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WASTE STREAM ANALYSIS OF TWO UNITED STATES ARMY DINING FACILITIES

by

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ABSTRACT

The purposes of this study were to characterize the waste stream at two United States Army dining facilities at Fort Riley, Kansas and to recommend policies and procedures to effectively manage solid waste at U.S. Army dining facilities.

A waste stream analysis was conducted at two facilities during two seven day periods, one in the first half and one in the second half of the month based on the military pay cycle. Both periods included weekday and weekend days. The weight, volume, collapsed volume, and specific weight of three categories of waste were recorded. The nutrient composition of service waste was determined.

The total weight and volume of food waste generated at both facilities during the 14 day periods was 8909.75 lbs or 0.70 lbs/meal and 7.36 cubic yards or 0.0006 cubic yards/meal, respectively. Greater than 70% of all waste generated by weight was food waste at both facilities. Food waste also composed the greatest percent of volume (29.74%) after other nonfood waste volume was collapsed. The composition of service food waste was moisture (70.81%); carbohydrate (16.47%); fat (6.43%); protein (5.16%); and ash (1.15%).

Total weight and volume of nonfood waste disposed was 3444.95 lbs or 0.28 lbs/meal and 52.81 cubic yards or 0.0041 cubic yards/meal, respectively. The packaging material

contributing the greatest percentage of volume of nonfood waste were cardboard and various other types of paper waste.

No significant differences in weight or volume of food, nonfood, and total waste generated per meal were found between the two facilities. A significant difference was observed in the weight of food, nonfood, and total waste and volume of food waste generated per meal at the NCO Academy in the second period. The difference in weight and volume may have been related to reduced purchasing during the second half of the month. No other significant differences related to the period were observed. No significant differences were found for either weight or volume of food, nonfood, or total waste generated per meal at either facility between weekdays and weekend days. Recommendations were made to reduce food and nonfood waste through purchasing strategies, foodservice management practices, recycling, and composting.

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CHAPTER I

INTRODUCTION

Media has bombarded the American public with environmental concerns surrounding the generation, reduction, and management of solid waste. Solid waste is defined by the Environmental Protection Agency (EPA) as discarded durable and nondurable goods, containers and packaging, food wastes, yard trimmings, and miscellaneous inorganic wastes (EPA, 1992a). The amount of solid waste produced by Americans has increased annually for the last three decades; more per capita than any other nation. As Americans have generated more waste, places to dispose of it have decreased (EPA, 1989a; 1990; 1992a). Many landfills have reached capacity and new landfills have become difficult to locate. Environmental concerns, unpleasant smells, and noise have been cited as reasons for the increasing public resistance to the opening of new landfills. The "Not In My Backyard" (NIMBY) mindset is shared by many Americans (EPA, 1989b).

The EPA (1989b) recommended a combination of actions to manage solid waste called the hierarchy of waste management which included: source reduction or prevention of waste; reuse, recycling, and composting; combustion or energy resource generation; and landfilling. The hierarchy emphasized the need for an integrated change in the nation's approach to producing and packaging products and disposing of waste. The EPA recommended a new standard that would minimize the amount and reduce the longevity and toxicity of future waste through changes or improvements in manufacturing. The intent of the standard was to maximize the amount of waste materials that were reused and recycled while minimizing the amount of waste generated.

The high visibility of waste generated by the foodservice industry and the external pressures facing managers from politicians, special interest groups, and the general public have made it critical for the foodservice industry to assume a leadership role in solid waste management. Americans have expressed the belief that take-out packaging from the fast food industry has contributed approximately 20 to 30% of the total solid waste stream (Rathje, 1991). Rathje (1991) determined that packaging from this segment of foodservice generated one-tenth of one percent of the total waste stream. Consumer belief that the quantity of waste generated by the fast food industry is significant was further supported by research by Becker, Ferris, King, Penka, Suwanaposee, and Thattacherry (1993). Respondents in this study indicated their belief that the fast food sector of the foodservice industry accounted for an average of approximately 32% of all solid waste currently generated in the United States. Regardless of the correctness of such perceptions, consumers are demanding that the foodservice industry take a more aggressive approach to managing the solid waste problem (Westerman, 1991).

Shortages of landfills, increased waste hauling fees, environmental concerns, and customer sentiment have made the "greening" of foodservice operations a financial necessity (Frumkin, 1989; Feldman, 1991; Hayes, 1991; King, 1991; Casper, 1992). Increasingly stringent government regulations at the state and federal level throughout the United States have called for bans on disposable foodservice packaging and have required that increased waste reduction measures be utilized including recycling (Townsend, 1990; Cummings & Cummings, 1991).

Leaders in the foodservice industry have reported the serious nature of public opinion in this area. They indicated that this attitude concerning the environment was not a fad but a permanent consumer demand which would directly affect a foodservice organization's profit margin (Martin, 1991). Public image and consumer confidence may hinge on a new and more aggressive role for foodservice establishments. In response, operators have employed the "three R's" - reducing, reusing/repairing, and recycling to respond to the solid waste problem (Townsend, 1990; Cummings & Cummings, 1991; Casper, 1992).

Army foodservice is challenged by similar solid waste management issues. New laws and regulations, increased costs associated with diminishing landfill capacity, and environmental concerns have forced these facilities to examine their solid waste management techniques (Funke, O., Forrest, R., Cockerill-Kafka, K., & Huppertz, C., 1992).

Before a foodservice operation can identify the most effective solid waste management methods for each specific situation, management must understand the type, weight, and volume of different components of the waste stream. A comprehensive waste stream analysis of the facility can provide this information. Data from waste stream analysis combined with information from the packaging industry, processors, and distributors can alert the operator to instances in which paper, plastic, food, and other waste components can be reduced, eliminated, and recycled (Cummings & Cummings, 1991; Casper, 1992).

Waste characterization studies or audits are necessary to identify the types and quantities of recyclable materials which are generated in an organization (Savage, Diaz, & Golueke, 1985; Casper, 1992; Clarke, 1992; Funke et al., 1992; EPA, 1992). By describing and quantifying the waste generated in foodservice facilities, information is provided that is valuable when making waste reduction decisions. The National Conference of State Legislature (1990) outlined steps in establishing a waste reduction program. The first step was to perform a waste minimization assessment by in-house staff or an independent outside expert. Results are then used to develop a comprehensive waste management program. McDonald's (1991) conducted a collaborative study with the Environmental Defense Fund to determine solid waste management options. Solutions were not identified until on-premise waste characterization studies were conducted.

Adequate methods for the characterization of solid waste streams that provide accurate data for planning purposes have not been used by most foodservice operators. Research conducted in the area of waste characterization at institutional or commercial foodservice establishments has been limited. More studies were needed to validate and enhance the previously proposed techniques of measuring and characterizing waste at these establishments. Research to expand the knowledge in this area and to provide new information and new solutions continue to be needed (EPA, 1989a, 1992a).

Previous methodology used by Army installations for the characterization of waste streams produced unreliable estimates of the type and amount of waste generated (Funke, et. al., 1992). Better methods to understand the type, weight, and volume of waste generated on Army installations needs to be identified. The purpose of this study was to provide information to the United States (U.S.) Army that can be used in planning and implementing successful solid waste management programs.

Justification

Scientific research on the management of solid waste in institutional foodservice establishments is limited. A method of waste stream analysis for determining type, volume, and weight of solid waste described by Shanklin and Ferris (1992) needs to be replicated in different settings to ascertain if relationships exist between the type, volume, and weight of waste produced at similar facilities. Documented studies are needed to identify factors in foodservice that influence solid waste generation and management. These studies will provide the data necessary to make recommendations to effectively reduce the volume and weight of solid waste generated in institutional foodservice operations. This reduction in weight and volume of solid waste will be effected through identification of source reduction areas and opportunities for increased recycling and reuse of waste. Future study is required to determine the usefulness of this type data in forecasting the type, volume, and weight of waste produced in foodservice operations.

Purpose and Objectives

The purpose of this study was to conduct a waste stream characterization study in an institutional foodservice setting at two U.S. Army dining facilities at Fort Riley, Kansas.

Specific objectives were:

(1) to characterize by type, weight, volume, and specific weight the waste generated in two institutional dining facilities.

(2) to determine if the weight and volume of food, nonfood, and total waste generated per meal served in these two facilities were significantly different.

(3) to ascertain if the weight and volume of food, nonfood, and total waste generated per meal within the two observation periods: the first and second halves of the monthly military pay-cycle were significantly different.

(4) to determine if the weight and volume of food, nonfood, and total waste generated per meal on weekdays and weekends were significantly different.

(5) to compare the type, volume, and weight of waste per meal served at U.S. Army facilities dining facilities with the type, volume, and weight per meal at other institutional settings.

(6) to report and compare the nutrient composition and moisture content of service food waste at both facilities.

(7) to recommend policies and procedures to effectively manage solid waste at U.S. Army dining facilities.

Hypotheses

The following research hypotheses were tested:

1. There is a difference in the weight and volume of food, nonfood, and total waste per meal generated in a military institutional foodservice establishment with a profit motive compared to a military institutional foodservice establishment managed by U.S. Army professional cooks.

2. There is a difference in the weight and volume of food, nonfood, and total waste per meal generated in a military institutional foodservice establishment between weekdays and weekends.

3. There is a difference in the weight and volume of food, nonfood, and total waste per meal generated during meals served during the first half of the monthly military pay cycle and the second half of the monthly military pay cycle in a military institutional foodservice establishments.

Definitions

Garrison - term that is used to describe fixed Army installation buildings where soldiers normally reside and work as opposed to the field which means simulated combat conditions where soldiers live in tents and are subsisted through the Army Field Feeding System.

Non-food waste: includes all types of containers and packaging as outlined below:

(1) Metal (Non-aluminum) - steel/tin cans (#10, 46-ounce, etc.) used as containers for vegetables, fruits, and soups, etc.

(2) Aluminum - aluminum carbonated beverage containers.

(2) Plastic containers - includes plastic containers composed of high density polyethylene (including plastic #1 and #2).

(3) Other plastic - includes plastic film, plastic wrappings from bread and snack bags, plastic coated chip packaging material, and shrink wrap; individual serving containers such as yogurt containers, disposable cereal bowls, ice cream cups, and condiment containers.

(4) Cardboard - corrugated cardboard boxes.

(5) Glass - amber, brown and clear glass used as bulk and retail food containers.

(7) Paperboard - includes thin paperboard retail boxes such as cereal boxes and individual milk cartons.

(8) Other paper - Baking sheets, liners, wrappers, bags, box liners, flour and sugar bags, office paper, and paper towels.

(9) Other waste - includes all other items not specified in the above list such as broken china, office supplies, twine, and metal cleaning screens.

(10) Service paper - includes napkins, straws, disposable paperware and other paper used solely by the diner and returned on the tray.

Production food waste: includes leftovers discarded from refrigerator storage; food waste generated during the production of food such as vegetable, fruit, and meat peelings and trimmings; and non-edible waste such as coffee grinds and egg shells.

Proximate analysis - nutrient analysis of service food waste (% protein, % carbohydrate, %fat), moisture content, and ash determination.

Service waste: includes food wastes such as uneaten food and non-edible scraps such as bones and peels returned on diners' trays (plate waste); food discarded from the service line due to over-production; and food that was never served.

Specific weight of waste: the weight of material per unit volume. In this study the unit is lbs/yd^3. Values given in this study for specific weight are a ratio of uncollapsed volume to weight except cardboard which is collapsed volume to weight.

Volume of waste: Volume of waste in cubic yards determined by measuring gallons and converting to cubic yards.

Weight of waste: Weight of waste in lbs determined by weighing on a portable 300 lbs scale.

REVIEW OF THE LITERATURE

Introduction

Neal & Schubel (1987) described waste products as a natural and inevitable result of living where population demographics and available technology determine the volume and composition of waste and the options for disposal. The location and size of the population and the available technology in the United States has changed dramatically over the past half century. These factors combined with the lack of proper emphasis on long-term waste disposal has created technical, health, environmental, economic, and political solid waste disposal problems.

Many parts of the United States are currently facing a municipal solid waste dilemma. Every year since 1960, there has been an increase in both the total tons of waste generated and the pounds generated per person. The underlying cause of this waste generation problem can be attributed to the underestimation of the importance of proper solid waste management by all levels of society. Consumers demanded products that supplied convenience, sanitation, and value. Industry designed, manufactured, and packaged these desired products with little regard for environmental issues. Local, state, and federal governments did not develop strategic long-term plans for the provision of safe and effective waste disposal. Disposal facility owners and operators considered environmental issues to be secondary. The general failure of all levels of society to assume responsibility for proper municipal waste management has resulted in adverse environmental impacts (EPA, 1989a).

The foodservice industry is plagued by the high visibility of foodservice waste. Shortages of landfills, increased hauling fees, environmental concerns, customer sentiment, and increasingly stringent federal and state government regulations have made the "greening" of foodservice operations a financial necessity and has pressured managers into taking a leadership role in solid waste management (Frumkin, 1989; Townsend, 1990; Cummings & Cummings, 1991; Feldman, 1991; Hayes, 1991; King, 1991; Casper, 1992).

This solid waste problem cannot be attacked without information concerning the quantity of solid waste in terms of weight and volume; composition or type of waste such as paper, plastics, etc.; and the sources which link specific activities or products to the generation of related types of waste. The waste stream assessment provides basic information needed to choose the appropriate waste management alternative for planning, design, contractual, financial, and regulatory decisions (EPA, 1989a).

History of Solid Waste Management

In the beginning of time, when man roamed the earth chasing the hunt, garbage such as bones, ashes, and animal hides were left behind or used as fuel. It was not until members of society decided to stay in one place that garbage became a problem (Rathje, 1989a). Even then, they took the easiest route to dispose of garbage; dropping it on the floor, brushing it into the corner and covering it with dirt. After several layers of dirt were packed down, doors and roofs had to be adjusted upward. Larger pieces of garbage that could not be kept inside were tossed into the street along with construction debris (Blegen, 1958). There, semi-domesticated animals, usually pigs, and vermin competed for the food scraps. Meanwhile, human scavengers, in exchange for the right to sell anything useful, carried most of what was left to vacant lots or to the outskirts of town (Melosi, 1981).

Over time, the ancient cities of the Middle East rose high above the landscape on massive mounds, known as tells, which were largely the garbage of prior generations. Civil engineer, Charles Gunnerson, (1973), estimated that these cities were raised approximately 4.7 feet per century on their own garbage.

Throughout history, the manner in which people have coped with the problem of garbage has changed very little. The ancient methods of disposing of garbage still exist today. Garbage is covered with dirt, now called landfilling; garbage is burned as fuel which is called resource recovery or combustion; scavengers, both animals and humans, are now merely recycling (Rathje, 1989b). Cities like San Francisco were built over closed dumps or landfills in the same way ancient cities were built. The age old methods simply use modern names.

The Institutionalization of Waste Disposal

In the nineteenth century, the "Waste not, want not" ethic motivated a thrifty approach to the use of goods and materials. Informal agreements with farmers and others were arranged to handle discarded materials such as manure. Seventy percent of large cities in the early 20th century had developed informal programs to discard waste. However, rapid industrialization during the late 19th and early to mid-20th centuries outpaced the capacity of those in-formal arrangements to adapt. Informal dumps appeared in and around the cities. When public officials acknowledged these dumps as offensive and as health concerns, public waste disposal law and programs were initiated (Melosi, 1981).

During World War II, the federal government encouraged communities and industries to recycle up to 25% of the waste stream to boost the war effort. After the war, commitment to recycling faded. Finally, in the mid 1960s and early 1970s widespread pollution and litter brought a rebirth of interest in recycling and waste reduction (Nicholls, 1991a).

Today, waste disposal programs exist for much the same reasons as when they were founded: to protect the public health and to minimize the negative sensory impact associated with solid waste. Letcher and Sheil (1986) defined waste as those goods or materials which no longer have value to the person doing the discarding. The authors questioned why some items discarded as waste today are seen as having no value when these same items were valued twenty years ago. The researchers also noted that some items become waste only because of the existence of modern solid waste disposal systems. The consumer has a convenient alternative and government has little time to sort valuable materials from those that are health risks.

Characterization of Municipal Solid Waste in the United States

The Environmental Protection Agency (1992a) defined municipal solid waste (MSW) as discarded durable and nondurable goods; containers and packaging; food wastes; yard trimmings; and miscellaneous inorganic wastes from residential, commercial, institutional, and industrial sources. Municipal solid waste does not include wastes from other sources, such as construction and demolition wastes, municipal sludges, combustion ash, and industrial process wastes that might also have been disposed in municipal waste landfills or incinerators.

The EPA (1992a) classified municipal solid waste into categories based on the physical properties of the waste. Paper and paperboard included newspapers, books, magazines, corrugated boxes, telephone books, cereal boxes, milk cartons, junk mail, paper towels, disposable plates and cups, and other nonpackaging paper such as cards, games, posters, and other pictures. In 1990, recovery of paper and paperboard for recycling was at the highest rate overall compared to other solid waste materials. An estimated 48% of all corrugated boxes were recovered in 1990 and 42.5% of newspapers were recycled. Over the same period, an estimated 22% of glass containers were recovered for recycling (EPA, 1992a). Ferrous metals were the largest category of metals in MSW. Overall, only 13% of total ferrous metals such as appliances, furniture, and packaging were recovered. Aluminum cans and other containers and packaging produced about one million tons of waste. About 53% of all aluminum containers and packaging was recovered through recycling in 1990. Most plastics in MSW were containers and packaging. Sixteen million tons were generated while only about 2% was recovered. Approximately 33% of soft drink bottles were recovered within that 2% of plastics. The predominant source of rubber in MSW was tires; other sources included: clothing, footwear, appliances, hot water bottles, etc. Four million tons were discarded and 4.4% was recovered. Included in that 4 million tons was 200,000 tons of tires of which 13% were recovered. Textiles in MSW were mainly discarded clothing, furniture, footwear, and other miscellaneous nondurables. An estimated 5.6 million tons of textile waste was generated with only about 4% being recovered. The sources of wood in MSW were mainly furniture and packaging. Slightly over twelve million tons of wood was generated as MSW and 7.3% was recovered (EPA, 1992a).

Food wastes included uneaten food and food preparation wastes in homes, restaurants, and institutional foodservice settings. Data on food waste was limited to sampling studies. Samples of total solid waste from various landfills across the United States were characterized to determine the type and amount of food waste by weight, volume, and specific weight. These data were used to extrapolate the total amount of food waste generated in the United States. Available data showed that the percentage of food waste in MSW had declined from 15% in 1960 to 8.1% in 1990. This decrease was due to the use of garbage disposals and the increased use of prepared foods at home and at restaurants. Food preparation waste from foods prepared at commercial food manufacturers was considered industrial waste rather than MSW. Recovery of food waste for composting or animal feed accounted for a small portion of the decrease in food waste but no significant recovery was identified by the EPA (1992a).

Yard wastes included grass, leaves, and tree trimmings from homes, businesses, and institutions. The amount of yard waste generated also was estimated using sampling studies. An estimated 35 million tons of MSW were generated in 1990. Recovery for composting was estimated to be about 12% or 4.2 million tons (EPA, 1992a).

A waste characterization study of municipal solid waste was conducted by Franklin and Associates in conjunction with the Environmental Protection Agency in 1990 (EPA, 1992a). The method used in this report to estimate the waste stream on a nationwide basis was called "material flows methodology". EPA's Office of Solid Waste and its predecessors in the Public Health Service sponsored work in the 1960s and early 1970s to develop the material flows methodology. This methodology utilized production data (by weight) for the materials and products in the waste stream, with adjustments for imports, exports, and product lifetimes. Material flows methodology was considered more accurate than the "source-specific" approach in which the individual components of the waste stream were sampled. Although that type of sampling method was extremely useful for defining a local waste stream, extrapolating from a limited number of studies could produce a skewed or misleading picture if used for a nationwide characterization of waste. Any errors in the sample or atypical circumstances encountered during sampling would be greatly magnified when generalized to represent the nation's entire waste stream (EPA, 1992a).

The 1990 EPA and Franklin study showed that the percentage and the weight, respectively of the materials discarded were paper and paperboard (37.5% or 73.3 million tons), yard trimmings (17.9% or 35.0 million tons), metals and plastics (8.3% or 16.2 million tons), glass (6.7% or 13.2 million tons), food (6.7% or 13.2 million tons), wood (6.3% or 12.3 million tons) and other (8.3% or 16.2 million tons). The total amount of 195.7 million tons discarded in 1990 averaged 4.3 pounds per person per day of municipal solid waste. After estimates for materials recovery for recycling and composting were subtracted, discards (defined as MSW remaining after recovery from recycling or composting by EPA) were 3.6 pounds per person per day. Virtually all of these discards were combusted or sent to a landfill; however, some waste is littered, stored, or disposed on site, particularly in rural areas (EPA, 1992a).

The determination of solid waste by volume is important to estimate the rate at which landfills will reach capacity. This information also can be useful in identifying the rate at which the volumes of various materials in the waste stream are changing (EPA, 1992a).

EPA (1992a) noted that volume estimates of solid waste are more difficult to make than weight estimates. A pound of paper whether flat sheets, crumpled wad, or compacted into a bale would be equivalent in weight. However, the volume occupied in each case would be different. The EPA 1990 study estimated the relative volume of materials as they would typically be found if compacted individually in a landfill. These estimates were based largely on empirical data that were then used to estimate specific weight factors (pounds per cubic yard) for components of solid waste under simulated landfill conditions. The EPA (1992a) cautioned that these individual component specific weights can only be used for comparison not to estimate landfill densities of mixed municipal solid waste.

The percentage of volume of total discards (after recovery) in 1990 were: paper and paperboard (32%), plastics (21%), metals (11%), yard trimmings (10%), wood (7%), rubber and leather (6%), textiles (6%), glass (2%), and other (5%) (EPA, 1992a). The EPA compared the volume and weight estimates for materials to calculate a ratio. A ratio of 1.0 indicated that the material occupied the same proportion by volume as by weight. Values greater than 1.0 meant that the material occupied a larger proportion of volume than weight. Four materials with ratios of approximately 2.0 or greater included: plastics (2.2), rubber and leather (2.2), aluminum (2.1), and textiles (1.9). By contrast, yard trimmings, food, and glass each had ratios of 0.5 or less. These materials are quite dense and occupy proportionately less volume in landfills (EPA, 1992a).

When the volume of materials was considered as products rather than materials, 33% of the volume of total discards in 1990 were containers and packaging which included glass, steel, aluminum, paper, plastic, and wood. Nondurable products such as newspapers, disposable tableware, disposable diapers, clothing, linens, and magazines composed 30% of total discards. Durable goods such as major appliances, rubber tires, batteries, and other miscellaneous durable waste comprised 23% of the total volume. The remaining 14% consisted of yard trimmings, food waste, and other type waste (EPA, 1992a).

Trends in Municipal Solid Waste Generation

Solid waste generation is defined by the EPA as the amount (weight, volume, or percentage of the overall waste stream) of materials and products as they enter the waste stream before materials recovery, composting, or combustion occurs (EPA, 1992a). Generation of municipal solid waste has increased steadily from 88 million tons in 1960 to over 195 million tons per year in 1990. Per capita generation increased from 2.7 pounds per person per day in 1960, to 4.3 pounds per person per day in 1990. EPA projected that per capita municipal solid waste generation will be 4.5 pounds per person per day by 2000 (222 million tons). This projection suggested a substantial slowing in the rate of increase in MSW generation. Achieving the projected decline is dependent on many diverse variables such as demographic changes, economic factors, consumer preferences, and social trends such as the decline in newspaper readership. The effect of these variables is difficult to predict. Changes included efforts in source reduction such as backyard composting, packaging reduction, and production of more durable products. Even if the projection proves correct and the amount of waste generated per person only increases by 0.2 lbs/person/day by 2000, the problem of what to do with 222 million tons of MSW will still exist (EPA, 1992a).

Food waste, yard waste, and packaging solid waste production percentages in 1988 are projected to decrease by 25%, 18%, and 4%, respectively by the year 2010. Durable and nondurable goods are projected to increase by 3% and 22%, respectively (Clark, 1992).

Solid Waste Management in the United States Army

Army installations with divergent missions are widely distributed throughout the United States and the world. A total of 28 Army divisions with 22 divisions located in the Continental United States (CONUS) existed as of July, 1992 (Funke et al., 1992). Within the United States, there were a total of 501,470 active Army personnel with 762,067 dependents at 71 major installations in 26 states (Funke et al., 1992).

Distinct differences in solid waste generation existed between troop-type installations and Army industrial installations. Troop-type installations are similar to small cities with transient populations (e.g. university communities). Waste composition at these installations varied depending on their mission and size. Some installations had periodic influxes of personnel such as training installations that hosted the National Guard and Reserve units. These practices impacted both waste generation and composition. Army industrial installations had waste characteristics comparable to industrial complexes that generated large amounts of special and hazardous wastes. A variety of different missions such as weapons inventory, armament manufacturing, and weapon test and evaluation were performed at 62 of these facilities in 1992 (Funke et al., 1992).

