Solid Waste Audit: Humboldt State University Residence Halls

Prepared for:
Sustainable Campus Fall 2002
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1 Problem Analysis

1.1 Background

Recycling has enjoyed a period of popularity since the first Earth Day in 1970. It is often an environmentally responsible option because it serves to divert waste from landfills, decreases mining demand and thus impact, and often reduces energy involved with the production of the recycled product. Recycling rates over 1999-2002 have declined and criticism of recycling has been on the rise.[1] Some critics have misrepresented recycling, deeming it as fraudulent by making money off a waste product, worse for the environment, or as a frivolous activity that makes no economic sense.[2] Although the recycling of cans and bottles has declined, the types of materials that have recycling potential have diversified and new markets available for recycled goods have increased the financial incentives of recycling. No longer limited to beverage containers, recycling now can be an option for construction/demolition products. Some institutions are now requiring landfill diversion rates included in their building contracts. In fact, Humboldt State University is moving towards such a requirement as of 2002-3.

Humboldt State University (HSU) has had a long history of waste reduction, starting in 1974 when Arcata Community Recycling Center installed recycling bins for office paper and cardboard. In 1987, an engineering class, working with the Campus Center for Appropriate Technology (CCAT), investigated campus recycling. The recycling program expanded that year when two students made a bet that they could retrieve $5.00 worth of recycling from garbage cans as they walked across campus. In 1986, the club evolved into a fully funded Associated Students' Program. In 1992 a job was created for a Solid Waste Reduction Coordinator and in 1997, the present Solid Waste Reduction Manager, Mr. Alec Cooley was hired. The decision for the University to create this position hinged in part on the rising costs of landfill space. The cost of landfill disposal was $10 to $15 per ton until the mid 1980's when prices starting going up. The landfill used at that time, near Freshwater, was experiencing increased costs due to its impending termination and more stringent EPA regulations. Costs per ton have leveled off the past few years at about $78, giving Arcata and other local areas one of the most expensive rates for landfill disposal. Landfill diversion thus became both an environmental and financial priority for HSU, now seen as a model for other universities to follow. Improving recycling rates and understanding the patterns of solid waste is part of the solution.

One of the best ways to evaluate and maintain a waste diversion program is to perform periodic solid waste audits. In 1992, the Solid Waste Reduction Task Force conducted one such audit under the auspices of Space and Facilities at HSU. According to their report, the campus was divided into four sections: Offices, Food Services, Landscaping, and Residence Halls. Each section was surveyed and estimates were calculated for the amounts and types of materials found in the waste stream. The audit of ten years ago was useful to us in identifying its strengths and weaknesses. Some aspects

[1] Cooley, Alec. Personal interview 30 Sep 2002.
[2] Ibid.

of the past audit have changed, such as the addition of more students accommodated by the new Creekview residence halls.

1.2 Problem Statement

We decided to perform another audit as a follow up to the one done 10 years ago. We believed this would provide students and faculty with up-to-date information about the type and amount of waste being generated and disposed. Due to limited resources, the scope of this waste audit was restricted to the Residence Halls. We suspect that the Residence Halls are responsible for a high volume of solid waste that includes recyclables. In order to verify our suspicion, another audit needs to be performed.

2 Goals and Objectives

2.1 Goal #1

Audit the waste stream of Humboldt State University's residence halls.

Objectives:

- Categorize each material type in the residence halls' waste stream for two days in October 2002.
- Quantify the amount of waste in each category by weight.
- Estimate the amount of waste in each receptacle by volume.

2.2 Goal #2

Analyze the findings between this audit and the 1992/3 audit.

Objective:

- Compare and contrast the two audits for material types, quantities, and methodologies.

2.3 Goal #3

Evaluate the recycling program for the residence halls.

Objectives:

- Rate the quality of recycling bin locations, accessibility, and markings.
- Survey resident students about their recycling habits and awareness.
- Assess the education program(s) geared toward residence halls.

3 Alternatives

In order to choose the best possible audit strategy, we considered several different options, and developed criteria by which to objectively select the most viable one.

Our criteria were:

1) The project needs to fit within the time constraints of a semester class.
2) We need to be able to coordinate logistics with non-group entities.
3) The project needs to be within the scope of limited human resource capacity and finances.
4) The sample size needs to be large enough to have confidence in our estimates.

3.1 Alternative 1: Two waste audits

This alternative would have required two waste audits at different times during the semester as a way to estimate the amount of waste produced. The first audit would have taken place on October 19th, and the second audit on November 9th. In order to keep the data consistent, the two audits would need to be performed with similar sampling procedures using the same day of the week (Saturday), the same scale, bins and grouping of materials. In this way the data would be easier to consolidate and analyze. The main benefit of this alternative is that there would be more available data and would provide a comparison. This option could allow us to judge whether or not our data represents a good sample.

In order to decide whether this alternative was the most appropriate, the audit team scrutinized it according to the established criteria. We decided this alternative would not fit within the time constraints of the semester class because limited human resources would make it difficult to coordinate logistics with non-group members. Even though this alternative is superior in its potential to provide a better confidence level in the data, it was determined that time constraints could limit the analysis of the results.

3.2 Alternative 2: Volume Measurements

We had the option of making volumetric estimates of waste in the dumpsters for a period of time or spending a block amount of time physically analyzing the contents of each dumpster. If we chose to estimate the volume, it would be necessary to survey the volume of the dumpsters over a period of time to produce an adequate sample. An advantage to this type of waste audit is that it would give us the ability to compare each individual dumpster and also monitor volumetric consistency over time. Another advantage is that this could be done within the limits of our class time. We would observe the dumpsters once a week on Monday, Wednesday or Friday prior to the dumping to each individual bin. Two or three representatives from our group would physically observe the level of solid waste for 8-10 weeks. The survey method would be simple and quick. First, a group member would distribute and compact the trash inside the dumpster using cardboard and his/her own body weight. Next a yardstick would be placed on top of the leveled trash to measure the amount of empty space in the dumpster. Then, with a quick

calculation, the approximate volume of waste could be determined for each dumpster. The previous audit used a conversion estimate of 174 lbs/yd^3. Once all observations were completed and recorded, we would have the ability to average the dumpster volume for each residence hall. We would then have an idea of the confidence interval in that average because we could mathematically measure the difference between the highest and lowest volumes. This would result in a broad, "educated-guess" estimation about the annual solid waste of the residence halls.

The previous audit performed ten years ago relied heavily upon estimation. During a one-week period they analyzed 148 "random samples": 28 from the dorms, 29 from food service, and 89 from the campus offices. Using a statistical formula for sampling methodology, they reported that the desirable number of samples is between 200 and 2000. Even larger sample sizes are required when there is a higher variability in a sample. The previous waste audit was a good start, but we were able to learn from their statistical shortcomings and agreed that the less estimation involved the better the number.

3.3 Alternative 3: Audit each Residence Hall separately

Once we decided to specifically audit the residence halls, we needed to choose a method of evaluation: looking at the garbage on a per building basis or simply evaluating the garbage for the entire residence halls. If the objective of our study was to compare each building, we would have needed to take these extra measures. One of the main goals of our study was to evaluate the entire waste stream of the students living in the residence halls, evaluate what could be diverted, and determine if more education was necessary. With the given time constraints of this class, it would have been much more labor intensive and time consuming on the audit day to survey the waste stream from individual residence halls.

3.4 Alternative Chosen: Single Waste Audit

This alternative would involve performing a single waste audit of one area of campus: the Residence Halls. The waste audit would include a thorough examination of the contents of all the dumpsters associated with students living on campus in campus-owned housing, as well as the recycling that was in the beverage container bins. It would not include the waste or recycling associated with the Campus Apartments, for example, as they do not belong to HSU and could house non-students. The waste and recycling would be considered as one group, rather than separated by housing complex or building. The waste and recycling would represent what is disposed of in a normal cycle of removal. The Arcata Garbage Company collects garbage from the residence halls each Monday, Wednesday and Friday.

A single solid waste audit fits with the first criteria related to the time constraint. With only a five-member team, it would prove difficult to perform more than one audit of one section of campus during a single semester. This alternative also matches the second criteria. There are many individuals that need to be notified about a project of this magnitude. By limiting the scope of the project to just the residence halls, the number of people and departments involved is limited as well. As a student project for Environmental Science 411, Sustainable Campus, the solid waste audit has limited resources, in terms of

both finances and human help. All expenses would have to be paid by the Dumpster Divers. A solid waste audit is labor intensive. The group would have to recruit a pool of volunteers, which could prove difficult due to the nature of the project. By limiting the scope of the project to just the residence halls, it is more likely that a thorough audit could be performed by the group and a handful of volunteers, thus, a single solid waste audit matches the third criteria. This alternative also matches the final criteria. The sample size for the audit needs to be large enough to have confidence in the numbers that will result. The single audit would need to be supplemented with additional volume estimates. These volume estimates would be taken several times throughout the semester at different times, but would need to closely represent a two-day period similar to the period of the actual audit.

4 Implementation

Alec Cooley, Solid Waste Reduction Manager for HSU, initially proposed a solid waste audit as a project for Sustainable Campus. With his support, authority, and credibility, we did not have to "sell" our project to others. The short and long-term benefits were well understood by Mr. Cooley. A well-done audit can be very costly if done by a professional consulting firm, but as a student project, there would be little out-of-pocket expenses. The desired outcome, updated information about the waste stream of even one segment of campus, would be a valuable tool in advancing waste reduction efforts. In addition, a complex project of this magnitude offers practical experience to students in time management, data collection and analysis, and insight into the realm of waste management.

Implementation of the project involved three main areas revolving around the three goals that were established:

- Carrying out the audit.
- Analyzing the findings.
- Evaluating the recycling program.

4.1 Carrying out the Audit

Implementation of the audit required several group brainstorming sessions and meetings with Mr. Cooley. Several aspects of an audit of this magnitude need advance planning: which portion of the waste stream to audit, how the materials should be collected, how to sort and weigh the materials, how many hours would be required, where the audit should take place, and what supplies would be needed.

4.1.1 Which portion of the waste stream to audit

One of the first decisions to be made is which portion of the waste stream to audit. Although we had decided as a group early in the process to focus only on the residence halls, there were still several options to consider. The waste stream for the residence halls ends up in two main places: dumpsters and recycling bins. Given that we had limited resources in terms of people and time, we chose to concentrate on the areas that had the

most potential to provide information about what students were throwing away. For this reason, we decided to audit the dumpsters and the recycling bins for beverage containers (glass, plastic, aluminum). According to Mr. Cooley, the recycling bins at the residence halls for paper materials (office pack, ledger, magazines, cardboard) are usually underutilized, except at the end of the semester. It was decided, therefore, not to include these items in the totals for recycling.

4.1.2 How to collect the materials

Once the targeted waste stream has been defined, the logistics of collecting the materials needs to be developed. For the garbage portion of the audit, we decided it would be easiest to work around the collection schedule for Arcata Garbage Company. They empty the dumpsters every Monday, Wednesday, and Friday. Since it would be easiest to perform the audit on a weekend, we decided that the garbage that normally would be collected on a Friday would be our "sample." In coordination with Arcata Garbage and Plant Operations, our group was responsible for collecting the garbage from the dumpsters on Friday, October 18, 2002. Using HSU's 15 cubic-yard packer truck, Mr. Cooley and Ms. Kellogg collected all the garbage from 13 dumpsters. The collection process took 1.5 hours, from 4:00 pm to 5:30 pm. This sample represented two days worth of garbage from all the residence halls on campus. The garbage was left in the back of the truck overnight in the Plant Operations back parking lot. By leaving the garbage enclosed in the truck overnight, we did not need to be concerned about rain or rats altering the weight of our sample.

Coordinating the recycling portion of the audit was somewhat simpler since HSU employees pick up the recycling from the residence halls. It was decided that the recycling sample for the audit should represent as much as possible the same two-day time period as the garbage sample. Therefore, the recycling needed to be collected on the same Friday as the garbage. In order to make sure that the recycling we audited was just for two days, all the recycling bins were emptied by Jerry Saner, the Recycling Collections Coordinator, on the Wednesday prior to our Friday collection. On Friday, October 18th, Ms. Kellogg and Ms. Benedi met Mr. Saner at Plant Operations at 2:00 pm. From there, they drove the recycling truck to each residence hall, collecting each building's recycling. This process took about 1 hour. After the recycling was collected from the bins, it was taken to the Recycling Work Site at LK Wood and Harpst St. for sorting.

4.1.3 How to sort and weigh the materials

Once the targeted waste stream was defined, the methods for sorting and weighing the materials needed to be determined. The previous audit was called a "waste characterization study" and was done according to the California Code of Regulations, Title 14, Article 6.1. The State of California designed the regulations to standardize information collected in order to compare different entities throughout the state. We chose not to follow these regulations to the letter as the purpose of our project was not to be compared to other entities. The goal was to develop an audit method that would reflect the nature of our specific institution, that could be replicated in the future, and that could be used to evaluate the recycling program that operates in the residence halls on campus.

The state regulations and the methodology followed in the 1992 audit were used as a starting point for our methods.

For this audit, we sorted materials from the recycling bins the same way that HSU sorts and delivers recycling to the Arcata Community Recycling Center (ACRC).

- Brown Glass
- Green Glass
- Clear Glass
- Aluminum Cans
- Steel/tin/soft aluminum
- Clear PET#1
- Colored PET #1
- Natural HDPE #2
- Colored HDPE #2

We also included a category for non-recyclable garbage that was in the recycling bins. Sorting occurred at the Recycling Work Site from approximately 3:00 pm until 5:30 pm. Using safety gear provided by Plant Operations (gloves and glasses), Ms. Benedi, Ms. Kellogg, and Mr. Gammill sorted the recycling into barrels. Beverage containers were emptied as part of the standard procedures for preparing recycling for ACRC. This is done to ensure that ACRC does not pay for the added weight of the contents, only the containers themselves. The barrels were segregated from all other recycling at the work site to ensure that nothing would be added or subtracted from them. The materials stayed at the Recycling Work Site until the following Tuesday, when Mr. Saner took them to ACRC to be weighed. The net weight for each category is reported in Appendix 1, titled Materials Found in the Recycling Bins.

Sorting and weighing the garbage from the dumpsters was substantially more difficult. Prior to the audit, certain categories of materials were assumed to be in the garbage, such as food, clothing, and recycling. However, not all categories could be anticipated. A log sheet was needed in order to properly organize the data. Ms. Benedi created a log sheet that listed each general category of waste, including recycling. Each general category was broken down into anticipated subcategories. To keep the log sheet as flexible as possible, blank space was allocated to each category so that all significant material types could be properly recorded. The log sheets used to collect the data are in Appendix 2, titled Data Collection Logs.

