present in these objects are reason for concern.

Recommendations

- Education should express the need to keep electronics out of the waste stream and the consequences they can have on the environment.
- Electronic waste bins should be provided in every building on campus and information distributed regarding the locations of these bins.

Media Storage – 0% W, 0%V

Media storage material found included CDs, DVDs, VHS tapes. These materials were found intermittently and do not represent a significant material in the waste stream.

Light Bulbs – 0% W, 0%V

Only one light bulb was found in the waste stream during the audit. The 12 volt light bulb was found in a trash bag from Taylor Hall. While this one bulb did not contain mercury, CFL bulbs used on campus should be kept out of the waste stream. The results of this study found no CFL bulbs in the waste stream.

Fiber/Cloth – 0% W, 0%V

Fiber/cloth found consisted of a few shirts and scrap fiber. The total amount of fiber discovered was less than 1lb and .05% of the total waste stream.

Batteries – 0% W, 0%V

Twenty-five batteries were found during the audit. While this represents just over 1lb of waste, batteries contain toxins that can harm the environment. If an average of 25 batteries were disposed of in the garbage each work day on campus, over 6,000 batteries would be sent from the campus to the landfill a year.

Recommendations

- Provide approved Environmental Health and Safety battery collection bins to administrative offices and faculty department offices though out campus.
- Educate the campus community on the importance of proper battery disposal.

Hazardous Material – 0% W, 0%V

Hazardous material was considered any material found that could cause bodily harm and was not disposed of properly in the trash. Because of the importance of this material, a list of hazardous materials and the locations in which they were found are listed below.

- ❑ Ayres Hall – Full can of stainless steel cleaner, one razor blade.
- ❑ Trinity Hall – A zip lock bag of miscellaneous pills.
- ❑ Holt Hall – One razor blade, broken vile with trace amounts of liquid, empty sodium chloride injection needle.
- ❑ Performing Arts Center – Partially full industrial cleaning spray.
- ❑ Butte Hall – Partially full keyboard cleaner.
- ❑ Physical Science – Paper filter with unknown powder on top, insulin syringe.
- ❑ Arthur Jay Hamilton Hall – Unlabeled syringe.

Recommendations

- Provide secure sharps boxes (for razors and syringes) in building on campus.
- Educate the campus community about proper disposal and the dangers of improperly disposing of hazardous material.

Reusable Materials –1%W, 0%V

As discussed in the methodology section of this document, reusable material was determined by the votes of waste audit volunteers. Table 2 shows the potential reusable items found and the resulting vote tally. All potential reusable items were determined to be reusable.

Recommendations

- Provide education and operation services to increase collection and redistribution of reusables.

Table 2. Reusable items vote. All votes were taken with seven of more individuals present. The column on the left hand side of the table provides the outcome of these votes (Yes:No).

Vote Y:N	Description
9:0	Coffee Mug
7:0	Sunglasses
7:0	Sunglasses
9:0	Surge Protector
9:0	Unopened Toothbrush
7:0	Metal Clothes Hangers (2)
5:2	Water Bottle
6:1	Tupperware
7:0	Ring (Jewelry)
6:1	Coffee Mug
6:2	Metal Tupperware
7:0	New Binder
7:2	Sleeve of Unused Disposable Cups
9:0	Full Roll of Scotch Tape
9:0	Box of Unused, Blank Envelopes
8:0	Roll of Unused Trash Bags

Waste Analysis by Location

All bags of waste collected on campus were separated and sorted by the location from which they came. In this section, the locations of waste collected will be analyzed in regards to the amount of possibly divertible material. An overview of all locations will be discussed, followed by specific high volume locations. Recommendations will be made regarding waste type and location. See Appendix E for a map of campus building locations.

Figure 14 shows the ratio of trash and divertible material found in the bags collected on campus. These results show that a majority of material found in each location could be diverted from the waste stream. Figure 15 illustrates that the locations

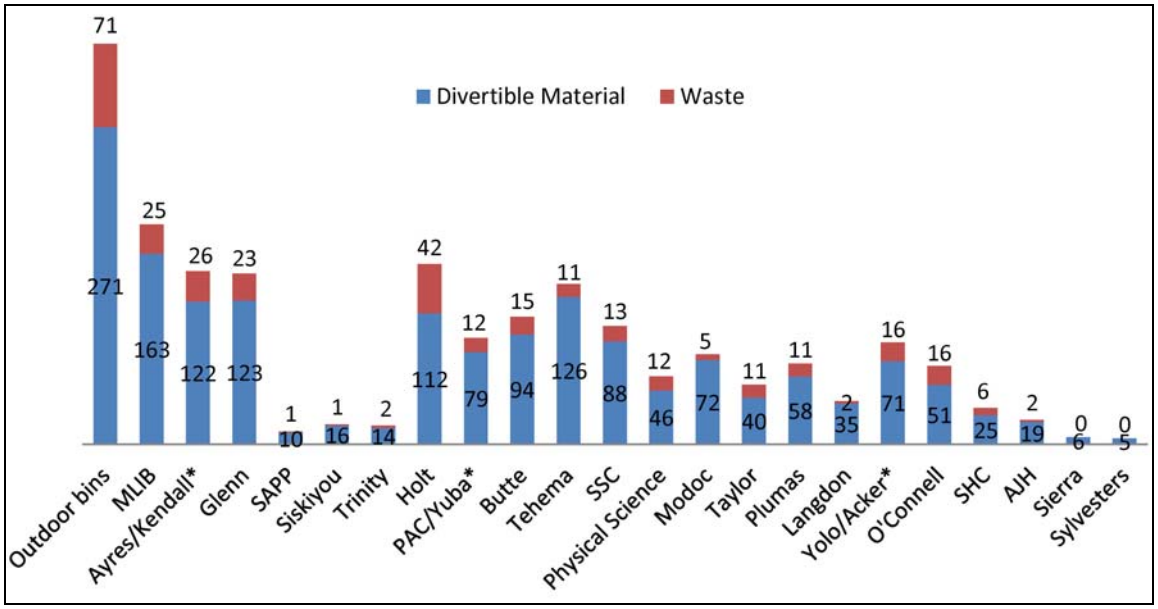

Figure 14. Total waste and divertible material (eight) per building. Depicts the total divertible (blue) and non-divertible (red) waste for each location collected during the study.

with the largest amount (in weight) of divertible material. The outdoor bins, Meriam Library (MLIB), Tehama Hall, Holt Hall, and Glenn Hall's specific waste characterization (by weight) will be further analyzed. Ayres/Kendall will not be analyzed because of contamination issues, which are discussed in the limitation section of this document.