Large installations with predominantly active units could have waste streams similar to municipal compositions. Fort Lewis, Washington is an example of a large installation with a large active duty population. The waste survey conducted at Fort Lewis in 1991 reflected the percentage by weight of the different materials in the waste stream as compared to the 1990 national estimates. The Fort Lewis data only characterized 47% of the solid waste; 43% was in the "other" category. Perhaps more careful characterization would have resulted in higher percentages in the specific categories and less in the "other" category. These types of studies have made generalizations about Army solid waste generation and composition difficult. The Army's current methods produced baseline information that was often inadequate or not comparable across installations (Funke et al., 1992). The data were consolidated in the Facilities Engineering and Housing Annual Summary of Operations which is also known as the Redbook. Discrepancies in data have resulted from inconsistent use of solid waste definitions, inadequate waste characterization methods at the installation level, and an unclear purpose for the data (Funke, et al., 1992).

Another estimate of Army waste generation could be derived by multiplying total CONUS Army personnel and dependents by the EPA per capita estimate for waste generation. In 1992 there were a total of 1,263,537 people (soldiers and dependents) who contributed to the Army solid waste stream (Funke et al., 1992). Using the EPA per capita estimate of 3.6 pounds/person/day after materials recovery, waste generation would be 2274.4 tons/day or 830,144 tons/year. Redbook figures estimated CONUS annual collection to be 6.4 million tons. The difference could be explained because national per capital estimates do not adequately reflect the waste patterns of the highly transient installation populations and because the population figures do not include the Department of the Army civilians that work on Army installations (Funke et al., 1992).

The Hierarchy of Integrated Solid Waste Management

Environmental and economic concerns logically dictate that waste reduction must be fostered. These concerns prompted the EPA, members of Congress, environmental organizations, and businesses to conceive and support a concept of the hierarchy of preferences among waste management techniques. The term "integrated waste management" referred to the "complementary use of a variety of waste management practices to safely and effectively manage the municipal solid waste stream with the least adverse impact on human health and the environment" (EPA, 1989a). These waste management tools were not very different than those used by ancient man - source reduction or thriftiness (including reuse of products), recycling of materials (including composting) or scavenging, waste combustion/ energy recovery or burning, garbage for heat and light, and landfilling or covering waste with dirt.

The hierarchy was proposed to effectively reduce the waste management problem. The underlying assumption behind this hierarchy was that it was the most cost-effective and environmentally sound method to use (Schall, 1993). The EPA (1989a) depicted the hierarchy of waste management graphically as a chain with four links: source reduction, recycling, combustion and landfill. The hierarchy is only as strong as the weakest link.

Source Reduction

The hierarchical chain begins with source reduction and reuse. Simply defined, source reduction means that if less waste is created, less pollution enters the environment. The objective is the management of both virgin materials and materials recovered from wastes, not the management of garbage (Schall, 1993). The federal government, through the creation of the Office of Pollution Prevention, has given source reduction its highest endorsement. The goal of source reduction is to design and manufacture products with the minimum amount of toxic content, minimum volume of packaging, and a longer useful life. These actions would reduce waste collection, processing and disposal cost, and slow the depletion of resources by avoiding production of unnecessary materials such as packaging (Schall, 1993). A number of factors affect the achievement of reductions in solid waste including the use of disposable goods, life-time of products, ease of repair, compactness and economy of size, packaging trends, and process changes (Waste Reduction, 1990). Source reduction has extended the life of available waste management capacity and made combustion and landfilling of wastes safer in the short and long term by reducing toxic components (EPA, 1989a).

Source reduction is a fundamentally different approach to managing municipal solid waste in that its real focus is in prevention of waste. Source reduction management techniques are generally divided into four basic categories: good operating practices, technology changes, material changes, and product changes (NSWMA, 1989). Good operating practices, such as preventative maintenance, minimize waste generation by increasing the lifetime of equipment and machines. Modifications to production processes or equipment are classified as a technology change. Material and product changes cause a decrease in rejection rates and consequently reduce waste.

Recycling

The second link in the hierarchical chain is recycling which included composting of food and yard waste. Recycling is the separation of reusable materials from the waste stream for reprocessing into new products. This link also includes reuse of materials. Recycling was proposed as a closed-loop system where resources are optimally utilized to benefit humankind while minimizing the production of waste. Letcher and Sheil (1986) noted the many environmental benefits derived from recycling which included: saving natural resources including trees, water, and ores and reducing energy use, air pollution, and water pollution during manufacturing of new items. In addition to the environmental protection aspects, recycling is a significant economic activity which can generate new jobs in waste recovery and increase employment opportunity along the manufacturing chain when recycled goods are incorporated into the final product.

Since the early 1970s, a growing segment of the population has come to value waste as a resource and to support programs devised for the reuse of solid waste. Recycling has prevented potentially useful materials from being combusted or landfilled and has resulted in savings of valuable landfill space, energy, and natural resources. Useful products were manufactured through recycling and a profit made especially when avoided costs of combustion and landfilling were considered (EPA, 1989a). The total amount of municipal solid waste recycled or composted in 1990 was 33.4 million tons, a 42% increase from the 23.5 million tons in 1988. Between 1988 and 1990, the percentage of MSW that was recycled increased from 13.1% to 17.1%. Materials to be recycled were usually separated at a Material Recovery Facility (MRF). In the United States in 1990, there were 92 of these facilities, an increase of 575% from 1988 (EPA, 1992a; Glenn, J. 1992a).

Recycling has great potential for reducing municipal solid waste and is only limited by the lack of markets for these diverted goods (Waste Reduction, 1990). The EPA (1992a) projected that 20 to 30 percent of MSW would be recycled or composted by 1995, and 25 to 35% by the year 2000. Factors affecting these projections included changes in the Resource Conservation and Recovery Act (RCRA) which regulates the treatment, storage, and disposal of solid waste; other federal or state legislation; industry efforts; and recycling technology (Kreith, 1990).

Composting Composting is categorized under recycling on the hierarchical chain. It is defined as the decomposition of organic materials under conditions designed to facilitate the action of anaerobic and aerobic bacteria and other natural elements such as weather and enzymatic actions. Initially, waste material is heated to 130 degrees Fahrenheit or more by the bacterial action. Numerous types of bacteria participate in the decomposition process with different ones entering the process as its optimal temperature is reached. The end product is a dark brown or black substance called humus (Neal and Schubel, 1987).

Organic material (food waste, yard waste, wood waste and paper products including diapers and sanitary products for feminine hygiene) composed more than two-thirds of the waste stream by volume in the United States (EPA, 1992a). Newspapers, office paper, and other types of paper were often included in composting because of weak or nonexistent markets for recycling (Beyea, Dechant, Jones and Conditt, 1992).

There has been increased interest in initiating composting programs in residential and commercial areas. Many studies have been done to determine the amount of compostable waste produced both in residences and commercial businesses such as restaurants and grocery stores (Goldstein, J., 1992; Beyea, et al., 1992; Goldstein, N., 1992; Hammer, 1992). Some of the concerns associated with composting included the safety of and demand for the end product, the operating costs, and compatibility of the technology with efforts to promote recycling and waste reduction (Glenn, 1992a; Hammer, 1992).

Resource Recovery or Combustion

Waste combustion is the third link in the hierarchy of desirable waste management options. Like landfilling, burning waste had its origins in antiquity. One of the first municipal incinerators in the United States was built in Allegheny, Pennsylvania in 1885. This new approach was viewed as a new sanitary way to eliminate garbage while simultaneously creating energy. These early designs were flawed and resulted in health problems (Neal & Schubel, 1987).

As recently as the 1950s, dumps were set on fire. These fires burned for weeks and the stench and pollution created led to regulations by communities which eliminated burning in open dumps and simple incinerators. In 1960, 30% of MSW generated was burned in combustors with no energy recovery and no air pollution controls. In the 1960s and 1970s, combustion dropped steadily reaching a low of less than 10% of MSW by 1980. In the 1980s, special facilities called resource recovery plants were built to burn waste at very high temperatures of more than 1000 degrees Fahrenheit. There were no visible emissions or odors. The ash produced was the only solid residue requiring disposal. All of these facilities had energy recovery and were designed to meet air pollution standards. The energy produced by burning garbage was recovered and used to produce steam for heat or electricity (Neal & Schubel, 1987; Kreith, 1990). In 1988, 14% of MSW generation was incinerated. EPA (1990) projected that more than 45 million tons of MSW will be combusted in 1995 and 55 million tons (approximately 25%) in 2000.

Waste combustion is useful in reducing the bulk of MSW with the added benefit of energy production. Combustion complements recycling by reducing the bulk of the nonrecyclable, nonreusable waste (EPA, 1989a). Combustion is not fault free. Problems such as the creation of toxic fumes that can be released into the atmosphere and the question of how to dispose of the remaining ash must be managed. For these reasons, burning trash has not been met with widespread approval (King, 1989).

The number of incinerators operating in the United States has continued to increase. In 1992, there were 171 operating plants with a total capacity available of 100,000 tons per day (Glenn, 1992a).

Landfilling

Landfilling is the last link in the hierarchy and the oldest practice of discarding refuse. In the past fifty years, the combined environmental impacts of smoke pollution, odor, attraction of pests, groundwater contamination, and other disadvantages associated with open dumps have led to the development of sanitary landfills. At a sanitary landfill, the solid waste received each day is spread out in thin layers, compacted and then covered that same day with a thin layer of soil. These three steps are necessary to reduce problems of fires, fly, and rat breeding, while conserving landfill space by compacting to the smallest practical volume. When a prescribed height is reached, the landfill is covered with a few feet of soil, compacted and closed (O'Leary, Canter & Robinson, 1986; Neal and Schubel, 1987).

The EPA (1989a) predicted that one-third of the remaining landfill capacity in the United States would be closed in the next few years. The EPA also estimated that the number of landfills being operated in the United States would decrease from 5500 in 1988 to 2157 by the year 2000.

The closure of many landfills and the difficulty in opening new sites have contributed to the increased fees associated with transporting and disposing garbage in landfills. Many consumers and businesses were looking for alternatives to defeat these ever-increasing costs. Tipping fees and surcharges have continued to increase throughout the United States. A National Solid Waste Management Association (NSWMA, 1988) survey found that tipping fees in the United States in 1988 averaged about $27 per ton for landfilling and $40 per ton for incineration.

In many communities, garbage hauling fees and tipping fees have increased considerably sometimes by as much as three times. Waste haulers have had to travel longer distances and/or have been required to separate trash before taking it to landfills. These increases have placed economic burdens on taxpayers, private entrepreneurs, and foodservice operators (King, 1989). In July, 1993, the average fees ranged from $64.96 in the northeastern United States to $13.46 in the central Rockies (Solid Waste Price Index, 1993). Surcharges on tipping fees ranging from $.85/ton to $2.00/ton have been legislated to provide funding for state solid waste management programs. Garbage bill surcharges also have been passed that range from $.20/month for small accounts to one percent of the gross receipts for those over $500 per month (Glenn, 1992a).

Even considering all the negative aspects of landfills, they continue to be necessary for those items that cannot be recycled, composted, or incinerated. They were necessary to dispose of the ash generated during incineration. Advantages can be obtained even from landfill sites, if they are engineered and built properly to provide the benefit of energy production through recovery of methane gas (EPA, 1989a).

Criticism of the Hierarchy

In the past few years, some criticisms have surfaced concerning the use of the EPA hierarchy. Problems identified include: (1) the difficulty of implementing source-reduction programs by solid waste managers, (2) the inadequate markets for recycled materials, and (3) the challenges associated with structuring private/public relationships that minimize costs and environmental impacts.

As a result of these concerns, the "menu-of-options" school of thought was revived. This school of thought argued that source reduction should be decided through free enterprise or by what the market demands. Another contention was that recycling, good up to a point, is overextended and largely uneconomical except for that which was already occurring as the result of private-sector scrap dealers. The real solution, these theorists proposed was to site more comparatively inexpensive landfills and incinerators. The effect, though not necessarily the intention, of the "menu-of-options" school would be largely a return to the practice of the disposal-based management system of the 1960s and 1970s (Schall, 1993).

Defense of the Hierarchy

Concerns about the environment, landfill contamination, associated costs, and decreasing capacity will not disappear. Disposal facilities will never be welcome even though they will always be inevitable necessities. The selection process of new sites is long and arduous. Thus, minimizing the amount of waste disposed by landfilling or combustion will always be an objective of solid waste managers, politicians, and citizens. Therefore, the disposal-based framework advocated by the "menu of options" school will not provide adequate answers to the problems of modern solid waste management (Schall, 1993).

When comparing alternative rungs in the hierarchical ladder, a simple comparison of per ton costs by different methods will not suffice. The total impact on the overall environment must be understood and a variety of factors considered which include: applicable laws and regulations, long-term planning and effects, volume of waste requiring handling and associated costs, drinking water and its location; the cost and availability of land; ambient air quality; transportation options; production and recycling costs with the existing and potential markets for recycled materials and the environmental impact (Neal & Schubel, 1986; Schall, 1993). Schall (1993) as a member of Tellus Institute for the Regional Planning Association of New York City developed three alternative future scenarios for managing solid waste.

Scenario 1 was based on implementing state mandated recycling/composting and source reduction goals, along with combustion and landfilling. Scenario 2 eliminated the source-reduction programs, but included recycling, composting, incineration, and land disposal. In scenario 3, all waste was either burned (with energy reccovery) or buried in landfills.

The cost per ton resulting from processes in each scenario were calculated including the environmental cost or benefit. The total benefit achieved through Scenario 1 and 2 was \$63.10/ton, and \$36.59/ton, respectively. The total cost for Scenario 3 was \$2.55/ton.

The overwhelming conclusion of Schall's (1993) research was that the solid waste hierarchy was on a firm technical, economic, and environmental foundation. The problems were not whether the framework of solid waste management was accurate, but rather the approach of solid waste managers. Schall (1993) proposed that solid waste managers stop managing garbage and begin participating in the larger endeavor of managing all of society's resources. The author suggested that managers need to assist in the development of an overall national materials policy that included source-reduction provisions and recycling and composting initiatives.

The Hierarchy and Army Solid Waste Management

Army solid waste management programs varied considerably among installations in terms of management, operations, and overall effectiveness. In general, Army MSW and construction debris have been landfilled and medical wastes (pathological and non-pathological) incinerated. No mandated system that explicitly identified a management hierarchy (Funke, et al., 1992).

Source Reduction Policy

Although Army regulation did not preclude source reduction, current Army policies focused on waste stream reductions as opposed to source reduction. Department of

Defense (DoD) directive (4165.60) stated that "the military is committed to a rigorous schedule of minimizing waste and reducing solid waste materials at the source whenever possible" (Funke, et al., 1992). Army Policy Memorandum for Obtaining Utility Services and Army Regulation (AR) 200-1, Environmental Protection, encouraged volume reduction of the waste stream. In response to this Memorandum, major commands within the continental United States have issued goals to reduce the volume of the waste stream within their jurisdiction. Training and Army Doctrine Command (TRADOC) set a goal to reduce every installation's landfilled solid waste by 50% by the year 2000 (Community of Excellence, 1991). The United States Forces Command (FORSCOM) has indicated the intent of reducing its waste stream by 35% in 1994, and 50% by the year 2000. Installations in other major commands also have established targets for source reduction, recycling, and purchasing of recycled materials in accordance with the President's Executive Order 12780 (Executive Order 12780, 1991; Funke, et al., 1992).

Through an extensive recycling program involving both residents and military activities, Fort Riley, Kansas has made significant progress in meeting solid waste reduction goals. The post's solid waste has been reduced by approximately 12% since 1990 (Mr. M. Goreham, December 10, 1992). The aim of the project was to decrease solid waste by another 30% by 1994. Another Fort Riley goal was to make the recycling program cost recoverable. New equipment and a more efficient means of collecting the materials was expected to decrease the cost of the operation according to the environmental engineer on the installation (Mr. Michael M. Goreham, personal communication, December 10, 1992). Fort Riley estimated their total revenues for 1991 at between $300,000 to $400,000. Overall, the Army reported total revenues during 1991 of more than $12 million (Funke et al., 1992).

Recycling Policy

Recycling programs have not been mandatory in the Army. The main criterion used at most installations to decide whether or not to establish a recycling program was based on the revenue generated. TRADOC, FORSCOM, and Army Material Command (AMC) estimated that 90 to 95% of Army installations had some form of recycling program and that installation recycling rates varied from 2 to 33 percent (Funke, et al., 1992).

In 1992, the Army Auditing Agency (AAA) reviewed 138 Army recycling programs and concluded that a "lack of clear guidance on recycling has caused the Army to fall short of its potential to effectively reduce its waste stream and generate income from recycling" (Beaton, 1992). The study found that there was no consistency in the items recycled from one installation to the next and that most programs were limited to a few high-value, easy-to-recycle items.

Recycling program decisions in the Army were motivated by the fact that Army recycling programs must be self-supporting. Unlike communities that may subsidize recycling from landfill tipping fees and other revenue sources, Army installations have not subsidized recycling efforts. Therefore, the items selected for recycling were those that would clearly pay for the program (Funke, et al., 1992).

Incineration Policy

Department of Defense policy was to use thermal plants when and where feasible to reduce the volume of solid waste landfilled and to produce energy otherwise wasted (DoD Directive 4165.60). The Army built seven MSW incinerators and one was under construction as of July, 1992. Of the seven constructed, only three were still operational in 1992. These incinerators were located at Fort Dix, New Jersey; Aberdeen Proving Grounds, Maryland; and Redstone Arsenal, Alabama. The incinerator pending construction will be located at Fort Lewis, Washington. The other four incinerators were closed due to environmental or economic concerns. The Army also operated 33 small incinerators at major Army hospitals to dispose of medical waste (Funke, et al., 1992). Army incineration policy has complied with regional/geographical policy and local community regulations.

Landfill Policy

Based on Headquarters, Department of the Army (HQDA) policy, utility services including landfill of waste are to be obtained from local, regional, or private utility systems rather than the Army owned systems. Installations must determine the lifecycle costs for the operation and maintenance of Army-owned systems (Offringa, 1991). Installations have the authority to use regional or private landfills when the lifecycle costs are less than 125% of the operation and maintenance costs of an Army-owned system. Also under proposed revisions to AR 420-47, Solid and Hazardous Waste Management, expansion of existing Army landfills will require HQDA approval (Funke, et al., 1992).

TRADOC, FORSCOM and AMC used 51 active solid waste landfills located on Army installations and 54 landfills located off Army property. A lifespan capacity study of 48 selected Army installations conducted in 1989 by the U.S. Army Construction Engineering Research Laboratory (USACERL) found that "11 installations had a one to five year landfill life expectancy, seven installations had 6 to 10 years of remaining capacity, 14 had more than 10 years life remaining, and 16 installations had no active landfills" (Griggs & Schanche, 1991). All 51 Army landfills must have state approved permits to operate. Headquarters, FORSCOM has estimated that 80 to 90% of its landfills would not meet the next round of permit requirements due to more stringent state standards for operation (Funke, et al., 1992).

The Army Environmental Hygiene Agency estimated that approximately 50% of Army landfills would be closed by October, 1993 because of new EPA Resource Conservation and Recovery Act (RCRA) landfill regulations. Significant new requirements have been incorporated in 40 CFR 258 including mandatory leachate, methane gas, and groundwater monitoring (EPA, 1991). It would be extremely expensive to upgrade landfills lacking these systems before the effective date (Funke, et al., 1992).

Legislation and Solid Waste Management

Federal Requirements

In 1965, Congress passed the Solid Waste Disposal Act, which supported alternatives to unregulated dumping and incineration. In 1970, the Resources Recovery Act amended the Solid Waste Disposal Act which created the EPA. The EPA was directed to review the potential for waste reduction; to publish guidelines on the collection, separation, recovery, and disposal of solid wastes; and to develop a plan for storage and disposal of hazardous waste (EPA, 1989a). In 1975, the Resource Conservation and Recovery Act (RCRA) encouraged states to develop solid waste management plans that would give priority to management approaches that conserved materials and energy resources (Nicholls, 1991a). The energy crisis of the late 1970s, removed the focus of the growing support for national legislation for recycling and waste reduction. Additionally, an interest in incinerating waste for energy and the emergence of toxic waste dumps as a national crisis altered the path of solid waste management (Nicholls, 1991a). By 1981, EPA's solid waste grant program to the states was eliminated by budget cuts.

In 1989, in response to the national scope of the problem and public pressure, the EPA published a report entitled Agenda for Action (EPA, 1989a). This publication emphasized the need for increased efforts in both source reduction and recycling of municipal solid waste and outlined a management hierarchy for solid waste management. The EPA set national goals for reducing the landfilling of solid waste by 25% through source reduction and recycling by 1992. The EPA (1992a) predicted that by the year 2000 reductions of solid waste by approximately 35% were possible through recycling, composting, and combustion.

On October 31, 1991, President George Bush signed Executive Order 12780 (Executive Order, 1991), Federal Agency Recycling and the Council on Federal Recycling and Procurement Policy. The purpose of this policy was to require federal agencies to promote cost-effective waste reduction purchasing practices and recycling. Federal agencies were required, in certain circumstances, to procure items made from recycled materials.

Environmental issues such as solid waste management are currently a political focus. Many states and local governments have adopted stringent regulations as well as generous tax credits and benefits for businesses which innovatively manage and reduce their generation of solid waste.

State Requirements

In view of the federal policy to place responsibility for solid waste management with states and localities, many different source reduction, recycling and disposal programs exist at the state level. These programs must meet the needs and opportunities of the local situation. Success of these programs have hinged on the voluntary efforts of an informed public.

Comprehensive waste reduction mandates and solid waste management legislation have increased dramatically in the past few years. For the better part of the last decade, most state legislation focused on recycling by either requiring municipalities to recycle and compost or restricting how materials can be disposed. Additionally, numerous states have enacted tax credits and other financial incentives to boost markets for recycled materials (Glenn, 1992b).

More than two-thirds of the states have some type of waste reduction goal ranging from 10 to 50% by the year 2000. Further legislation has required lower municipalities to comply with these state reduction goals. These reductions are to be accomplished through recycling, composting and source reduction.

Banning certain waste products such as tires, batteries, used oil, yard waste, and paper goods from disposal facilities has surfaced in recent legislation. The ban having the most impact on reducing the amount of solid waste has been on yard waste (Glenn, 1992b).

The National Conference of State Legislatures (Kreith, 1990) outlined some examples of solid waste management legislation initiated in recent years. These included: 1) taxes on disposable products such as diapers and packaging (exemptions were allowed if manufacturers could show that the products were recyclable or made from recycled materials); 2) taxes or fees on restaurants that use disposable dishware for their sit-down customers and as an incentive or reward, decreasing existing taxes or fees for restaurants that do not; 3) taxes on packaging that is larger than the product requires (e.g., cracker boxes that make contents look larger); 4) the banning of the use of state landfills and incinerators by towns that fail to develop recycling programs; 5) the mandating of degradable bags; and, 6) the requirement for governments to purchase materials with certain percentages of recycled content. An update from the National Conference of State Legislatures noted that 28 states enacted solid waste legislation in 1992 that included issues from solid waste definition to recycling, composting, and landfilling (Iott, 1992).

Municipalities and consumers expected manufacturers to accept some of the burden of waste disposal and the recovery of materials. One legislative approach was to require manufacturers to accept products or packages after their useful life expired. Deposits on beverage containers is an another example. Recently, a deposit/take back requirement has been applied to tires and car batteries in some states. Manufacturers also were expected to design systems to handle wastes caused by their products, especially hazardous wastes such as nickel-cadmium batteries (Glenn, 1992b).

The building and strengthening of markets for recycled goods has been aided through various state legislation. One example is the state requirement for newspaper publishers to use newsprint made with recycled paper. Recycled content requirements for newspapers range from 7.5% to 80% postconsumer recycled paper content.

Many states also offer income tax credit ranging from 20% in Colorado to 50% in Louisiana for businesses that use materials containing recycled waste in manufacturing. Tax deductions have been offered to encourage businesses to purchase recycled goods (Glenn, 1992b).

Procurement requirements for state and local governments have encouraged recycling markets by requiring that a certain percentage of all products purchased be made from recycled materials. This legislation focuses on eliminating two things: bias against recycled products and price preferences, particularly for paper and paper products (Glenn, 1992b).

State funding has been identified as essential when enacting any state solid waste legislation. One source has been the landfill tip fee surcharge which was passed by over half of the states by 1991. Another source of funding has been advanced disposal fees (ADF) which have been considered for a wide variety of products and packages. To date most states have passed legislation which charged ADFs on only a narrow range of products such as tires and motor oil. ADFs produce funding that can be used for clean-up projects or overall waste reduction efforts (Glenn, 1992b).

Kansas State Law Regarding Waste Management

On May 5, 1992, the Governor of Kansas signed into law the Local Solid Waste Management Plan, which amended Kansas State Act 65-3406, dated January 1, 1971. Changes to this act are summarized below (Local Solid, 1992).

The law strengthened the authority of the Secretary of Energy and Natural Resources. The state secretary was given authority to approve or disapprove county solid waste management plans. Background investigations of individuals applying for permits under this law were authorized. The secretary was authorized to consider the financial, technical, and management capabilities of the applicant as conditions for issuance of a permit. The secretary may reject the application without conducting an investigation into the merits of the application if the secretary finds that: 1) the applicant has previously violated this subsection; 2) a previous permit was revoked; and, 3) the applicant fails to comply with the provisions of the air, water or waste statutes of Kansas, any other state or the federal government of the United States (Local Solid, 1992).