In order to sort and weigh the materials in manageable amounts, the group decided that some type of container system would work in conjunction with a scale. Mr. Cooley borrowed a small doctor's office type scale from the Campus Center for Appropriate Technology (CCAT) and delivered it to the audit site on October 19th. Ms. Kellogg borrowed recycling bins (16 from ACRC, 2 from friendly neighbors, and 2 from home) during the week prior to the audit and brought them to the audit site on October 19th. The bins were used to hold the materials as they were weighed on the scale. Two sizes of bins were used. The blue bins weighed 4.5 pounds and the green bins weighed 3.5 pounds. As bins were filled with a single material type, they were weighed. At Mr. Cooley's suggestion, we weighed the recycling found in the dumpsters with any contents that they may have included. The reason for this was to obtain a true weight for the materials that would have ended up in the landfill. HSU would have been charged for the full weight of a beverage container and its contents at the local Transfer Station.

All group members participated in weighing and recording materials throughout the two days. The gross weight (bin weight + material) was recorded on the log sheet. A notation system was used to indicate whether any given weight was with a blue or green bin. The group felt there would be more room for error if we tried to subtract the bin weights off every time we recorded measurements than if we made that calculation part of the math process after the audit was over. We also tried to use the same size bin consistently for each material type to reduce the chance for errors.

Sorting the garbage was physically very challenging. All participants were instructed to wear old clothing that was protective, especially footwear. Gloves and safety glasses were provided. Preparations started on Saturday morning at 9:00 am in the back parking lot of Plant Operations. Mr. Cooley and the five group members set up tables and covered them with plastic tarps. Safety gear was set out. Food and beverages for the day were arranged. Empty barrels were brought over from the Recycling Work Site to collect the recycling. In order to dump the contents of the collection vehicle onto the ground in an appropriate spot, the vehicle needed to be moving. By 10:00 am, the garbage was dumped from the collection vehicle and spread out on the ground. The photograph in Figure 1 shows how the sorting area looked approximately one hour after the garbage was dumped from the truck. Kirk Gammill is shown sifting through the pile later in the day in Figure 2. Every effort was made to keep the "spreading" to a minimum to reduce cleanup efforts at the end of the audit. Five group members, a handful of dedicated volunteers, and Mr. Cooley worked through the pile for two days for a varied number of hours each. Approximately 90 hours were spent in total from set up to cleanup over the two days.

Figure 1. Plant Operations parking lot about one hour after starting the audit.

Figure 2. Kirk Gammill sorting through the pile.

Initially, it was easy to segregate materials from the pile. Recyclables were easy to identify and categorize. As soon as a bin was full, it was weighed, the data was recorded on the log sheet, and the materials were dumped into the appropriate barrel. Paper products, such as plates and cups were visibly abundant, as was cardboard. Maintaining the integrity of the material types was an important aspect of the project. Potential categories were discussed and defined so that each participant understood what to include or not to include. This was especially necessary with categories like cardboard, which could qualify as recyclable or non-recyclable. For example, cardboard with waxy coatings or certain levels of contamination, such as too much pizza grease, are not considered recyclable by ACRC. Clean corrugated cardboard and chipboard cereal boxes are recyclable.

As soon as a category was agreed upon, it was eligible to be removed from the pile, segregated, and weighed. If a type of material wasn't specifically in a category, then it remained part of the pile until the end. Whatever remained was then categorized as "garbage." The benefit of this procedure is that materials aren't first weighed as "garbage" and then determined to be a category later. If that happened, the "garbage" would essentially have to be sorted twice in order to collect credible data. This is to be avoided at all costs!

The final categories and weights collected for the audit are in Appendix 3, titled Materials Found in the Dumpsters.

4.1.4 Cleanup

Once all the material was categorized and weighed, cleanup began with all five group members and Mr. Cooley participating. All the recyclable materials were concentrated in one area in the parking lot, as shown in Figure 3. Mr. Saner would be responsible for transporting them to ACRC. Everything else that was destined for the landfill was bagged and piled up neatly near the edge of the parking lot, as seen in Figure 4. Mr. Cooley was to arrange their transportation to the Eureka Transfer Station. The plastic tarps were folded up and set aside so they could be donated to the Campus Recycling Program (CRP). The tables were folded up and put away in Plant Operations. The parking lot was thoroughly swept. Mr. Cooley was to return everything that he borrowed on our behalf and clean out the collection vehicle. Ms. Kellogg transported the recycling bins home and washed them on Sunday (1.5 hours), and then returned them on Monday to their rightful owners.

Figure 3. Recycling, culled from the garbage, is segregated from the materials that will eventually be taken to the Transfer Station.

Figure 4. Bagged garbage ready to be hauled to the Transfer Station.

4.1.5 How many hours would be required

None of the participants in this project had ever performed a solid waste audit. While we hoped that it wouldn't take more than one day, we needed to be sure that we had plenty of time to set up, sort and weigh, and clean up what we collected. The biggest block of time available to all group members was a weekend. Performing the audit on a weekend made the most sense with respect to all other conditions as well. It fit with collecting the garbage and recycling on a Friday, the intended audit site would be relatively free of other activity, and class schedules wouldn't interfere. We also anticipated that more volunteers would be potentially available on a weekend than during the week. The best use of time would be to collect the solid waste on Friday and begin the audit on Saturday morning. If for any reason we did not finish on Saturday, we would still have Sunday.

The group members coordinated schedules in mid-September and decided that the weekend of Friday, October 18th through Sunday, October 20th was the most

suitable. Mr. Cooley was consulted also. He confirmed that all other involved parties and authorizations were in place.

As it turned out, the audit took almost the entire weekend. As mentioned earlier, we had a very small group of volunteers. The five group members worked varying hours on Friday until about 5:30 pm, Saturday from 9:00 am to 7:00 pm, and Sunday from 9:30 am to 2:30 pm. On Saturday evening, we had to consolidate everything into a "neat" pile, cover everything with plastic, and put the tables away. On Sunday morning, we expanded everything back out and continued working. We stopped for lunch on Saturday and Sunday and everyone took periodic breaks as needed to rest and prevent injury.

4.1.6 Where the audit should take place

We anticipated needing a fairly large space in which to perform the audit. We did not know how much solid waste would be generated in two days, but we wanted to make sure that we had room to work. We needed room for the collection vehicle, barrels, bins, tables, a big pile of garbage, and people. During brainstorming sessions, we decided it was important to have access to electricity, water, and restroom facilities. With Mr. Cooley's help, we were authorized to use the back parking lot of Plant Operations, which is shown in Figure 5. Mr. Cooley's credibility went a long way in obtaining permission for a bunch of students to dump a bunch of garbage onto the newly surfaced parking lot.

The obvious place to audit the recycling collected on Friday was at the Recycling Work Site at LK Wood and Harpst St. Sorting tables and empty barrels are already in place (Figure 6), and Mr. Cooley had the authority to approve the activity.

Figure 5. Back parking lot at Plant Operations.

Figure 6. Sorting tables and barrels at the Recycling Work Site.

4.1.7 Supplies

Over the course of the whole planning process, a list of supplies was generated:

- Tables
- Tarps
- Scissors
- Recycling bins
- Scale
- Protective gear
- Boom box
- Electrical cord
- Volunteers
- Food/beverages
- Plastic bags
- Digital camera
- Yard stick
- Clip board
- Recycling barrels

Mr. Cooley was able to procure many of the items on this list at no cost and have them brought to and from the audit site. Ms. Thompson made a significant contribution by purchasing and preparing the food and beverages and purchasing the plastic tarps. Ms. Kellogg arranged for the recycling bins.

All group members made valiant efforts to recruit volunteers by making announcements in classes, asking professors to make announcements in classes, and bribing friends with expensive dinners. Ms. Kellogg made a flyer (Appendix 4), which she and Ms. Benedi posted around campus a week before the audit was to take place. The four volunteers that we did recruit were extremely hardworking and very helpful; however, we were still very shorthanded.

4.2 Analyzing the Findings

4.2.1 Statistical Methodologies

There were two sets of data collected in this waste audit. One set represents the materials found in the recycling bins located at the residence halls and the other set represents all the materials found in the dumpsters at the residence halls. In 1992, the recyclables were classified as diverted materials. In this audit, we refer to it as recycling from the recycling bins. The data for the recyclables can be found in Appendix 1, Materials Found in the Recycling Bins. The second set of data in this audit includes the materials found in the dumpsters and can be found in Appendix 3, titled "Materials Found in the Dumpsters."

The analysis of the data obtained for the 2002 Waste Audit was based on weight percent proportions. This methodology was performed in several sections, one based on a general range of categories, and a second section measured the subcategories within each major category. The last section compares the weight proportion samples between the 1992 and 2002 audits.

4.2.2 Results by category

The breakdown of the percentages for the material found in the dumpsters is shown in Appendix 5, titled Total % for Materials Found in the Dumpsters. The broad categories include plastic, paper, glass, metals, and garbage. For 2002, the garbage category made up the largest component (60.3%). Paper was the second largest percentage (14.6%), plastic (13.4%), glass (9.0%), and metals (2.7%). The first four components, nearly 40% of the total, contain both recyclable and non-recyclable materials.

4.2.3 Results within categories

The weight percent proportions were also calculated within each category. For example, plastic was divided into subcategories indicating the type of plastic used: PET plastic (#1), HDPE (#2), Non-recyclable, Food wrappers, and Plastic bags (Appendix 3). The comparison of the subcategories gives the study a more precise look at the most commonly used materials within each broad category.

4.2.3.1 Plastic

The breakdown of the percentages for plastics is shown in Appendix 6, titled Plastics Found in the Dumpsters. PET plastic (#1) was by far the largest plastic material at (48.2%). Non-recyclable plastics and Plastic bags had similar percentages at (15.8%) and (15.2%) respectively, followed by Food wrappers (11.8%) and HDPE (#2) (9.0%). The total weight for plastic was 282.35 lbs.

4.2.3.2 Paper

The breakdown for the paper percentages is shown in Appendix 7, titled Paper Found in the Dumpsters. Nearly one half of the materials in this category (49.6%) were recyclable in the condition in which they were found in the dumpsters. It is worth noting that the other half, which we considered as nonrecyclable included both non-recyclable paper products as well as recyclable products that were found in bad condition and therefore became non-recyclable. The three largest individual components in this category are non-recyclable cardboard (28.6%), cardboard (28.1%), and waxy packaging (12.1%). Additional components are Office pack (8.7%), Magazines/Catalogs (6.9%), and Newsprint (6.0%). The dishware category included to-go containers such as coffee cups and food packaging, and accounted for (9.7%) of the paper total. The total weight for paper was 309.95 lbs.

4.2.3.3 Glass

The breakdown for glass can be found in Appendix 8, titled Glass Found in the Dumpsters. Clear glass is the largest component (80.7%), followed by Brown glass (13.7%) and Green glass (5.6%). The total weight for glass was 189.40 lbs.

4.2.3.4 Metals

The graph for metals can be found in Appendix 9, titled Metals Found in the Dumpsters. Steel cans had the highest percentage for metals (44.1%), followed closely by electronics (42.8%) and aluminum cans (13.1%). The total weight for metals was 56.50 lbs.

4.2.3.5 Garbage

The graphical representation for the breakdown of all other materials can be found in Appendix 10, titled Garbage Found in the Dumpsters. The subcategory "garbage" is defined as anything that could not be identified and measured as a single category. This subcategory accounted for the largest component (56.6%). The construction component was 19.6%. A large portion of this component came from some very heavy metal doors. It is not expected that this type of material would form part of the garbage component on a regular basis at the residence halls. Food, leaves, grass made up the last significant individual component (18.0%). The remaining six components together made up 5.9% of the total in this category. The total weight for garbage was 1270.30 lbs.

4.2.4 Results by comparison between the 1992 and 2002 waste audits

4.2.4.1 Materials found in the Dumpster

Weight percent proportions based on the results from the 1992 and 2002 waste audits were compared. In this case, the percent proportions technique was the most appropriate option based on the available data. Other tests would have consisted of including the one-sample 2002 waste audit as a sample within the 1992 audit. In order to do this, the estimated standard errors for the 1992 Residence Halls would be needed. These values were not provided in the 1992 audit, so that option was discarded. A second option would require more than one equivalent sample within the 2002 audit. By doing a two-sample audit, necessary data such as confidence intervals, standard deviations, and standard errors would be available. These values would allow for a more accurate comparison between audits. This option was also discarded since only one "sample" was taken in the 2002 audit.

Based on the available data, the proportional comparison became the most appropriate option. This type of comparison only shows a visual representation based on the percentages by groupings between audits. See Appendices 11 through 15 for graphical representations of the comparison results. Even though the differences in the 1992 and 2002 audits may be visually obvious, it is important to back this representation with a statistical test.

As a way to statistically validate the difference in proportions between each audit, a Goodness of Fit test was done following the rules for Conditions of Validity. Please refer to Appendix 16, titled Goodness of Fit, for calculations and conditions of validity. The test done in this example is for the broad paper category. We chose this category

first because the subcategories were so similar between the 1992 and 2002 audits, as can be seen in Appendix 12. The results for the paper category showed that the 1992 and 2002 audits were not equal in terms of percent of subcategories. The formal statistical conclusion shows, with a 95% confidence level, the percentages found for paper in 1992 are not equal to the percentages observed in 2002. Because the percentages for the subcategories do not match, we are only able to say that there are differences between the audits, but we cannot determine any trends. These differences could indicate a change in the population, a change in the types of materials being used today compared to ten years ago, or a change in the types of recyclable materials. A good example of a change in types of materials used can be seen in the rise of PET plastic (#1) in the 2002 audit. In the 1992 audit this material did not appear anywhere, but in 2002, this material accounts for 49% of the total plastics (Appendix 11). This representation does not necessarily indicate that PET plastic (#1) was not used in 1992, but it doesn't appear in the data. We also ran Goodness of Fit tests on plastic and the total materials found in the dumpsters, which showed similar results, but they are not included in this report to reduce redundancy.

Although the Goodness of Fit tests illustrate that the two audits cannot be compared in some ways, there is another way to compare them.

From the 1992 study, a numerical comparison can be made of the number of pounds of garbage that was disposed per day. In the 1992 study the total tons per month (TPM) was calculated based on the professional estimate that 25 tons of waste were produced each month.[3] Out of a 12-month period, students disposed of garbage on a full-time basis (25TPM) for 9 months. For the remaining 3-month period, students were estimated to dispose of half the amount of garbage (25TPM/2). The waste audit in 1992 used the following formula to represent the stated assumptions.

$$(25TPM*9months) + [(25TPM/2)*3\ Months]$$

Using this formula and the estimated annual waste (77.9 tons/year) from residence halls in 1992, we calculated the daily amount of waste disposed: 499.33 lbs/day. These calculations are in Appendix 17, titled Waste Generated 1992.