Outdoor Bins

Outdoor bins held the largest amount (16% of total material collected) of waste and divertible material when compared to the other locations where bags were collected. Thirty-six percent of the material (food scraps 25%, compostable paper 11%) found in these bins is easily compostable in any industrial compost facility. A large amount of organic liquid (19%) was also found in these locations. Easily recyclable materials such as paper (6%), cans and bottles (5%), and cardboard (5%), make up 16%

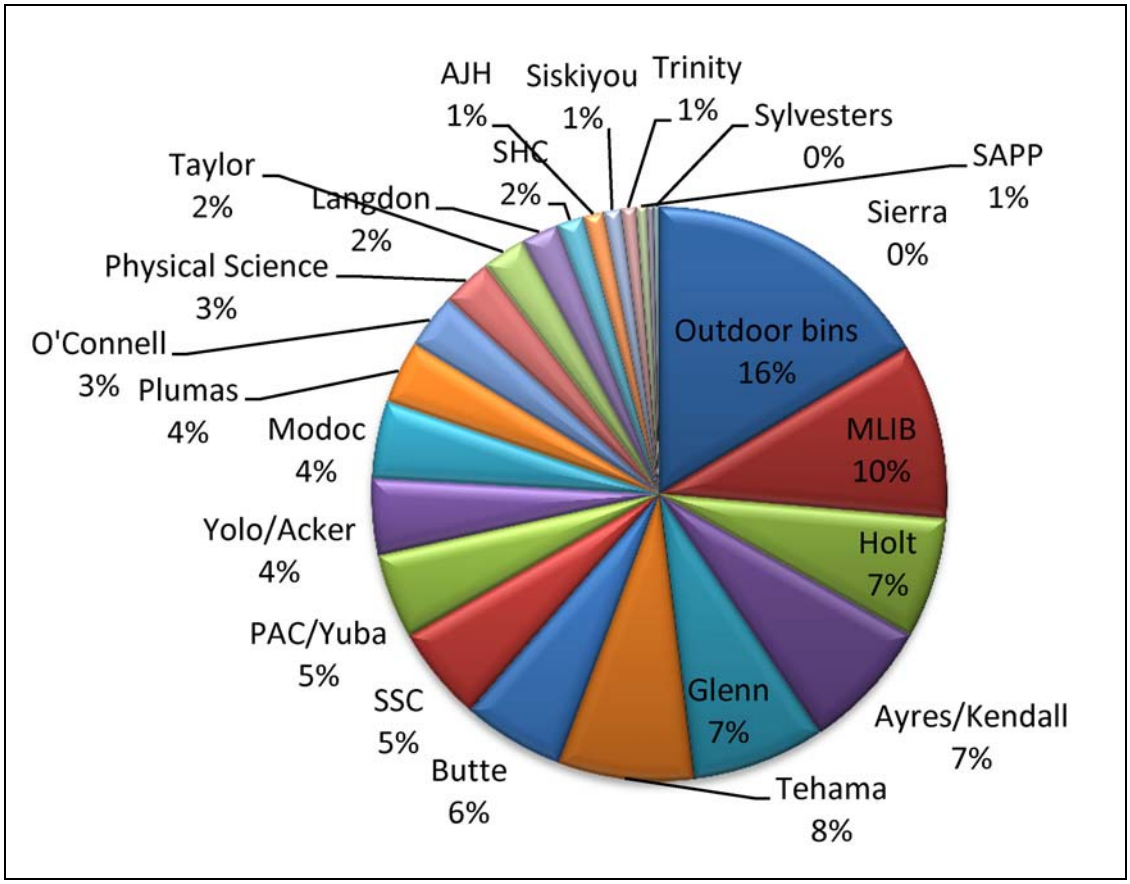

Figure 15. Divertible material by location. Graphs the locations with by the percentage of divertible material they have in comparison with the total amount of divertible material collected on campus.

of the material found. Books, construction material, glass (other), Styrofoam, hazardous material, electronic waste, media storage, light bulbs, and reusable materials were not found in any outdoor location. See Figure 16, for a composition of materials found in outdoor locations.

Recommendations

- Provide recycling bins at every outdoor trash location on campus and/or remove trash bins on campus to create a one to one ratio of trash and recycling outdoor bins.