This new law required every county in Kansas to submit a solid waste management plan and to establish a solid waste management committee that included citizens of the city and county. Several new requirements were added to the solid waste management plan including: 1) a requirement to highlight which elements of the plan required public education and how that training would be delivered; 2) the adoption of suitable measures to require recovery and recycling of solid waste for reuse; 3) the adoption of rules and regulations establishing standards for public and private transporters of solid waste; 4) the establishment of the owner's responsibility for landfill sites and long-term care of such a sites for 30 years instead of 10 years; and, 5) the authority to develop and implement statewide market development for recyclable materials (Local Solid, 1992).

A major change was a schedule for reduction of waste volume with goals of 25% by 1997 and 50% by 2002. The annual fee for a solid waste processing or disposal permit of $50.00 was changed to an initial application fee not to exceed $10,000, with annual fees not to exceed $5,000. Additionally, the funds were to be deposited in the state solid waste management fund as opposed to the state treasury (Local Solid, 1992).

Many states throughout the United States are enacting similar laws. These states are overhauling their programs to reap the benefits of solid waste management which include reduction of solid waste, conservation of resources, and development of new jobs.

Army Regulation Regarding Solid Waste Management

Army solid waste policy has been primarily focused on seeking regional and cost effective solutions, maintaining compliance for disposal operations, and initiating recycling programs. Individual installations have been responsible to ensure compliance with solid waste regulations at the federal, state, and local level. Army Regulations 40-5, Preventive Medicine; 200-1, Environmental Protection; 420-47, Solid and Hazardous Waste Management; and TN 420-47-02, Installation Recycling Guide established solid waste policy and provided guidance to assist installations in compliance with applicable laws while promoting resource recovery that did not jeopardize natural resources or health (Funke, et al., 1992).

Like many large organizations, the Army and Department of Defense guidance for the management of solid waste has been fragmented and overlapping. However, initiatives to improve and integrate solid waste policy was on-going through the Department of Defense Resource Conservation and Recovery Committee and at the Headquarters, Department of the Army level. The Army proposed policy which required installations to produce SWM plans to reduce solid waste but allowed each flexibility to deal with the local situation and law. One of eight strategic Army goals for the twenty-first century, "Be a model steward of America's resources that are entrusted to the Army", provided the framework for establishing regulation and policy in the area of solid waste management (Shannon & Sullivan, 1993).

Food Service and Solid Waste Management

Public image and consumer confidence may be dependent on a new and more aggressive role for foodservice establishments in the area of solid waste management. Operators are employing the "three R's" - reducing, reusing/repairing, and recycling to cope with the solid waste problem (Townsend, 1990; Cummings & Cummings, 1991; Casper, 1992). The foodservice industry which markets a solid waste management program initiated prior to being forced to do so by legislation or consumer demand can enjoy an immediate customer-service benefit of positive public relations. The proactive foodservice operator is projecting concern for preserving the environment for future generations (Shanklin, 1991b). Many foodservice operators have already successfully employed environmental programs.

Waste Stream Characterization Studies

Waste characterization has been described as a step in the solid waste management problem that is often neglected but is probably the most essential step to the success of any waste management program. The waste management hierarchy described by the EPA (1990) is a driving force in prompting the compilation of detailed and increasingly differentiated waste characterization data as an essential first step to sound, long-term integrated waste management planning (Clark, 1992). Waste characterization studies not only identify the percentage of the waste stream that is recyclable or combustible but also potentially preventable and reusable. Savage, et al. (1985) defined waste characterization as "the determination of mass, volume, and composition, and to some extent, the identification of particular components that could exert an undesirable impact on the public well being (e.g. hazardous and toxic wastes)".

A comprehensive waste stream analysis of foodservice establishments must be conducted to determine the composition and amount (weight, volume, and specific weight) of waste generated. The determination of amounts and types of solid waste through scientific methods permits managers to make valid projections that determine the success of solid waste management plans. Such an analysis combined with information from the packaging industry, processors, and vendors can alert the operator to instances in which paper, plastic, food, and other waste components can be prevented, reduced, eliminated, and recycled (Savage, et al., 1985; Kreith, 1990; Cummings & Cummings, 1991; Casper, 1992).

Before a foodservice establishment can begin to identify the most appropriate mix of solid waste management methods, it must acquire knowledge of the waste stream (Savage, et al., 1985; Casper, 1992; Funke et al., 1992; Clarke, 1992). The economic penalties for errors regarding amounts and rates of solid waste production in any foodservice establishment far outweigh the expense of a characterization study. McDonald's (McDonald's, 1991) in a collaborative study with the Environmental Defense Fund did not begin researching solid waste management options until on-premise waste characterization studies were conducted.

Quantity and Type of Waste Disposed in Foodservice Organizations

Based on studies by the National Solid Waste Management Association, Nicholls (1991a) reported that family style restaurants generate 25 pounds of waste/seat/week; fine dining establishments, 30 pounds of waste/seat/week; cafeteria-style dining, 30 pounds of waste/seat/week; and fast-food restaurants, 450 pounds of waste for every $1,000 in sales. School foodservice waste was estimated to be one pound of waste per student per day.

The National Solid Waste Management Association (1989) estimated that customers generated the following amounts of solid waste:

cafeterias	1 pound/meal served
fast food restaurants	200 pounds/$1000 in sales
restaurants	1.5 pounds/meal served
school foodservice	0.5 pounds/meal served

A series of studies investigating solid waste in foodservice establishments have been conducted. A literature review by Altschul (1976) concluded that reports on plate waste in institutional foodservice operations were generally "sparse, anecdotal, journalistic, and not up to scientific standards." Since that time a series of plate waste studies which often focused on the acceptability aspects of foodservice operations by observing the amount of service waste generated have been conducted. These studies were initiated because of increased food costs and the need for resource conservation. Each succeeding study built upon previous research eventually producing scientific methods for measuring weight, volume, and specific weight of solid waste generated in foodservice establishments.

College/University Foodservice

Gines, Schweitzer, and Wright (1980) estimated plate waste in dining halls on a university campus to be 1 to 1.5

ounces per person per meal. Waste of food items ranged from 17% to 22% of total food items served.

Kelley, Jennings, Funk, Gaskins, and Welch (1983) noted that "the lack of published studies describing methodologies applicable to collegiate foodservice operations suggested a need for a technique to assess quantitatively edible plate waste for such operations". This study provided standards for the measurement of service waste through pre-meal and post-meal weighing techniques and formulas. Costs per ounce of food waste also was calculated. Five percent of all trays were weighed in the sample to estimate total plate waste. Extrapolated data were then analyzed as factorials for three meals (breakfast, lunch, and dinner) by 10 food groups to determine significant differences. Total plate waste per person per day was analyzed using a randomized complete block design in which meals were treatments and days were blocks. The overall mean waste was 0.55 lbs per day per student. Almost 500 pounds of edible food was wasted per day, which amounted to more than 50,000 pounds edible food wasted during the semester. Cost of waste per day for all students was determined to be $237 per day for plate waste on days when three meals were served. This would account for a loss of approximately $26,400 per semester (Kelley et al., 1983).

A plate waste study in a university dining hall was conducted by Norton and Martin (1991). The purpose of the study was to provide information regarding the relationships among plate waste, portion control, unlimited second servings, and cost. Plate waste from 9% of the trays returned during brunch, lunch, or dinner was collected and weighed for 10 randomly selected days. Waste of individual items was separated and weighed using a Berkel Electronics Digital scale. Formulas for calculating waste, percent waste, and cost were given. Total cost of waste per meal was computed by adding the costs of the individual menu items. The data from the sample of 20 meals was multiplied by 10 to extrapolate to the total of 214 meals served during the semester to estimate total waste in pounds and total cost of waste for semester. Mean waste per tray and cost of waste per tray were computed for each meal and each day. One-way analysis of variance (ANOVA) was used to determine the significant differences between levels of waste on replications and between meals.

The mean waste for each student was 0.12 pounds per day or $.13 per day. Pounds of waste were not significantly different on study days. Waste at dinner meals was significantly higher than for brunch or lunch. Researchers' explanations for the large amount of waste were given: portions were too large, additional servings were not eaten, self-serve items lacked portion control, and unlimited second servings were available.

The results of this study indicated that plate waste is a continuing problem in university dining halls. Monitoring plate waste can help university dining halls to reduce food and labor costs. Strict portion control and limiting or eliminating second servings could achieve further plate waste reduction. Students should be made aware of the cost of waste. Items that generated a large amount of waste should undergo sensory testing to determine if the items are acceptable to consumers or if vendors or specifications need to be changed.

Shanklin & Ferris (1992) completed a waste stream analysis in a convenience food system and a centralized conventional food production unit at two dining centers at a university located in the midwest. The purpose of the analysis was to quantify the weight and volume of waste disposed and to determine the composition of the waste generated. Composition, weight, volume, and collapsed volume of waste generated were compared between the two facilities. The service (plate) waste, production waste, packaging materials waste, and total waste generated in the two systems are illustrated in Table 1.

This study described in detail methods for determining volume and collapsed volume of different components of the waste stream. Volume was determined by using a calibrated measuring device which provided a more accurate measure of volume than previous subjective methods. During the pilot

Table 1. Type and weight of waste per meal generated in two types of university dining halls

Type of Waste	Centralized Unit (lbs/meal)	Convenience Unit (lbs/meal)
Food Waste		
Production waste	0.16	0.11
Service waste	0.20	0.18
Packaging Waste	0.15	0.10
Total Waste	0.51	0.39

study and during the first five days of this study, records were kept of the pre-collapsed and post-collapsed volumes of both the paperboard and plastic containers. From these data, a collapsed volume factor for each type of container was calculated and used to convert all further volumes to collapsed volumes as follows:

Volume of Paperboard Containers (yards^3) x 0.4848 = Collapsed Volume of Paperboard (yards^3)

Volume of Plastic Containers (yards^3) x 0.6480 = Collapsed Volume of Plastic Containers (yards^3)

A table of conversion factors derived from Gould and Gould (1988) was used to convert metal can volumes to collapsed volumes.

School Foodservice

In the late 1980s, school foodservice faced dwindling enrollment and an associated reduction in revenues at a time when food costs, and costs for disposing waste increased. Effective methods of solid waste management came into focus during this time. In 1990, Mann and Shanklin, reported that "limited research had been published that documented solid waste management practices, solutions implemented and problems encountered by school food service directors." The researchers suggested that research was needed in this area.

Hollingsworth, Shanklin, Gench, and Hinson (1990) studied the effect of the type of packaging on student acceptability and the weight and volume of solid waste for the milk component of school food service. The comparison was made using gable-top cartons and polyethylene (PE) pouches. Data were collected in six schools for breakfast and lunch for two ten day periods. The weight and volume of solid waste was determined and reported using descriptive statistics. T-tests were calculated to determine significant differences between outcomes in weight and volume of waste with the different milk containers.

The PE pouches were found to significantly decrease the amount of waste produced at the lunch meal. Approximately 72% of the waste generated was from the service area. Food waste composed 65.19% and 41.00% by weight and volume, respectively of the service waste. An average of 0.5 pounds of waste was disposed per meal served.

A study that compared the volume of waste generated by and cost of two types of serviceware systems was conducted by Riley, Shanklin and Gench (1991). The objective of this study was to quantify the volume of waste generated and the associated cost in eight elementary schools using two serviceware systems: permanent trays and disposables (Group A) and foam trays and other disposables (Group B). Eight elementary schools were divided into two groups based on type of serviceware systems used. Waste was sorted into three categories: plastic utensils, polystyrene serviceware, and food and other waste. Volume of waste was estimated for each type of waste by researchers by observing waste containers and determining them as full, three-fourths full, half full or one-fourth full. Volume was estimated in cubic yards using the following formula:

Gallon Capacity of bag x Estimated Percentage Volume (100% = full, 75% = 3/4, 50% = 1/2, and 25% = 1/4) = Number of Gallons

Number of gallons x 0.005 = Cubic yards

The mean volume of waste was calculated for each type of waste by group. T-tests were used to compare the mean volume of waste to determine significant differences. Mean volume of waste per participant for breakfast and lunch for each group was: Group A: 0.64 and 0.59 gallons; Group B:

1.05 and 0.81 gallons. Cost per meal for labor, disposables and trash removal was $0.11 for Group A and $0.07 for Group B. Even though schools in Group B generated more waste, their overall dollar costs were less. Cost of labor for maintaining permanent trays accounted for the difference.

In this setting, the cost in dollars for using disposable trays was less than using permanent trays. The researchers noted, however, that a prudent foodservice director must consider numerous factors including: 1) availability of labor and water; 2) costs of labor, energy, disposables, water, detergent, and waste disposal; 3) government regulations; 4) consumer attitude regarding recycling and the environment; 5) recycled materials markets; 6) local and state ordinances; and 7) capital required to purchase and maintain warewashing equipment. The researchers also recommended that "the foodservice director investigate the feasibility of implementing a recycling program or other appropriate alternatives to respond to increasing solid waste disposal costs and ecological concerns related to disposable serviceware" (Riley et al., 1991).

Mann, Shanklin and Cross (1993) conducted research designed to assess the status of solid waste management practices in school foodservice. A survey was administered to a national sample of 1450 school foodservice directors. The overall results revealed that limited solid waste management practices had been implemented. A systems and decision model for solid waste management in school foodservice was developed using the results of the survey. The systems model for solid waste management illustrated the relationship among components of a foodservice operation. The decision model described processes used to manage solid waste and included five key program components: government regulations, serviceware selection, volume reduction, source reduction, and solid waste removal. The decision model provided directors with a means to identify and examine waste management alternatives.

A waste stream analysis was conducted in six school foodservice operations by Hollingsworth, Shanklin, Gench, and Hinson (1992). The purpose of the study was to identify the amount and type of waste generated in production and service areas. Waste was separated by type of material - paper, glass, cardboard, plastic, and food waste for a period of four weeks. The percentages of types of waste produced in the production area by weight and volume were:

corrugated cardboard	28.6% and 55.4%
metal including #10 cans	14.2% and 13.9%
paper	5.2% and 8.2%
grease	7.9% and 0.07%
plastic	5.2% and 8.2%
food waste	65.2% and 41.1%

The total waste in weight and volume generated per student was 0.51 pounds or 0.0003 cubic yards for one sampling period and 0.46 pounds or 0.0002 cubic yards for the second sampling period. Applications noted from this research included: 1) types of menu items served impacted the weight and volume of solid waste generated; 2) increased foodservice employees' awareness of food and packaging waste resulted in a decrease of waste; 3) the market form of food purchased and type of packaging materials influenced volume of waste generated; 4) the feasibility of recycling containers needed to be investigated; and 5) amounts and type of waste generated is essential knowledge if appropriate reduction strategies are to be implemented.

Hotel Properties

Shanklin, Petrillose, and Pettay (1991) designed a questionnaire to identify solid waste management practices in the hotel industry. The survey was sent to sixteen randomly selected hotel companies on the basis of size (number of hotels owned or operated), type (luxury, resort, midscale, extended stay, or budget), and geographic location. Questionnaires also were sent to 160 individual properties within four geographic regions of the United States. Respondents rated the importance of eight variables using a 5-point Likert scale, with 1 being most important and 5 least important. Issues impacting the decision to initiate a solid waste management program rated most important by both corporate executives and general managers were waste disposal fees (mean rating of 2.00 and 1.74) and public image (mean rating of 2.00 and 2.32). The number and type of practices implemented by properties to manage solid waste varied by geographic location, corporation's emphasis on importance of recycling and reduction of waste disposal costs, and the infrastructure of the organization.

Pettay (1992) conducted a waste stream analysis of the food and beverage operations of two selected hotel properties (Hotel M and Hotel L). The purposes of the study were to analyze and compare the waste streams of the two properties, compare associated costs and to develop a plan for implementing a recycling program in one of the properties. The waste at each site was weighed and the volume determined by using the following formula:

$$\frac{\textbf{Inches of trash liner bin used}}{\textbf{Total inches of trash liner}} \times \textbf{capacity in gallons} = \textbf{gallons}$$

gallons x 0.005 = cubic yards

Descriptive statistics were used to analyze the weight and volume of waste produced at both sites within each category. The amount of waste generated was computed per day and week. T-tests were computed to determine significant differences between waste generated at Hotel L and Hotel M. The food and beverage operation generated 1.32 pounds/meal (Hotel M) and 1.61 pounds/meal (Hotel L). Excluding glass beverage containers from the bar operations, Hotel M and Hotel L discarded 1.14 and 1.30 pounds/meal, respectively. Food waste was greater than 60% of the total waste disposed.

The composition of waste by volume at Hotel M and Hotel L were as follows:

	Hotel M %	Hotel L %
Production food waste	39.7	25.4
Service food waste	33.3	42.4
Paperboard	8.6	8.1
Cardboard	6.5	6.6
Other metal	5.9	5.3
Plastic	3.5	3.7
Glass	1.3	8.1
Aluminum beverage containers	1.2	0.4

No significant differences in weight of waste generated was found between Hotel L and Hotel M. No significant differences were observed for the following variables: mean volume of waste per dollar of sales, mean weight of waste per dollar of sales, and the mean weights and volumes of each packaging material with the exception of glass. Researchers recommended further study to examine the relationship between dollar sales and weight and volume of waste at hotel properties. The study also reinforced the concept of savings through recycling and emphasized the importance of educating employees and the total involvement of management to the success of a solid waste management program.

Each of these researchers have reported the large amount of waste generated in the foodservice industry. In order to cope with this overwhelming issue, foodservice operators are finding ways to reduce and recycle waste that can reduce solid waste management costs, preserve the environment, and foster consumer goodwill.

The Hierarchy of Solid Waste Management as Adopted by the Foodservice Industry

The hierarchy of solid waste management as outlined by the EPA (1989b) is being adopted in different forms by foodservice operators (King, 1990). Operators are concerned with the following waste management considerations: labor costs, sanitation, space requirements, water consumption, electrical consumption, volume reduction, design variation in feeding methods, security, hauling costs, serviceware costs, transportation costs, operator morale, safety, fire hazards, animal and rodent control, and the environmental impact of the establishment including sewage, landfill, odor control, toxicity and visual aesthetics (Nicholls, 1991a). Operators are solving these problems by instituting the elements of the hierarchy of solid waste management.

Source Reduction

Solid waste generation can be reduced by foodservice organizations by implementing source reduction and reuse principles. The McDonald's Corporation in a collaborative effort with the Environmental Defense Fund highlighted actions to reduce solid waste (McDonald's, 1991). McDonald's changed from polystyrene foam "clamshells" to paper-based wraps for packaging sandwich items. The wraps provided a 70-90% reduction in packaging volume, resulting in significantly less space consumed in landfills. The practice of chlorine bleaching of paper has been a significant source of water pollution. Considerable environmental benefits will result from McDonald's switch from chlorine-bleached paper to brown, unbleached paper or paper bleached with benign chemical processes. McDonald's has studied all packaging systems and has eliminated over 6 million pounds of waste per year by repackaging frozen french fries and using orange juice concentrate. The most dramatic decrease in packaging was obtained by changing the delivery method of soft drink syrup. Instead of using cardboard containers, syrup is pumped directly from delivery trucks into tanks. This change eliminated 68 million pounds of packaging annually (Frumkin, 1989).

Subway, the Milford, Connecticut based sandwich chain, recently began a source-reduction program. The specification for cardboard boxes in which sliced meat was received was changed to allow for reuse of the container. After the five 3-pound packages of meat have been removed, the box unfolds into a large-order carryout container. Subway has marketed this program by printing the slogans "Save a Box, Save a Tree" and "This Box Works at Subway" on the sides of the box (Townsend, 1990).

Some foodservice establishments have solved the bulk of recycling challenges by centralizing preparation of food.

Food is bagged and transported in reusable containers. The procurement of foods and other supplies in bulk also reduced waste (Westerman, 1991).

Recycling

An increasing number of institutional and commercial foodservice operators have begun to participate in reducing the solid waste stream by implementing recycling programs. Many states already have statutes requiring recycling and others have goals to recycle 50% of the solid waste stream by 2000 or earlier. Fines and lost goodwill of both the community and consumers have been the alternative for not complying with recycling regulations.

Foodservice establishments have supported the principle of recycling by not only participating in recycling programs but have also supported it through purchasing products with recycled content (Opitz, 1992). Numerous trade journals have reported the benefits of a good recycling program. By considering both generated revenues from recyclable materials, the savings derived from diverting waste and eliminating hauling and tipping fees, and the enhanced public image, recycling can be profitable (Frumkin, 1989; Townsend, 1990; Feldman, 1991; Westerman, 1991; Opitz, 1992; Weinstein, 1992,).

Disadvantages associated with recycling for foodservice establishments have included the necessity for additional storage space, the time that must be devoted to sorting and preparing materials for pick-up, the search for a vendor willing to take the separated recyclables and the training required for employees. There also were incidental costs of introducing any waste reduction method, including research to identify the proper solution for a problem (King, 1990).

Reuse is a part of the recycling initiative. The reuse of plates and tableware in foodservice establishments has been studied. Gehr (1990) reported that a computer model of a hypothetical school cafeteria serving 200 meals per day was developed. Three options were analyzed: Case A (all disposables), Case B (reusable plates and serviceware made of plastic with a life expectancy of three years), and Case C (washable plates and disposable serviceware). Labor, energy, and replacement costs were considered for all three cases. Expressed in present dollar value, this analysis showed that a $10,000 savings over a 20 year period would be realized if reusable dishes and serviceware were chosen over disposables. There would also be environmental savings as well.

Composting

As of 1992, the composting of food waste from grocery stores, restaurants, and produce warehouses has been initiated in only a few areas (Goldstein, N., 1992). McDonald's determined that about 34% of on-premise waste consisted of organic materials such as eggshells, coffee grounds, and other food scraps. Used paper items such as discarded napkins represented another organic component of waste. In 1991, McDonald's began testing to evaluate whether this waste could be composted into high quality soil or humus product (McDonald's, 1991).

Many trade journals are reporting initiation of composting programs throughout the United States that are impacting the foodservice industry. The major incentive for foodservice establishments is cost savings. The cost of landfilling is increasing every year and composting offers a less costly disposal option (Youde and Prenguber, 1991; Musick, 1992; Scott, 1992).

Incineration

Some large foodservice corporations have tested the use of small incinerators. McDonald's evaluated incinerators at two units in Oklahoma and Illinois. The garbage was reduced to ash comprising 1/500th of its original volume. The smoke tested far below federal guidelines for air pollution and met restrictions set up by all states with the exception of New York. Individual incinerators cost approximately $32,500 with an additional $20,000 cost for installation (McDonald's, 1991).

There are drawbacks to incineration. Public resistance to placement of incinerators is very high. Incinerators are not cost effective unless significant quantities of waste are burned. The small and medium sized incinerators require a fuel source to start and sustain the combustion.

Incinerators typically require licensed personnel for operation and service to ensure the incinerator is operating within pollution-control standards and local code requirements (Frumkin, 1989; Borsenik and Stutts, 1992).

Landfilling

The goal of many foodservice establishments is to reduce the amount of waste going to the landfill. Methods combining source reduction, recycling, and composting have substantially reduced the amount of waste being hauled to the landfill. A final method available to the foodservice industry is reduction of solid waste volume through mechanical compacting.

Volume Reduction of Solid Waste

A major benefit cited for the use of compactors, pulpers, densifiers, and balers has been the reduction in the amount of space required to store uncompacted garbage. This equipment has decreased both the dumpster capacity required at foodservice establishments and the volume of material transported to landfills. Costs of purchasing garbage cans, dumpsters, and the labor cost to carry the waste and secure the area is reduced. Hauling costs are likewise reduced. Other benefits are increased sanitation, elimination of odors, and the reduction of large waste items to manageable units (Nicholls, 1991a & 1991b).

Pulpers are designed to reduce paper, food, and plastics to a uniform semi-dry pulp. The benefits cited for pulping include: 1) elimination of costs of purchasing and handling plastic bags; 2) decreased water consumption by 66% compared to use of garbage disposal; 3) elimination of drain-clogging problems; 4) reduction of waste volume up to 80%; 5) reduction of dumpster costs, and 6) improved sanitation (Wildow, 1991).

Compactors can reduce the volume of waste by as much as 80%. Compaction ratios of 5:1 or more are reasonable which result in reduced transportation and disposing costs. Compacted waste that has been contaminated with food is less likely to smell than the same waste that is not compacted. Higher specific weight of solid waste results in less surface area and less insect and rodent infestation (Humphrey, 1991).

Densifiers are high-pressure compactors designed to condense material which is then transported to a recycling plant. Like balers, their major advantage is compressing or binding materials so that they can be more easily handled and transported. Volume reduction is an additional benefit.

Recycling Food Waste

Three alternatives to landfilling food waste have included: composting, donating food to charitable causes, and selling or giving food wastes to local farmers or businesses to use as livestock feed. Several trade journals have reported the composting of food waste throughout the United States. Although not in widespread use, composting of food waste can greatly reduce the amount of solid waste transported to landfills (Youde and Prenguber, 1991; Musick, 1992; Scott, 1992).