From the 2002 audit, we used the two-day total waste from the dumpsters for the basis of our calculation. We divided the two-day total by 2 to calculate one day's worth of garbage.

$$2{,}018\ lbs\ of\ garbage\ /\ 2\ days = 1{,}009\ lbs/day$$

Table 1. Comparison of garbage disposal rates.

1992	499.33 lbs/day
2002	1009.00 lbs/day

[3] Ward, Tedd. HSU Waste Generation Study. May 1992.

When comparing the two values in Table 1, an increase by a factor of two is observed in the year 2002. One reason for the increase in the waste stream may be due to an increase in the residence hall population over the last 10 years; more people would likely generate more garbage. A second reason for the increase in the waste stream could be from an increase in packaging for food products over the last 10 years.

A true measure of an increase or decrease in waste generation would be stated in terms of pounds per person per day. We know that there are approximately 1,350 students currently living in the residence halls. At the time of this writing, the number of students living on campus in 1992/93 was not available, so an accurate comparison cannot be made at this time. However, it is reasonable to assume that the number of students living on campus has not doubled over the last 10 years.

4.2.4.2 Materials Found in the Recycling Bins

The diverted materials were compared between audits as a way to determine the progress of waste management today. Refer to Appendix 18, titled Comparison of Materials Found in the Recycling Bins, for graphical representation of the results. In 1992, the only recyclable materials diverted in the residence halls were glass and metals. In the 2002 audit, materials diverted include glass, metals, and plastic. Paper was not considered in the 2002 audit as previously stated and garbage was counted but not considered for analysis. A comparison of the percentage of material types in the recycling is not valuable due to the changes in categories. But the changes in the categories are worth noting. As would be expected, plastic bottles make up a significant portion of the recycling today, replacing many glass and aluminum containers from 10 years ago.

4.2.4.3 Source of Potential Recyclables

The Source of Potential Recyclables pie chart (Appendix 19) shows that a significant amount of recycling was found in the dumpsters. While the amount of recycling from the bins only includes beverage containers, the recycling from the dumpsters includes paper materials such as cardboard and office pack, as shown in Appendix 20, titled Recycling Data 2002. As a reminder, the weight of the beverage container recyclables from the dumpsters includes the weight of any contents left at the time of disposal. This is not the case for the same material types found in the recycling bins. Refer to Section 4, Implementation for more details on these procedures.

Although the extra weight of the beverage contents leads us to overstate the weight of potential recycling from the dumpsters, the data still represents a significant amount of recycling that is not diverted. There is certainly an opportunity for improvement in the reduction of waste in the residence halls.

4.2.5 Volume Measurements

With limited time and limited human resources, it became necessary to find a statistical means to verify that the audit conducted was a representative sample of the waste stream of the HSU residence halls. The chosen method was to measure the

amount of trash within each individual dumpster by volumetrically measuring the amount of space occupied by the contained garbage. In order to make such a task valid, consistent, and comparable with the data from the audit, it was necessary to perform such a measurement on the day of the audit as well as on other days.

It was necessary to determine the location of all dumpsters at the residence halls. The locations are shown on the map in Appendix 21. To perform a volumetric measurement of each receptacle, we measured the amount of empty space within each dumpster and assumed that the rest of the bin was filled with garbage. However, since garbage isn't disposed in an orderly and consistent manner, it was necessary to physically level out the trash in each container. We then needed a way to compact the trash so the measurement would not be skewed by pockets of empty space amongst the rubbish. Compaction was achieved by placing a piece of cardboard on top of the trash while having a group member stomp and compress the heap with their body weight. In order to reduce variables in the measurements, one member of the group (Mr. Gammill) was chosen to be the consistent weight of compaction.

Once all the trash was compacted, a yardstick was placed upright within the dumpster and used to measure the amount of empty space from the top of the compacted trash to the rim of the receptacle. It was assumed that the amount of empty space was horizontally consistent throughout the entire dumpster. This method of measurement was performed at each individual dumpster at all the residence halls. All of these measurements are available in Table 2.

Table 2. Measurements of empty space in the dumpsters. All measurements are in inches.

Dumpster Location	18-Oct	13-Nov	20-Nov
Redwood Manor	26	28	34
Redwood #1	14.5	25	36
Redwood #2	38	33	0
Redwood #3	34	N/A	N/A
Sunset #1	30	19	19
Sunset #2	8.5	27	26
Hemlock	22	25	29
Maple	18	14	14
Chinquapin	22	4	11
Madrone	12	18	27
Creekview #1	29	29	16
Creekview #2	31	29	19
Creekview #3	16.5*	24	9
Cypress	20	36	28

* This dumpster was missed on October 18th. The data shown is the average of Creekview #3 from the other two volume measurements.

To maintain consistency among the three volume measurements and the physical waste audit, they each needed to represent two days of accumulated waste. Arcata Garbage Company currently collects garbage from the residence halls each

Monday, Wednesday, and Friday between 8:30 am and 3:30 pm. Volume measurements were conducted on each of these three days -- Friday October 18th, Wednesday November 13th, and Wednesday November 20th. We had greater success in obtaining measurements early in the morning than in the afternoon.

An inconsistency in dumpster shape was noticed during the collection of data. In order to have consistency in each measurement, it was necessary to measure each dumpster in order to determine the actual amount of volume inside each individual bin. This was performed by using a measuring tape to determine the lengths of the various sides of each dumpster. This data also became necessary when calculating the amount of cubic yards occupied by the trash in each individual bin. A visual inspection followed by data calculation, led to the conclusion that there are four types of dumpsters. Appendix 22, titled Dumpster Measurements and Shape Descriptions, includes the measurements of the four types of dumpsters and lists each dumpster by type.

After determining the amount of empty space and the measurements of each dumpster, it became possible to quantify the amount of trash in each individual bin into a volumetric measurement. It was necessary to note the dumpster type when calculating each individual volumetric measurement of trash. The formulas used, as well as an example of how the measurements were calculated, are given in Appendix 23, titled Dumpster Volume Calculations. The results of each individual bin were quantified into cubic yard measurements and are listed in Table 3.

Table 3. Measurements of garbage in the dumpsters. All measurements are in cubic yards.

Dumpster Location	18-Oct	13-Nov	20-Nov
Redwood Manor	.949	.716	.435
Redwood #1	1.251	.726	.175
Redwood #2	.075	.325	1.975
Redwood #3	.275	N/A	N/A
Sunset #1	.476	1.025	1.028
Sunset #2	1.550	.626	.676
Hemlock	.876	.726	.525
Maple	1.075	1.275	1.275
Chinquapin	.876	1.776	1.430
Madrone	1.376	1.075	.626
Creekview #1	.525	.526	1.176
Creekview #2	.243	.329	.895
Creekview #3	1.151	.776	1.526
Cypress	1.008	.216	.609

Once all of the data was collected and organized, it was necessary to find a statistical means to verify that the audited sample was a valid representation of the amount of trash disposed of in the residence halls over a period of two days. The first step was to prove the normality of all the data collected in order to locate any outliers or skewed data. This test was performed using the program Minitab, which is available on the computers at HSU. The data from Table 3 was entered into columns and a test was

run to determine the normality of the data. An example of the results for the October 18th evaluation is available in Appendix 24, titled Normal Probability Plot. Normality within each data set gave statistical confidence to the measurements and made it possible to mathematically compare each measurement.

An analysis of variance (ANOVA) test was the chosen statistical method for verifying the significance of the audited sample. This test compares the means of more than two sets of data. The null hypothesis in this test was that all of the means are equal and the alternative hypothesis was one or more of the means is not equal to any of the other means. In order to perform such an analysis, there is a set of required assumptions that must be met, they are:

1) The samples are independent random samples.
2) Each sample is selected from a normal population.
3) The variances of each population are identical.

Consequently, if the assumptions and the null hypothesis are true, the data is comparable within the designated confidence level.

The trash from each dumpster was quantified into a volumetric measurement and this data was used to run the ANOVA test in Minitab. The results of the test will supply a p-value, which is used to test for the acceptance or rejection of the null hypothesis. The analysis of variance test was performed with a 95% confidence interval and Levene's test for significance yielded a p-value of .607. As is shown in Appendix 25, titled Test for Equal Variances, the null is accepted. This means that at a 95% confidence interval, all three volumetric means are equal. This result gives strength to the data received from the audit and verifies that the chosen sample was a valid representation of the quantity of garbage disposed over a two-day period.

A total of 2,108.5 pounds of waste was disposed in the residence halls' dumpsters during the audited two-day period. By combining this data with the collected volume measurements, it became possible to determine the average density of this portion of the waste stream. The calculations determined that the average density was 180.12 pounds per cubic yard (Appendix 23). This is higher than the 1992 study that determined an average density of 174 pounds per cubic yard.

There are some discrepancies that must be taken into consideration when viewing this data. The volume measurement performed on October 18th was done between 11:30 am and 12:30 pm. The trash receptacles weren't taken to the audit site until 4:00 pm on the same day. It should be noted that group members visually determined that there was more trash added to the dumpsters during that period of time. The additional garbage not accounted for in the volume measurements would cause an increase in the average density of the trash.

It is also necessary to note that during the first volume measurements, one of the dumpsters was accidentally excluded. This dumpster had to be included in the calculation of volume measurements because the trash it contained was included in the physical audit. To replace the missing data, Mr. Gammill calculated the average of the empty space for Creekview #3 based on the two other recorded volume measurements from November 13th and 20th.

When viewing the collected data, it should also be noted that during the two November volume measurements, there was no Redwood #3 dumpster. This doesn't directly affect the data because lack of dumpster space was never a problem on the days of collection. There were no overflowing receptacles and therefore, the missing dumpster only represents less available volume but in no way directly affects the validity of the volume measurements.

4.3 Evaluating the Recycling Program

4.3.1 The Survey

One of the objectives of the third goal for this project was to survey students living on campus about their recycling habits and awareness. We wanted to determine if it was possible to see a correlation between what students said they did and the results of the audit. Another objective of the same goal was to assess the education program(s) geared toward residence halls. It was decided that we would develop a survey to be given twice to students living in the residence halls, once before the audit and once after. The audit was coincidentally going to occur about the same time that the Campus Recycling Program had scheduled a "dorm education" campaign. By giving our survey before and after these events, we hoped to evaluate both student recycling habits/awareness and the effectiveness of the education campaign.

Ms. Cisneros prepared several drafts and obtained the necessary forms to submit a survey for approval in accordance with University guidelines regarding human subjects. On November 20th, Ms. Cisneros tested the survey by giving it to members of the Sustainable Campus class. Some of the questions proved to be slightly confusing, so another draft of the survey was required. Unfortunately the survey was never submitted for approval and therefore never given to students living on campus.

The original plan called for all students living on campus to complete the survey. This would eliminate the need to statistically determine how to achieve a proper representative sample of the residence halls' population. CRP suggested that we might be able to arrange to have the Living Group Advisors distribute the surveys through their mandatory meetings with their respective residence halls.

4.3.2 Education

CRP asked us to participate in their "dorm education" campaign during the semester by preparing posters that highlighted statistics from the audit. They were planning to create a trash mound during the week of November 11th that would be visible from the walkway of the Jolly Giant Commons building (the "J") and wanted posters to accompany the display. The trash mound was to be moved on November 14th to the Art Quad as part of CRP's America Recycles Day event on November 15th (see Figure 7).

During the week of November 11th, Ms. Thompson, Ms. Benedi, and Mr. Gammill prepared four posters, one of which can be seen in Figure 8. CRP used them as planned, although the first trash mound was located on the volleyball pit between Redwood and Sunset Halls instead of at the "J".

Figure 7. CRP's trash mound on America Recycles Day, 11/15/02, in the Art Quad.

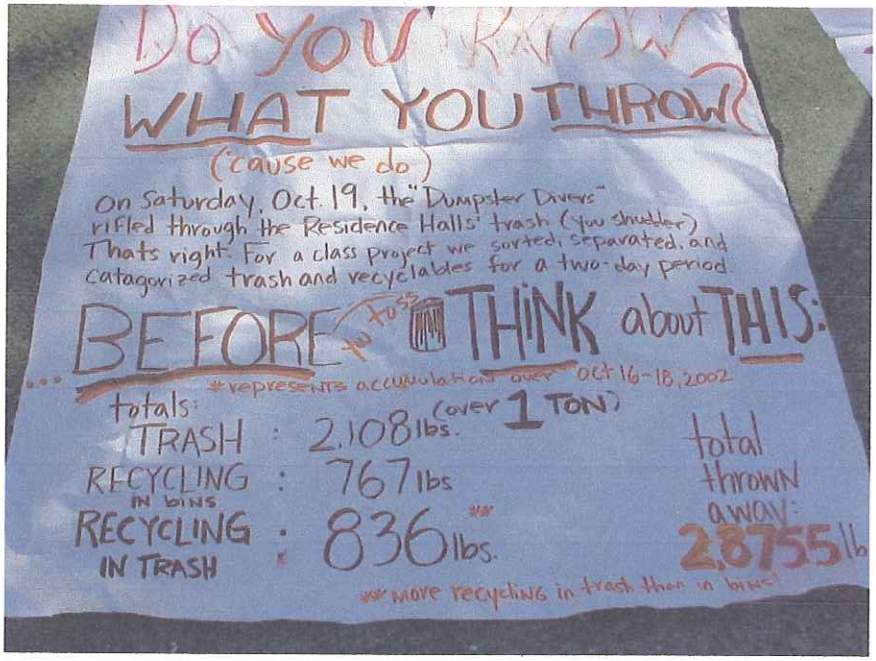


Figure 8. Education poster for CRP's trash mound by Liz Thompson.[4]

[4] The poster shown in Figure 8 contains an error. The amount of recycling found in the dumpsters was not 836 lbs. as stated. The correct number is 794 lbs.

4.3.3 Rating Recycling Bins

The last objective was to rate the quality of residence hall recycling bin locations, accessibility, and markings. We did not prepare a written list of evaluation criteria. Instead, we chose to evaluate the recycling bins on our individual subjective impressions. Between the five members of the group, we visited all of the residence halls' recycling bins five times: three times on October 18th when we estimated dumpster volumes, collected the recycling, and collected the garbage; and November 13th and November 20th when we estimated dumpster volumes.

As a group, we rated the location and accessibility of all residence halls recycling bins as very good. The recycling bins are located in convenient locations near all other disposal containers. Anyone who wanted to recycle would easily find the bins near their building. The bins are accessible by anyone. They are not locked up. Bins for paper materials have lids that are lightweight and easy to open with one hand. Most of the bins for cans and bottles have lids with holes in them, allowing for disposal without moving the lid, as shown in Figure 9. We rated the markings on the bins as average. Many of the bins had large stickers on them containing the traditional recycle triangle, although this was not consistent. Many of the bins for cans, glass, and plastic contained no markings on their sides to indicate the name of the material type, such as "glass" or "PET #1." However, all these bins had very clear markings on their lids. Overall, we feel that the recycling bins provided at the residence halls offer students who want to recycle every opportunity to do so with ease.