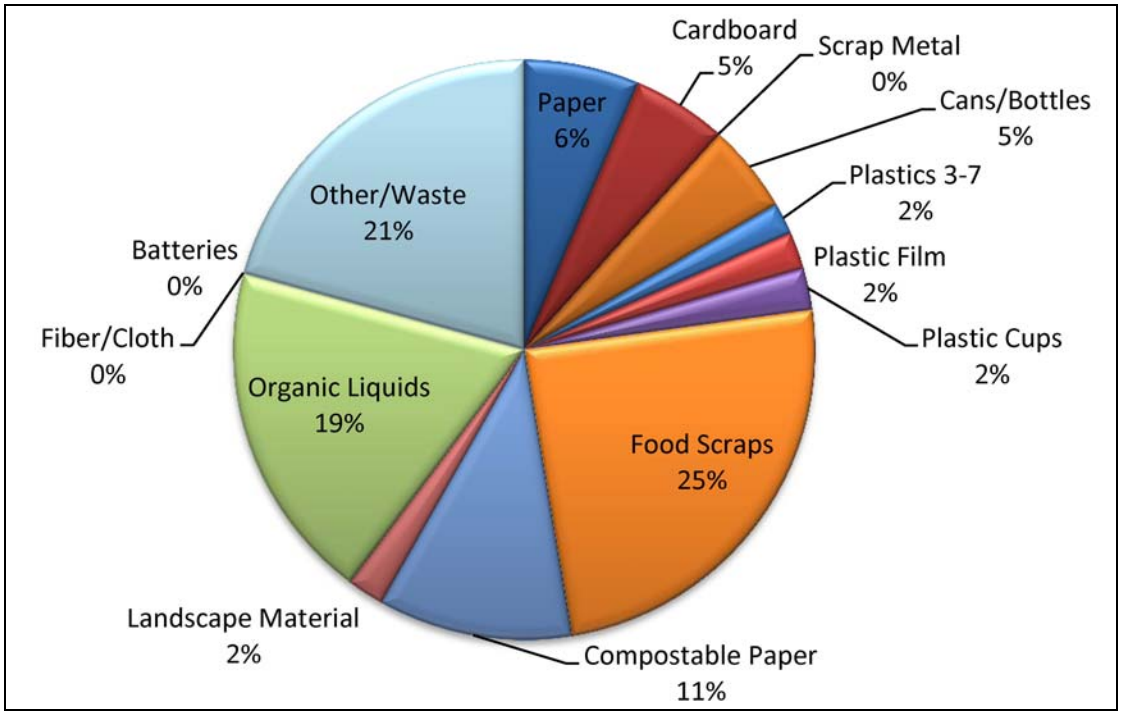

Figure 16. Outdoor waste bins. Presents the categories of materials found from all outdoor bins on campus and the percentage each material was accountable for in these locations.

- Provide more composting collection on campus. This includes indoor and outdoor locations.
- Educate the campus community about wasted organic liquids.
- Purchase outdoor bins with covers to adequately keep out rain water.
- Correctly label recycling and trash bins as to what is acceptable in each bin and make them noticeably recognizable from each other.

<u>Meriam Library (MLIB)</u>

The library on campus created the most material (10% of total material collected) out of any other building location at the time of this waste analysis. Compostable materials made up 46% of the waste stream coming from MLIB, while 14%

was recyclable paper and 6% cans and bottles. Over 80% of all materials coming from this location can be easily recycled or composted. See Figure 17, for a composition of materials found in Meriam Library.

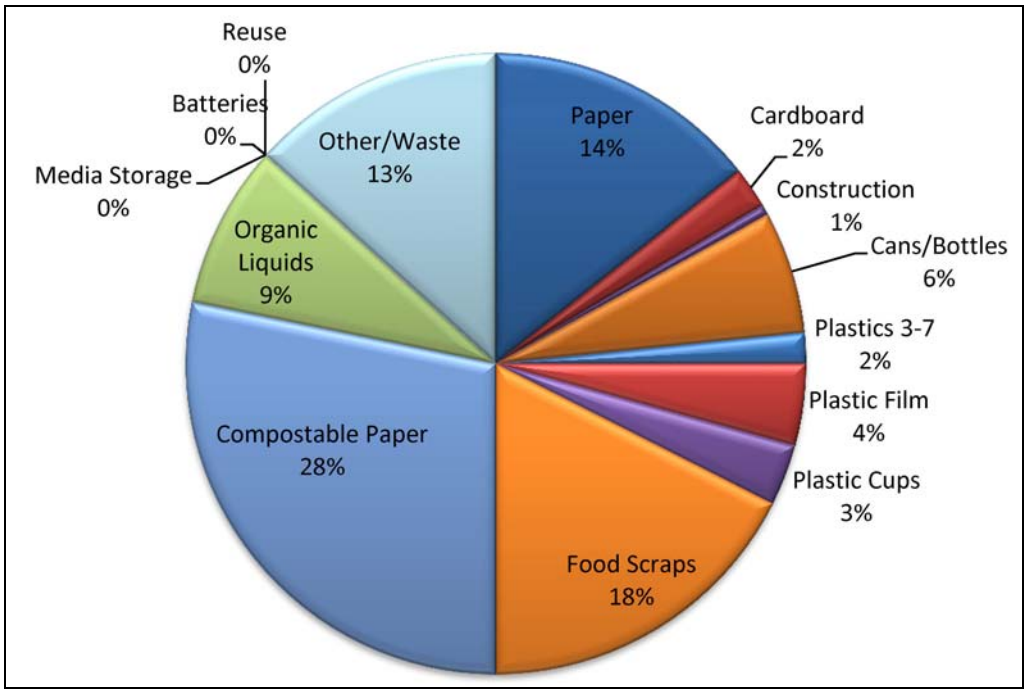

Figure 17. Meriam Library. Presents the categories of materials found from all bins inside Meriam Library and the percentage each material was accountable for at this location.

Recommendations

- Composting for food and paper towels should be located in the bathrooms throughout the building. An education effort should be put forth to inform customers of the building of the composting programs existence.
- More recycling bins should be provided in the building. Because of the buildings use, paper bins should be especially present. Every trash bin in the building should have one paper and one cans/bottle bin next to it.

- Signage regarding the reduction of paper towels should be prevalent in every restroom in the building.

Tehama Hall

Eight percent of all the material collected for during this audit came from Tehama Hall. Of that, 29% was mixed paper, 25% compostable paper, 19% food scraps, and 6% cans and bottles. The high level of mixed paper ending up in the waste stream was a significant finding in this building. See Figure 18, for a composition of materials found in Tehama Hall.