The increase in homelessness and hunger in the United States has resulted in donation programs where some foodservice organizations distribute excess food. Food donations remove food from the solid waste stream which benefits both the foodservice organization and the environment. The practice also enhances the image of an organization since it projects concern for people and needy people receive nutritious foods (Finding Acclaim, 1992).

Feeding food waste to swine has been practiced for centuries throughout the world. Some cities had laws protecting pigs and other garbage-eating animals (Melosi, 1981). This activity ranged from maintaining a few animals fed household food waste to large commercial operations where hogs were fed processed food-waste. The spread of disease was identified as a potential problem in certain sources of food waste. Federal and state laws required that steps be taken to eliminate the problem by cooking the waste. Some farmers or businesses that collect food waste are paid a fee for doing so while others pay a price for the waste or pick it up for free. Approximately 50 farmers in New Jersey were licensed to feed human food wastes to hogs. These operations were fairly large and fed from 800 to several thousand head a year. Waste was collected from all types of foodservice organizations (Burdick, 1958; Derr, Price, Suhr, & Higgins, 1988).

Innovative new businesses are being formed to respond to the country's need to divert solid waste from the landfill. In Minnesota, a swine feed business called Second Harvest has reduced disposal costs and the amount of waste going to the landfill by picking up food waste at foodservice establishments and producing a low cost feed for swine that was very high quality (Polanski, 1992).

The United States military has been reducing its waste stream by diverting food wastes to swine farmers for over thirty years. A study conducted by Burdick (1958) determined the chemical composition of military garbage and evaluated it as a feeding source for swine. Garbage varied greatly in chemical composition and nutritive value depending upon the source and composition of the materials. Burdick's review of the literature cited many studies that had been conducted during a 30 to 40 year period beginning in the late 1910's. One researcher found that by using the protein content as a criterion of quality, military garbage was found to be superior, followed by civilian foodservice establishments, municipalities, and residences. Another researcher found that while military garbage was not superior in protein content, it was consistently free of extraneous material making it a superior feed. Burdick's study revealed that for growing pigs and breeding stock, military garbage supplied the recommended amounts of all nutrients except pantothenic acid. There are no recent studies on the quality of military garbage as a swine feed (Recycling, 1993).

Summary

Many areas in the United States face serious problems in the safe and effective management of municipal solid waste. The amount of waste generated in the United States in 1990 was 195.7 million tons or 4.3 pounds per person per day and this amount is projected to increase to 222 million tons by the year 2000, or 4.5 pounds per person per day (EPA, 1992a). The reduced number of landfills, increased costs for waste disposal, and increased regulation have intensified this national problem. The EPA's tiered integrated waste management strategy which includes source reduction, recycling (including composting), incineration (preferably with energy recovery), and landfilling provides a framework for planning the most effective methods of handling of this waste problem with the least impact on human health and the environment. The high visibility of waste generated by the foodservice industry, particularly the fast-food segment, demands that the industry assume a leadership role in the innovative management of solid waste. The hierarchy of waste management once again is the framework for meeting this challenge. Additionally, public perception and public acceptance must be weighed carefully in developing long-term plans for dealing with this problem.

Identifying the components of the waste stream in a foodservice organization must be the first step toward addressing solid waste management. Characterization which analyzes the weight and volume and composition of solid waste generated involve the scientific sampling of an organization's waste stream. By determining the composition of the waste stream, characterization studies provide valuable data for establishing waste management goals, tracking progress toward those goals, and highlighting opportunities for source reduction and recycling in foodservice organizations (EPA, 1992a).

United States Army institutional foodservice shares similar solid waste management concerns with the civilian foodservice industry. Because of the enormity of the U.S. Army organization, additional issues of inaccurate data and fragmented solid waste organization at the installation and headquarters levels has been identified as a concern. One of the major problems identified by Funke et al. (1992) in their study of U.S. Army solid waste management was the lack of uniform information collection and analysis systems to accurately characterize the waste stream. Characterization of the waste stream was identified as the starting point for improving Army solid waste management.

CHAPTER III

METHODOLOGY

This descriptive study was designed to quantify the amount and type of solid waste generated in two U.S. Army dining facilities. The study involved three phases: Phase 1: Training and Preparation; Phase 2: Waste Stream Analyses; and Phase 3: Data Analyses.

Description of Facilities

The Non-commissioned Officer's Academy Dining Facility

The Non-commissioned Officer's (NCO) Academy Dining Facility is located at Camp Forsyth, on Fort Riley, Kansas. The facility is housed in a separate building constructed in response to World War II as a company-size dining facility designed to serve approximately 200 individuals per meal. There have been several minor renovations since construction but the overall design remains unchanged (Mr. J.D.W. Warden, personal communication, March 15, 1993).

Currently, the dining facility serves breakfast, lunch, and dinner seven days per week to soldiers attending the Non-commissioned Officer's Academy which offer leadership classes year-round. The Platoon Leadership Development Course (PLDC) is offered approximately 8 times per year and enrolls between 125-150 soldiers per class. Other basic Non-commissioned Officer leadership courses are offered intermittently throughout the year to small groups of approximately 5-20 soldiers (LTC J. H. Whitworth, personal communication, February 10, 1993).

The soldiers who eat at the NCO Academy dining facility are 90% male and the majority are 30 years of age or younger. All students in the PLDC course have the rank of Specialist and are generally in the first six years of enlistment. Students attending the Basic Non-commissioned Officers' course receive training in higher skill levels within their military occupational specialty and leadership (J. H. Whitworth, personal communication, February 10, 1993). These soldiers are Sergeants or Staff Sergeants and have achieved career status.

Soldiers who normally reside in the barracks when not at the NCO Academy receive rations (breakfast, lunch, and dinner). Each soldier is issued a meal card by the soldier's assigned company. This meal card is valid at the NCO Academy dining facility. Soldiers who are married or who normally reside off-post when not attending training at the NCO Academy receive a monthly payment of $206.15 in lieu of a meal card. During their training phase at the NCO Academy, these soldiers forfeit their monthly allowances for rations and are issued meal cards. The dining facility is provided with a headcount projection to assist in forecasting production requirements. Other soldiers who are in the area during meal time are authorized to eat at the

NCO Academy dining facility. Soldiers without meal cards pay a cash price for each meal (AR 30-1, 1991).

The facility is managed through a government contract with a private institutional foodservice organization headquartered in Wichita, Kansas. The contract is awarded using a closed bid system for a two year period with an option for an additional three years. Salaries of employees and a profit margin are included in the bid (Mr. J.D.W. Warden, personal communication, March 15, 1993).

There are three personnel shifts that operate the facility. Personnel include 10 cooks and assistants and 7 individuals who perform cleaning and maintenance duties (Kitchen Patrol - KPs). The facility is managed by a retired U.S. Army Non-commissioned Officer who was a military cook (Mr. J.D.W. Warden, personal communication, March 15, 1993). The facility schedule and meal cost are outlined in Table 2.

The equipment in the facility is provided and maintained by the U.S. Army. The Dining Facility Manager is accountable for the equipment and signs a hand receipt which lists the type and amounts of all equipment and furnishings located in the building. The contract employees perform operator level and preventative maintenance (AR 30-1, 1991).

The facility operates on a debit and credit system based on the number of soldiers dining in the facility. The cash collected from soldiers not on meal cards is forwarded

Table 2. NCO Academy Dining Facility meal schedule and cost

	Monday-Friday	Weekends/Holidays	Cost[a]
Breakfast	0600-0730	0600-0730	$0.95
Lunch	1130-1300	1130-1300	$1.90
Dinner	1630-1800	1630-1800	$1.90

[a]A surcharge of $2.30 for breakfast and $4.55 for lunch and dinner is applied to meal cost for commissioned officers, civilians, and some family members (as of May, 1993).

to the U.S. Army Finance & Accounting Agency on Fort Riley and is not retained by the dining facility. A daily accounting of the number of soldiers who presented meal cards and the number of soldiers who paid cash for meals is compiled and reported through the Army Food Management Information System (AFMIS) to the Troop Issue Subsistence Agency (TISA). Dining facilities are linked to TISA by computer through the AFMIS. The credit per meal is based on the Basic Daily Food Allowance (BDFA) which is established by Department of the Army. The BDFA is based on current United States market prices for food and is updated quarterly. As of May, 1993 the BDFA for every soldier eating breakfast in the facility was $.95; lunch, $1.90; and dinner, $1.90. The number of soldiers multiplied by the BDFA value for that particular meal is debited against the facility account and used to purchase food at TISA (CW4 D C. McNece, personal communication, September 15, 1993). The TISA is the source of supply for all food items purchased by the dining facilities on Fort Riley. Through the AFMIS, orders are entered as credits against the balance of revenue generated through the reporting of headcount from previous days. There is a continual balancing of accounts so that by the end of the month, the revenue generated through the headcount must equal the value spent on food at TISA or be within -3%. U.S. Army dining facilities that do not use the automated AFMIS system, must balance their accounts so that the revenue generated through the headcount must equal the value spent on food at TISA or be within +/- 3%. Failure of a dining facility manager to maintain this range results in initial inspection and assistance (AR 30-1, 1991). In both systems, accounts must equal or negatively spent by the end of the fiscal year (September 30). Continued failure may result in an investigation by the post food advisor or an officer outside of the chain of command and could result in the relief of the manager if he or she is found negligent. Contracted facilities are subject to the same regulations and could be considered in breach of contract.

The 1-34 Armor Dining Facility

The 1-34 Armor Dining Facility is located on Custer Hill at Fort Riley, Kansas. The facility is housed in a wing of a building constructed during the late 1950s as a company-size barracks. The dining facility was designed to serve approximately 200 individuals per meal. There have been several minor renovations since construction but the overall design is unchanged (SFC R. A. Olson, personal communication, May 21, 1993).

Currently, the dining facility serves breakfast, lunch, and dinner, Monday through Friday, and Brunch and Supper on Saturday and Sunday to soldiers assigned to the 1-34 Armor Battalion and Headquarters Company, 1st Brigade. The facility is usually closed on alternating weekends and may close when the majority of soldiers are performing field duty (SFC R. A. Olson, personal communication, May 21, 1993).

The majority of soldiers who dine at 1-34 Armor Battalion Dining Facility are 40 years of age or younger . Only males dine at the facility. Soldiers who normally reside in the 1-34 Armor Battalion barracks are issued a meal card that entitles them to eat every meal at their own dining facility or in any other dining facility on Fort Riley. Soldiers who are married or who normally reside off-post receive a monthly payment of $206.15 in lieu of a meal card. These soldiers may eat meals at the 1-34 Armor Dining Facility or any other Fort Riley dining facility for the regulated fee as outlined in Table 2. The battalion dining facility is provided with a headcount feeder report by each unit using the facility. This report provides the dining facility manager with the assigned personnel strength of the 1-34 Armor Battalion and Headquarters Company, 1st Brigade. The information is used to forecast production demand.

Soldiers are not normally required to dine at the unit dining facility for meals and could frequent other unit dining facilities or civilian foodservice establishments. Other unit soldiers who are in the area during meal time also are authorized to dine at the 1-34 Armor Battalion Dining Facility (AR 30-1, 1991).

The facility is managed by Non-commissioned Officers of the U.S. Army. There are two personnel shifts that operate the facility; personnel include eight cooks and assistants and five civilian individuals who perform cleaning and maintenance duties (Kitchen Patrol - KPs) through a contract. There is also a inventory control clerk, an administrative clerk, and a baker (AR 30-1, 1991). The facility schedule is outlined in Table 3.

The equipment in the facility is provided by the U.S. Army. The Dining Facility Manager accepts accountability for the equipment by signing a hand receipt. The assigned cooks and kitchen police are responsible for operator level maintenance and preventive maintenance (AR 30-1, 1991).

Financial management, revenue generation, and procurement of supplies is regulated by AR 30-1, The Army Food Service Program, and is the same as described for the NCO Academy Dining Facility. Failure to meet standards outlined by AR 30-1 or meet the range requirements of plus/minus 3% at the end of month reconciliation could result in an investigation by an officer outside the chain of command and the relief of the manager (AR 30-1, 1991).

Table 3. 1-34 Armor Battalion Dining Facility meal schedule and cost

	Mon/Wed/Fri	Tues	Thurs	Sat/Sun[b]	Cost[a]
Breakfast	0700-0845	0630-0800	0530-0700	0900-1200	0.95
Lunch	1130-1300	1130-1300	1200-1330		1.90
Dinner	1630-1800	1630-1800	1530-1700	1500-1700	1.90

[a]A surcharge of $2.30 for breakfast and $4.55 for lunch and dinner is applied to meal cost for commissioned officers only.

[b]Brunch and dinner are the only meals served on weekends.

Study Design

Dependent Variables

The waste generated at each facility was collected and separated into four categories: production food waste, service food waste, service paper waste, and packagi .ȷ waste divided into eight categories. Each of these categ‸ ies are described in the definition section. The study involved five dependent variables: type, volume, weight, specific weight of waste generated, and the proximate analysis of service food waste. The weight, volume, collapsed volume, and specific weight of food waste (production and service), nonfood waste (service paper waste and packaging) and total waste per meal was determined.

Independent Variables

Independent variables investigated included type of dining facility, the day of the week, the period of the month according to the military pay cycle, and the number of soldiers dining at each facility.

Type of Dining Facility The two types of dining facilities in which waste stream analyses were conducted included a contracted military dining facility under the management of a civilian contractor and a military dining facility under the management of professional soldiers.

Day of the Week Comparisons were made using mean values for weight and volume by lbs/meal and cubic yards/meal, respectively by type of day - weekday versus weekend.

Period Comparisons were made using mean values for weight and volume by lbs/meal and cubic yards/meal by sample period - the first versus second half of the month according to the military pay cycle.

Headcount The number of soldiers dining in each facility was determined and the impact of headcount projection analyzed.

Control Factors

Facility Operation The two facilities were selected for this study due to similarities in their operations which served as a measure of control. Both dining facilities operated under the auspices of AR 30-1, The Army Foodservice Program (AR 30-1, 1991). This regulation establishes policies, procedures, responsibilities, objectives, and basic standards for the Army Food Service Program in garrison and field training exercises relating to menus and dining facility operating procedures. This regulation also governs every area within dining facility operations including procurement procedures, portion control, sanitation, food safety, and access.

Purchasing Function The Troop Issue Support Agency (TISA) serves as the wholesaler for all food items required at Ft Riley dining facilities. Both facilities involved in this study obtained all supplies at the same TISA. Therefore, all food items used in both facilities had the same specifications, source, and price.

Equipment Both facilities received equipment and furnishings basically "free of charge" as part of the initial set-up of the facility. There were some differences in the equipment assigned to each facility. However, the equipment differences did not affect waste generation.

Waste Management Post-imposed recycling regulations provided guidance for the separation and disposal of all solid waste generated in both facilities. Fort Riley requires all dining facilities to participate in a post-wide recycling program. The dining facilities recycled glass (clear, amber and brown), aluminum, steel/tin cans, cardboard, #1 and #2 plastic containers, and food waste. Both facilities were provided waste containers and hauling at no charge. Fort Riley has contracted with a local swine farmer to transport food waste from each dining facility off the installation. All recyclables are transported by a separate solid waste contractor to the Fort Riley Recycling Center and prepared for market. No incentives are paid or received for recycling or the reduction of waste volume at the dining facility level.

Phase 1

Phase 1 involved a training and observation period. The chain of command, the management and the staff of both facilities were briefed concerning the purpose, objectives, and methods involved in the study. The researcher interviewed managers at both facilities to obtain data on current procedures. Appropriate personnel were identified to assist in data collection and were instructed in the proper methods of waste separation and weight and volume determinations. During Phase I, all materials for data collection were identified and positioned on site prior to the research phase.

Sample Size Determination

Sample size required to determine and make inferences about significant differences found between mean values with two independent samples within a 95% confidence interval was calculated. The population variance was unknown, therefore, information from a previous study conducted by Shanklin & Ferris (1992) was used to estimate population variance and to determine tolerable error.

Below is the equation used to determine sample size (Ott, 1988):

$$n = \frac{(Z_{\alpha/2})\sigma^2}{E^2}$$

$(Z_{\alpha/2})^2 = 1.96^2$(for a 95% confidence interval, 2-sided test) = 3.84

Table 4 illustrates the variance for pounds/meal for service waste, production waste, packaging waste, and total waste for both facilities as determined by Shanklin & Ferris (1992).

Table 4. Variances in weight of waste disposed for service, production, packaging, and total waste at two university dining halls

Type of Waste	Centralized Conventional Food Production (CCFP) (Lbs/meal)	Centralized Conventional Food Production (CCFP) Variance	Convenience Food System (CFS) (Lbs/meal)	Convenience Food System (CFS) Variance
Service	0.206	0.144	0.164	0.004
Production	0.196	0.010	0.109	0.002
Packaging	0.160	0.001	0.105	0.001
Total	0.574	0.028	0.390	0.003

The tolerable error for each variable was determined. The variance and the error factor were inserted into the given equation (Ott, 1988) and the sample size was determined and are presented in Tables 5 and 6.

Table 5. Sample size determination - convenience food system (CFS)

Type of Waste	Variance (Lbs/Meal)	Tolerable Error (Lbs/Meal)	Sample Size (Days)
Service	0.004	0.04	10.2
Production	0.002	0.03	8.5
Packaging	0.001	0.02	9.6
Total Waste	0.003	0.01	11.5

Table 6. Sample size determination - centralized conventional food production (CCFP)

Type of Waste	Variance (Lbs/meal)	Tolerable Error (Lbs/meal)	Sample Size (days)
Service	0.144	0.10	55.3
Production	0.010	0.05	15.4
Packaging	0.001	0.02	9.6
Total Waste	0.028	0.10	10.7

The facilities in the study shared similarities with both facilities in the Shanklin & Ferris (1992) study. The headcounts were similar to headcounts at the Convenience Food System (CFS) unit. The NCO Academy Dining Facility and the 1-34 Armor served a combined headcount that ranged from 500 to 1480 soldiers daily. Food preparation in both facilities more closely resembled the methods used in the centralized conventional food preparation facility.

A total of fourteen days was selected as the sample size. This sample size was larger than all required sample size calculations except for service waste at the CCFP. The variance for service waste at this facility was extremely large, probably due to variable amounts of moisture present in the paper or attributable to error or extraneous variables. The sample size calculation for service waste was not used to determine sample size for this study. Four weekend days were included to allow for comparisons between waste generated on weekdays and weekends. Previous studies have shown differences in the amount of waste generated on weekdays and weekends. This study determined whether a significant difference in the weight or volume of waste was generated on weekdays and weekend days for the two dining facilities. The two periods selected are seven days in length; one period of seven days was selected at the beginning of the month and one period of seven days was selected at the end of the month in terms of the military pay cycle. These periods were selected to compare waste generated during these two time periods to determine if time of month in reference to the military pay cycle is a factor in the number of soldiers served per meal and consequently the waste generated.

Random sampling of days was not used due to facility closures, training, time, and cost constraints during the study timeframe. The days selected included weekdays and weekend days in the first and second half of the month according to the military pay cycle during the summer season only. The facilities are representative of the two types of facilities characteristically seen in the United States Army. Table 7 illustrates the schedule of data collection.

Table 7. Scheduled data collection

Month		1-34 Armor	NCO Academy
June 1993	Weekdays[a]	7-11	7-11
	Weekend Days[b]		12,13
July 1993	Weekdays	26-30	26-30
	Weekend Days	10,11,31,1 Aug	31,1 Aug

[a] Total Weekdays = 10

[b] Total Weekend days = 4

Phase 2 - Data Collection

Waste stream analyses were conducted at each site during Phase 2.

Weight Determination

A 300 pound calibrated scale located at each facility was used to determine weight. All trash containers were numbered and weighed prior to usage in the study. The actual weight of the solid waste in each container was determined using the following formula:

Weight of Solid Waste = Total Weight - Weight of Container

Volume Determination

Volumes for the 32 gallon containers was ascertained using a measuring device designed and tested extensively during the Shanklin & Ferris (1992) study (Figure 1 - Appendix C). This device was constructed using a wooden 1"x2" stick approximately 36" long attached to a wooden base approximately 12"x12" wide. The device was graduated from 1 to 32 gallons. These graduations were determined by adding water to a 32 gallon container in 1 gallon increments and marking the water level after each addition.

To estimate volumes for the 32 gallon containers, the measuring device was placed on top of the solid waste in the container and the volume read directly from the scale. A flat object was placed across the top edges of the container aligned against the measuring device which avoided parallax in readings.

All gallon volumes were converted to cubic yards using the following formula:

$$\textbf{Volume (gallons)} \times 0.005 \ \frac{\textbf{yard}^3}{\textbf{gallon}} = \textbf{Volume (yard}^3\textbf{)}$$

Paperboard and Plastic Container Volumetric and Collapsed Volumetric Conversions To determine the collapsed volume of plastic containers, a mean collapsed volume factor was derived from the Shanklin and Ferris (1992) reference. The total volume of containers was determined and then multiplied by this factor to obtain the collapsed volumes. The following formula was used:

$$\textbf{Total Volume of Plastic Containers (yards}^3\textbf{)} \times 0.6480^{*} = \textbf{Collapsed Volume of Paperboard (yards}^3\textbf{)}$$

*** n=28**

To determine the volume of collapsed paperboard containers, a collapsed volume factor was determined during the study by measuring the initial volume of the paperboard waste, manually compacting the waste, measuring the compacted volume of the waste, and then dividing the initial volume by compacted volume. A mean collapsed volume factor was determined for paperboard waste. The following formula was used:

Total Volume of Paperboard Containers (yards^3) x 0.4340* = Collapsed Volume of Plastic Containers (yards^3)

***n=28**

<u>**Other Plastic Volumetric and Collapsed Volumetric Conversions**</u> To determine the volume of collapsed plastic other than containers, a collapsed volume factor was determined during the study by measuring the initial volume of the other plastic waste, manually compacting the waste, measuring the compacted volume, and then dividing the initial volume by the compacted volume. A mean collapsed volume factor was determined for other plastic. The following formula was used:

Total Volume of Other Plastic (yards^3) x 0.5822* = Collapsed Volume of Other Plastic (yard^3)

***n=28**

<u>**Non-Aluminum Container Volumetric and Collapsed Volumetric Conversions**</u> Non-aluminum containers were counted and measured during the study. The volumes of the individual cans were calculated using the following formula:

$$\text{Volume of the Can (inches}^3) = \Pi r^2 (\text{inch}^2) \times \text{Length of Can (inch)}$$

$$\text{Can Volume} \times \frac{1 \text{ yard}^3}{46656 \text{ inch}^3} = \text{Volume in Cubic Yards}$$

The radius and the length of each type of can were either obtained from Gould and Gould (1988) or measured directly from the can.

A collapsed volume factor was determined by dividing the calculated volume of cans collected per day by the actual volume of the same cans once they had been manually collapsed. The collapsed volume was determined by removing the top and bottom of each can, manually flattening the cans, and measuring the volume using the volume determination device in a 32 gallon can. A mean value for the collapsed can factor was derived over a five day period and used throughout the rest of the study to determine the collapsed volume of non-aluminum cans using the following formula:

$$\underset{(\text{yards}^3)}{\textbf{Total Volume of Cans}} \times 0.4766^* = \underset{(\text{yards}^3)}{\textbf{Collapsed Volume of Cans}}$$

***n=9**

Corrugated Cardboard Box Volumetric and Collapsed Volumetric Conversions The length, width, and depth of corrugated cardboard boxes were measured. The total volume of the individual boxes was calculated using the following formula:

$$\underset{(\text{inch}^3)}{\textbf{Total Volume of Box}} = \underset{(\text{inch})}{\textbf{Length}} \times \underset{(\text{inch})}{\textbf{Width}} \times \underset{(\text{inch})}{\textbf{Depth}}$$

All volumes were then converted to cubic yards using the following formula:

$$\textbf{Volume of the Box } (\text{inch}^3) \times \frac{1 \text{ yard}^3}{46656 \text{ in}^3} = \underset{(\text{yard}^3)}{\textbf{Volume of the Box}}$$

The collapsed volume factor for cardboard boxes was derived over a five day period. Boxes of the same size were broken down and flattened and placed in a rectangular stack. The dimensions (length, width, and depth) of the stack were measured and the volume of the stack determined. The uncollapsed volume of boxes was divided by the collapsed volume of the stack to compute a mean collapsed volume factor for cardboard boxes for the rest of the study using the following formula:

$$\underset{(\text{yards}^3)}{\textbf{Total Volume of Cardboard Boxes}} \times 0.1442^{*} = \underset{(\text{yards}^3)}{\textbf{Collapsed Volume of Cardboard Boxes}}$$

***n=19**

Specific Weight Determination

The specific weight of the food waste (production and service), service paper waste, and other packaging wastes was determined using the following formula:

$$\frac{\textbf{Weight (lbs)}}{\textbf{Volume (yard}^3\textbf{)}} = \textbf{Specific weight (lbs/yard}^3\textbf{)}$$

Tchobanoglous et al. (1993) noted that specific weight expressed as lb/yd^3 is commonly referred to in the solid waste literature incorrectly as density. In U.S. customary units, density is expressed correctly as $slug/ft^3$. Specific weights of solid wastes vary greatly by geographic area, season, and length of time in storage (Tchobanoglous et al., 1993). Values for this study were derived in the midwestern

United States, during the months of June and July, and the waste was in storage less than 6 hours.