Figure 9. Recycling Bins at Redwood Manor. The dumpster is located just out of frame to the left.

5 Monitoring and Evaluation

The purpose of this section is to verify that the goals and objectives have been met.

5.1 Goal 1. Audit the waste stream of Humboldt State University's residence halls.

This goal and its three objectives were met. The audit was performed on October 19th and 20th, 2002. The material was categorized by material type. Each material type was weighed. Estimates of all the dumpsters associated with the residence halls were made on three different days (October 18th, November 13th, and November 20th).

5.2 Goal 2. Analyze the findings between this audit and the 1992 audit.

This goal and its objectives were met. The two audits had similar goals and are comparable in some aspects of their data, as related to material types and quantities. There are some differences, however, related to methodologies. The 1992 audit follows the State legal standards for a waste characterization study. The 2002 audit does not. The end result is similar. Both audits provide information on the quantity and the types of items that make up the waste stream for the residence halls.

5.3 Goal 3. Evaluate the recycling program for the residence halls.

This goal and two of its objectives were met. The recycling bin locations, accessibility, and markings were judged by this group to be very appropriate. The bins are located near or next to garbage dumpsters. There are recycling bins for each material type that is collected by the campus. The bins are adequately marked.

The education program geared toward the residence halls is lacking in both leadership and in student volunteers. Historically, the Campus Recycling Program (CRP) has taken the lead in promoting recycling on campus. They are credited with sustaining the campus recycling movement that was begun in the 1970's, as well as leading the effort to persuade school administrators to establish a permanent staff position to coordinate solid waste reduction efforts. The overall recycling program at HSU is considered by many to be a model for other campuses.

Today, CRP has significant problems encouraging recycling in the residence halls among those who do not already recycle. CRP currently has five paid staff positions dedicated to education, including keeping the web site updated. Only two of those positions are filled. This lack of leadership at the student level appears to be representative of the lack of student volunteers who are willing to work on education projects geared toward their fellow students. Understanding the causes behind this lack of interest in educating others should be a critical focus of CRP in order to develop strategies that can overcome them.

The most recent example of residence hall education shows that lack of interest does not rest with CRP alone. In October 2002, a recycling contest was proposed to the Residence Hall Association (RHA) and the Living Group Advisors (LGA) by CRP as a means of encouraging waste reduction in the residence halls. CRP agreed to use up to $200 of supplies and cash, while the RHA and LGA groups agreed to donate $500 toward a prize for the winning residence hall. Even though they agreed to advertise the contest and encourage participation among the residents of the dorms, most of the LGA's did not do so. CRP tabled in the "J" for 5 nights during the dinner hour in the week leading up to the start of the contest period. Most students, surveyed informally, were unaware of the contest. Those that were aware did not indicate much excitement about the contest, the $500 prize, or their willingness to participate. CRP officially canceled the contest, as it was felt that $500 should not be given to any group who might win by accident. CRP is scheduled to reevaluate the contest proposal when school is back in session in January 2003.

Our group planned a student survey to help meet our educational goals. It is not enclosed in the report as it was never completed nor implemented. A preliminary survey was given to the class to test its approach and the class offered suggestions for clarity and eliminating bias. This undertaking can be time consuming because of the process campus surveys must go through before being approved for distribution. Although our group never distributed the survey, we still believe it would be a valuable tool in assessing the current recycling trends in the residence halls.

5.4 Conclusion

The audit was successful in that it provided a greater understanding of HSU's waste stream, but in hindsight, we noted four specific modifications that would allow a future audit to run smoother and produce more concrete data.

First, volunteers are crucial to minimize physical strain on the group. We suggest at least twenty organized volunteers for future audits.

Second, it would be helpful to determine in advance what kind of statistical analysis is desired. It is of great benefit to know up front how you are going to use the data so that you know what type of information to acquire. It is equally as important to understand archived data in order to determine compatibility for statistical analysis. Never underestimate the amount of time and cooperation it takes to compile and analyze extensive data.

Third, on the day of the physical audit, take the volume measurements right before the garbage is collected so there is no discrepancy between volume estimate and the weight measurement. Even though it would slow down the collection process, this step would boost the validity of the density calculation.

Finally, a survey would be useful to gauge the recycling habits and attitudes of students living on campus. With a revolving student population in the residence halls, continual education is a key element to foster participation in the recycling program. A survey could provide the necessary information to develop an appropriately targeted education program.

Appendix 1: Materials Found in the Recycling Bins

Material (Paper products)	**lbs**	**Material** (Garbage)	**lbs**
Cardboard		Garbage	31
White ledger			
Newsprint			
Magazines/Catalogs			
Dishware			
Non-recyclable			
Material (Glass)	**lbs**		
CA redemption			
Other recyclable glass			
Non-recyclable glass			
Brown glass	96		
Green glass	77		
Clear glass	274		
Material (Metals)	**lbs**		
Steel/soft Aluminum	38		
Aluminum scrap			
Aluminum cans	28		
Ferrous metals			
Non-ferrous metals			
Mixed metal materials			
Material (Plastic)	**lbs**		
Clear PET plastic (#1)	153		
Colored PET plastic (#1)	23		
Natural HDPE (#2)	44		
Colored HDPE (#2)	34		
Total Recyclable Materials	767		
Total Garbage	31		
Total All Materials	798		

Appendix 2: Data Collection Logs

garbage 24.5 / 39.0 / 39.0 / 29.0 / 45.0 / ~~20.25~~
36.25 / 22.25 / 30 / 61 / 38 / 26.5
756 = 27 794 19.50 / 32.75 / 16.50 / 23.50 / 22.25
25.75 / 33.75 / 6.25 / 24.5 / 29.75 / 30 / 20.25 / 30.75
30 / 27.75

blue bins 2.8 lbs
* green bins 1.7 "

Non-recyclable plastics	

GARBAGE I[illegible] 8 - blue + green

Material (Paper products)	Tons 11.25 / 21.25 / 6.75 / 4.0	Material	Tons
Cardboard	19.0 / 11.25 / 10.5 / 13 / 14.25	Leaves, grass	
White ledger		Food *	27.75 / 41.0 / 38.25 / 36.5 / 36.75 / 30.0 / 26.5 / 8.5
Newsprint	21.25	Styrofoam	9 / 4.25 / 3.25
Magazines/Catalogs	21.25 /	Batteries - 5.25 /	
[illegible]		CDs - 3.50	
Non-recyclable		Books - 8.75	
Office pack	25.0 / 7.5	Magazines - 4.5	
Waxy packaging (non recycl)	22.25 / 16.75 / 7		
Material (Glass)	Tons		
CA redemption			
other recyclable glass			
Non-recyclable glass	28.75		
Brown glass	13.5		
green glass	42, 37, 39.25, 40.0, 8.5 /		
clear glass			
Material (metals)	Tons		
Aluminum cans	5 / 5		
Aluminum scrap			
steel cans	16.5 / 14.0 /		
ferrous metals			
non-ferrous metals			
mixed metal materials			
Electronics	27.0 /		
Material (plastic)	Tons		
PET plastic (#1)	9 / 10.5 / 13 / 12.25 / 12.75 / 10.0 / 7.25 / 12 / 14 / 18 / 10.25 / 8.0 / 11.0 / 18.0 / 5.0 / 8.5 / 4.25		
HDPE-clear (#2)	10 / 9 / 10.5 / 6.75 /		
Film plastics			

food wrappers / chips/cookies 11.0 / 14.0 / 10 / 4.25 / 8
non recyclable plastic 24.25 / 13.5 / 8.50 / 9.5
plastic bags 9.5 / 4.75 / 21.5 / 6.75 / 11.25 / 3.5 / 3.25

- material weights include bins weights.
- recycling containers that contained contents - included in weight

Waxy packaging - non recyclable = milk cartons, etc.

Paper plates/cups/food service
29.75 / 5.75

mop & vacuum = 24.0

construction & demolition
84.5 / 36.75 / 24 / ~~38.50~~
40.50 / 17.25 / 44
21.25

nonrecyclable cardboard
34.75 / 24.25 / 15.25 / 6.5 / 17 /
5.25

GARBAGE

~~MATERIALS FOUND IN THE RECYCLING BINS~~

Material (Paper products)	Tons
Cardboard	
White ledger	
Newsprint	
Magazines/Catalogs	
Dishware	
Non-recyclable	
Material (Glass)	Tons
CA redemption	
other recyclable glass	
Non-recyclable glass	
Brown glass	
green glass	
clear glass	
Material (metals)	Tons
Aluminum cans	
Aluminum scrap	
steel cans	
ferrous metals	
non-ferrous metals	
mixed metal materials	
Material (plastic)	Tons
PET plastic (#1)	
HDPE clear (#2)	
Film plastics	

Bathroom 26.0/$9.25/

textiles - 2925

Appendix 3: Materials found in the Dumpsters

Material (Paper products)	**lbs**
Cardboard*	87.15
Non-recyclable cardboard	88.70
Newsprint*	18.45
Magazines/Catalogs*	21.25
Dishware(plates,cups)	29.90
Non-recyclable	
Office pack*	26.90
Waxy packaging (non-recy)	37.60
Material (Glass)	**lbs**
Non-recyclable glass	
Brown glass*	25.95
Green glass*	10.70
Clear glass*	152.75
Material (Metals)	**lbs**
Aluminum cans*	7.40
Steel cans*	24.90
non-ferrous metals	
Electronics	24.20
Material (Plastic)	**lbs**
PET plastic (#1)*	136.15
HDPE(#2)*	25.50
Non-recyclable plastics	44.55
Food wrappers	33.25
Plastic bags	42.90
Total Recyclable Materials*	794.15
Total Garbage	1314.35
Total All Materials	2108.50

Material (Garbage)	**lbs**
Food, leaves, grass	228.85
Garbage	718.40
Styrofoam	8.10
Batteries*	2.45
Compact Disks	0.70
Books*	5.95
Construction/Demolition	248.65
Bathroom	30.75
Textiles	26.45

Appendix 4: Volunteer Flyer

DUMPSTER DIVING 101

SUSTAINABLE CAMPUS CLASS IS PERFORMING A SOLID WASTE AUDIT OF THE HSU RESIDENCE HALLS AND WE NEED YOUR HELP.

WHEN:

SATURDAY, OCTOBER 19TH, 10:00 AM - ??

WHERE:

PLANT OPERATIONS BACK PARKING LOT

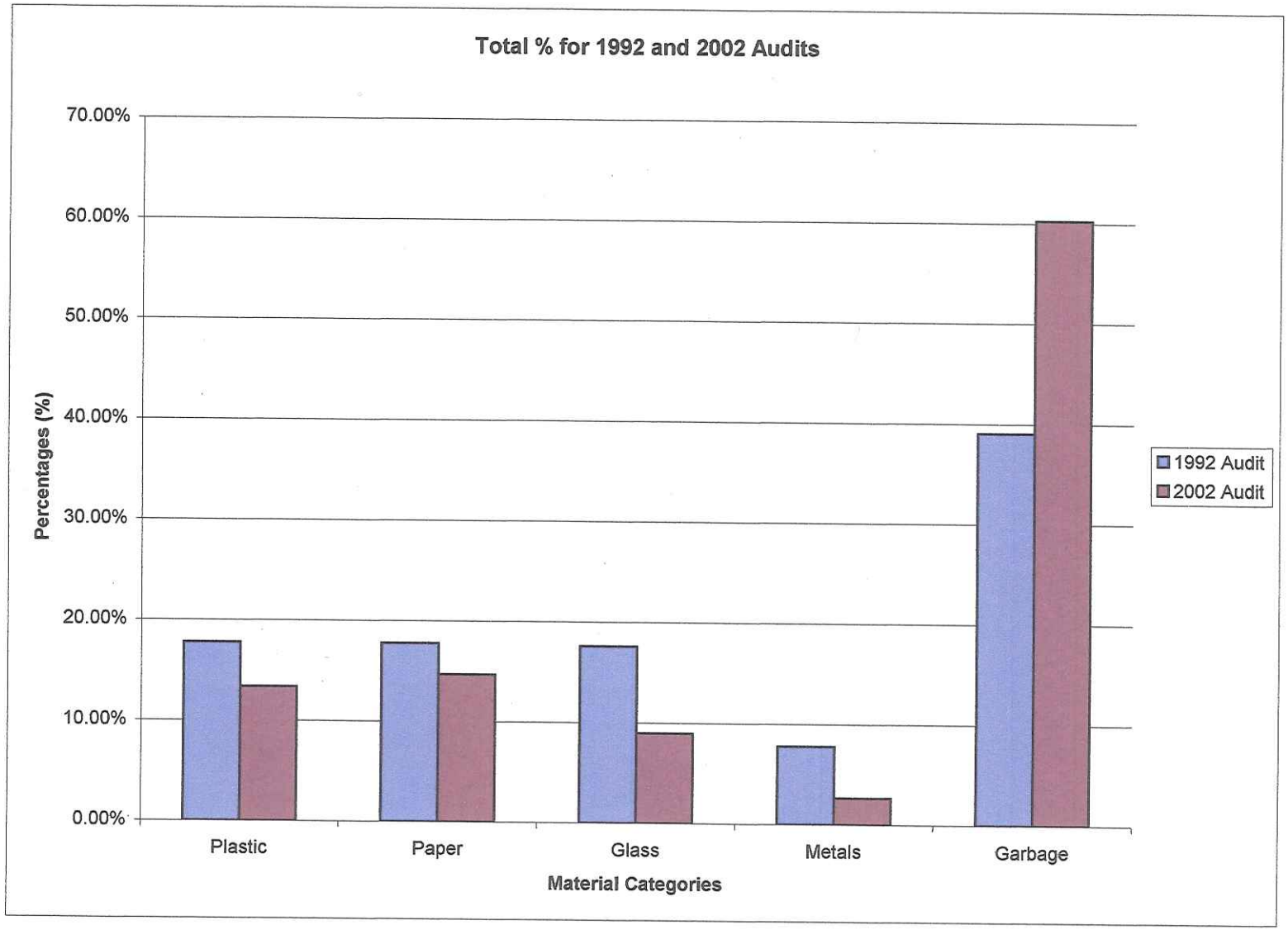
WEAR:

CLOSE-TOED SHOES, LONG PANTS

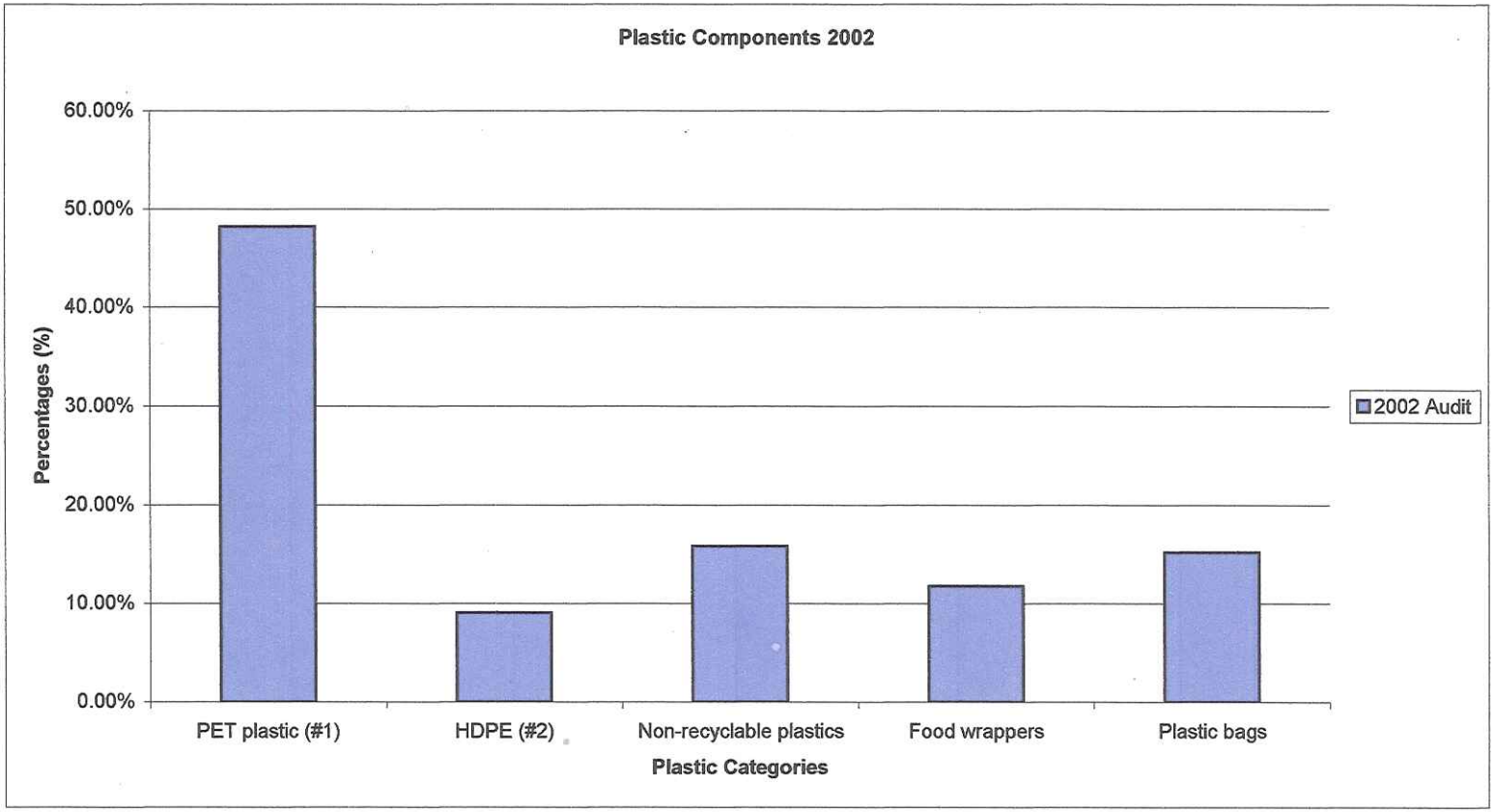
IF YOU WOULD LIKE TO VOLUNTEER
TO HELP SORT AND WEIGH
THE WASTE STREAM,
PLEASE CALL OR EMAIL:

PHYLLIS @ 826-4162 OR pek1@humboldt.edu

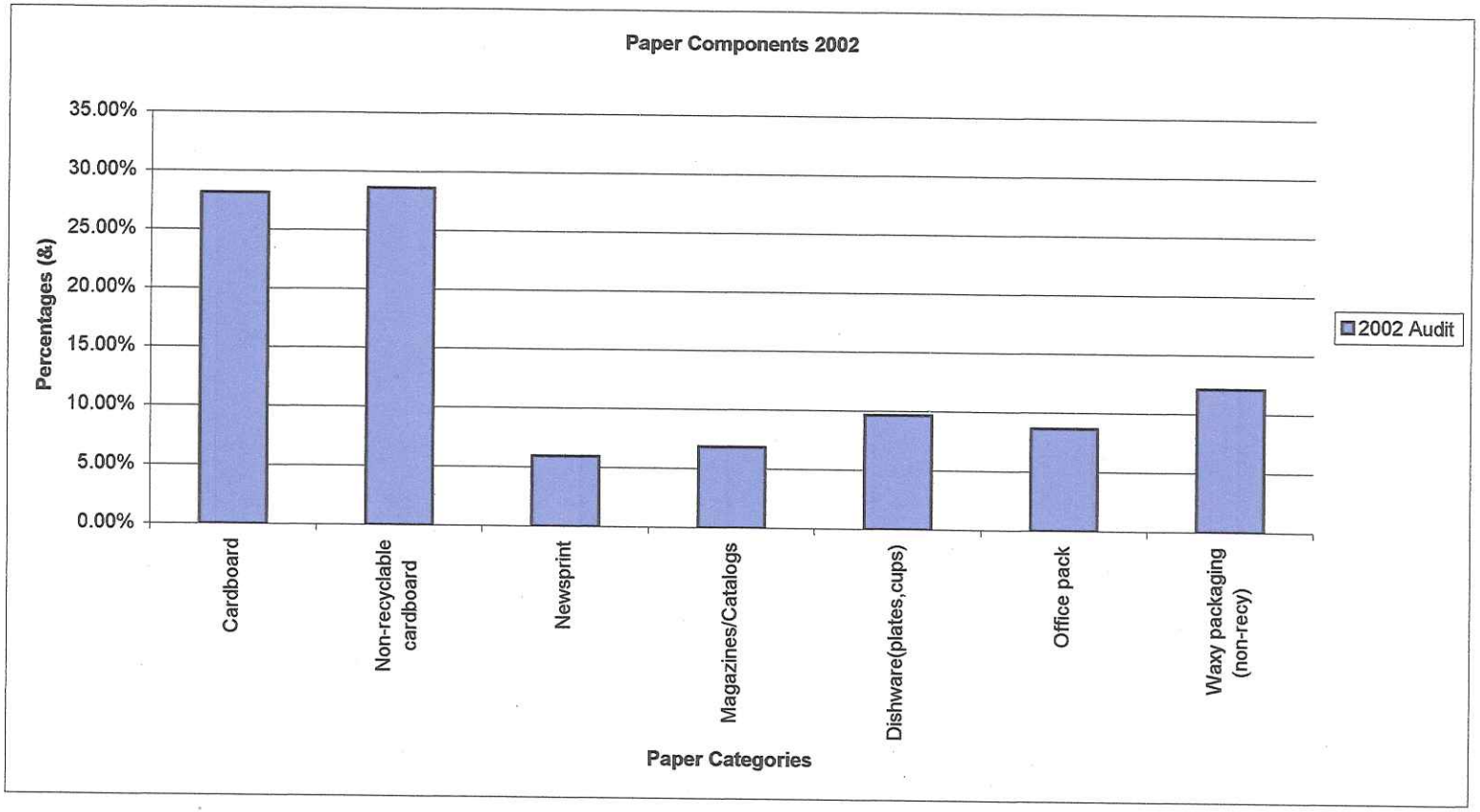
Appendix 5: Total % for Materials Found in the Dumpsters



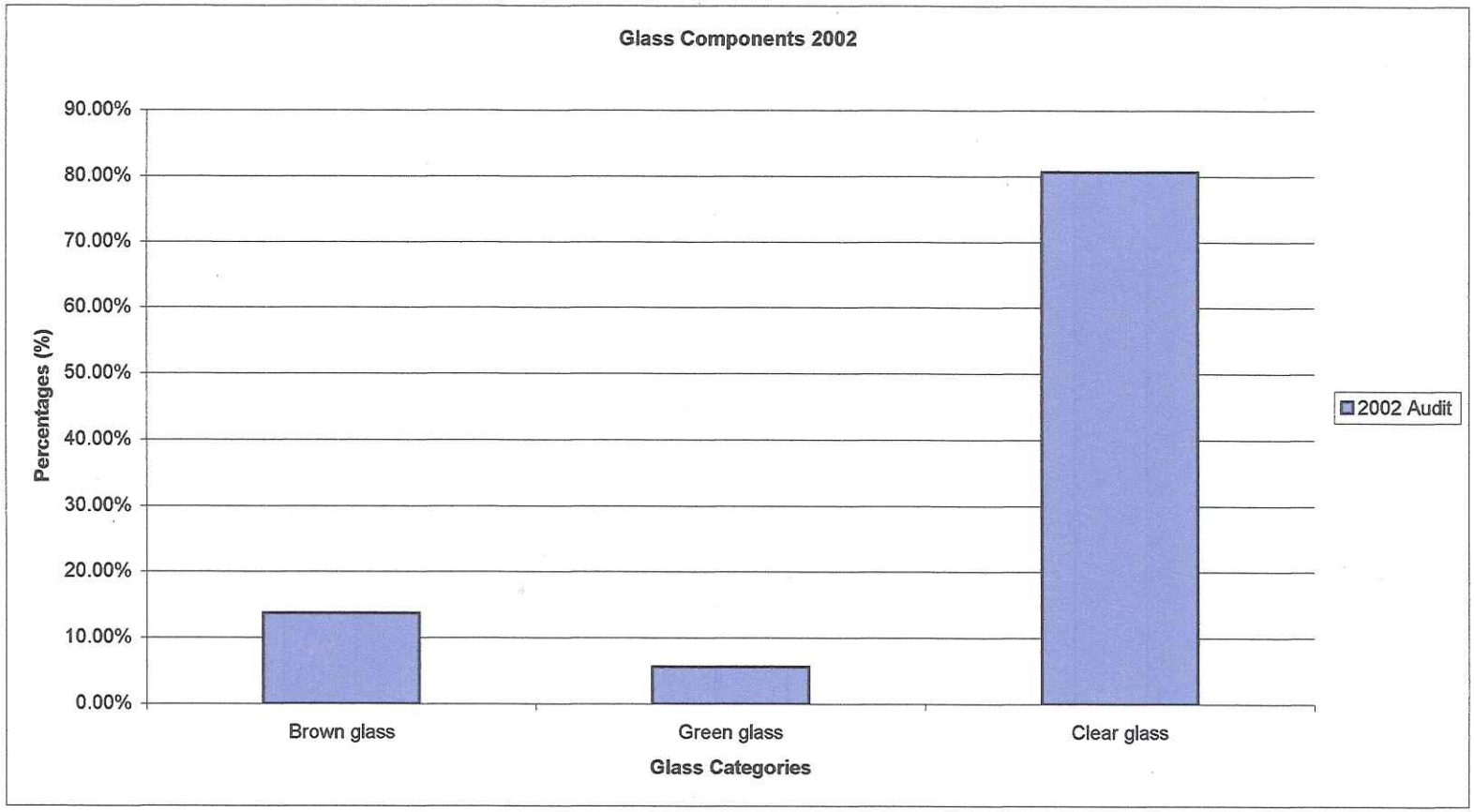
Appendix 6: Plastics Found in the Dumpsters



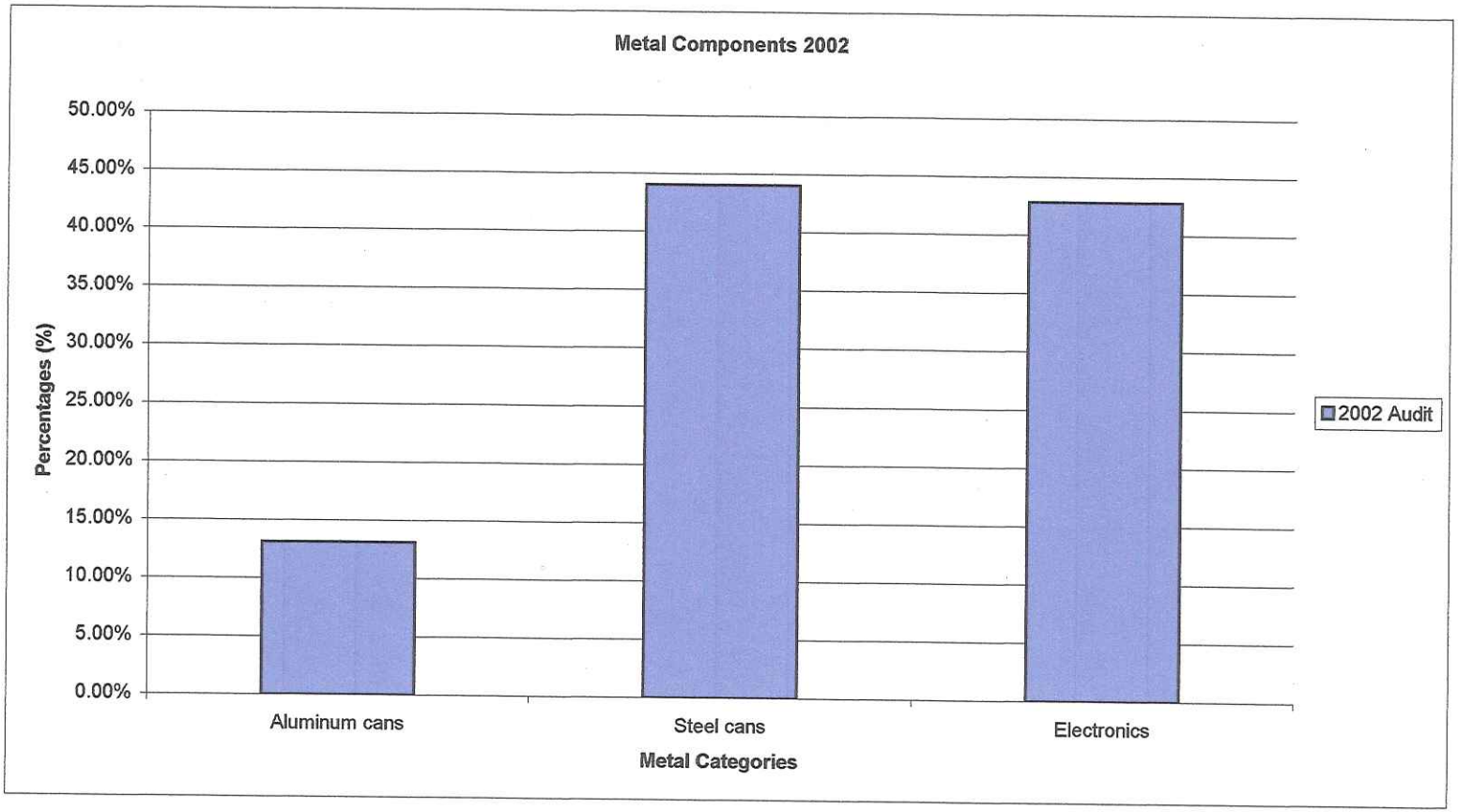
Appendix 7: Paper Found in the Dumpsters