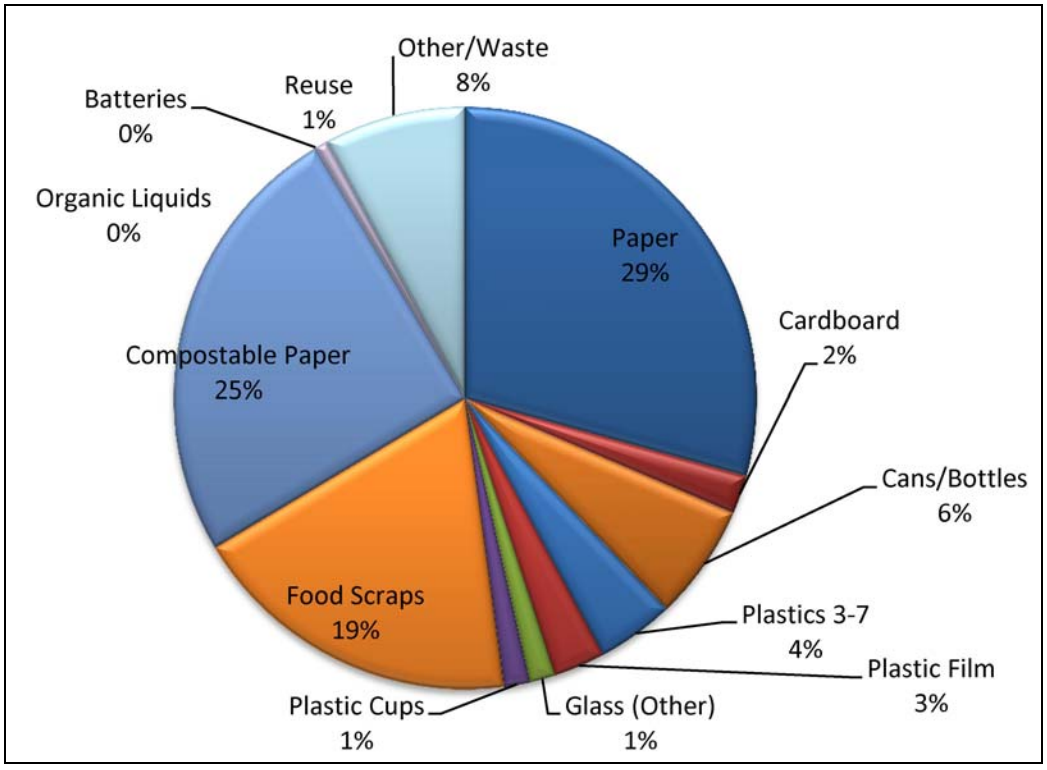

Figure 18. Tehama Hall. Presents the categories of materials found from all bins inside Tehama Hall and the percentage each material was accountable for at this location.

Recommendations

- Provide more paper and cans and bottle recycling bins in public areas in the building.
- Provide more paper and cans and bottle recycling bins in offices throughout the building.
- Place paper towel and food scrap collecting bins in the building along with signage about the program.

Holt Hall

Materials coming from Holt Hall represented 7% of all materials collected for the audit. 48% of the materials collected from Holt were compostable (30% compostable paper, 18% food scraps), while 12% was easily recyclable (6% paper, 6% cans and bottles). 1% of the materials were considered hazardous in nature and special attention should be paid to ensure they do not end up in the trash. Hazardous materials collected from Holt included, one razor blade, a broken vile with trace amounts of and unknown liquid, and an empty sodium chloride injection needle. See Figure 19, for a composition of materials found in Holt Hall.

Recommendations

- Focus Environmental Health and Safety education efforts on Holt Hall to reduce the improper disposal of potentially hazardous materials and provide infrastructure for the proper disposal of such materials.
- Setup composting collection bins for paper and food scraps.
- Increase paper and cans and bottle recycling bins throughout the building.

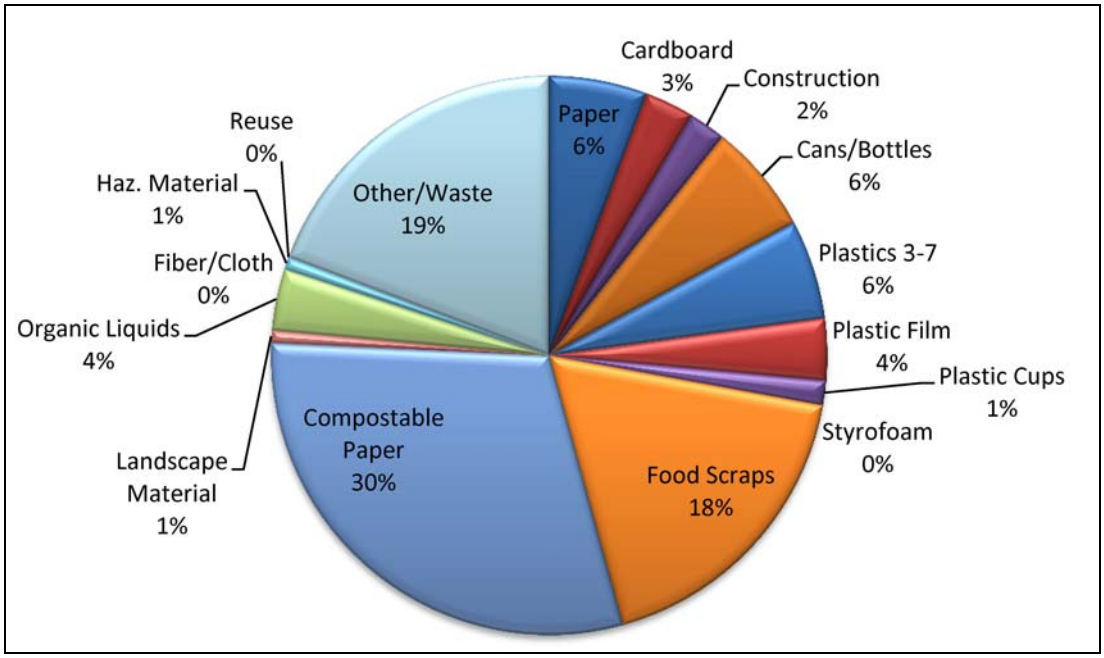

Figure 19. Holt Hall. Presents the categories of materials found from all bins inside Holt Hall and the percentage each material was accountable for at this location.