Proximate Analysis

A proximate analysis of service food waste was performed to determined the percent moisture, protein, fat, carbohydrate and ash. The nutrient value of food waste is important when considering alternatives to landfilling food waste such as animal feed and composting. The proximate analysis was performed by a graduate student in the Department of Hotel, Restaurant, Institutional Management and Dietetics, Kansas State University using AOAC methods (AOAC, 1990).

Moisture Content The moisture content of service food waste was determined by dry-and-weigh physical analysis which requires weighing a sample before and after drying with heat in a forced air oven. The difference in weight constitutes the crude moisture evaporated from the sample. The percent moisture content is determined using the following formula.

$$\% \text{ Moisture} = \frac{(\text{Wt of dish} + \text{Wt of Sample}) - (\text{Wt of dish} + \text{Dry Sample})}{(\text{Wt of Dish} + \text{Wet Sample}) - (\text{Wt of the Dish})} \times 100$$

Protein Content Percent protein was determined using the Kjeldahl method which assays for nitrogen present in foods by liberating the nitrogen from proteins by use of a strong oxidizing agent (H_2SO_4). The percent of protein present in the sample is calculated using the following formula.

$$\textbf{\% Protein} = \frac{(A-B) \times (N) \times (14.007) \times (6.25)}{\text{mg of sample}} \times 100$$

where A = ml of acid used for titrating the sample
B = ml of acid used for titrating the blank
N = normality of the acid used for titrating (meq/ml)
6.25 = standard correction factor for nitrogen
100 = correction factor for percentage
14.007 = molecular weight of nitrogen (mg/ml)

Fat Content The fat content was determined using the Soxhlet procedure using diethyl ether. The solvent was passed over the service food waste sample until all the fat material had been dissolved in the solvent. The solvent was then removed by heat from the fat and the % fat determined by difference.

Ash Content Ash content was determined by incinerating service food waste samples at 500-600° C for 2 or more hours in high-heat resistant containers.

Carbohydrate Content Percent carbohydrate present in service food waste was estimated by subtracting the total percent of protein, lipid, water,and ash content from the 100%.

Sample Collection Samples of service food waste were collected on three days, one weekend and two weekdays, for each individual meal (breakfast, lunch, and dinner). The food waste was mixed prior to sample collection to ensure the food waste throughout the can was as homogeneous as possible. Samples were collected using a core sampling technique in which a cylindrical plastic pipe, diameter 1.25 inches and approximately 24 inches in length, was plunged into the service waste contained in a 32 gallon can. A cap was then placed on the unsubmerged end and the sample weighing approximately 1 kilogram was drawn from the waste generated per meal. The collected sample was blended to achieve homogeneity of the food waste.

Phase 3: Data Analysis

Phase 3 included comparisons of type, weight, volume, density, moisture content, and nutrient content of waste generated in the two facilities and other institutional foodservice organizations.

Descriptive Statistics

Mean values for total solid waste generated (including the four types of waste - production and service food waste, service paper waste, and packaging waste) by weight and volume were determined per meal by facility, type of day (weekend and weekday), sample period (1st half and 2nd half based on the military pay cycle) and by facility (NCO Academy and 1-34 Dining Facilities). The combined total waste generated at both facilities over the entire fourteen day study also was described by weight, volume, and specific weight. The mean values for moisture content and proximate nutrient content of service food waste was determined for each breakfast, lunch and dinner sample by facility.

The four types of waste - production food waste, service food waste, service paper waste, and packaging waste also were described individually. The mean weight, volume, specific gravity of production waste, service paper waste, and packaging waste was determined. The mean weight, volume, specific weight, moisture content, and proximate nutrient content of service food waste was determined.

Inferential Statistics

The inferential statistics used in this study were intended to provide comparative information between the two studied dining facilities only. The data collected in these two sample dining facilities were independent and unrelated. The distribution for the data was tested for normality using Microsoft Excel 4.0 (1993) and was found to be normally distributed ($p<.05$). The sample variances were compared for each category of waste described and appropriate t-tests were used for equal and unequal variances. The pooled t-test was calculated to determine significant differences between dining facilities for the following variables: mean per meal weight and volume of waste by day, sample periods, and by facility (Microsoft Excel, 1993).

Study Limitations

The methods used for collecting the service food waste samples for proximate analysis were the best that were available within the cost and time constraints of this study. It was not possible to completely homogenize the waste when samples were taken. Therefore, there is a high probability that the samples taken were not totally representative of the food waste collected for each meal.

It was not possible to randomly sample the days in which data was collected. Therefore, the data obtained from this study are merely descriptive of the dining facilities studies and cannot be used to make generalizations about Army dining facilities. However, careful consideration was given to the selection of the two facilities to ensure that each dining facility was representative of other contracted and Army operated dining facilities currently operating in the U.S. Army. Additionally, the days that were selected for the study were chosen solely for their position in the month relative to the military pay cycle, on the basis of being weekdays or weekend days, and on the whether the facility would be in operation. The researcher had no other information such as projected headcounts, menu, special meals, or weather forecasts that may have biased selection of the data collection days. Consequently, there was no deliberate systematic tendency to over- or under-represent some part of the operation of either facility.

It was not possible to totally isolate the service paper waste. The diners removed nonfood waste from their trays prior to leaving trays at the dishroom. The researcher observed soldiers throwing food waste away with the service paper waste. Before the service paper waste was weighed or the volume was determined, food waste was removed by hand from the paper waste by the researcher. However, it was not possible to remove the moisture absorbed by the napkins from the food waste. Therefore, it is possible that the weight of the paper service weight would have been less if the food waste had been separated prior to disposal by the diners.

The paperboard and "other plastic" categories of waste were collapsed by putting the waste in a 32 gallon can and then a person who weighed approximately 170 lbs jumped on the trash until it appeared to no longer collapse. Although this method was probably similar to methods that could conceivably be used in day-to-day operations of a small foodservice establishment, the results can not be compared to collapsed volumes that could be obtained through the use of compactors which undoubtedly would have provided a greater reduction of volume. However, similar methods were used by Shanklin & Ferris (1992) and can provide a comparison of facilities.

Non-aluminum metal cans were collapsed by removing the top and bottom of the containers and then a person jumped on them until they were flattened. Once again, mechanical compacting may have produced a greater volume reduction.

Summary

This chapter described the three phases of the study. Detailed procedures for the determination of weight, volume, collapsed volume, and specific weight of waste, including formulas, were provided for each type of material characterized by the waste stream analysis. Methods for proximate analysis of service food waste also were described. Statistical methods used to analyze data were summarized.

CHAPTER FOUR

RESULTS AND DISCUSSION

Introduction

The purposes of this study were to characterize the waste stream at two United States Army dining facilities at Fort Riley, Kansas and to recommend policies and procedures to effectively manage solid waste at U.S. Army dining facilities.

Data were collected at the two facilities during two seven day periods, one in the first half and one in the second half of the month based on the military pay cycle. Both periods included weekdays and weekend days. The early week in both facilities was typical of weeks throughout the year. However, during the second week at the 1-34 Armor Battalion Dining Facility two additional battalions with approximately 400 personnel were entitled to be served. This increase resulted from closure of another dining facility.

T-tests were computed to examine differences between the NCO Academy and 1-34 Armor Dining Facilities for the following variables: 1st Period, 2nd Period, and total period food waste, nonfood waste, and total waste by weight (lbs) and volume ($yards^3$) per meal. T-tests were computed to examine differences within facilities for the following variables: Weekday and Weekend food waste, nonfood waste, and total waste by weight (lbs) and volume ($yards^3$) per meal; 1st Period and 2nd Period food waste, nonfood waste, and total waste by weight (lbs) and volume ($yards^3$) per meal. T-tests also were computed to determine significant differences between total food waste, nonfood waste, and total waste by weight (lbs) and volume ($yards^3$) per meal for both facilities combined for the following variables: weekdays and weekend days and 1st period and 2nd period. The mean weight, volume, collapsed volume, and specific weight of each type of packaging material were computed and compared.

NCO Academy Dining Facility

Facility Profile

A total of 5452 meals were served during the 14 day data collection period. Table 8 illustrates that a total of 2135 and 3317 meals were served at breakfast, lunch, and dinner during the 1st and 2nd periods, respectively. The mean weekday headcount for breakfast, lunch, and dinner were 111, 87, and 96 meals and 180, 151, and 164 meals during periods 1 and 2, respectively. Mean weekend headcount for breakfast, lunch, and dinner during the 1st and 2nd periods were 126, 77, and 139 and 173, 188, and 156, respectively.

Headcount at U.S. Army dining facilities is projected based on the Subsistence Report and Field Ration Request Form, Department of the Army (DA) Form 2970. Soldiers who are authorized basic subsistence through the use of a

Table 8. Meals served at the NCO Academy (NCOA) and 1-34 Armor (1-34 AR) Dining Facilities during the 14 day period

	MEAL							
	Breakfast		Lunch		Dinner		Total	
PERIOD	NCOA	1-34 AR[a]	NCOA	1-34 AR[b]	NCOA	1-34 AR	NCOA	1-34 AR
1st Period	807	1119	590	922	738	1164	2135	3205
Mean Wkday	111	159	87	164	96	134	98	152
Mean Wkend	126	162	77	-	139	248	114	205
2nd Period	1248	1435	932	1416	1137	1252	3317	4103
Mean Wkday	180	239	151	283	164	200	165	241
Mean Wkend	173	120	188	-	156	125	172	123
Total	2055	2254	1522	2338	1875	2416	5452	7308

[a]Breakfast weekend meals represent brunch.

[b]1-34 Armor does not serve lunch on weekends. A brunch is served that combines breakfast and lunch.

mealcard are designated as subsistence in kind (SIK). This DA Form has been automated through the AFMIS system. The projected average headcount for the 1st and 2nd data collection periods was 83 and 159 SIK per meal, respectively. Additional meals were served to military personnel who were not authorized a mealcard and paid cash. In addition to the SIK, the manager of this facility stated that he expected approximately 20 individuals per meal. The mean headcount for breakfast, lunch, and dinner was higher for the 2nd data collection period. Throughout the 14 days of data collection, the actual headcount was at least 92% of the projected headcount or higher 34 of the 42 meals. The actual headcount was less than 80% on only one occasion.

A sample daily menu at the NCO Academy is presented in Appendix A on the Dining Facility Operations Meal Production Planning Production History Report. This report includes the adjusted and actual headcount, the recipe name, estimated portions to prepare, actual portions prepared, leftover portions, and number of portions discarded.

Total and Per Meal Waste

For the purposes of this study, waste was divided into three categories: food waste (production and service), nonfood waste (service paper, other paper, metals, aluminum, paperboard, plastic containers, other plastic, glass, corrugated cardboard, and other), and total waste. The weight, volume, and collapsed volume of waste was determined for the total period, per day, and per meal for breakfast, lunch, and dinner and the two data collection periods for the three waste categories.

Weight Table 9 illustrates the composition by weight of the total waste stream generated at the NCO Academy Dining Facility. A total of 5130.00 lbs of waste was generated during 14 day data collection period. The total weight was composed of 3769.00 lbs of food waste and 1361.00 lbs of nonfood waste. An average of 269.22 lbs of food waste and 97.23 lbs of nonfood waste was generated per day. Food waste and nonfood waste composed 73.47% and 26.53%, respectively. Mean weight per/meal of food and nonfood waste was 0.69 lbs and 0.25 lbs, respectively. The NCO Academy Dining Facility generated a mean of 366.45 lbs or 0.94 lbs per day and per meal of total solid waste, respectively.

Volume Table 10 illustrates the volume of the total waste stream generated at the NCO Academy Dining Facility. A total of 18.95 cubic yards of waste was generated during the 14 day data collection period. The total volume was composed of 3.16 and 15.79 cubic yards of food waste and nonfood waste, respectively. A daily average of 0.23 and 1.13 cubic yards of food waste and nonfood waste,

Table 9. Type and weight of waste generated at the NCO Academy Dining Facility during the 14-day period

Type of Waste	Total (lbs)	Percent Weight[c]	Average (lbs/Day)	Total (lbs/Meal)
Food Waste				
Production	736.25	14.35	52.59	0.13
Service	3032.75	59.12	216.63	0.56
Total	3769.00	73.47	269.22	0.69
Nonfood Waste				
Paper				
Service	328.75	6.41	23.48	0.06
Other	198.75	3.87	14.20	0.04
Metal	104.75	2.04	7.48	0.02
Aluminum	13.25	0.25	0.95	0.01[d]
Paperboard	152.00	2.96	10.86	0.03
Plastic				
Container[a]	17.50	0.34	1.25	0.01[d]
Other[b]	162.75	3.17	11.63	0.03
Glass	42.00	0.82	3.00	0.01
Cardboard	236.00	4.60	16.86	0.04
Other[c]	105.25	2.05	7.52	0.02
Total	1361.00	26.51	97.23	0.25
Total Waste	5130.00	----	366.45	0.94

[a]Includes plastic bottles, jars, jugs.

[b]Includes plastic wrap, disposable serving containers, condiment packaging, and other miscellaneous waste of primarily plastic construction.

[c]Percent weights calculated using data in total lbs column. Percentages do not equal 100 due to rounding.

[d]Per/meal values were rounded up to 0.01 when calculated values were less than 0.005 lbs/meal. Per/meal totals do not equal sum of subcomponents due to rounding.

Table 10. Type and volume of waste generated at NCO Academy Dining Facility during the 14-day period

Type of Waste	Total (Yds^3)	Percent (Yds^3)[d]	Average (Yds^3/Day)	Total (Yds^3/Meal)
Food Waste				
Production	0.9263	4.88	0.0662	0.0002
Service	2.2375	11.80	0.1598	0.0004
Total	3.1638	16.68	0.2260	0.0006
NonFood Waste				
Paper				
Service	1.8488	9.76	0.1321	0.0003
Other	1.1500	6.07	0.0814	0.0002
Metal	0.6999	3.69	0.0500	0.0001
Aluminum	0.2688	1.41	0.0192	0.0000
Paperboard	2.3600	12.45	0.1686	0.0004
Plastic				
Container[a]	0.1188	0.63	0.0085	0.0000
Other[b]	1.9100	10.08	0.1364	0.0004
Cardboard	7.4954	39.56	0.5354	0.0014
Other[c]	0.4325	2.28	0.0309	0.0001
Total	15.7850	83.30	1.1275	0.0029
Total Waste	18.9487[e]	---	1.3535	0.0035

[a]Includes plastic bottles, jars, jugs.

[b]Includes plastic wrap, disposable serving containers, condiment packaging, and other miscellaneous waste of primarily plastic construction.

[c]Includes waste not defined by the study such as broken china, metal cleaning screens, and twine.

[d]Percent weights calculated using data in total lbs column. Percentages do not equal 100 due to rounding.

[e]Total volume was collapsed 45% to 10.3506 cubic yards.

respectively was generated. Total volume was composed of 16.68% food waste and 83.30% nonfood waste or 0.0006 and 0.0029 cubic yards per meal of food waste and nonfood waste, respectively. The NCO Academy Dining Facility generated a mean of 1.3535 cubic yards of waste per day and 0.0035 cubic yards per meal.

Collapsed Volume The collapsed volume was determined for the following components of the waste stream: metal cans, aluminum, paperboard, plastic containers, other plastic, and corrugated cardboard. Total uncollapsed volume was 18.95 cubic yards. By collapsing these components, the overall volume of total waste was reduced 45% to 10.35 cubic yards. Comparison of volume and collapsed volume of waste for both facilities for the 14-day period is illustrated in Table 11.

Specific Weight The specific weight of total waste was computed by dividing the total weight of waste by the total volume of waste. The specific weight for total waste generated at both facilities is illustrated in Table 12. The mean specific weight of food waste and nonfood waste at the NCO Academy was 1191.29 and 149.88 lbs/cubic yard, respectively. The mean specific weight of the total waste stream was 407 lbs/cubic yard.

Table 11. Volume and collapsed volume of waste generated at both dining facilities during the 14-day period

Type of Waste	Total Volume (Yds^3)	Collapsed Volume (Yds^3)	Percent Difference (%)	Percent Collapsed Volume
Food Waste				
Production	1.8775	1.8775	0.00	7.59
Service	5.4775	5.4775	0.00	22.15
Total	7.3550	7.3550	0.00	29.74
NonFood Waste				
Paper				
Service	3.3513	3.3513	0.00	13.55
Other	2.4613	2.4613	0.00	9.95
Metal	2.0333	0.9686	-52.36	3.92
Aluminum	0.4338	0.2022	-52.36	0.81
Paperboard	5.4038	2.6056	-56.60	10.53
Plastic				
Container[a]	0.2769	0.1750	-35.16	0.71
Other[b]	3.9163	2.2801	-41.78	9.22
Cardboard	34.2480	4.9368	-85.58	19.96
Other[c]	0.6825	0.6825	0.00	2.76
Total	52.8072	17.6634	-66.55	70.26
Total Waste	60.1622	25.0184	-58.42	---

[a]Includes plastic bottles, jars, jugs.

[b]Includes plastic wrap, disposable serving containers, condiment packaging, and other miscellaneous waste of primarily plastic construction.

[c]Includes waste not defined by the study such as broken china, metal cleaning screens, and twine.

Table 12. Type, weight, volume, and specific weight of waste generated at both dining facilities during the 14-day period

Type of Waste	Total Weight (lbs)	Total Volume (Yds^3)	Range Specific Wt (lb/Yd^3)	Mean Specific Weight (lbs/Yd^3)
Food Waste				
Production	1403.50	1.88	105.26-1310.81	746.54
Service	7506.25	5.48	305.00-2188.64	1369.75
Total	8909.75	7.36	400.26-3499.45	1210.56
NonFood Waste				
Paper				
Service	692.55	3.35	94.01- 587.50	206.73
Other	448.65	2.46	82.35- 593.33	182.38
Metal	338.50	2.03	31.79- 360.19	166.75
Aluminum	24.75	0.43	16.67- 180.00	57.56
Paperboard	418.75	5.40	33.33- 144.80	77.55
Plastic				
Container[a]	44.75	0.28	52.63- 512.82	159.82
Other[b]	402.00	3.92	43.47- 215.15	102.55
Cardboard[d]	782.50	4.93	86.08- 178.13	158.72
Other[c]	175.50	0.68	66.88- 700.00	258.09
Total	3444.95	22.99		149.85
Total Waste	12354.70	30.35		407.07

[a]Includes plastic bottles, jars, jugs.

[b]Includes plastic wrap, disposable serving containers, condiment packaging, and other miscellaneous waste of primarily plastic construction.

[c]Includes waste not defined by the study such as broken china, metal cleaning screens, and twine.

[d]Volume for cardboard is collapsed.

Food Waste

Total food waste was composed of production and service food waste. Production food waste consisted of leftovers discarded from cold storage and non-edible waste such as coffee grinds, egg shells, meat trimmings, and vegetable and fruit peelings. Service waste included food wastes such as uneaten food returned on diners' trays, non-edible scraps such as bones and peels returned on diners' trays, food discarded from the service line due to over-production, and food that was never served.

Weight Total food waste as illustrated in Table 9 was composed of 736.25 and 3032.00 lbs of production and service waste, respectively or 73.47% of the total waste stream. An average of 52.59 and 216.63 lbs of production and service food waste, respectively was generated daily. The weight of the waste was composed of 19.5% production waste and 80.5% service waste. A mean of 0.14 lbs/meal of production waste and 0.56 lbs/meal of service waste were disposed daily. Each meal generated a mean total of 0.69 lbs.

Volume Table 10 illustrates the composition of the total waste stream generated by volume at the NCO Academy Dining Facility. A total of 3.16 cubic yards of food waste was generated during the 14 day period. The total volume of food waste was composed of 0.93 cubic yards or 0.0002 cubic yards/meal of production food waste and 2.24 cubic yards or 0.0004 cubic yards/meal of service food waste. An average of 0.2260 cubic yards/day of food waste was generated. Total volume of food waste was composed of 29.28% and 70.72% production and service food waste, respectively. Each meal generated a mean total of 0.0006 cubic yards of food waste.

Collapsed Volume Collapsed volume was not determined for food waste.

Specific Weight The mean specific weight of production and service food waste was 794.83 and 1355.42 lbs/cubic yard, respectively. The mean specific weight of the food waste was 1191.29 lbs/cubic yard. Mean specific weight for total waste generated at both facilities combined is illustrated in Table 12.

Proximate Analysis The proximate analysis of service food waste generated at the NCO Academy provided the following information as illustrated in Table 13:

Moisture content. The mean moisture content for breakfast, lunch and dinner meals was 66.58%, 69.67%, and 69.81%, respectively.

Protein content. The mean protein content for breakfast, lunch and dinner was 5.96%, 4.66%, and 5.99%, respectively.

Fat content. The mean fat content for breakfast, lunch and dinner was 7.32%, 5.25%, and 6.11%, respectively.

Table 13. Proximate analysis of service food waste for breakfast, lunch, and dinner at the NCO Academy Dining Facility

Meal	Moisture (%)	Protein (%)	Fat (%)	Carbohydrate (%)	Ash (%)
Breakfast	66.58	5.77	7.32	18.66	1.49
Lunch	69.67	4.68	5.25	19.52	0.89
Dinner	69.81	5.90	6.11	17.00	1.09
Total Mean[a]	68.69	5.54	6.23	18.40	1.15

[a] Total mean percents do not equal 100 due to rounding.

<u>**Ash content.**</u> The mean ash content for breakfast, lunch, and dinner was 1.49%, 0.89%,and 1.09%, respectively.

<u>**Carbohydrate content.**</u> Carbohydrates are the starches and sugars present in food waste. Carbohydrate content was determined as the remaining percent after protein, fat, moisture, and ash were subtracted. The mean carbohydrate content for breakfast, lunch, and dinner was 18.66%, 19.52%, and 17.00% respectively.

Nonfood Waste

Nonfood waste was sorted into 10 types of waste: service paper, other paper, metal, aluminum, paperboard, plastic containers, other plastic, glass, cardboard, and other nonfood waste that was not specifically defined in this study.

Weight Table 9 illustrates the composition of the nonfood waste generated by weight at the NCO Academy Dining Facility. A total of 1361.00 lbs of nonfood waste was generated during 14 day data collection period. Service paper waste (24%) composed the greatest percentage of the total nonfood waste and contributed an average of 23.48 lbs/day or 0.06 lbs/meal. The composition of the weight by percentage of total nonfood waste in declining order of the other materials included: corrugated cardboard (17%), other paper (15%), other plastic (12%), paperboard (11%), metals (8%), other nonfood waste (8%), glass (3%), plastic containers (1%), and aluminum (1%). An average of 97.23 lbs or 0.25 lbs/meal of nonfood waste was disposed daily.

Volume Table 10 illustrates the composition of the nonfood waste generated by volume at the NCO Academy Dining Facility. A total of 15.79 cubic yards of nonfood waste was generated during the 14 day period. Uncollapsed corrugated cardboard (47%) composed the greatest percentage of total volume of nonfood waste. The other materials constituted the following percent of total volume: paperboard (15%), service paper (12%), other plastic (12%), other paper (7%), metal cans (4%), other nonfood waste (3%), aluminum (2%), and plastic containers (1%). An average of 1.13 cubic yards or 0.0029 cubic yards/meal of nonfood waste was disposed daily.

Collapsed Volume Collapsed volume was determined for the following components of the waste stream: metal, aluminum, paperboard, plastic containers, other plastic, and corrugated cardboard. Total uncollapsed volume for nonfood waste was 15.79 cubic yards. By collapsing these components, the volume of nonfood waste was reduced 54.48% to 7.02 cubic yards. A comparison of uncollapsed and collapsed volume for both facilities for the 14 day period is illustrated in Table 11.

A factor for collapsed volume of plastic containers was used from the Shanklin & Ferris (1992) study of a university foodservice. They found that the initial volume of plastic containers was reduced by a mean percent of 64.80% by manually collapsing the containers for 12 measurements. Throughout this study, the volume and manually collapsed volume of paperboard containers were compared. The volume of paperboard containers was reduced by 43.40%; this percentage was based on 28 measurements.

A collapsed volume factor for non-aluminum metals was determined by comparing the calculated volume of cans collected per day to the actual volume of cans once they had been manually collapsed. The volume of cans was reduced by a 52.36%; this percentage was based on nine measurements.

This percentage was used to determine the collapsed volume of aluminum cans.

A collapsed volume factor for other plastic, not containers, was determined by comparing the initial volume of other plastic waste to the collapsed volume. The mean percent decrease using 28 measurements was reduced by 58.22.

The collapsed volume factor for corrugated cardboard boxes was derived by comparing the initial volume of boxes of the same length, width, and height to the volume of a stack of these boxes once they had been flattened. The mean percent decrease based on 19 measurements was 85.58.