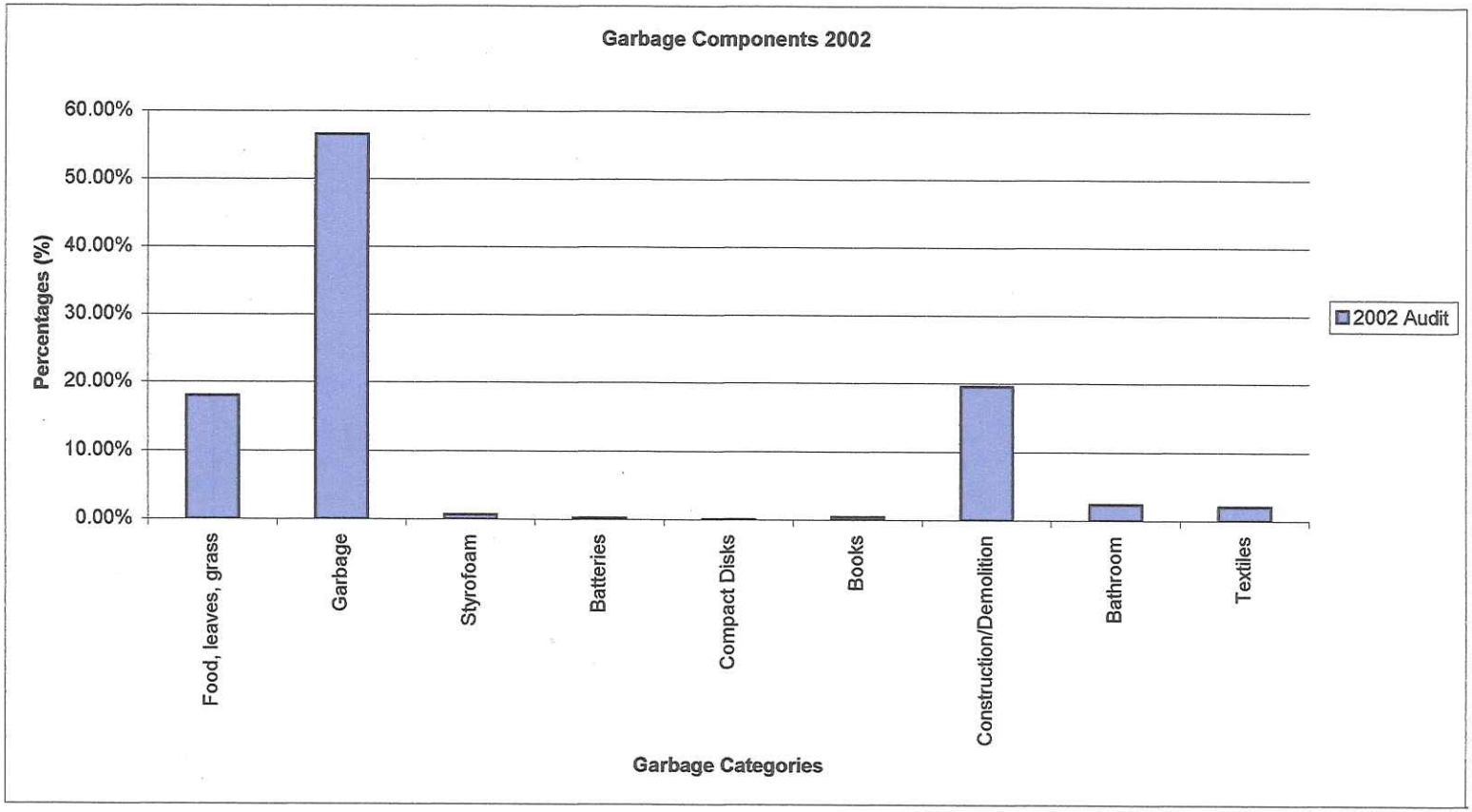
Appendix 8: Glass Found in the Dumpsters



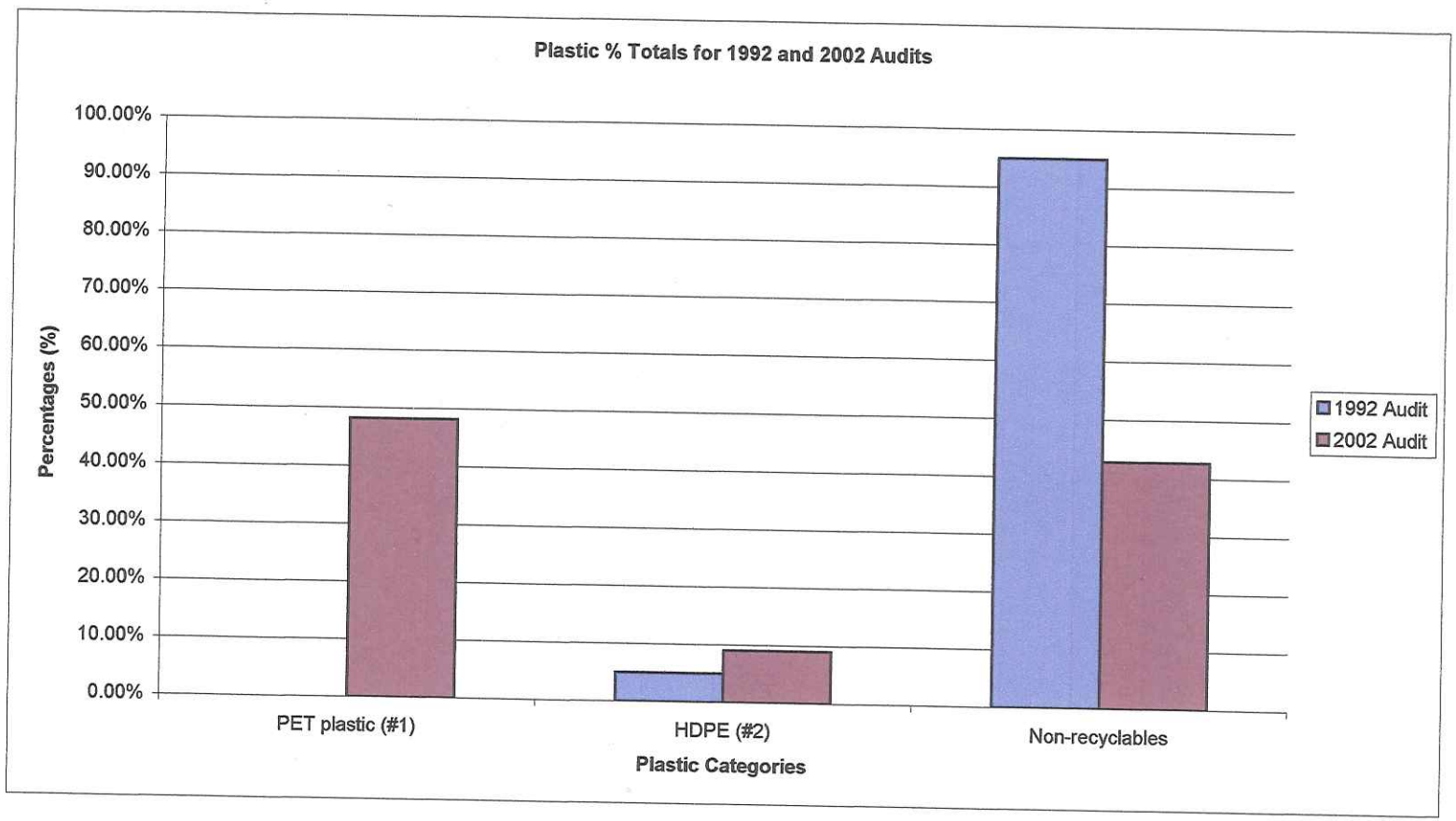
Appendix 9: Metals Found in the Dumpsters



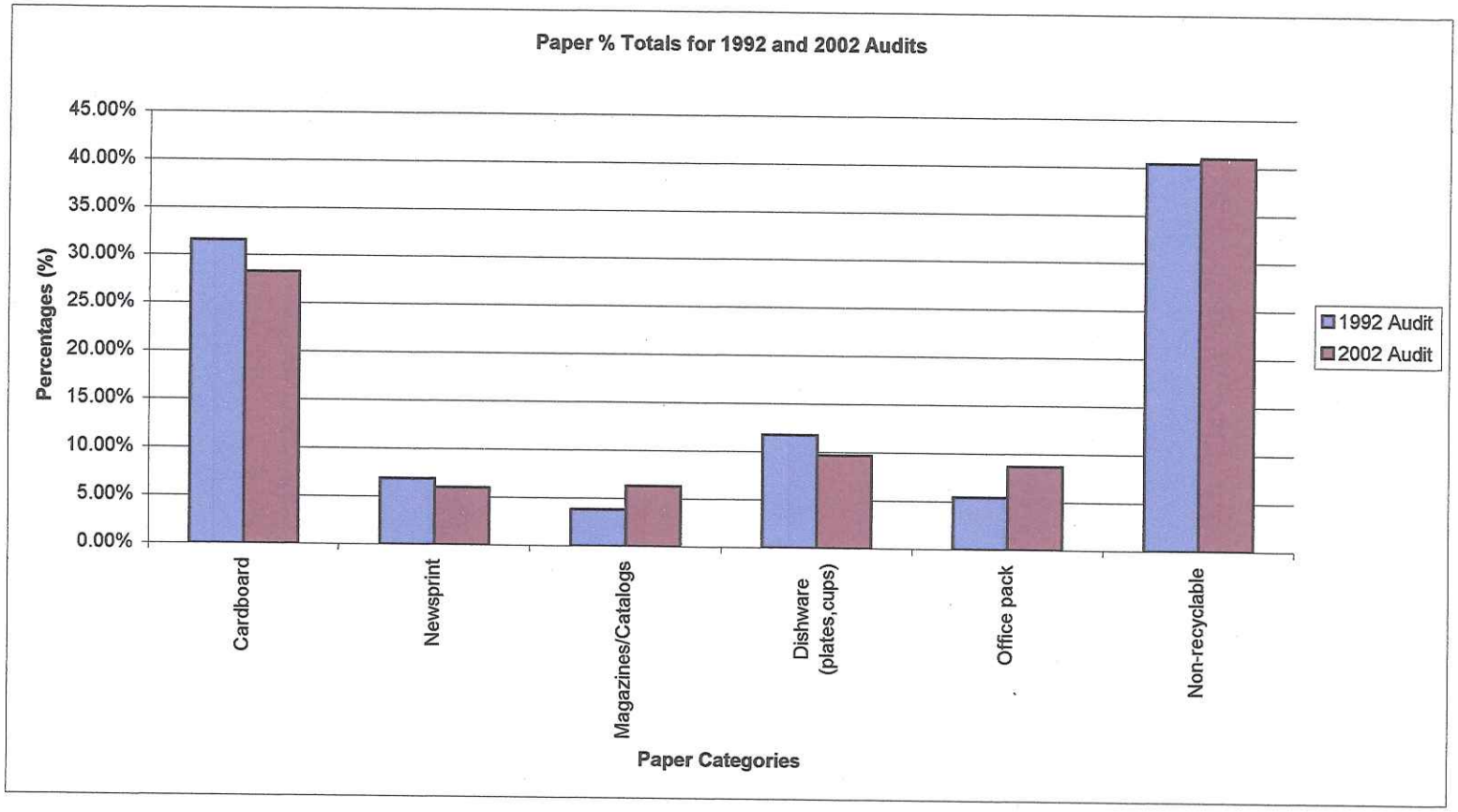
Appendix 10: Garbage Found in the Dumpsters



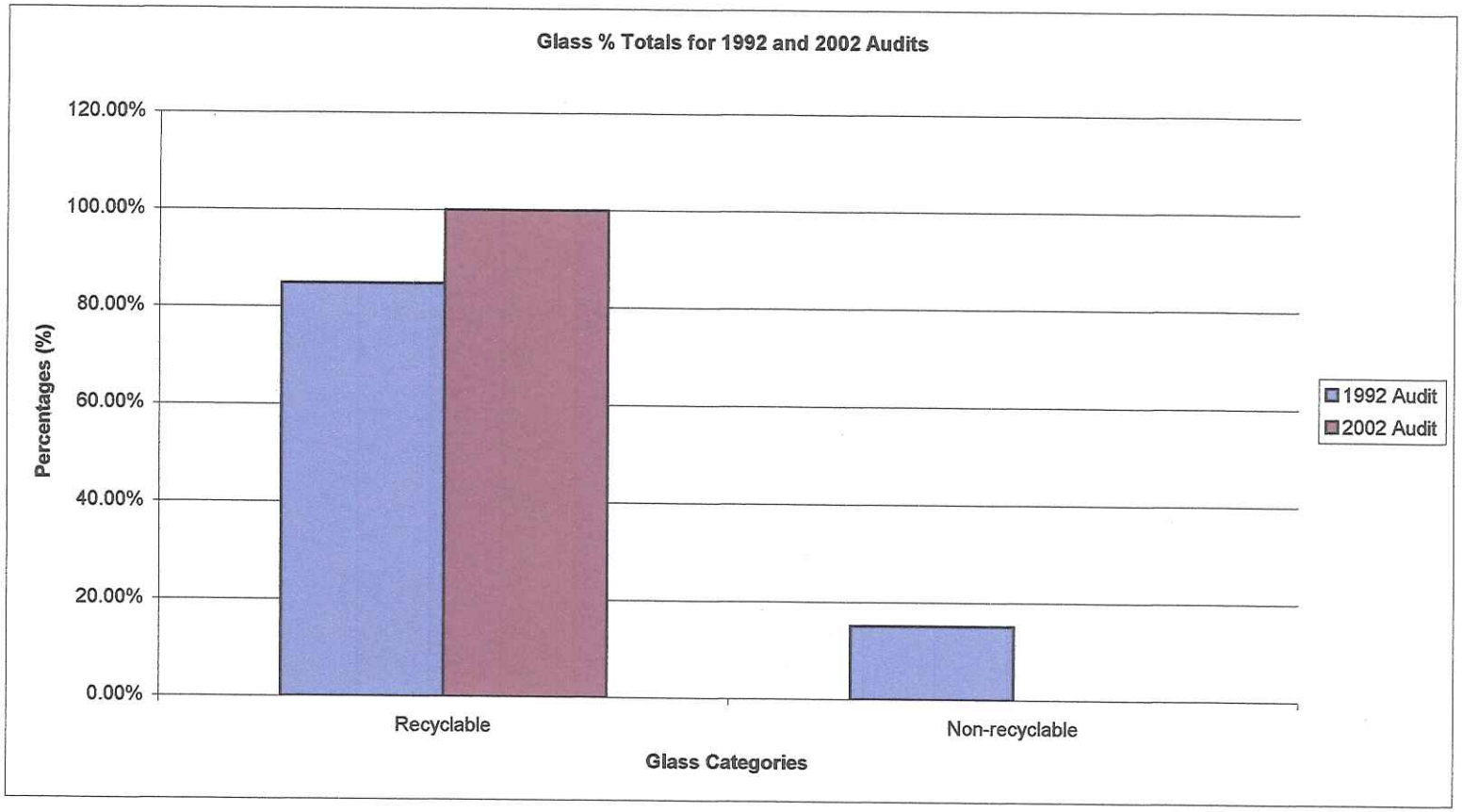
Appendix 11: Plastic Proportional Comparison