Glenn Hall

Glenn Hall created a significant (7%) amount of material. It is surprising to find that 31% of material coming from this building consisted of organic liquid. This proportion is vastly higher than any other building on campus, and constitutes 26% of the total amount of organic liquid found in all 23 locations. This could have been the result of human error in recording the data, or an irregular event in the building that caused an unusual amount of organic liquid to be disposed off. For the purpose of this study, we are assuming that Glenn Hall disposed of this amount of liquid and recommendations will reflect this assumption. Besides a large amount of organic liquid, Glenn Hall waste consisted of 19% compostable paper, 14% food scraps, 10% cans and bottles, and 5% mixed paper. See Figure 20, for a composition of materials found in Glenn Hall.

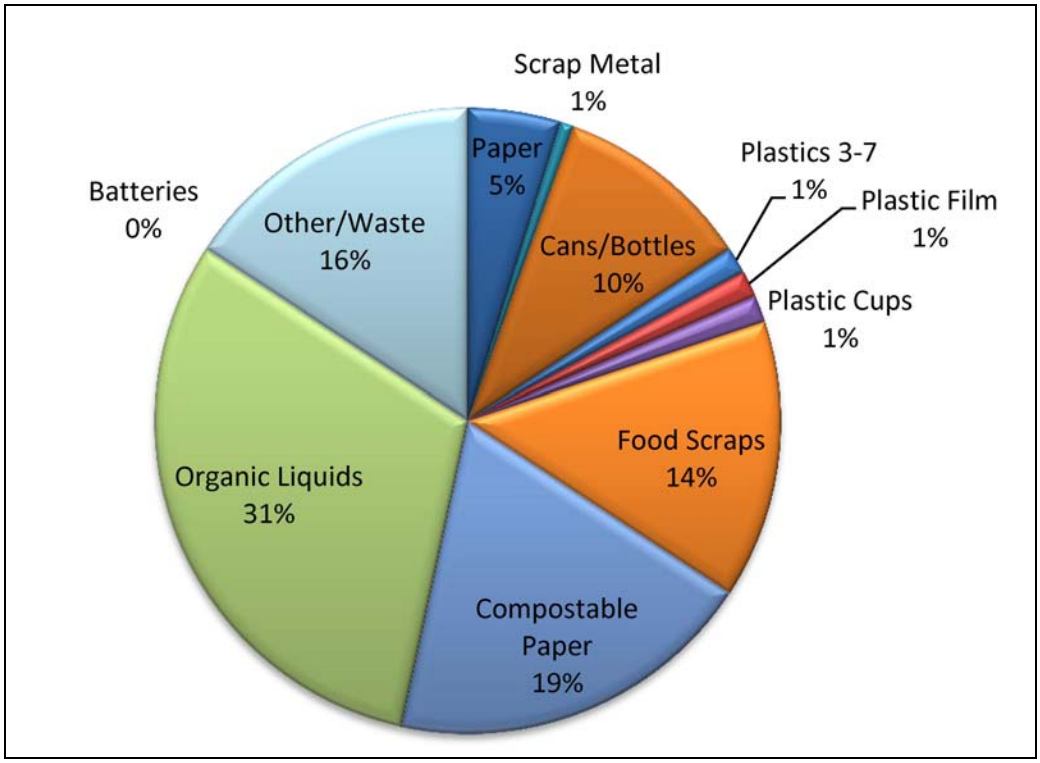

Figure 20. Glenn Hall. Presents the categories of materials found from all bins inside Glenn Hall and the percentage each material was accountable for at this location.

Recommendations

- Conduct another audit on Glenn Hall specifically to determine it the amount of organic liquid found was an anomaly or is normally disposed of inside the building.
- Educate inhabitants of the building about food and organic liquid waste and ways to reduce this waste.
- Provide more cans and bottle and paper recycling bins for the building.

CHAPTER V

LIMITATIONS

Introduction

Although this study provides CSU, Chico with a characterization and analysis of specific waste generated on campus and set of recommendations to reduce this waste, it has limitations that must be addressed. Limitations are presented in general and then by categories related to collection, human bias/error, and analysis.

General Limitations

Because this study focused on waste generated over a 24-hour period, there is no guarantee that the waste collected over this time is an accurate representation of the waste produced on campus throughout the year. It is suggested that follow up waste characterization studies are conducted at different times of the year and that their results are compared to the findings of this study.

While this study is meant to represent waste created on an average school day at CSU, Chico, much of the waste created annually comes from special events (move in, move out, sporting events, and community events). It is recommended that waste characterization studies are implemented during these times of year when an increased amount of waste is created. It is believed that this waste is not only abundant, but unique when compared to the day to day waste created at CSU, Chico.

This study focused on waste which is disposed of in semi-permanent dumpsters around CSU, Chico's campus. The study did not focus on dumpsters brought in by third party contractors for demolition, remodel, or construction debris. Contactors provide their own dumpsters and are responsible for what goes in them and when they get hauled off. Even though, CSU, Chico does not directly analyze what goes into these dumpsters, the waste is being generated by projects on campus and this waste stream should be thoroughly investigated in later studies. The study did not focus on waste created through special projects on campus, such as renovations, major cleanups, large maintenance projects, or other instances that can create a large amount of waste.

Waste on campus is produced by the public in many buildings on campus. The buildings where the majority of waste is believed to be produced by the public have been excluded. While some of the waste analyzed in the study is undoubtedly from public use, this is typical of a campus located close to an urban center.