Specific Weight The specific weight of nonfood waste was derived by dividing the total weight of waste by the total volume of waste. Specific weight was determined for the total waste generated by both facilities over the 14 day period and is illustrated in Table 12. The mean specific weight of all nonfood waste combined at the NCO Academy was 144.56 lbs/cubic yard. The specific weights in lbs/cubic yard for other materials in the waste stream were: service paper (177.82), other paper (172.83), metal cans (149.66), aluminum cans (49.29), paperboard containers (64.41), plastic containers and other plastic (147.31 and 85.21), and cardboard (210.71).

Weekend and Weekday Waste Generation

The mean weight and volume of waste generated at the NCO Academy on weekdays and weekends during the two data collection periods is illustrated in Tables 14, 15, 16 and 17. The weight/meal and volume/meal of waste generated during the week and on weekends at the NCO Academy Dining Facility was determined for food waste, nonfood waste, and total waste (Tables 18 and 19). No significant differences ($p<.05$) were found for weight/meal of food waste, nonfood waste, or total waste between weekdays and weekends. There was a significant difference ($p<.05$) between the volume of waste generated per meal of nonfood waste and total waste on weekdays and weekends (Table 19). The greater volume of nonfood waste generated during the week may be related to quantity of cardboard boxes disposed. When supplies were received, boxes were opened and discarded. No significant difference was found between the volumes of food wastes generated per meal.

Period I and Period II Waste Generation

The weight and volume of waste generated during the first data collection period (1st half of the month according to the military pay cycle) and the 2nd data collection period (2nd half of the month according to the military pay cycle) at the NCO Academy Dining Facility was determined for food waste, nonfood waste, and total waste. Results are presented in Tables 14, 15, 16, and 17. As illustrated in Table 20, significantly less food, nonfood, and total waste by weight was generated per meal during the 2nd period ($p<.05$). Significantly less food waste by volume

Table 14. Type and weight of waste generated on weekdays and weekends at the NCO Academy Dining Facility during the 1st Period[a]

Type of Waste	Total (lbs)	Average (lbs/Day)	Weekday (lbs/Meal)	Weekend (lbs/Meal)	Total (lbs/Meal)
Food Waste					
Production	340.50	48.64	0.17	0.14	0.16
Service	1377.25	196.75	0.66	0.61	0.65
Total	1717.75	245.39	0.83	0.75	0.81
Nonfood Waste					
Service	161.75	23.11	0.09	0.06	0.08
Other	462.25	66.03	0.22	0.21	0.22
Total	624.00	89.14	0.31	0.26	0.30
Total Waste	2341.75	334.54	1.14	1.01	1.11

[a] 1st period defined as meals served during the first half of the monthly military pay cycle.

Table 15. Type and weight of waste generated on weekdays and weekends at the NCO Academy Dining Facility during the 2nd Period[a]

Type of Waste	Total (lbs)	Average (lbs/Day)	Weekday (lbs/Meal)	Weekend (lbs/Meal)	Total (lbs/Meal)
Food Waste					
Production	395.75	56.54	0.14	0.07	0.12
Service	1655.50	236.53	0.49	0.52	0.50
Total	2051.25	293.04	0.63	0.59	0.62
Nonfood Waste					
Service	167.00	23.86	0.05	0.05	0.05
Other	570.00	81.43	0.18	0.14	0.17
Total	737.00	105.29	0.23	0.19	0.22
Total Waste	2788.25	398.33	0.86	0.78	0.84

[a]2nd Period defined as meals served during the second half of the monthly military pay cycle.

Table 16. Type and volume of waste generated on weekdays and weekends at the NCO Academy Dining Facility during the 1st Period[a]

Type of Waste	Total Waste (Yds^3)	Average (Yds^3)	Weekday (Yds^3/Meal)	Weekend (Yds^3/Meal)	Total (Yds^3/Meal)
Food Waste					
Production	0.5112	0.0730	0.0002	0.0002	0.0002
Service	1.1025	0.1575	0.0006	0.0004	0.0005
Total	1.6138	0.2305	0.0008	0.0006	0.0007
Nonfood Waste					
Service	1.1163	0.1595	0.0006	0.0003	0.0005
Other	5.7955	0.8279	0.0030	0.0021	0.0027
Total	6.9118	0.9874	0.0036	0.0024	0.0032
Total Waste	8.5256	1.2179	0.0044	0.0030	0.0039

[a]1st period defined as meals served during the first half of the monthly military pay cycle.

Table 17. Type and volume of waste generated on weekdays and weekends at the NCO Academy Dining Facility during the 2nd Period[a]

Type of Waste	Total Waste (Yds^3)	Average (Yds^3)	Weekday (Yds^3/Meal)	Weekend (Yds^3/Meal)	Total (Yds^3/Meal)
Food Waste					
Production	0.4150	0.0593	0.0001	0.0000	0.0001
Service	1.1350	0.1621	0.0003	0.0004	0.0003
Total	1.5500	0.2214	0.0004	0.0004	0.0004
Nonfood Waste					
Service	0.7325	0.1046	0.0002	0.0002	0.0002
Other	8.1407	1.1630	0.0027	0.0019	0.0025
Total	8.8732	1.2676	0.0029	0.0021	0.0027
Total Waste	10.4232	1.4890	0.0033	0.0025	0.0031

[a]2nd period defined as meals served during the second half of the monthly military pay cycle.

Table 18. Mean weight per meal of food, nonfood, and total waste generated on weekdays and weekends at both facilities

	NCO Academy (lbs/Meal)		1-34 Armor (lbs/Meal)		Both Facilities (lbs/Meal)	
Type of Waste	Weekday	Weekend	Weekday	Weekend	Weekday	Weekend
Food Waste	0.73	0.67	0.71	0.83	0.72	0.75
Nonfood Waste	0.27	0.23	0.30	0.26	0.29	0.25
Total Waste	1.00	0.90	1.01	1.09	1.01	1.00

There were no significant differences ($p<.05$) between the weight of weekday and weekend per meal waste.

Table 19. Mean volume per meal of food, nonfood, and total waste generated on weekday and weekends at both facilities

	NCO Academy (Yds^3/Meal)		1-34 Armor (Yds^3/Meal)		Both Facilities (Yds^3/Meal)	
Type of Waste	Weekday	Weekend	Weekday	Weekend	Weekday	Weekend
Food Waste	0.0006^a	0.0005^a	0.0006^a	0.0006^a	0.0006^a	0.0006^a
Nonfood Waste	0.0031^a	0.0023^b	0.0053^a	0.0035^a	0.0045^a	0.0029^a
Total Waste	0.0037^a	0.0028^b	0.0059^a	0.0041^a	0.0051^a	0.0034^a

[ab]Values with different superscripts in the same column are significantly different ($p<.05$).

Table 20. Mean weight per meal of food, nonfood, and total waste generated during the 1st period and the 2nd period at both facilities

	NCO Academy (lbs/Meal)		1-34 Armor (lbs/Meal)		Both Facilities (lbs/Meal)	
Type of Waste	1st Period[a]	2nd Period	1st Period	2nd Period	1st Period	2nd Period
Food Waste	0.80[b]	0.62[c]	0.71[b]	0.70[b]	0.75[b]	0.66[b]
Nonfood Waste	0.29[b]	0.22[c]	0.30[b]	0.27[b]	0.30[b]	0.25[c]
Total Waste	1.09[b]	0.84[c]	1.01[b]	0.97[b]	1.05[b]	0.91[b]

[a] 1st and 2nd periods are defined as meals served in the 1st half or 2nd half of the monthly military pay cycle, respectively.

[bc] Values with different superscripts in the same column are significantly different ($p<.05$).

was generated per meal in the 2nd period ($p<.05$) (Table 21). Less food items were purchased in the 2nd period which may account for the decrease in nonfood waste volume. The menus, including the market form of foods served during the two periods at both dining facilities, were analyzed to determine impact on waste weight and volume. No relationship could be identified between the menu alternatives or forms of food served during the two periods and waste generation. Similar types of meals were served at both facilities during both periods.

1-34 Armor Dining Facility

Facility Profile

A total of 7308 meals were served during the 14 day data collection period. Table 8 illustrates that a total of 3205 and 4103 meals were served at breakfast, lunch, and dinner during the 1st and 2nd periods, respectively. Throughout the 1st period, the mean weekday headcount for breakfast, lunch and dinner were 159, 164, and 134 meals compared to headcounts of 239, 283, and 200 during the 2nd period. Mean weekend headcount for brunch and dinner were 162 and 248 during period 1 and 120 and 125 for period 2.

Headcount was projected at this Army dining facility in accordance with AR 30-1 as described for the NCO Academy. The projected headcount for the 1st and 2nd data collection periods was 220 and 620 SIK per meal, respectively. Additional meals also were served to military personnel who

Table 21. Mean volume per meal of food, nonfood, and total waste generated during the 1st period and the 2nd period at both facilities

	NCO Academy (Yds^3/Meal)		1-34 Armor (Yds^3/Meal)		Both Facilities (Yds^3/Meal)	
Type of Waste	1st Period[a]	2nd Period	1st Period	2nd Period	1st Period	2nd Period
Food Waste	0.0008[b]	0.0005[c]	0.0006[b]	0.0006[b]	0.0006[b]	0.0005[b]
Nonfood Waste	0.0032[b]	0.0027[b]	0.0069[b]	0.0035[b]	0.0054[b]	0.0032[b]
Total Waste	0.0040[b]	0.0032[b]	0.0074[b]	0.0041[b]	0.0060[b]	0.0037[b]

[a] 1st and 2nd periods are defined as meals served in the 1st half or 2nd half of the military pay cycle, respectively.

[bc] Values with different superscripts in the same column are significantly different ($p<.05$).

were not authorized a mealcard and paid cash. The increase in authorized SIK between the 1st Period and 2nd Period in this facility resulted from serving two additional battalions during the 2nd Period because another facility was closed due to training. The mean headcount for breakfast, lunch and dinner was higher for the 2nd data collection period. It was hypothesized that more soldiers were likely to dine at any Army dining facility during the 2nd Period just prior to payday. Because this facility assumed the responsibility of feeding two additional battalions, differences in headcount was not possible to analyze. The 1-34 served only 58% of the authorized headcount. A sample daily menu at the 1-34 Dining Facility is presented in Appendix B on the Dining Facility Operations Meal Production Planning Production History Report.

Total and Per Meal Waste

Total waste and waste/meal were determined for 3 categories: food waste (production and service), nonfood waste (service paper, other paper, metals, aluminum, paperboard, plastic containers, other plastic, glass, corrugated cardboard, and other), and total waste.

Weight Table 22 illustrates the composition of the total waste stream generated by weight at the 1-34 Armor Dining Facility. A total of 7224.75 lbs of waste was generated during 14 day data collection period. The total weight was composed of 5140.75 lbs of food waste and 2084.00 lbs of

Table 22. Type and weight of waste generated at the 1-34 Armor Dining Facility during the 14-day period

Type of Waste	Total (lbs)	Percent Weight	Average (lbs/Day)	Total (lbs/Meal)
Food Waste				
Production	667.25	9.24	47.66	0.09
Service	4473.50	61.92	319.54	0.61
Total	5140.75	71.16	367.20	0.70
Nonfood Waste				
Paper				
Service	363.80	5.04	25.99	0.05
Other	249.90	3.46	17.85	0.03
Metal	233.75	3.24	16.70	0.03
Aluminum	11.55	0.16	0.83	0.01[d]
Paperboard	266.75	3.69	19.05	0.04
Plastic				
Container[a]	27.25	0.38	1.95	0.01[d]
Other[b]	239.25	3.31	17.09	0.03
Glass	74.75	1.03	5.34	0.01
Cardboard	546.50	7.55	39.04	0.07
Other[c]	70.50	0.98	5.04	0.01
Total	2084.00	28.84	148.88	0.29
Total	7224.75	---	516.08	0.99

[a]Includes plastic bottles, jars, jugs.

[b]Includes plastic wrap, disposable serving containers, condiment packaging, and other miscellaneous waste of primarily plastic construction.

[c]Includes waste not defined by the study such as broken china, metal cleaning screens, and twine.

[d]Percent weights calculated using data in total lbs column. Percentages do not equal 100 due to rounding.

nonfood waste. An average of 367.20 lbs or 0.70 lbs/meal and 148.88 lbs or 0.29 lbs/meal of food waste and nonfood waste, respectively was disposed daily. The weight of the waste was composed of 71.16% food waste and 28.84% nonfood waste. The 1-34 Armor Dining Facility generated a mean total of 516.08 lbs or 0.99 lbs/meal of total waste per day.

Volume Table 23 illustrates the composition of the total waste stream generated by volume at the 1-34 Armor Dining Facility. A total of 40.71 cubic yards of waste was generated during 14 day data collection period. The total volume was composed of 4.19 cubic yards or 0.0005 cubic yards/meal of food waste and 36.52 cubic yards or 0.0050 cubic yards/meal of nonfood waste. A daily average of 0.30 and 2.61 cubic yards of food waste and nonfood waste, respectively was generated. Total volume was composed of 10.30% food waste and 89.71% nonfood waste. Overall, the 1-34 Armor Dining Facility generated a mean daily total of 2.91 cubic yards of waste or 0.0056 cubic yards/meal.

Collapsed Volume The collapsed volume was determined for the following components of the waste stream: metal cans, aluminum, paperboard, plastic containers, other plastic, and corrugated cardboard. Total uncollapsed volume was 40.71 cubic yards. By collapsing these components, the volume of total waste was reduced 64.59% to 14.42 cubic yards. Comparison of volume and collapsed volume of waste for both facilities for the 14-day period is illustrated in Table 11.

Table 23. Type and volume of waste generated at the 1-34 Armor Dining Facility during the 14-day period

Type of Waste	Total (Yds^3)	Percent (Yds^3)[d]	Average (Yds^3/Day)	Total (Yds^3/Meal)
Food Waste				
Production	0.9513	2.34	0.0679	0.0002
Service	3.2400	7.96	0.2314	0.0004
Total	4.1913	10.30	0.2994	0.00065
NonFood Waste				
Paper				
Service	1.5025	3.69	0.1073	0.0002
Other	1.3113	3.22	0.0937	0.0002
Metal	1.3334	3.27	0.0952	0.0002
Aluminum	0.1650	0.41	0.0118	0.0000
Paperboard	3.0438	7.47	0.2174	0.0004
Plastic				
Container[a]	0.1581	0.38	0.0113	0.0000
Other[b]	2.0063	4.93	0.1433	0.0003
Cardboard	26.7526	65.71	1.9109	0.0037
Other[c]	0.2500	0.61	0.0179	0.0000
Total	36.5228	89.71	2.6088	0.0050
Total Waste	40.7141[e]	---	2.9081	0.0056

[a]Includes plastic bottles, jars, jugs.

[b]Includes plastic wrap, disposable serving containers, condiment packaging, and other miscellaneous waste of primarily plastic construction.

[c]Includes waste not defined by the study such as broken china, metal cleaning screens, and twine.

[d]Percent weights calculated using data in total lbs column. Percentages do not equal 100 due to rounding.

[e]Total volume was collapsed 65% to 14.4181 cubic yards

Specific Weight The specific weight of total waste was derived by dividing the total weight of waste by the total volume of waste. The specific weight for total waste generated at both facilities is illustrated in Table 12. The mean specific weight of food waste and nonfood waste at the 1-34 Armor Dining Facility was 1226.53 and 151.12 lbs/cubic yard, respectively. Overall the mean specific weight of the total waste stream was 403.39 lbs/cubic yard.

Food Waste

Total food waste was composed of production and service food waste. Production food waste consisted of leftovers discarded from cold storage, and non-edible waste such as coffee grinds, egg shells, meat trimmings and vegetable and fruit peelings. Service waste includes food wastes such as uneaten food returned on diners' trays, non-edible scraps such as bones and peels returned on diners' trays, food discarded from the service line due to over-production and food that was never served.

Weight As illustrated in Table 22, total food waste was composed of 667.25 and 4473.50 lbs of production and service waste, respectively. Food waste composed 71.16% of the total waste stream. An average of 47.66 lbs or 0.09 lbs/meal and 319.54 lbs or 0.61 lbs/meal of production and service food waste, respectively was generated daily. The weight of food waste was composed of 12.98% production waste and 87.02% service waste or 0.09 lbs and 0.61 lbs/meal, respectively. Each meal generated a mean total of 0.70 lbs of food waste; a mean of 367.20 lbs of total food waste was disposed daily.

Volume Table 23 illustrates the composition of the total waste stream generated by volume at the 1-34 Armor Dining Facility. A total of 4.19 cubic yards of food waste was generated during the 14 day period. The total volume of food waste was composed of 0.95 cubic yards of production food waste and 3.24 cubic yards of service food waste. A daily average of 0.30 cubic yards of food waste was disposed. Total volume of food waste was composed of 22.69% production food waste and 77.30% service food waste. Each meal generated a mean total of 0.0005 cubic yards of food waste.

Collapsed Volume Collapsed volume was not determined for food waste.

Specific Weight The mean specific weight of production and service food waste 701.41 and 1380.71 lbs/cubic yard, respectively. Means specific weight of total production and service food waste for both facilities is illustrated in Table 12. The mean specific weight of the food waste was 1226.53 lbs/cubic yard.

Proximate Analysis The proximate analysis of the service food waste generated at the 1-34 Dining Facility provided the information illustrated in Table 24.

Table 24. Proximate analysis of service food waste for breakfast, lunch, and dinner at the 1-34 Armor Dining Facility

Meal	Moisture (%)	Protein (%)	Fat (%)	Carbohydrate (%)	Ash (%)
Breakfast	70.09	5.57	9.05	13.94	1.35
Lunch	73.96	4.82	6.55	13.73	0.95
Dinner	74.73	3.91	4.29	15.94	1.14
Total Mean[a]	72.93	4.77	6.63	14.54	1.15

[a] Total mean percentages do not equal 100 due to rounding.

Moisture content. The mean moisture content for breakfast, lunch and dinner meals was 70.09%, 73.96%, and 74.73%, respectively.

Protein content. The mean protein content for breakfast, lunch and dinner was 5.57%, 4.83%, and 3.91%, respectively.

Fat content. The mean fat content for breakfast, lunch and dinner was 9.05%, 6.55%, and 4.29%, respectively.

Ash content. The mean ash content for breakfast, lunch, and dinner was 1.35%, 0.95%, and 1.14%, respectively.

Carbohydrate content. The mean carbohydrate content for breakfast, lunch, and dinner was 13.94%, 13.73%, and 15.94%, respectively.

Nonfood Waste

Nonfood waste was sorted into 10 types of waste: service paper, other paper, metal, aluminum, paperboard, plastic containers, other plastic, glass, cardboard, and other nonfood waste that was not specifically defined in this study.

Weight Table 22 illustrates the composition of the nonfood waste generated by weight at the 1-34 Armor Dining Facility. A total of 2084.00 lbs of nonfood waste was generated during 14 day data collection period. Corrugated cardboard waste (26%) composed the greatest percentage of the total nonfood waste and contributed a daily average of 39.04 lbs or 0.07 lbs/meal of waste. The percentage of other materials by total weight of nonfood included: service paper (17.5%), paperboard (12.8%), other paper (12.0%), other plastic (11.5%), metal cans (11.2%), glass (3.6%), other waste (3.4%), and aluminum (0.5%). A mean of 148.88 lbs or 0.29 lbs/meal of nonfood waste was discarded daily.

Volume Table 23 illustrates the composition of the nonfood waste generated by volume at the 1-34 Armor Dining Facility. A total of 36.52 cubic yards of nonfood waste was generated during the 14 day period. Corrugated cardboard (73.2%) composed the greatest percentage of total volume of nonfood waste. The other materials constituted the following percent of total volume: paperboard (8.3%), other plastic (5.5%), service paper (4.1%), metal cans (3.7%), other paper

(3.4%), other waste (0.7%), aluminum (0.5%), and plastic containers (0.4%). A mean of 2.61 cubic yards or 0.0050 cubic yards/meal of nonfood waste was disposed daily.

Collapsed Volume Collapsed volume was determined for the following components of the waste stream: metal cans, aluminum, paperboard, plastic containers, other plastic, and corrugated cardboard. Total uncollapsed volume for nonfood waste was 36.52 cubic yards. By collapsing these components, the overall volume of nonfood waste was reduced 72% to 10.23 cubic yards. A comparison of uncollapsed and collapsed volume for both facilities for the 14 day period is illustrated in Table 11.

Specific Weight The specific weight of nonfood waste was determined by dividing the total weight of waste by the total volume of waste. Specific weight was determined for the total waste generated by both facilities over the 14 day period and is illustrated in Table 12. The mean specific weight of all nonfood waste at the 1-34 Armor Dining Facility was 151.23 lbs/cubic yard.

The specific weights in lbs/cubic yard for other materials in the waste stream were: service paper (242.13), other paper (190.57), metal cans (175.30), aluminum cans containers (87.64), plastic containers and other plastic (70.00), paperboard (172.36 and 119.25), and corrugated cardboard (136.28).

Weekend and Weekday Waste Generation

The mean weight and volume of waste generated at the 1-34 Armor Dining Facility on weekdays and weekends during the two data collection periods are illustrated in Tables 25, 26, 27, and 28. The per meal weight and volume of waste generated on a weekday and weekends at the 1-34 Armor Dining Facility was determined for food waste, nonfood waste, and total waste as illustrated in Tables 18 and 19. No significant differences ($p<.05$) were found in the weight of food waste, nonfood waste, or total waste per meal between weekdays and weekends. No significant differences ($p<.05$) were observed between the volume of waste generated per meal for food waste, nonfood waste, or total waste.

Period I and Period II Waste Generation

The weight and volume of waste generated during the 1st data collection period (1st half of the month according to the military pay cycle) and the second data collection period (2nd half of the month according to the military pay cycle) at the 1-34 Armor Dining Facility was determined for food waste, nonfood waste, and total waste. Results are illustrated in Tables 25, 26, 27, and 28. No significant differences were found in the weight of food, nonfood and total waste disposed per meal during the 1st and 2nd periods (Table 20). No significant differences were found in the volume of food, nonfood, and total waste generated per meal during the 1st and 2nd periods ($p<.05$) was found (Table 21).

Table 25. Type and weight of waste generated on weekdays and weekends at the 1-34 Armor Dining Facility during the 1st Period[a]

Type of Waste	Total (lbs)	Average (lbs/Day)	Weekday (lbs/Meal)	Weekend (lbs/Meal)	Total (lbs/Meal)
Food Waste					
Production	455.00	65.00	0.16	0.08	0.14
Service	1816.50	259.50	0.61	0.48	0.57
Total	2271.50	324.50	0.77	0.56	0.71
Nonfood Waste					
Service	184.25	26.32	0.06	0.04	0.06
Other	782.25	111.75	0.26	0.20	0.24
Total	966.50	138.07	0.32	0.24	0.30
Total Waste	3238.00	462.57	1.09	0.80	1.01

[a]1st Period defined as meals served during the first half of the monthly military pay cycle.

Table 26. Type and volume of waste generated on weekdays and weekends at the 1-34 Armor Dining Facility during the 1st Period[a]

Type of Waste	Total Waste (Yds^3)	Average (Yds^3)	Weekday (Yds^3/Meal)	Weekend (Yds^3/Meal)	Total (Yds^3/Meal)
Food Waste					
Production	0.5488	0.0784	0.0002	0.0001	0.0002
Service	1.2375	0.1768	0.0004	0.0004	0.0004
Total	1.7862	0.2552	0.0006	0.0005	0.0006
Nonfood Waste					
Service	0.7600	0.1086	0.0003	0.0001	0.0002
Other	21.2089	3.0298	0.0075	0.0040	0.0067
Total	21.9689	3.1384	0.0078	0.0041	0.0069
Total Waste	23.7551	3.3936	0.0084	0.0046	0.0074

[a]1st period defined as meals served during the first half of the monthly military pay cycle.

Table 27. Type and weight of waste generated on weekdays and weekends at the 1-34 Armor Dining Facility during the 2nd Period[a]

Type of Waste	Total (lbs)	Average (lbs/Day)	Weekday (lbs/Meal)	Weekend (lbs/Meal)	Total (lbs/Meal)
Food Waste					
Production	212.25	30.32	0.05	0.08	0.05
Service	2657.00	379.57	0.60	1.02	0.65
Total	2869.25	409.89	0.65	1.10	0.70
Nonfood Waste					
Service	179.55	25.65	0.04	0.04	0.04
Other	937.90	133.99	0.23	0.23	0.23
Total	1117.45	159.64	0.27	0.27	0.27
Total Waste	3986.70	569.53	0.92	1.37	0.97

[a]2nd period defined as meals served during the second half of the monthly military pay cycle.

Table 28. Type and volume of waste generated on weekdays and weekends at the 1-34 Armor Dining Facility during the 2nd Period[a]

Type of Waste	Total Waste (Yds^3)	Average (Yds^3)	Weekday (Yds^3/Meal)	Weekend (Yds^3/Meal)	Total (Yds^3/Meal)
Food Waste					
Production	0.4025	0.0575	0.0001	0.0001	0.0001
Service	2.0025	0.2861	0.0005	0.0004	0.0005
Total	2.4050	0.3436	0.0006	0.0006	0.0006
Nonfood Waste					
Service	0.7425	0.1061	0.0002	0.0001	0.0002
Other	13.8115	1.9730	0.0035	0.0014	0.0033
Total	14.5540	2.0791	0.0037	0.0015	0.0035
Total Waste	16.9590	2.4227	0.0043	0.0021	0.0041

[a]2nd period defined as meals served during the second half of the monthly military pay cycle.