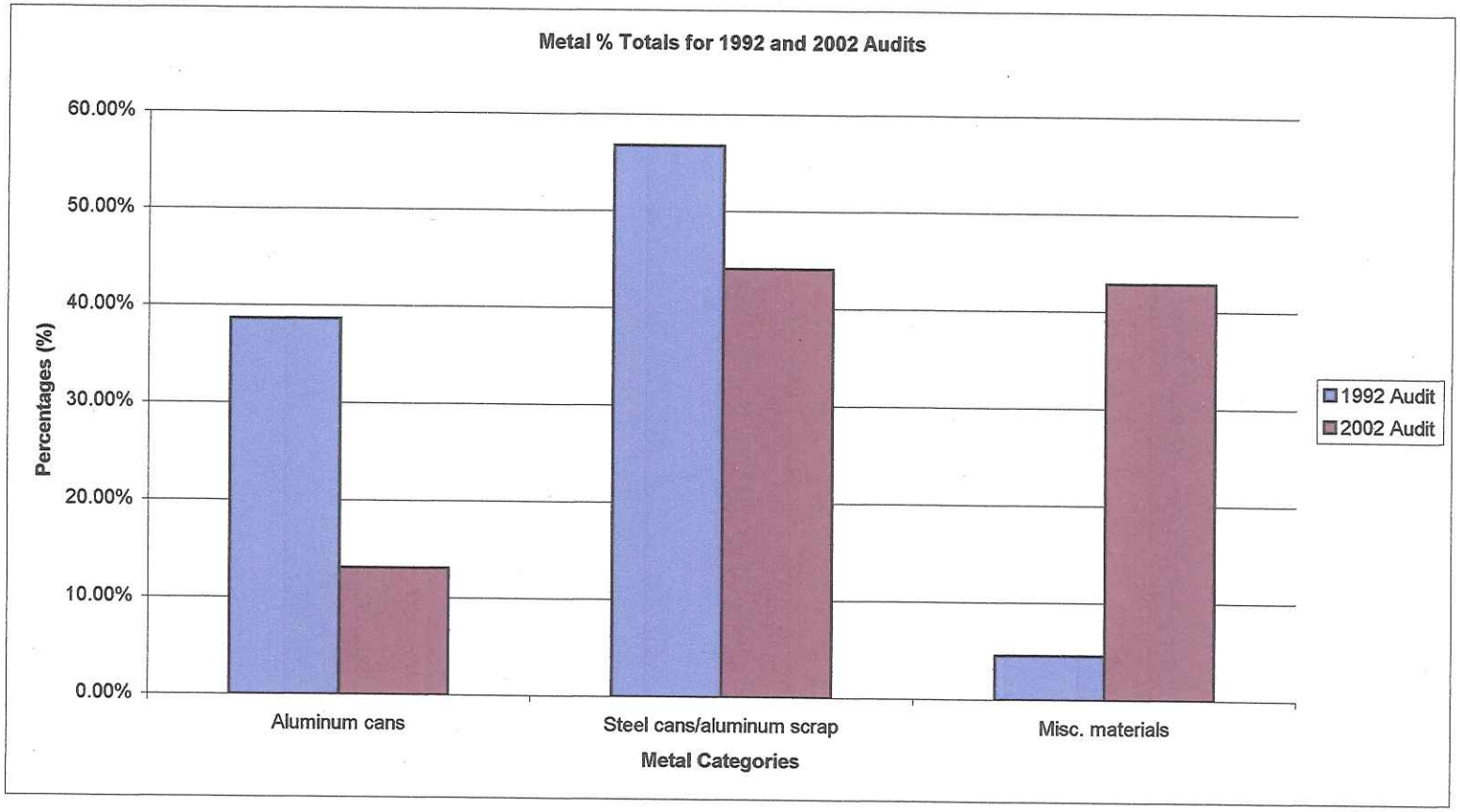
Appendix 12: Paper Proportional Comparison



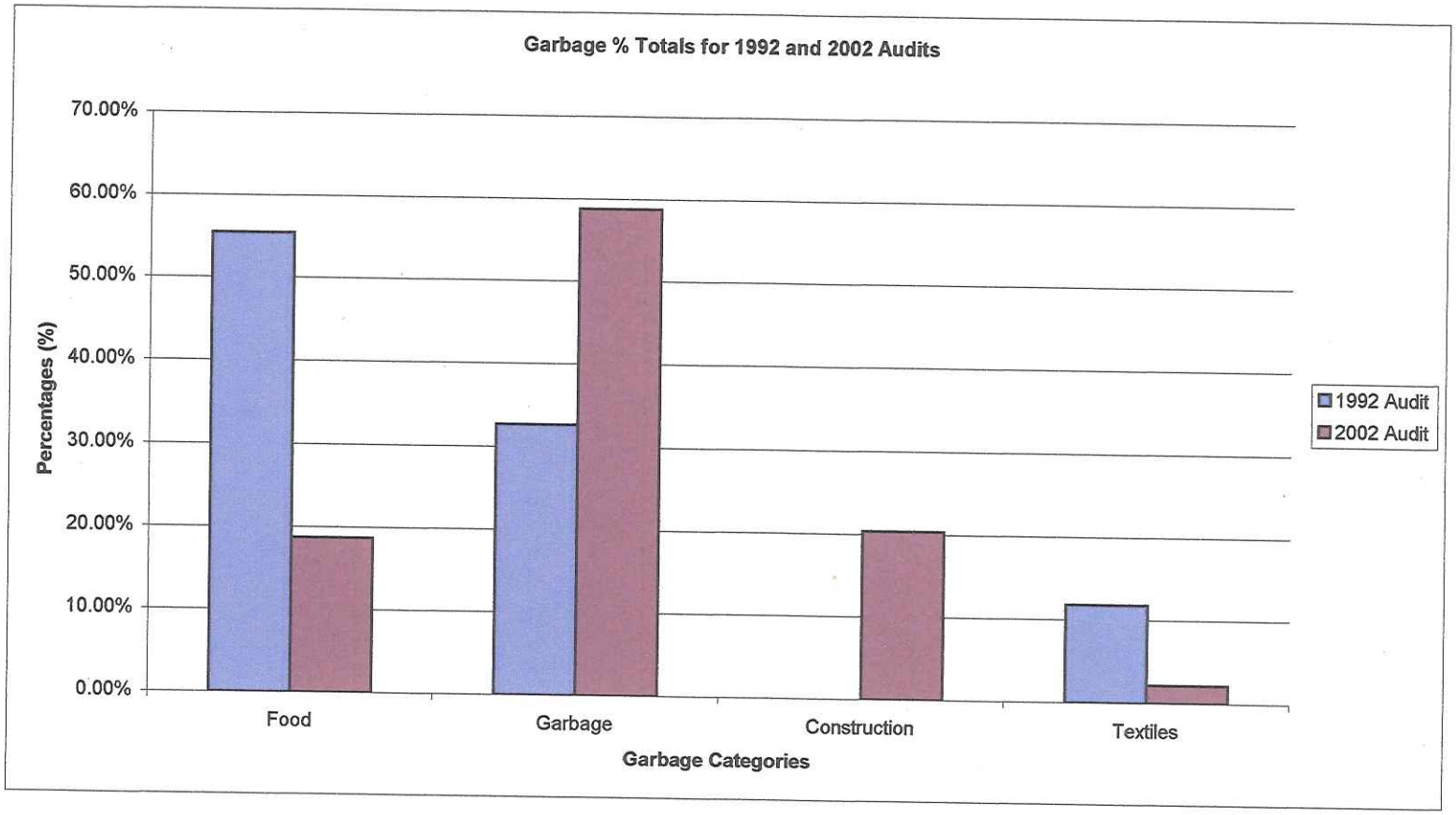
Appendix 13: Glass Proportional Comparison



Appendix 14: Metal Proportional Comparison



Appendix 15: Garbage Proportional Comparison



Appendix 16: Goodness of Fit Test

Comparing the 1992 and 2002 Audits with a Goodness of Fit Test: Inference of Proportions

Conditions of Validity

1) Observations within sample are independent of each other
2) Sample size must be large enough with the expected frequency of at least 5
3) The null hypothesis must specify numerical values for category probabilities

Comparison for Goodness of Fit for the Paper category

Categories: Carboard (CB), Office Pack (OP), Newsprint (NP), Magazines (Mag.), Dishware (Dish), and Non-recyclable (NR)

Ho = 2002 data

	CB	OP	NP	Mag.	Dish	NR
	28.3%	8.7%	6.0%	6.3%	9.7%	41.0%
	0.283	0.087	0.06	0.063	0.097	0.41
Obs.	23,000	4,000	5,000	2,800	8,600	29,400
Exp.	20,602	6,333.6	4,368	4,586.4	7,061.6	29,848

Example of Expected Value Calculation

Obs. = Observed data from 1992
Exp. = Observed x (%Ho)
Exp. For Cardboard Category=23,000*0.283=20,602

Example Calculation for Test Statistic (X_s^2)

$X_s^2=(O-E)^2/E$
X_s^2=[(20,602-23,000)2/23,000]+[(6,333.6-4,000)2/4,000+[(4,368-5,000)2/5,000]+[(2,800-4,586.4)2/4,586]+[(8,600-7,061.6)2/7,061.6]+[29,400-29,848)2/29,848]=1,501

Degrees of Freedom

Df=Number of samples-1
Df=5

P<0.0001
If P<alpha then reject Ho
Alpha=0.05
0.0001<0.05, therefore we reject Ho, stating that the models are not equal

Conclusion: We are 95% confident that the 1992 and 2002 Paper categories are not equal to each other.

Appendix 17: Waste Generated 1992

Calculations

Comparison by weight between the 1992 and 2002 audits, based on the 1992 assumptions.

Assumption:

1) Garbage disposed at an estimated 25 TPM (Tons per month)
2) This model represents the times with full disposal and the 3 month period of time with half disposal.