Collection Limitations

Analysis of the original scope of this study was not possible because of the misplacement of eight buildings bags. Each of these buildings represented a small area of the campus and produced an inconsequential amount of waste. Most of these locations were on the outskirts of campus and were linked to campus services (warehouses, facilities management buildings). This blunder illustrates the importance of communication between the researcher and custodial staff to ensure that all bags are set out of individual buildings. In one instance two buildings (Kendall Hall and Ayres Hall) bags were placed in the same location. This made it nearly impossible to disseminate

which bags came from which building. The bags were still sorted and data gathered was used to determine the makeup of the campuses waste stream as a whole.

Human Limitations

As discussed above, human error must be accounted for in any study. When conducting a waste audit human error can occur in both the collection and sorting phase. While the researcher communicated expectations and provided detailed instructions (see appendices E and F for examples of information provided to custodial staff) to custodial staff, a small amount of human error still occurred. When working with 65 volunteers/ interns it is expected that some materials will be miss-sorted. To account for this limitation, the researcher did preliminary trainings with sorters, trained at the sorting site, provided direct oversight of all sorting, and established a location to put questionable materials. A research assistant was thoroughly trained during the weeks prior to the audit and this assistant was able to provide oversight if the researcher was not present or was occupied with other tasks.

It is understood that the determination of reusable materials was more qualitative than quantitative in evaluation. Most students involved in the auditing process and therefore voting on reusable items were likely more environmentally mindful. Considering this, it is plausible (even likely) that participants were more apt to vote that item was reusable then other members of campus. This must be taken into consideration when viewing and making interpretations of the results of this audit. The voting process was determined to be the best solution to include a category which cannot be ignored.

Analysis Limitations

It must be pointed out that all categories used in this study can (and many were) become contaminated. Organic liquids spill and contaminate paper, food scraps attach to compostable paper, and one type of material is sometime attached or stuck inside another type of material. All materials were sorted into the categories the most closely related with before being disposed of and mingling with all the other categories. Contamination of materials affected weight is some cases. One example would be a piece of paper drenched in organic liquid being placed in the paper category. This piece of paper weighed significantly less before it was contaminated with liquid. While all categories were separated as thoroughly as possible, cross contamination is a limitation and should be considered when viewing the results of this study.

Consideration should be given to certain materials coming from outdoor bins. While no precipitation occurred during the sample time, water from landscape irrigation could misrepresent the amount of organic liquids disposed of in these bins. Landscape materials such as sticks and leaves should also be evaluated since this material has the potential to fall into outdoor waste bins from neighboring trees. Since this study was conducted in April in relatively mild weather conditions, there is no reason to assume that negligible amounts of this material ended up in the outdoor bins sampled.

The mobility of materials is an important concept to understand when viewing and interpreting the results of this study. Just because a material was recovered from a specific location on campus, does not mean that it was necessarily generated at or even near that location. For some materials such as bathroom paper towels, it is safe to assume that the material was disposed of a short distance from where it was used. Other materials

such as beverage containers and food products could have been purchased across campus, from a local business, or brought from home. This study did not try to disseminate the origination of the materials found, but recognized the contribution this information has to reducing waste on a university campus. If material origination locations can be determined, education campaigns aimed at reducing waste can launched at these locations.

CHAPTER VI

GENERAL RECOMMENDATIONS AND CONCLUSION

General Recommendations

The concluding section of this paper will give an overview of some of the recommendations that have a significant potential to reduce waste at CSU, Chico and further research opportunities.

Compostable material is by far the largest category of material found in the waste stream at CSU, Chico. Compostable paper (24%) and compostable food scraps (19%) combine for a total of 43% of the weight of all materials in trash bins around campus and 33% of the volume (29% compostable paper, 4% food scraps). Every effort should be made to eliminate this material from waste bins. It is important for attention to be paid in Request for Proposals (RFPs) to waste haulers that can accept large amounts of compostable materials. Collaboration between custodial staff, AS Recycling, and environmental health can safety should be formed in order to provide and service composting bins for paper towels in every restroom on campus. This would not only significantly reduce the most prominent material (compostable paper) in the campus waste stream, but has the potential to reduce food scraps as well. If the university population was directed to dispose of food scraps in the nearest bathroom compost bin, this infrastructure could provide easy access to composting for all.

Recycling bins for paper and cans and bottles should be placed at a one-one-one ratio so that all bins are present at disposal and recycling locations. By providing people on campus with recycling options at every trash location, the rates or recycling will increase. This can be done by a conjunction of removing underutilized trash locations and increasing recycling bins at the remaining locations. AS Recycling should collaborate with custodial staff to determine where trash bins can be removed and/or recycling bins be added. Special focus should be applied to outdoor bin locations because the majority of materials (16%) come from these locations.

In conformity with the one-one-one trash bin to recycling cans and bottle to recycling paper bin method, recycling services should be provided in all classrooms across campus. As the result of providing trash bins in classrooms and not recycling bins, potentially recyclable materials are ending up in the waste stream. Studies should be conducted to assess if removing trash containers from all classrooms and providing more waste and recycling collection stations in hallways is a viable option. If not, recycling bins should be placed in classrooms and it should be determined whether AS Recycling staff or custodial staff could best service these bins.

Future Research

Continual research should be conducted on emerging recycling, packaging, and composting technologies to determine what can be further removed from the waste stream. By purchasing materials on campus that can easily be reused, recycled, or composted, these materials can be diverted from the landfill at the end of their use.

Assessments and audits of the waste stream at CSU, Chico should be a never-ending endeavor. It is recommended that specialized audits be conducted on areas that this project did not focus on. Since the largest waste generators are University Housing and the Associated Student, the researcher suggests conducting audits of these areas separately and on a regular basis. The methodology of this study can be improved and a similar study of the entire campus should be conducted at intervals of no less than every five years. Results from waste audits should be highly publicized on campus and in the community to help educate on what constitutes the current waste stream and to determine waste reduction policy and procedures at CSU, Chico.