Comparison of the Two Facilities

Total Waste

Weight A total of 12354.70 lbs of waste was generated at both facilities during the 14 day study (Table 29). The NCO Academy and the 1-34 Armor Dining Facilities generated an average 0.94 lbs/meal and 0.99 lbs/meal, respectively. No significant differences at $p<.05$ were found between the two facilities (Table 30). The mean weight of total waste generated per meal for both facilities was 0.98 lbs.

Volume A total of 60.16 cubic yards of waste was generated at both facilities during the 14 day study. Table 31 illustrates the total waste by volume generated at both dining facilities. The NCO Academy generated 0.0035 cubic yards of waste per meal served and the 1-34 Armor Dining Facility generated 0.0056 cubic yards of waste per meal. No significant differences were observed in volume of waste per meal ($p<.05$) (Table 32). The mean volume of total waste disposed by both facilities per meal was 0.0047 cubic yards.

Collapsed Volume The total volume of waste generated by both facilities during the 14 day study was reduced 50.55% from 60.16 cubic yards to 29.75 cubic yards by collapsing 7 components of the waste stream. The percentage volume

Table 29. Type and weight of waste generated at both dining facilities during the 14-day period

Type of Waste	Total (Lbs)	Percent (Lbs)[d]	Average (Lbs/Day)	Total (Lbs/Meal)
Food Waste				
Production	1403.50	11.36	50.13	0.11
Service	7506.25	60.75	268.08	0.59
Total	8909.75	72.12	318.21	0.70
NonFood Waste				
Paper				
Service	692.55	5.61	24.73	0.05
Other	448.65	3.63	16.02	0.04
Metal	338.50	2.74	12.09	0.03
Aluminum	24.75	0.20	0.88	0.01
Paperboard	418.75	3.39	14.96	0.03
Plastic				
Container[a]	44.75	0.36	1.60	0.01
Other[b]	402.00	3.25	14.36	0.03
Glass	116.75	0.94	4.17	0.01
Cardboard	782.50	6.33	27.95	0.06
Other[c]	175.50	1.42	6.28	0.01
Total	3444.95	27.87	123.04	0.28
Total Waste	12354.70	---	441.24	0.98

[a]Includes plastic bottles, jars, jugs.

[b]Includes plastic wrap, disposable serving containers, condiment packaging, and other miscellaneous waste of primarily plastic construction.

[c]Includes waste not defined by the study such as broken china, metal cleaning screens, and twine.

[d]Percent weights calculated using data in total lbs column.

Table 30. Weight of waste per meal generated during the 1st Period, 2nd Period and total period at the NCO Academy and 1-34 Armor Dining Facilities

	1st Period (lbs/Meal)		2nd Period (lbs/Meal)		Total Period (lbs/Meal)	
Type of Waste	NCO Academy	1-34 Armor	NCO Academy	1-34 Armor	NCO Academy	1-34 Armor
Food Waste	0.80[a]	0.71[a]	0.62[a]	0.70[a]	0.69[a]	0.70[a]
NonFood Waste	0.29[a]	0.30[a]	0.22[a]	0.27[a]	0.25[a]	0.29[a]
Total Waste	1.09[a]	1.01[b]	0.84[a]	0.97[a]	0.94[a]	0.99[a]

[ab]Per meal values with different superscripts are significantly different ($p<.05$).

[c]1st and 2nd periods are defined as meals served in the 1st half or 2nd half of the military pay cycle respectively.

Table 31. Type and volume of waste generated at both dining facilities during the 14-day period

Type of Waste	Total (Yds^3)	Average (Yds^3/Day)	Total (Yds^3/Meal)	Percent (Yds^3)
Food Waste				
Production	1.8775	0.0670	0.0001	3.15
Service	5.4775	0.1956	0.0004	9.18
Total	7.3550	0.2626	0.0006	12.33
NonFood Waste				
Paper				
Service	3.3513	0.1197	0.0003	5.62
Other	2.4613	0.0879	0.0002	4.13
Metal	2.0333	0.0726	0.0002	3.41
Aluminum	0.4338	0.0155	0.0000	0.72
Paperboard	5.4038	0.1930	0.0004	9.06
Plastic				
Container[a]	0.2769	0.0099	0.0000	0.46
Other[b]	3.9163	0.1399	0.0003	6.56
Cardboard	34.2480	1.2231	0.0026	57.40
Other[c]	0.6825	0.0244	0.0000	1.14
Total	52.8072	1.8681	0.0041	87.67
Total Waste	60.1622[d]	2.1308	0.0047	---

[a]Includes plastic bottles, jars, jugs.

[b]Includes plastic wrap, disposable serving containers, condiment packaging, and other miscellaneous waste of primarily plastic construction.

[c]Includes waste not defined by the study such as broken china, metal cleaning screens, and twine.

[d]Total volume was collapsed 50.55% to 29.75 cubic yards.

Table 32. Volume of waste per meal generated during 1st Period, 2nd Period and total period at the NCO Academy and 1-34 Armor Dining Facilities

	1st Period (lbs/Meal)		2nd Period (lbs/Meal)		Total Period (lbs/Meal)	
Type of Waste	NCO Academy	1-34 Armor	NCO Academy	1-34 Armor	NCO Academy	1-34 Armor
Food Waste	0.0008	0.0006	0.0005	0.0006	0.0006	0.0006
Nonfood Waste	0.0032	0.0069	0.0027	0.0035	0.0029	0.0050
Total Waste	0.0040	0.0074	0.0032	0.0041	0.0035	0.0056

There were no significant differences ($p<.05$) between the volume of waste per meal between the NCO Academy and the 1-34 Armor Dining Facilities in the 1st, 2nd, or entire period of study.

reduced when materials were collapsed was: metal cans (-52.36%), aluminum (-53.36%), paperboard (-56.60%), plastic containers (-35.10%), other plastic (-41.78%), and cardboard (-85.58%) (Tables 11 and 31). The total volume of waste generated by the NCO Academy was reduced 45% from 18.95 to 10.35 cubic yards and the total volume of waste generated by the 1-34 Armor Dining Facility was reduced by 65% from 40.71 to 14.42 cubic yards. Differences in volume reduction is related to percentages of nonfood waste components (Table 33).

Specific Weight The mean specific weight of the total waste stream for both facilities combined for the 14 day period was 407.07 lbs/cubic yard.

Food Waste

Weight A comparison of the type and percent of waste by weight generated at both dining facilities combined during the 14 day period is illustrated in Table 29. Food waste composed the largest percentage of total waste by weight for both the NCO Academy (73.47%) and the 1-34 Armor (71.16%) dining facilities (Tables 9, 22, and 34). The NCO Academy generated 0.69 lbs of food waste per meal and the 1-34 Armor Dining Facility generated 0.70 lbs of waste per

Table 33. Comparison of the type and percent of waste by volume generated at both dining facilities during the 14-day period

Type of Waste	NCO Academy (%)	1-34 Armor (%)
Food Waste		
Production	4.89	2.34
Service	11.81	7.96
Total	16.70	10.29
Nonfood Waste		
Paper		
Service	9.76	3.69
Other	6.07	3.22
Metal	3.69	3.27
Aluminum	1.41	0.41
Paperboard	12.45	7.48
Plastic		
Container[a]	0.63	0.39
Other[b]	10.08	4.92
Cardboard	39.56	65.71
Other[c]	2.28	0.61
Total Nonfood	83.30	89.71
Total	100.00	100.00

[a]Includes plastic bottles, jars, jugs.

[b]Includes plastic wrap, disposable serving containers, condiment packaging, and other miscellaneous waste of primarily plastic construction.

[c]Includes waste not defined by the study such as broken china, metal cleaning screens, and twine.

Table 34. Comparison of the type and percent of waste by weight generated at both dining facilities during the 14-day period

Type of Waste	NCO Academy (%)	1-34 Armor (%)
Food Waste		
Production	14.35	9.24
Service	59.12	61.92
Total	73.47	71.16
Nonfood Waste		
Paper		
Service	6.41	5.04
Other	3.87	3.46
Metal	2.04	3.24
Aluminum	0.25	0.16
Paperboard	2.96	3.69
Plastic		
Containers	0.34	0.38
Other[b]	3.17	3.31
Glass	0.82	1.03
Cardboard	4.60	7.55
Other[c]	2.05	0.98
Total	26.51	28.84

[a]Includes plastic bottles, jars, jugs.

[b]Includes plastic wrap, disposable serving containers, condiment packaging, and other miscellaneous waste of primarily plastic construction.

[c]Includes waste not defined by the study such as broken china, metal cleaning screens, and twine.

meal. No significant difference was observed in weight of food waste/meal between these two facilities ($p<.05$) (Table 30). The mean weight of food waste disposed per meal for both facilities combined was 0.70 lbs.

Volume A comparison of the type and percent of waste by volume generated at both dining facilities combined during the 14 day period is illustrated in Table 31. Food waste composed 16.70% and 10.29% of the total waste stream at the NCO Academy and the 1-34 Armor Dining Facilities, respectively (Tables 10, 23, and 33). The NCO Academy and 1-34 Armor Dining Facilities both generated a mean volume of 0.0006 cubic yards per meal (Table 32).

Nonfood Waste

Weight Service paper waste and corrugated cardboard were the two nonfood materials which composed the greatest percentage by weight at both facilities. NCO Academy Dining Facility disposed 6.41% service paper waste and 4.60% corrugated cardboard; 1-34 Armor Dining Facility discarded 5.04% service paper waste and 7.55% corrugated cardboard (Table 33). The NCO Academy generated 0.25 lbs of nonfood waste per meal and the 1-34 Armor Dining Facility generated 0.29 lbs of waste per meal which was not significantly different ($p<.05$) (Table 30). The mean weight of nonfood waste disposed per meal by both facilities combined was 0.27 lbs (Table 35).

Table 35. Type and weight of waste generated on weekdays and weekends at both dining facilities during the 14-day period

Type of Waste	Total (lbs)	Average (lbs/Day)	Weekday (lbs/Meal)	Weekend (lbs/Meal)	Total (lbs/Meal)
Food Waste					
Production	1403.50	50.13	0.12	0.09	0.11
Service	7506.25	268.08	0.58	0.60	0.59
Total	8909.75	318.21	0.70	0.69	0.70
Nonfood Waste					
Service	692.55	24.73	0.06	0.03	0.05
Other	2752.40	98.30	0.22	0.21	0.23
Total	3444.95	123.03	0.28	0.24	0.28
Total Waste	12354.70	441.50	0.98	0.93	0.98

Volume Corrugated boxes composed the largest percentage of nonfood waste for both dining facilities (Tables 10, 23, and 33, 36). The NCO Academy discarded 0.0029 cubic yards of nonfood waste per meal and the 1-34 Armor Dining Facility generated 0.0050 cubic yards of nonfood waste per meal. No significant differences in volume of nonfood waste was found between the two dining facilities ($p<.05$) (Table 32). The mean volume of nonfood waste generated per meal by both facilities combined was 0.0040 cubic yards (Table 36).

Collapsed Volume By collapsing 7 components of the nonfood waste stream: metal cans (-52.16%), aluminum (-52.36%), paperboard (-56.40%), plastic containers (-35.16%), other plastic (-41.78%), and cardboard (-85.58%), total nonfood waste at the NCO Academy was reduced 54% from 15.79 to 7.19 cubic yards. Nonfood waste at the 1-34 Armor Dining Facility was reduced 65% from 36.52 to 10.23 cubic yards (Tables 10 and 23).

Table 36. Type and volume of waste generated on weekdays and weekends at both dining facilities during the 14-day period

Type of Waste	Total Waste (Yds^3)	Average (Yds^3)	Weekday (Yds^3/Meal)	Weekend (Yds^3/Meal)	Total (Yds^3/Meal)
Food Waste					
Production	1.88	0.07	0.0001	0.0001	0.0002
Service	5.48	0.20	0.0004	0.0005	0.0004
Total	7.36	0.27	0.0006	0.0006	0.0006
Nonfood Waste					
Service	3.35	0.12	0.0003	0.0002	0.0003
Other	49.46	1.75	0.0042	0.0027	0.0037
Total	52.81	1.87	0.0045	0.0029	0.0040
Total Waste	60.17	2.14	0.0050	0.0034	0.0046

Specific Weight The specific weight of nonfood waste at the NCO Academy and 1-34 Armor Dining Facilities was 144.55 lbs/cubic yard and 151.23 lbs/cubic yard, respectively. The specific weight of cardboard was calculated using the collapsed volume. The uncollapsed volume was used to calculate specific density for all other components of the waste stream (Table 12).

Weekend and Weekday Waste Generated

No significant differences were observed for weight and volume of waste generated per/meal between weekdays and weekends at either the NCO Academy or the 1-34 Armor Dining Facilities. Weight and volume of food, nonfood and total waste generated at both facilities was combined to give an overall weight and volume per/meal for weekday and weekend food, nonfood, and total waste. No significant differences were determined between weekdays and weekends for lbs/meal of food waste (0.72 lbs and 0.75 lbs), nonfood waste (0.29 lbs and 0.25 lbs) or total waste (1.01 lbs and 1.00 lbs) or cubic yards/meal of food waste (0.0006 and 0.0006 cubic yards), nonfood waste (0.0045 and 0.0029 cubic yards), or total waste (0.0051 and 0.0034 cubic yards) (Tables 18 and 19). It was not determined if there was a significant difference between the combined weight and combined volume of waste generated at the NCO Academy and the 1-34 Dining Facilities disposed on weekend days and weekdays.

Period I and Period II Waste Generation

Weight of waste generated per meal during the 1st period, 2nd period, and the total period was analyzed to determine if significant differences existed between the two facilities. A significant difference at p<.05 was found for total weight per meal at the NCO Academy (1.09 lbs/meal) and the 1-34 Armor Dining Facilities (1.01 lbs) during the 1st period (Table 30). No significant differences in weight of waste per meal were observed for food or nonfood waste during the 1st period. No significant differences in weight of waste per meal were observed for food, nonfood, and total waste during the 2nd period or during the total period between the two facilities. No significant differences between the volume of waste generated per meal during both periods and the total period between the NCO Academy and the 1-34 Armor Dining Facilities were observed.

Significance of Information Derived from Waste Characterization Studies and Recommendations

Headcount

The ability to predict the number of people that will be dining during a specific meal, day, or period is a critical factor in accurately forecasting production demand. Failure to accurately forecast production can result in over and under production of food, both of which can cause an increase in solid waste generation. Over production can result in excess food, some of which cannot be saved and must be disposed. This practice increases the weight and volume of food waste. If more customers than expected arrive for a meal, under production of food is often offset through the use of convenience foods which are often packaged individually and may cause increased nonfood waste.

The NCO Academy Dining Facility's mission is to serve meals to soldiers attending leadership courses at the academy. Due to the short meal times and restriction to the training areas adjacent to the dining facility, the NCO Academy Dining Facility manager's ability to project actual headcount should be enhanced. The unknown factor is the number of soldiers, not currently enrolled at the NCO Academy leadership course, who decide to dine at the NCO Academy facility. The manager of this facility stated that he expected approximately 20 individuals per meal in addition to those soldiers projected on DA Form 2970 which is based on historical records (Mr. J.D.W. Warden, personal communication, March 15, 1993). Throughout the 14 days of data collection, the actual headcount at the NCO Academy Dining Facility was 92% or higher of the projected headcount for 34 of the 42 meals served. The actual headcount was less than 80% of the facility's projection only once during the study.

Unlike the NCO Academy Dining Facility's mission to serve meals to soldiers attending specific leadership courses, the 1-34's mission is to serve personnel assigned to that battalion and the Headquarters Company, 1st Brigade. The factors that cause the customarily steady headcount at the NCO Academy do not exist at the 1-34 Dining Facility. Soldiers assigned to the 1-34 Armor Battalion are generally free to eat at any Army dining facility or civilian foodservice establishment they desire. Therefore, the 1-34 Dining Facility manager's ability to project actual headcount is more difficult and is based on past experiences, the season, the weather, and to some extent the time of the month based on the military pay cycle (SFC R.A. Olson, personal communication, 7 June 1993). During the study, the 1-34 served only 58% of the authorized headcount daily. There was a large variation from meal to meal. The NCO Academy, as proposed, was able to predict the actual headcount more accurately. However, in this study, there does not seem to be a correlation between headcount projection accuracy and quantity of food waste. As illustrated in Table 30, no significant difference in the weight of food waste per meal generated between the NCO Academy and 1-34 Armor Dining Facilities was observed during the 1st, 2nd, and total period.

It was further hypothesized that more soldiers were likely to eat at an Army dining facility during the 2nd Period. It was projected that when changes in headcount were combined with menu and purchasing cycles, these factors may affect waste generation. Significantly less food waste, nonfood waste, and total waste weight was generated at the NCO Academy during the 2nd period as illustrated in Table 20 ($p<.05$). Army dining facilities must reconcile their accounts within plus or minus 3% of revenue generated by the end of the month on the manual system, or balance evenly or be within minus 3% on the AFMIS system. It is possible that the difference in weight of waste disposed at the NCO Academy Dining Facility during the 2nd period may be attributable to the manager's actions to meet end of month objectives through more careful production planning, fewer food items being purchased and placed in inventory, and hence, less packaging weight. A significant decrease in food waste volume also occurred during the 2nd period at the NCO Academy ($p<.05$) as illustrated in Table 21.

No significant difference in the weight or volume of waste/meal generated at the 1-34 Armor Dining Facility was observed between the 1st and 2nd period. Differences may have been obscured by the substantial increase in projected headcount during the last week of July, 1993.

Food Waste

A large amount of food waste can be an indicator of several foodservice problems. Some of these problems can include: poor forecasting of production demand and the consequent over-production of food which is not used and cannot be saved; cooks not following food production worksheets and preparing greater number of servings than the worksheet indicated; customers' dissatisfaction with the sensory attributes of the food or general dislike of menu alternatives; portion sizes are too large; diners self serving too much food; and food spoilage resulting from poor inventory practices.

Food waste was the largest component by weight of waste generated in both dining facilities in this study. All food waste generated at dining facilities on Fort Riley is currently picked up and used by a local swine farmer as livestock feed. Over this 14 day study, the two facilities generated 8,909.75 lbs of food waste which would have gone into landfill if it had not been diverted to the swine farmer. This practice reduced the total weight of waste generated by 70% and diverts approximately 500 tons of food waste per year from the landfill. Since Fort Riley has 12 functioning dining facilities, an estimated 3000 tons of food waste is diverted from the landfill annually.

Food waste can be reduced through a series of steps: 1) strict adherence to scheduled food production which is based on accurate headcount projections; 2) the periodic review of menu items to ensure they meet the customer's expectations for flavor, appearance, and portion size; 3) identification of techniques to reduce waste from self-service items; and 4) good inventory control practices that confirm that produce and other perishable foods are used on first in - first out basis to prevent spoilage. Once food waste has been generated, the amount sent to landfills can be reduced by: 1) recycling food waste in the form of livestock feed, 2) donating over-production to charities, 3) composting, and 4) selling food wastes to manufacturers of value added products such as pet foods and fish foods.

Food safety requirements at U.S. Army dining facilities are stringent (Technical Bulletin Med 530 - Occupational and Environmental Health, Food Service Sanitation) and may increase food waste unnecessarily. The regulation outlines that food products that are "creamed, receive excess handling such as hashes, gravies and dressings, or are highly perishable such as most seafood" may not be retained as leftovers and served at subsequent meals. Although TB Med 530 only gives examples of foods that conceivably could receive "excessive handling", foodservice personnel in the U.S. Army routinely dispose all products containing eggs, dairy products, and seafood. With good sanitation, strict temperature control, good hygiene practices, and prevention against contamination during service, these products could be safely stored under proper refrigeration and served within 24 hours at other meals. This is a routine practice at other types of foodservice operations. TB Med 530 presently references specific types of foods as examples for the handling of potentially hazardous foods (PHF). By eliminating reference to specific types of foods, foodservice managers who practice high standards of sanitation and do not handle foods excessively during preparation could hold more foods as leftovers and thereby reduce food waste.

TB Med 530 prohibits the freezing of leftover foods. U.S. Army dining facilities which have access to sufficient freezer space could freeze leftover foods that had been prepared in accordance with proper handling and sanitation regulations and stored at the proper temperatures to prevent microbial growth. This is also a common practice at commercial and school foodservice operations and could reduce food waste. TB M d 530 currently provides guidelines that include labeling with date of time of preparation for the storage of frozen pre-prepared foods at 0°F for up to 45 days which could be applied to the treatment of frozen leftovers.

The best method of reducing food waste is proper production demand forecasting and proper food service management, such as the use of small batch preparation, progressive cookery, and knowledge of diner preferences. However, there are times when unintentional over-production of food does occur. The donation of food that was over-produced is strictly prohibited by AR 30-1. The researcher observed a significant quantity of edible food being disposed for swine feed. A program, whereby, needy Army families could be provided with excess food resulting from unintentional over-production should be investigated.

Controls currently exist to prevent intentional over-production and pilferage through high dollar items accounting requirements and end of month reconciliations.

The researcher observed that when a dining facility was closed for the weekend, all leftovers and any opened containers of food, including high cost condiments such as soy sauce, steak sauce, etc. were disposed rather than transferred to another facility. Transfers of food from one dining facility to another is authorized; however, the procedures are lengthy and time consuming and require the approval of the post food advisor. The food items that are transferred to another facility are not deducted from the releasing dining facility's account nor is the receiving dining facility charged for these items. Regulations currently exist to prevent pilferage of these items. Elimination of requirements to coordinate with the post food advisor would simplify and may enhance the transfer process and thereby reduce waste by curtailing current practices of disposing of all leftovers and opened containers. Additionally, the use of bulk condiments portioned into approved dispensers could reduce the disposal of these food items.

Most U.S. Army dining facilities offer a short order line for lunch and dinner meals that include made-to-order sandwiches that can be partially prepared up to one hour prior to service provided they are maintained at safe temperatures and are protected from contamination. TB Med 530 requires that these sandwiches are disposed three hours after preparation. However, if these sandwiches are individually wrapped and labeled (DA Label 177) with the production date and time, they could be held for up to 24 hours under proper temperature controls. Dining facility managers should prepare all sandwiches in this manner in order to reduce food waste and cost.

Individual portions of food once served to a diner in a U.S. Army dining facility are not retrieved for re-serving. However, TB Med 530 does allow for the reuse of unsliced, hardskinned fruits that are washed and unopened commercially packaged, non-potentially hazardous foods such as packaged crackers and individually packaged condiments. Personnel in the dishroom should be instructed to remove these items from diner's trays which would reduce food waste generation. Before this practice is implemented, dining facility managers must assess the impact on productivity of the dishroom personnel.

Proximate Analysis

An alternative to landfilling food wastes is low-cost feed for livestock. Polanski (1992) reported that 13 states allow the feeding of food waste to livestock after being heated to 212°F for 30 minutes. In order to formulate a well-balanced ration for food-waste fed livestock, a definite knowledge of the nutrient composition of food waste must be obtained (Burdick, 1958). This knowledge provides the basis for blending various feed supplements to make the food waste meet all the nutritional requirements of the livestock. Additionally, this information is essential to emerging new concepts for the use of food waste such as pet foods, and feed on fish farms (Sehgal & Thomas, 1987).

Moisture Content The optimum moisture content of waste for aerobic composting ranges from 50 to 60% (Tchobanoglous, et al., 1993). Knowledge of the moisture content of waste will assist in determining the amount of moisture that needs to be added to the compost material. Secondly, the weight of food waste is impacted by moisture content and will affect costs associated with hauling waste. Moisture content is also a factor when incinerating waste.

The high percentage of moisture in this service food waste resulted from the types of leftover foods discarded from the service line. Food that contain a high amount of water including vegetables, gravies, and soups were disposed directly to the waste container and not drained.

Protein Composition Tchobanoglous et al (1993) reported percent of nitrogen in mixed slaughterhouse waste as 7.0-10.0. The protein content of service waste in this study was a mean 5.03%. Foods containing a high percentage of protein, are generally high cost foods such as meats. The high percentage of protein in the service food waste in this study could indicate potential to decrease food costs.

Protein content also is a critical parameter in the control of composting in which the carbon/nitrogen content must be maintained at designated levels (Tchobanoglous, et al., 1993).

Nonfood Waste

Identifying the type and amount of nonfood waste generated in a foodservice establishment will provide data necessary to develop a solid waste management plan. Management can use this data to identify appropriate strategies to effectively reduce the volume and weight of solid waste through reduction initiatives, recycling, and composting. Nonfood waste composed 87.68% and 27.88% by volume and weight, respectively of waste generated in this study. Currently 61% by volume and 30% by weight of nonfood waste is recycled on Fort Riley. Nonfood waste currently recycled on Fort Riley includes metal cans, aluminum, plastic containers, glass, and cardboard. Nonfood waste that is not currently recycled from dining facilities include: service and other paper, other plastic, and other nonfood waste.