(25 * 9 mos) + (25/2 * 3 mos) = 77.0 tons/year

(X * 9) + (X/2 *3) = 77.9

9X + 3X/2 = 77.9

18X +3X = 155.8

21X = 155.8

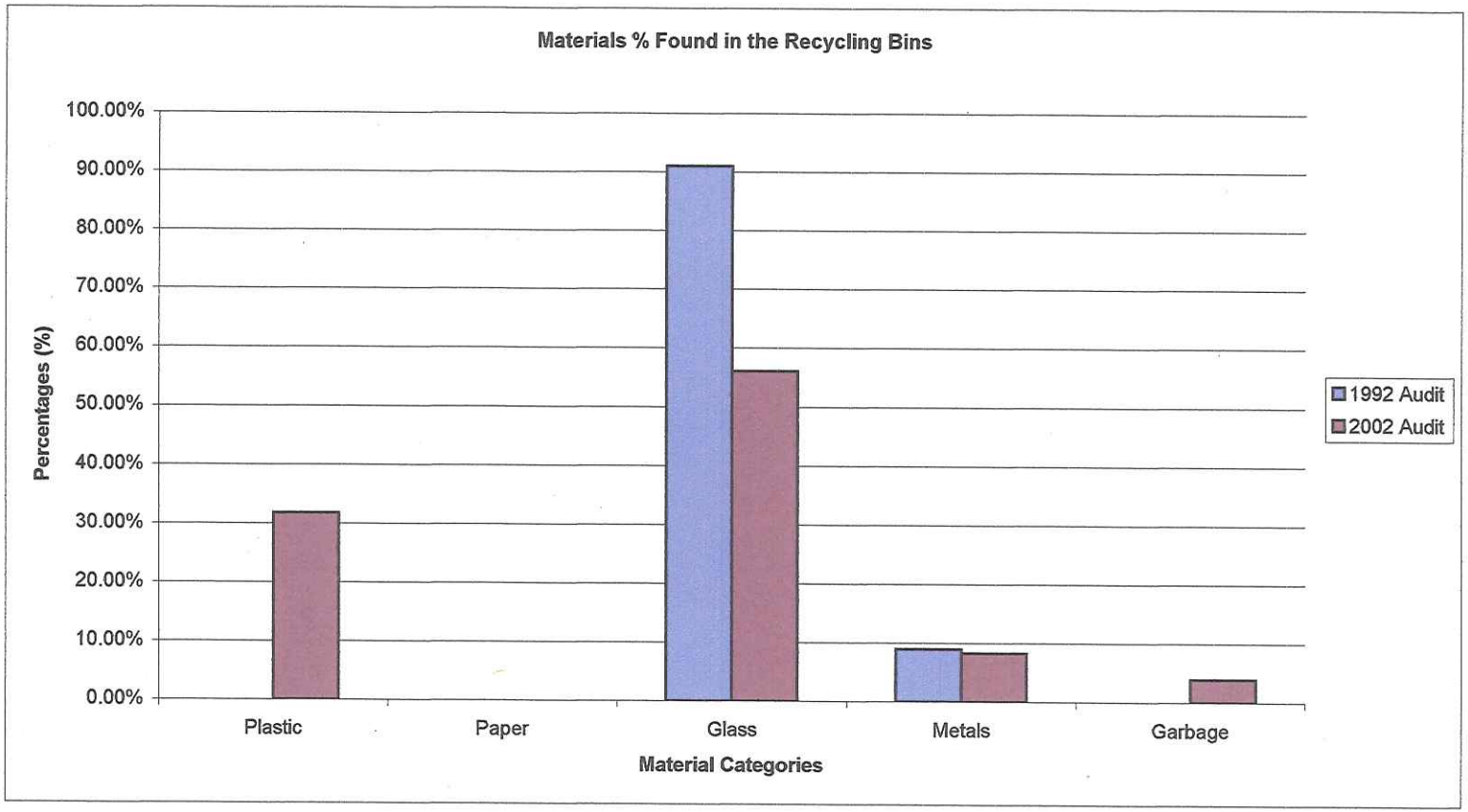
X = 155.8 / 21

X = 7.42 tons/month

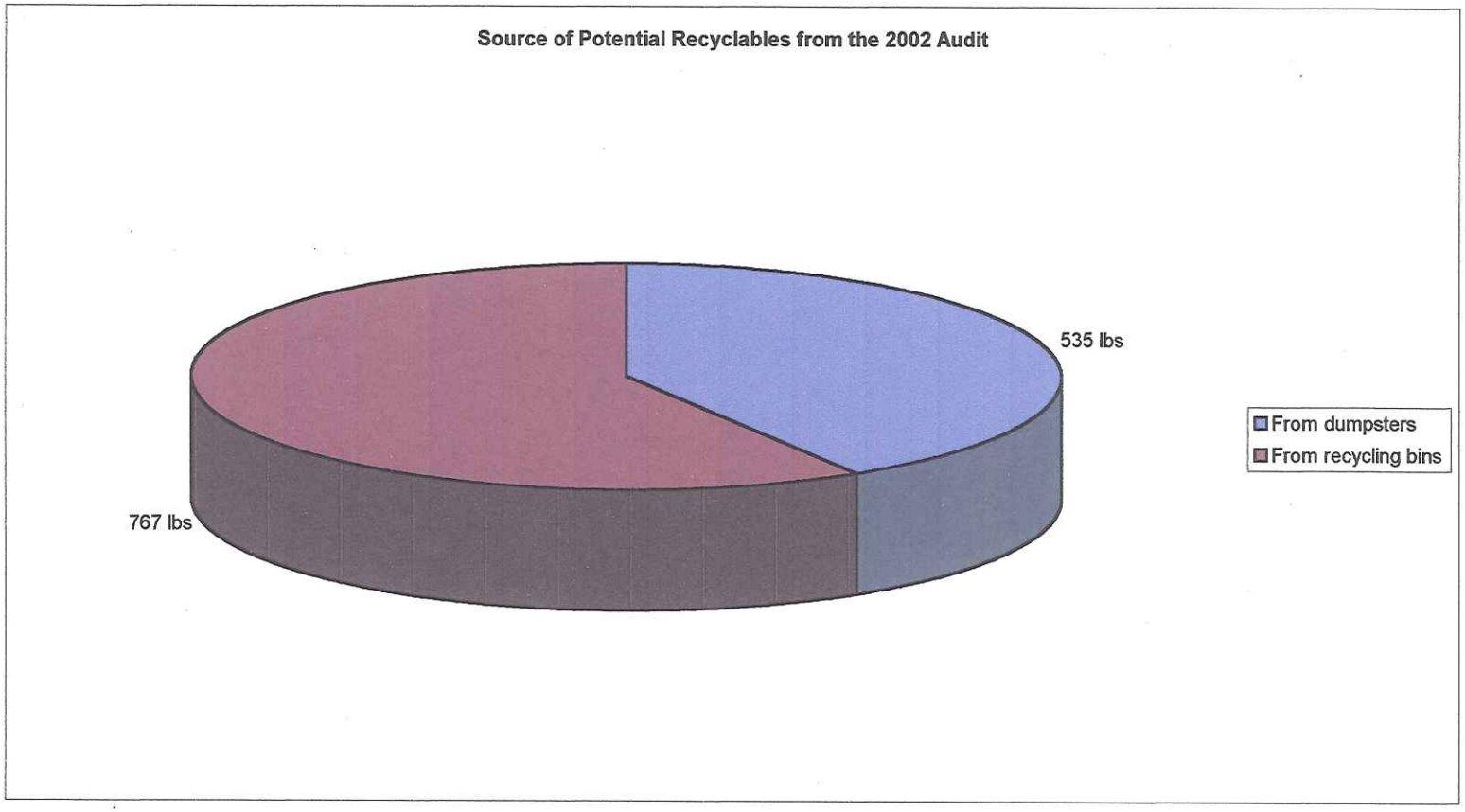
7.42 * (2000 lbs) = 14,980 lbs /mo in 1992

14,980 / 30 days = 499.33 lbs/day in 1992

Appendix 18: Comparison of Materials Found in the Recycling Bins



Appendix 19: Source of Potential Recyclables

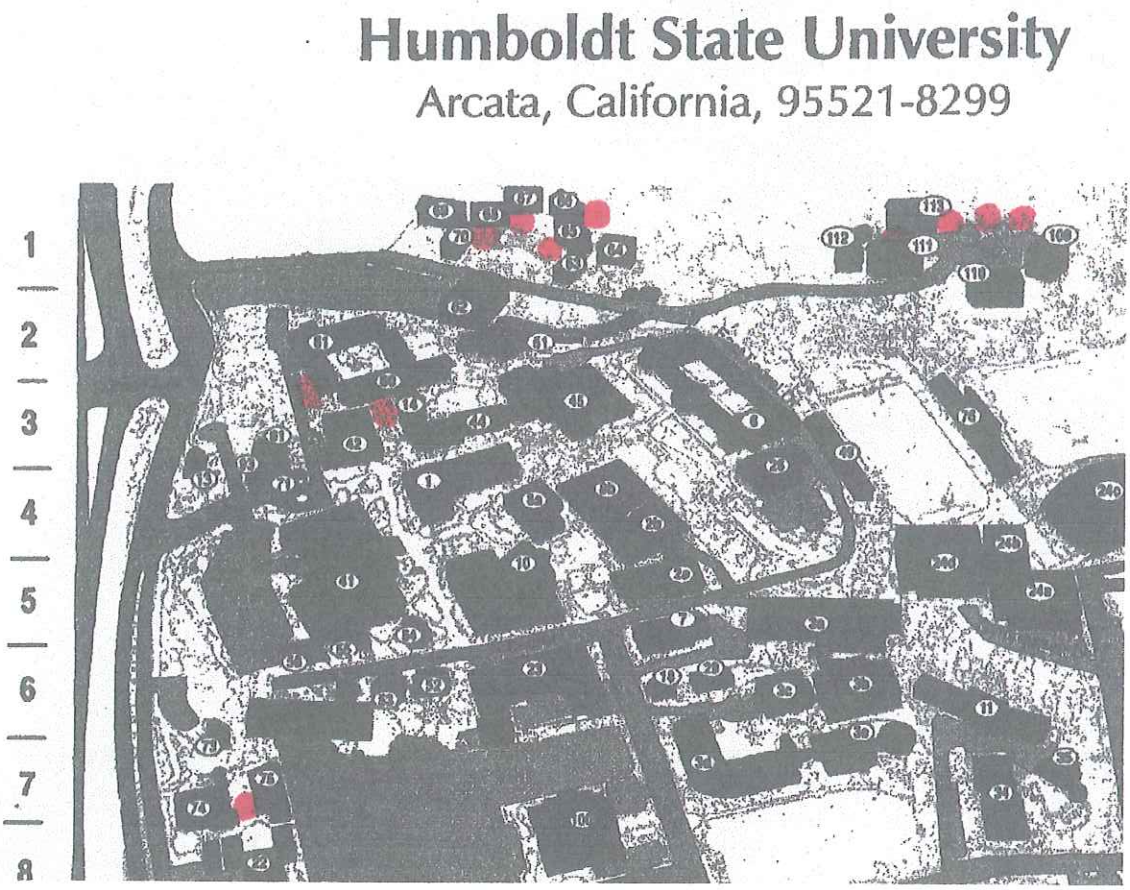


Appendix 20: Recycling Data 2002

Recycling Found in the Dumpsters		Recycling Found in the Recycling Bins	
	lbs		lbs
Brown glass	25.95	Brown glass	96.00
Green glass	10.70	Green glass	77.00
Clear glass	152.75	Clear glass	274.00
Total glass	189.40	Total glass	447.00
PET plastic (#1)	136.15	PET plastic (#1)	176.00
HDPE (#2)	25.50	HDPE (#2)	78.00
Total plastic	161.65	Total plastic	254.00
Aluminum cans	7.40	Aluminum cans	28.00
Steel/Alum scrap	24.90	Steel/Alum scrap	38.00
Total metal	32.30	Total metal	66.00
Cardboard	87.15	Garbage	31.00
Newsprint	18.45		
Magazines/Catalogs	19.55		
Office pack	26.90		
Total Paper	152.05		
Total Dumpster Recycling	535.40	Total Recycling Bin Recycling	767.00

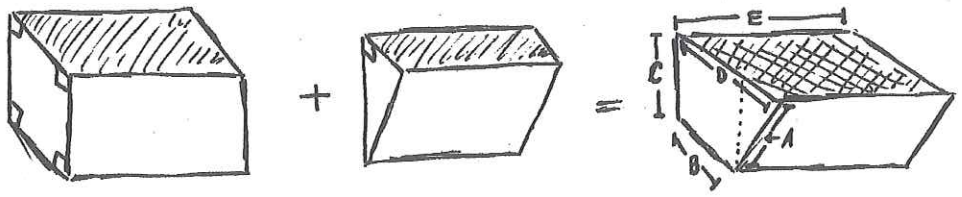
Total Potential Recycling	lbs	%
From Dumpster	535.40	41.11%
From Recycling Bins	767.00	58.89%
Total	1302.40	100.00%

Appendix 21: Map of Campus Dumpsters



Appendix 22: Dumpster Measurements and Shape Descriptions

General Shape of Dumpster



Dumpster #1 = A = 44
B = not measured
C = 43 5/16
D = 39 1/2
E = 59 15/16

Dumpster #2 = A = not measured
B = 37 1/2
C = 39 1/2
D = 40 7/8
E = 59 9/16

Dumpster #3 = A = 36 5/8
B = 32
C = 36 1/2
D = 35 5/8
E = 60

Dumpster #4 = A = 40 1/4
B = 37 1/2
C = 39 3/4
D = 40 3/4
E = 59 3/4

* All measurements in inches

Type of Dumpster

1. Redwood Manor - #1
2. Redwood - #2
3. Sunset - #2
4. Chinquapin - #2
5. Hemlock - #2
6. Madrone - #2
7. Maple - #2
8. Creekview 1 - #2
9. Creekview 2 - #3
10. Creekview 3 - #2
11. Cypress - #4

Appendix 23: Dumpster Volume Calculations

VOLUME OF CUBE = H × L × W

VOLUME OF WEDGE = (H × L × W)/2

VOLUME OF DUMPSTER = VOLUME OF CUBE + VOLUME OF WEDGE

★ 1 YARD = 36 INCHES

EXAMPLE: REDWOOD #1 FROM 10/18 (DUMPSTER #2)

H = MEASUREMENT C – INCHES FROM THE TOP
= 39.5 – 14.5 = 20 INCHES × $\frac{1 \text{ YARD}}{36 \text{ INCHES}}$ = .694 YARDS

L = MEASUREMENT B
= 37.5 × $\frac{1 \text{ YARD}}{36 \text{ INCHES}}$ = 1.042 YARDS

W = MEASUREMENT E
= 59 9/16 INCHES × $\frac{1 \text{ YARD}}{36 \text{ INCHES}}$ = 1.655 YARDS

VOLUME OF CUBE = .694 × 1.042 × 1.655 = 1.197 YD³ OF TRASH

H = .694 YARDS

L = MEASUREMENT D – MEASUREMENT B
= 40 7/8 – 37 1/2 = 3 3/8 INCHES × $\frac{1 \text{ YARD}}{36 \text{ INCHES}}$ = .094 YARDS

W = 1.655 YARDS

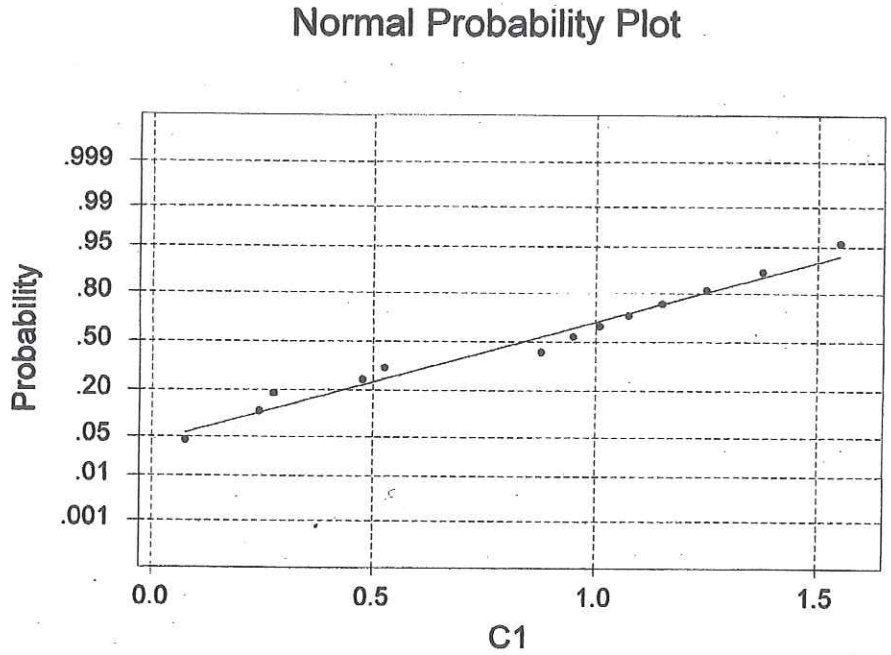
VOLUME OF WEDGE = .694 × .094 × 1.655 = .1076/2 = .054 YD³ OF TRASH

VOLUME OF TRASH IN REDWOOD #1 ON 10/18 = 1.197 + .054 = 1.251 YD³

10/18
- TOTAL AMOUNT OF GARBAGE = 11.706 YD³
- TOTAL AMOUNT OF GARBAGE = 2,108.5 LBS

– 2,108.5 LBS ÷ 11.706 YD³ = 180.12 LBS/YD³

Appendix 24: Normal Probability Plot



Average: 0.836136
StDev: 0.451279
N: 14

Anderson-Darling Normality Test
A-Squared: 0.285
P-Value: 0.573

Appendix 25: Test for Equal Variances

$H_0 = \mu_1 = \mu_2 = \mu_3$

$H_A = \mu_1 \neq \mu_2 \neq \mu_3$

* AT 95% CONFIDENCE INTERVAL
$\alpha = .05$

IF $P < \alpha$ REJECT H_0

IF $P > \alpha$ ACCEPT H_0