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APPENDIX A

Material Locations	
Acker Gymnasium (AGYM)	Shurmer Gymnasium (SGYM)
Alumni House (ALUM)	Sierra Hall (SH)
Aymer J. Hamilton (AJH)	Siskiyou Hall (SSKU)
Ayres Hall (AYRS)	Student Health Center (SHC)
Boiler Chiller Plant	Student Services Center (SSC)
Butte Hall (BUTE)	Taylor Hall (TALR)
Colusa Hall (CLSA)	Tehama Hall (THMA)
FMS Yard	Trinity Hall (TRNT)
Glenn Hall (GLNN)	Yolo Hall (YOLO)
Holt Hall (HOLT)	Yuba Hall (YUBA)
Kendall Hall (KNDL)	
Langdon Hall (LANG)	
Laxson Auditorium (LAXS)	
Meriam Library (MLIB)	
Modoc Hall (MODC)	
O'Connell Technology Center (OCNL)	
Outdoor Waste Receptacles	
Performing Arts Center (PAC)	
Physical Science Building (PHSC)	
Plumas Hall (PLMS)	
Property Surplus	
Regional and Continuing Education (RCE)	
Roth Planetarium (ROTH)	
Campus Shipping and Receiving	

APPENDIX B

Material Sign Examples

Clipart source: Microsoft Word 2010.

APPENDIX C

Material Records Example

BUILDING: *Example*	Weight/Volume		
Paper	22/25	2/5	7/10
Cardboard	18/36		
Books	0		
Construction	0		
Scrap Metal	17/20		
Cans & Bottles	10/20		
Plastics 3-7	5/7		
Plastic Film	1/10		
Glass (other)	0		
Plastic Cups	2/5	3/7	
Styrofoam	0		
Food Scraps	84/20		
Compostable Paper	14/25	11/25	11/30
Landscaping Material	0		
Organic Liquid	16/3		
Fiber/Cloth	0		
Hazardous Material	0		
Universal Waste	0		
Data Storage	0		
Light Bulbs	0		
Batteries	0		
Reusable Material	<1/<5		List in Margin →
Other/Waste			

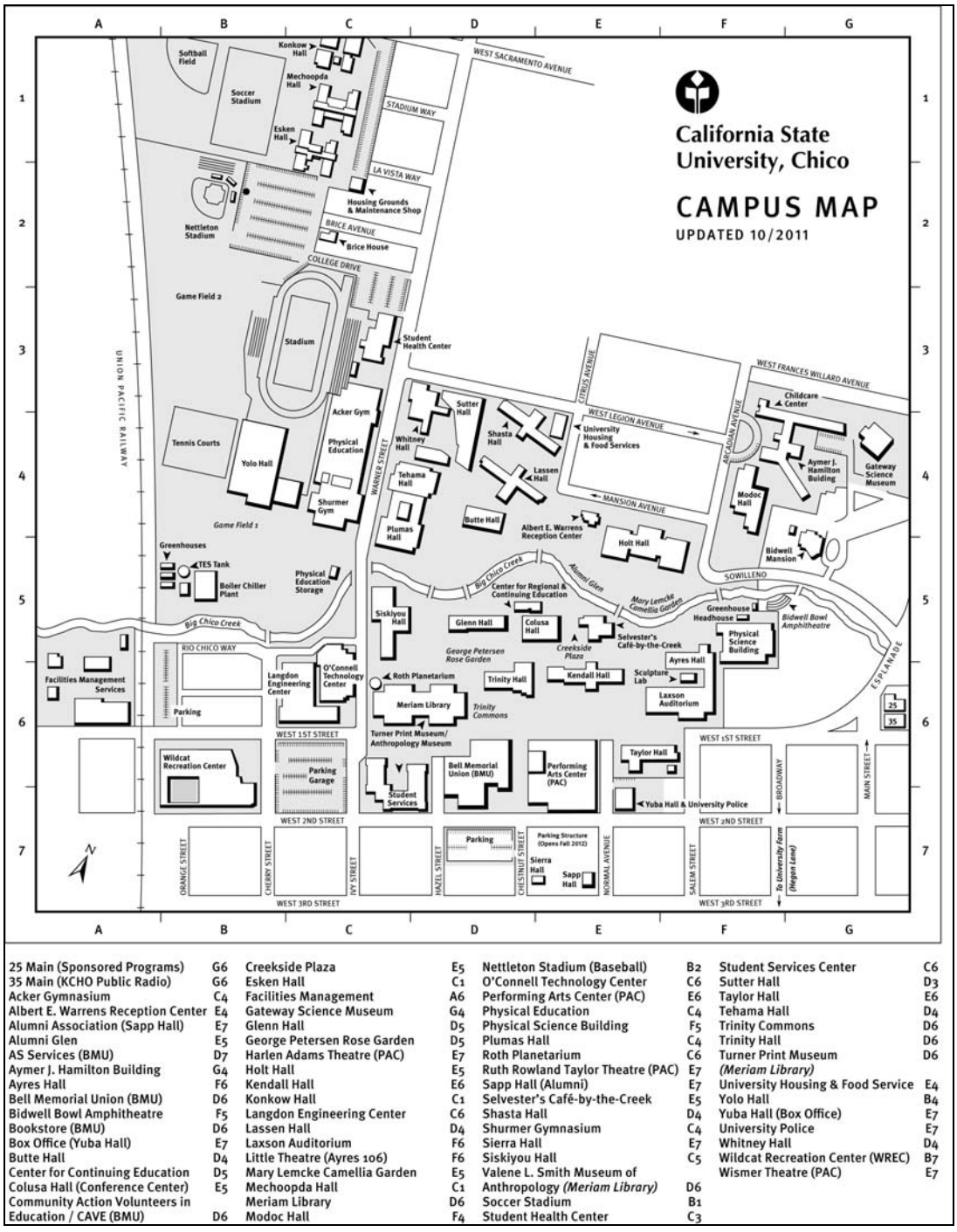
1 Coffee Cup Vote -9:0

APPENDIX D

Material Representation: Divertible vs.
Non – Divertible

Currently Recyclable Compostable, or Reusable	% of Waste Stream by Weight	Currently Not Recyclable or Compostable	% of Waste Stream by Weight
Food Scraps	29	Other/Waste	16
Compostable Paper	24	Plastics 3,5,7	3
Paper	12	Plastic Cups	2
Organic Liquid	9	Glass Other	0
Can and Bottles	6	Hazardous	0
Cardboard	4		
Plastic Film	3		
Reuse	1		
Batteries	0		
Electronic	0		
Media Storage	0		
Light Bulbs	0		
Fiber/Cloth	0		
Scrap Metal	0		
Landscape Materials	0		
Construction Material	0		
Books	0		
Styrofoam (block)	0		

APPENDIX E



25 Main (Sponsored Programs)	G6	Creekside Plaza	E5	Nettleton Stadium (Baseball)	B2	Student Services Center	C6
35 Main (KCHO Public Radio)	G6	Esken Hall	C1	O'Connell Technology Center	C6	Sutter Hall	D3
Acker Gymnasium	C4	Facilities Management	A6	Performing Arts Center (PAC)	E6	Taylor Hall	E6
Albert E. Warrens Reception Center	E4	Gateway Science Museum	G4	Physical Education	C4	Tehama Hall	D4
Alumni Association (Sapp Hall)	E7	Glenn Hall	D5	Physical Science Building	F5	Trinity Commons	D6
Alumni Glen	E5	George Petersen Rose Garden	D5	Plumas Hall	C4	Trinity Hall	D6
AS Services (BMU)	D7	Harlen Adams Theatre (PAC)	E7	Roth Planetarium	C6	Turner Print Museum	D6
Aymer J. Hamilton Building	G4	Holt Hall	E5	Ruth Rowland Taylor Theatre (PAC)	E7	*(Meriam Library)*	
Ayres Hall	F6	Kendall Hall	E6	Sapp Hall (Alumni)	E7	University Housing & Food Service	E4
Bell Memorial Union (BMU)	D6	Konkow Hall	C1	Selvester's Café-by-the-Creek	E5	Yolo Hall	B4
Bidwell Bowl Amphitheatre	F5	Langdon Engineering Center	C6	Shasta Hall	D4	Yuba Hall (Box Office)	E7
Bookstore (BMU)	D6	Lassen Hall	D4	Shurmer Gymnasium	C4	University Police	E7
Box Office (Yuba Hall)	E7	Laxson Auditorium	F6	Sierra Hall	E7	Whitney Hall	D4
Butte Hall	D4	Little Theatre (Ayres 106)	F6	Siskiyou Hall	C5	Wildcat Recreation Center (WREC)	B7
Center for Continuing Education	D5	Mary Lemcke Camellia Garden	E5	Valene L. Smith Museum of		Wismer Theatre (PAC)	E7
Colusa Hall (Conference Center)	E5	Mechoopda Hall	C1	Anthropology *(Meriam Library)*	D6		
Community Action Volunteers in		Meriam Library	D6	Soccer Stadium	B1		
Education / CAVE (BMU)	D6	Modoc Hall	F4	Student Health Center	C3		

Source: California State University, Chico. 2008. Campus map. http://www.csuchico.edu/taps/documents/csuchico_campus_map.pdf (accessed October 28, 2011). Used with permission.

APPENDIX F

Custodial Instructions Email

AS recycle Trash pick-up 4/6

We ask you to place your trash outside of your building in one location on Tuesday night 4/5 by 12:30am or 1am at the very latest. Do not throw trash in any dumpster!

The following are the locations to place your trash:

810 Oak Street Warehouse/ East entrance
25 Main/ South side
35 Main/ North side
Acker Gym/ North side of Yolo
AJH/ South side of AJH by custodial closet
Ayers/ West side
Boiler Chiller Plant/ South side by gate
Butte/ East side
FMS yard/ South side of main office
Glenn/ East side
Holt/ North side
Kendall/ East side
Langdon/ West side landing
Laxson/ North side doors
MLIB/ West side, down at bottom of driveway, close to door into basement
Modoc/ North West entrance
O'Connell/ west side entry
PAC/ East side landing
PHSC/ West side entry (left)
Plumas/ East side entry
Property Surplus Warehouse / East entrance
SAPP/ North side in parking lot
Sierra/ South side
Siskiyou/ South creek side by drive way
SHC/ North side entry
SSC/ East (BMU) side
Taylor/ South side
Tehama/ East side entry
Trinity/ North side entry
Yolo/ North side
Yuba/ East side of PAC landing

APPENDIX G

Custodial and Grounds
Grounds Staff Email

Custodial Staff

- Empty ALL bins inside buildings on Monday (4/4) evening shift and dispose of as usual.
- Empty ALL bins inside buildings on Tuesday (4/5) evening shift and place outside of buildings entrance (nothing goes to the dumpsters).
- Service cardboard like normal.
- The only buildings that this will not be done are: Continuing Edu. and the Gateway Science Museum.

Grounds Crew

- Empty ALL outdoor trash bins on Tuesday (4/5) morning and place in the FMS yard trash dumpster.
- Empty ALL (except Nettleton, Track/Stadium, and parking lots/structures) outdoor trash bins on Wednesday (4/6) morning and drop by the waste audit location in the vacant tennis court area. Have them call my cell phone 228-1525, if they have any questions.

My schedule (just so you are in the loop):

- Wednesday (4/6) morning at 5am, I will be collecting bags from the outside of each building entrance. I should have everything collected and setup at the waste audit site by 8am.
- Wednesday (4/6) – Friday (4/9), I will be sorting with 7-9 volunteers at any given time. Recology trucks may be coming onto campus in the mornings during this time to collect waste that has already been sorted.
- I can be reached anytime at 228-1525.