Nonfood waste generation can be reduced by foodservice organizations by implementing source reduction and reuse principles. Suggested approaches described in trade and government publications (Frumkin, 1989; King, 1990; Townsend, 1990; McDonald's, 1991; EPA, 1992b) include:

1) Develop a waste reduction purchasing strategy. Make your preferences for products that are manufactured with recycled content and that can be recycled known to manufacturers, distributors, and customers.

- Purchase bulk or concentrated items. Larger food containers can reduce the amount of packaging used (provided the larger size does not lead to food spoilage). For example, a single 16-ounce can uses 68 grams of metal, or 40% less than the 95.4 grams used in two 8-ounce cans. Bulk condiments, for example, can be served in reusable pump dispensers. Currently, the dining facilities on Fort Riley purchase condiments such as soy sauce, hot sauce, steak sauce, etc. in consumer sized containers. This practice generates excessive packaging waste (glass and plastic containers). Excessive food waste was observed since bottles were often disposed one-third full. The contents of bulk containers divided into reusable pumps would eliminate more than half of the glass currently generated at these facilities. TB Med 530 presently allows for the use of approved dispensers.

- Do not purchase individual, disposable items such as individual condiments, disposable plastic prefilled cereal bowls, or individual ice cream cups. More than half of the other plastic waste generated at both facilities consisted of individual, disposable cereal bowls; yogurt containers; juice and milk boxes; and individual ice cream cups. The facilities could easily provide cereal from bulk dispensers. Cereal could be served in permanent ware bowls that could be washed, sanitized, and reused. Individual juice, milk, and ice cream containers should be eliminated since both facilities have dispensing machines and the permanent ware and serviceware needed to serve these menu items.

- Purchase items that contain recycled material whenever possible. The U.S. Army should develop product specifications which include packaging reduction.

- Purchase items packaged in recyclable or reusable containers. Purchasing agents should consider reusable products which meet sanitation guidelines. TB Med 530 permits the use of cloths for wiping foods spills on kitchenware and food-contact surfaces provided they are rinsed frequently in a sanitizing solution, and stored in a sanitizing solution between uses. Reusable cloths also may be used to clean nonfood-contact surfaces such as counters, dining tables tops and shelves provided they are rinsed, sanitized and used for no other purpose. During this study, the cleaning personnel used heavy weight, highly absorbent paper towels for cleaning. The researcher observed that these paper towels composed approximately half or more of the other paper waste category. This waste could be reduced through the use of cloth towels.

- Purchase items that are available in refillable or reusable containers, e.g., plastic racks for bread products, fresh meats, fruits and vegetables which can reduce cardboard packaging. Reuse bags, containers, and other items when practical and sanitation standards can be achieved.

2) Consider the production of waste based on the market form of food selected. Prepared foods generate more packaging waste, whereas, conventional production systems which use fresh fruits and vegetables generate more production food waste. Since Army dining facilities at Fort Riley have developed a diversion for food waste to swine farmers and have the capability to prepare menu items from fresh produce, efforts should be made to ensure scratch preparation whenever possible.

3) Adopt practices that reduce waste toxicity. Use less hazardous and toxic alternatives or components to accomplish the same task such as unbleached paper napkins.

4) Control the use of disposables such as napkins and straws by customers.

5) Maintain and repair durable products and replace less frequently. Foodservice purchasing agents must consider quality when making capital equipment purchases.

6) Borrow and share items used infrequently.

When these reduction initiatives have been exhausted, recycling will further reduce the volume and weight of nonfood waste. An increasing number of institutional and commercial foodservice operators have begun to participate in reducing the solid waste stream by implementing recycling programs.

In this study, 83% and 75% of the total waste stream by weight and volume, respectively were recycled. The disadvantages associated with recycling such as storage space, time devoted to sorting, and preparing materials for pick-up can all be easily overcome in a military setting. The close proximity of many dining facilities and other operations makes an Army installation ideal for developing a recycling system. Many installations currently operate a Material Recovery Facility (MRF) which generates revenue used to sponsor family and community activities. Fort Riley has a comprehensive recycling program; estimated total revenue generated for 1991 from recycling was between $300,000 to $400,000 (Funke et al., 1992).

Recycling programs can be enhanced through education of employees. Throughout this study, soldiers and civilians employed at both dining facilities expressed genuine interest in recycling. Management's emphasis on the importance of recycling and the structuring of recycling systems to make them convenient would enhance the recycling efforts that are currently in place.

Composting of organic components of the waste stream is another alternative to reduce the weight and volume of waste that is landfilled. Paper and paperboard waste which composed 13% and 19% by weight and volume, respectively of the waste stream in this study could be diverted at Fort Riley through composting. This additional waste management strategy would further reduce the total waste stream at both dining facilities to an aggregate of 96% and 94% by weight and volume, respectively.

Collapsed Volume

Even after adopting efficient waste reduction initiatives and using available recycling programs, solid waste may still need to be disposed. It is essential to reduce the volume of this waste. At some sites, waste hauling charges are based on the size of waste bins and frequency of pickups. The advantages associated with reducing the volume of solid waste were outlined by Nicholls (1991). They included: 1) reduction in space required to store waste, 2) reduction in the number of garbage containers or dumpsters required, 3) reduction of disposal or/cartage costs, 4) reduction in pilferage through increased security, 5) more sanitary working environment, and 6) reduction in the volume of waste going to the landfill. A total of 60.16 cubic yards of waste was generated at both dining facilities during the 14 day study. The volume of six components of the nonfood waste stream was reduced through compaction by the following percentages: cardboard waste (85.58%) metal cans (52.36%), aluminum cans

(52.36%), paperboard waste (56.60%), other plastic (41.78%) and plastic containers (35.16%). The total volume of waste was reduced 50.55% to 29.75 cubic yards.

Machines are available to reduce the volume of waste generated in foodservice facilities. However, waste volume reduction can be satisfactorily accomplished at small U.S. Army dining facilities where the purchase of such costly machines is not feasible and recycling programs are not yet available through simple manual compaction such as the breaking down of boxes and the crushing of cans and plastic containers.

Comparison to Other Studies

Weight and Volume of Waste Per Meal The style of service in the two U.S. Army dining facilities was similar to cafeteria-style foodservice establishments. Total food waste generated at the NCO Academy and the 1-34 Dining Facilities was 0.94 and 0.99 lbs/meal, respectively. Total volume per meal was 0.0035 and 0.0056 cubic yards at the NCO Academy and 1-34 Armor Dining Facilities, respectively. The National Solid Waste Management Association (NSWMA)(1989) estimated that cafeterias generated 1.0 lbs/meal. Data from these two facilities were similar to this estimate.

In five studies of school and university foodservice, Kelley et al. (1983); Hollingsworth et al. (1990, 1992); Riley et al. (1991); and Shanklin & Ferris (1992), it was reported that approximately 0.50 lbs/meal of waste was generated. In a study of food and beverage operations of two hotels, Pettay (1992) reported that 1.32 and 1.61 lbs/meal was disposed. The weight/meal of waste generated in these two military dining facilities was approximately equal to 1 lbs/meal which was the amount estimated by the NSWMA (1989) for a cafeteria style foodservice, which was greater than what was reported in the school and university studies and less than Pettay's (1992) findings.

Riley et al (1991) further reported that 0.0032 and 0.0029 cubic yards/meal were generated at breakfast and lunch combined in school foodservice using conventional serviceware systems. Shanklin & Ferris (1992) determined that 0.0036 cubic yards/meal was generated in a university foodservice operation. Pettay (1992) reported a much higher per meal volume of total waste: 0.013 and 0.014 cubic yards at two hotel properties. In this study, a mean 0.0048 cubic yards/meal was generated which is greater than the volumes reported in Riley et al. (1991) and the Shanklin and Ferris (1992) studies, but less than the volume reported by Pettay.

In this study, food waste represented 72.12% and 12.25% by weight and volume, respectively. Food waste has been shown to compose the greatest percentage by weight of the solid waste stream in foodservice organizations. Results of this study support those of Hollingsworth et al. (1990); Rabasca (1993); Pettay (1992); and Shanklin & Ferris (1992).

Cardboard (6.33%) and service paper (5.61%) constituted the two materials contributing the greatest percentages by weight of nonfood waste. Likewise, Shanklin & Ferris (1992) found that cardboard (9.12%) and service paper (5.54%) were the two items contributing the greatest quantity by weight percentage of nonfood waste.

Specific Weight Tchobanoglous et al. (1993) indicated that it is difficult to report the specific waste of solid waste because of differences caused by the amount of compaction, season of the year, and length of time in storage. The specific weights reported in this study were based on waste that was not compacted, collected during the summer season, and which had been in storage less than 4 hours (Table 12). Tchobanoglous, et al. (1993) reported the range of specific weights for wet commercial food wastes as 800-1600 lbs/cubic yard. The range in this study was 407.83 - 3499.48 lbs/cubic yard, with an average specific weight of 1210.56 lbs/cubic yard. A comparison of the range of specific weights determined for nonfood waste components of the total waste stream for both facilities with values reported by Tchobanoglous et al. (1993) showed that specific weights determined for this study were within reported ranges except for cardboard and aluminum containers. Tchobanoglous et al.'s (1993) listed cardboard in the uncompacted waste category with a range of 70-135 lbs/cubic yard but it was not clear whether the boxes were flattened before the volume was determined. The specific weight for cardboard in this study was 158.72 lbs/cubic yard which was derived from the collapsed (flattened) volume of cardboard boxes. The specific weight for aluminum cans in this study was 57.56 lbs/cubic yard which was less than the Tchobanoglous et al. (1993) range of 110-405 lbs/cubic yard. A comparison of the specific weight for other material in the waste stream in this study with ranges reported by the Tchobanoglous et al (1993) study are illustrated in Table 37.

Summary

An average of 0.98 lbs and 0.0047 cubic yards/meal of waste was generated at two U.S. Army dining facilities. The percentages of waste by weight and volume, respectively of the waste stream were: corrugated cardboard (6.33 and 56.93), food waste (72.12 and 12.25), paperboard (3.39 and 8.98), other plastic (3.25 and 6.51), service paper (5.60 and 5.57), other paper (3.63 and 4.09), metal cans (2.74 and 3.38), other waste (1.42 and 1.13), aluminum (0.20 and 0.72), and plastic containers (0.36 and 0.46). The specific weights determined for components of the waste stream were within previously reported ranges except cardboard and aluminum (Tchobanoglous et al., 1993).

No significant differences were found between the weight of waste/meal generated on weekdays and weekends at either facility or overall. Significantly less volume of nonfood and total waste was generated per meal on weekends

Table 37. Comparison of the specific weight of elements of the total waste stream at two U.S. Army dining facilities and typical ranges reported by Tchobanoglous et al. (1993)[a]

Type of Waste	Mean Specific Weight (lbs/Yd^3)	Range Specific Weight (lbs/Yd^3)	Ranges Reported by Tchobanoglous[a] (lbs/Yd^3)
Food Waste	1210.56	407.83 - 3499.48	800 - 1600
Paper			
Service	206.73	94.01 - 587.50	70 - 220
Other	182.38	82.35 - 593.33	
Metal Cans	166.75	31.79 - 360.19	85 - 270
Aluminum	57.56	16.67 - 180.00	110 - 405
Paperboard	77.55	33.33 - 144.80	
Plastic			
Containers	159.82	52.63 - 512.82	70 - 220
Other	102.55	43.47 - 215.15	
Cardboard	158.72	86.08 - 178.13	70 - 135
Other	258.09	66.88 - 700.00	
Total	407.07	- - -	235 - 305[b]

[a]The data in column 4 are from Integrated Solid Waste Management, Engineering Principles and Management Issues (p. 70-71) by G. Tchobanoglous, H. Theisen, and S. Vigil, 1993, New York:McGraw-Hill, Copyright 1993 by McGraw-Hill. Adapted by permission of the author.

[b]Range for mixed (combustible and noncombustible) rubbish.

at the NCO Academy Dining Facility ($p<.05$). Significant differences were also detected for food waste generated during the 1st and 2nd periods. Less food waste volume was generated at the NCO Academy Dining Facility during the 2nd period ($p<.05$). Additionally, significantly less food, nonfood, and total waste by weight was generated at the NCO Academy during the 2nd period. When the two facilities were compared, significantly less ($p<.05$) total waste was generated per meal at the NCO Academy during the first periods. However, the difference was only 0.08 lbs per meal. For the 14 day period, no significant differences were found between the weight or volume of waste generated per meal between the NCO Academy and the 1-34 Armor Dining Facilities.

Results of this study support the findings of previously cited waste characterization studies. Food waste constitutes the largest percentage by weight of the waste stream at military dining facilities. Cardboard and service paper waste were the two nonfood materials contributing the largest percentages by weight and volume. Nonfood waste constituted 87.77% of the total volume of the waste stream.

A major difference between this study and previous studies was the large percentage of waste that was recycled. A total of 83% by weight and 75% by volume was diverted from the landfill in these dining facilities. Materials recycled included: cardboard, plastic containers, glass, cans, aluminum and food waste to swine farmers.

CHAPTER FIVE

SUMMARY AND CONCLUSIONS

Purpose of the Study

The purposes of this descriptive study were to characterize the waste stream at two United States Army dining facilities at Fort Riley, Kansas and to recommend policies and procedures to effectively manage solid waste at U.S. Army dining facilities.

Specific Objectives

Specific objectives were:

(1) to characterize by type, weight, volume, and specific weight the waste generated in two institutional dining facilities.

(2) to determine if the weight and volume of food, nonfood, and total waste generated per meal served in these two facilities were significantly different.

(3) to ascertain if the weight and volume of food, nonfood, and total waste generated per meal within the two observation periods: the first and second halves of the monthly military pay-cycle were significantly different.

(4) to determine if the weight and volume of food, nonfood, and total waste generated per meal on weekdays and weekends were significantly different.

(5) to compare the type, volume, and weight of waste per meal served at U.S. Army facilities dining facilities

with the type, volume, and weight per meal at other institutional settings.

(6) to report and compare the nutrient composition and moisture content of service food waste at both facilities.

(7) to recommend policies and procedures to effectively manage solid waste at U.S. Army dining facilities.

Characterization of Waste

The total weight and volume of food waste generated at both facilities during the 14 day period was 8909.75 lbs or 0.70 lbs/meal and 7.36 cubic yards or 0.0006 cubic yards/meal. The mean specific weight of food waste was 1210.56 lbs/cubic yard. Total weight and volume of nonfood waste disposed was 3444.95 lbs or 0.28 lbs/meal and 52.81 cubic yards or 0.0041 cubic yards/meal, respectively. Specific mean weights for nonfood waste were: service and other paper (206.73 and 182.33 lbs/cubic yard); metal cans (166.75 lbs/cubic yard); aluminum (57.56 lbs/cubic yard); paperboard (77.55 lbs/cubic yard); plastic containers and other plastic (159.82 and 102.55 lbs/cubic yard); corrugated cardboard (22.85 lbs/cubic yard) and other waste (258.09 lbs/cubic yards).

The percentage by weight of waste in descending order was: food (72.12%), cardboard (6.33%), service paper (5.60%), other paper (3.63%); paperboard (3.39%); other plastic (3.25%); metal cans (2.74%); other waste (1.42%);

glass (0.94%), plastic containers (0.36%), and aluminum (0.20%). The percentage by volume before collapsing of waste in descending order was: cardboard (56.93%); food (12.25%); paperboard (8.98%); other plastic (6.51%), service paper (5.57%); other paper (4.09%); metal cans (3.38%); other waste (1.13%); aluminum (0.72%), and plastic containers (0.46%). The percentage by volume after collapsing of waste in descending order was: food (29.74%), cardboard (19.96%), service paper (13.55%), paperboard (10.53%), other paper (9.95%), other plastic (9.22%), metal cans (3.92%), other waste (2.76%); aluminum (0.81%), and plastic containers (0.71%). Overall the volume was reduced 58.42% by collapsing six categories of nonfood waste.

Comparison of the Two Facilities

No significant differences ($p<.05$) were found between the weight and volume of food, nonfood, and total waste generated per meal in the two facilities over the total period. The NCO Academy dining facility which is a civilian contracted facility generated 0.69 lbs/meal or 0.0006 cubic yards/meal of food waste, 0.25 lbs or 0.0029 cubic yards/meal of nonfood waste, and 0.94 lbs/meal or 0.0035 cubic yards of total waste. The 1-34 Dining Facility which is operated by U.S. Army professionals generated 0.70 lbs/meal or 0.0006 cubic yards/meal of food waste, 0.29 lbs or 0.0050 cubic yards of nonfood waste, and 0.99 lbs/meal or 0.0056 cubic yards of total waste. Market form of food served at both facilities was similar. Analysis revealed no impact on weight or volume of waste due to market form of food served between the facilities.

Comparison of Period I and Period II Waste Generation

Significant differences ($p<.05$) were observed in the weight of food, nonfood, and total food waste generated per meal at the NCO Academy between the 1st period (0.80, 0.29, and 1.09, respectively) and 2nd period (0.62, 0.22, and 0.84, respectively). The weight of waste per meal was significantly less during the second period. No significant differences were found between the weight of waste generated per meal during the 1st and 2nd periods at the 1-34 Dining Facility. The quantity of food waste, nonfood waste, and total waste disposed was 0.71, 0.30, and 1.01 lbs/meal and 0.70, 0.27 and 0.97 lbs/meal for the 1st and 2nd periods, respectively. The volume of food waste generated at the NCO Academy was 0.0008, 0.0032 and 0.0040 cubic yard/meal and 0.0005, 0.0027 and 0.0032 cubic yards/meal for the 1st and 2nd periods, respectively. The volume of food waste generated per meal at the NCO Academy during the 1st period was significantly greater ($p<.05$) than the 2nd period. No significant differences were observed in the volume of waste generated during the 1st and 2nd periods at the 1-34 Dining Facility for food waste (0.0006 and 0.0006 cubic yards), nonfood waste (0.0069 and 0.0035), and total waste (0.0074 and 0.0041).

Comparison of Weekday and Weekend Waste Generation

A significant difference was found between the volume of nonfood and total waste generated per meal at the NCO Academy between weekdays and weekend days. The volume of waste per meal was significantly less on weekend days. Management practices at this facility resulted in fewer boxes being emptied and disposed on the weekends; this practice impacted the volume of nonfood waste and total waste generated. No other significant differences were found for either the weight or volume of food, nonfood, and total waste generated at either facility between weekdays and weekends.

Comparison to Other Studies

A comparison of the type, volume, and weight of waste per meal generated at these two Army dining facilities with data reported from other waste characterization studies revealed that the mean total waste per meal (0.97 lbs or 0.0045 cubic yards) was higher than Shanklin & Ferris (1992) found at a university dining hall. A total 0.51 lbs/meal and 0.0033 cubic yards/meal of total waste/meal was found by Shanklin and Ferris. The weight and volume of total waste per meal was less than reported in a study conducted at two hotel food and beverage operations. Pettay (1992) found that a total of 1.1 lbs/meal or 0.13 cubic yards/meal in one facility and 1.32 lbs/meal or 0.14 cubic yards/meal in a second hotel property. The weight of waste generated per meal in this study was similar to estimations reported by the National Solid Waste Association (1989) of 1.00 lbs/meal in a cafeteria style foodservice.

The proximate analysis of service food waste revealed that the greatest percentage of food waste was moisture (70%) which is typical of wet commercial food waste (Tchobanoglous et al, 1993). The optimum moiscure content for aerobic composting is in a range of 50-60%. The moisture content of the food waste could be adjusted to this level through the addition of paper or other organic matter. The weight of food waste is directly related to moisture content. Draining of liquids from soups, vegetables, and other foods with high moisture content could decrease the weight of this waste and costs of hauling. The high protein and fat content (5.16% and 6.43%) may indicate that an excessive amount of high cost meats are being disposed.

Proposed Waste Efficiency Model

Currently, the driving force behind the management practices of Non-Commissioned Officers directing U.S. Army foodservice organizations is the accurate prediction of production demand which guides the production of the correct number of wholesome, nutritious, and satisfying meals to meet the needs of soldiers. A secondary goal is to meet fiscal regulations regarding the end of month reconciliation between the number of soldiers served and the dollars spent on procurement of food and other supplies. If the foodservice manager meets these two goals, he or she has successfully performed his or her assigned mission.

Currently concern about the generation of waste at U.S. Army dining facilities by managers is lacking because waste is hauled from the dining facilities essentially free of charge to the individual operation. In addition, quantity of waste disposed has no impact on the manager's two primary goals - service of meals and achieving end of month financial reconciliations. However, in view of diminishing landfill capacity and the associated increased costs of waste disposal, there is a heightened awareness of waste generation at the installation and higher levels within the U.S. Army. Utilization of an input/output model to study the efficiency of systems in U.S. Army dining facilities in terms of waste generation is recommended.

Spears (1991) described a systems model which included six elements: input, control, memory, transformation, feedback, and output. This model could be adapted for use by the U.S. Army foodservice for the management of solid waste, specifically food waste. The input to the system would be total pounds of foods used to produce specified number of meals. The transformation process would include the preparation and service of the meals. The memory component would include records such as the automated "Dining Facility Operations Meal Production Planning and

Production History Report" which contains the number of servings of individual menu items that were prepared, served, leftover, and disposed. Feedback would consist of monthly food advisor inspections and reports from the post environmental specialists on waste generation. The output would be meals and quantity of food waste generated. The percent of food purchased that was disposed as waste could be derived by comparing the number of pounds of food products that enter a facility with the number of pounds of food waste disposed. A correction factor for inedible food waste generated through production as opposed to overproduction would have to be included. This percentage could be used as an efficiency factor to compare the management practices of foodservice organizations. A step further would be to use this factor to estimate the cost in dollars of food waste. By multiplying the total food cost of meals served (breakfast x $.95, lunch and dinner x $1.90) by this waste factor, an approximate cost of food waste could be calculated. For example, if only 10% of the total food prepared was discarded as waste at a facility similar to the NCO Academy Dining Facility which served 2135 soldiers during a week, an estimated $328 of reimbursable food costs would be lost weekly which multiplied by 52 weeks in a year is approximately $17,000 of food wasted annually.

Further study is required to determine if this input/output model would be a useful tool to U.S. Army installations in the evaluation of the efficiency of dining facilities in regard to the utilization of food. The same input/output model could be used to evaluate efficiency of nutritional quality of meals consumed compared to food served.

Recommendations

Policies and procedures to effectively manage solid waste at U.S. Army dining facilities which were recommended included implementing waste reduction measures, including purchasing bulk foods, eliminating single service containers, purchasing reusable containers, and purchasing goods with recycled content and products packaged in recyclable containers, and initiating assessment of acceptability of menu items for customer satisfaction and evaluation of proper portion size. Other recommendations for the reduction of food waste included alternative uses such as investigating the feasibility of donating excess unserved food to charitable organizations, modifying regulations on the transfer of food from one dining facility to another due to closure and reevaluating regulations on the reserving of food items considered to be potentially hazardous and the freezing of excess foods. Recycling at Fort Riley is already optimized but training of civilian and military cooks and civilian dishwashing and sanitation personnel could enhance these efforts.

Study Limitations

Due to the nature of the operations in these two dining facilities, food waste definitions of production and service waste in this study differed from definitions used in previous studies. Excess food on the serving line was included in service waste rather than production waste. Therefore, it was not possible to examine in detail the amount of food waste that was due to over-production as opposed to waste disposed by the diner. Future studies should categorize food waste into production and service waste. Production waste should be separated into two waste streams: food waste generated in the actual preparation of food and over-production waste - food waste generated through the disposal of food not served either off the serving line or leftovers from refrigerated storage.

Methods used to collect the service food waste samples for proximate analysis were the best available within the cost and time constraints of this study. More precise methods should be developed to ensure that samples are representative of total waste.

Random selection was not used when determining the days for data collection due to facility closures and training and time and cost restraints. Future research should use random selection of days throughout the year at randomly selected dining facilities to obtain data that can be generalized to the total population of Army dining facilities.

It was not possible to totally isolate the service paper waste from food waste. The diners removed nonfood waste from their trays prior to leaving trays at the dishroom. At times, soldiers discarded food waste along with the nonfood waste. The researcher and associates manually removed the food waste from the service paper waste but absorption of moisture from the food was unavoidable and may have increased the weight of service paper waste. Future studies that may have access to additional personnel assigned to separate waste at the dishroom would facilitate more accurate measurement of service food and service paper waste.

Manual methods for compacting waste and crushing containers were used to collapse nonfood waste. Methods that can be duplicated with accuracy, such as use of mechanical compactors, should be considered for future studies.

Future Research

The information derived from this study is beneficial to waste and environmental managers at Fort Riley. Additional studies using the same techniques should be performed throughout the Army in different seasons on randomly selected days to determine if these facilities were representative of U.S. Army dining facilities in general.

Studies to assess accuracy of forecasting of headcount, quantity of food produced, and consequent waste disposal are recommended. Data from such studies would provide vital information useful in reducing food waste which was the largest component by weight of the waste stream.

The Dining Facility Operations Meal Production Planning and Production History Report contains the number of servings in individual menu items that were prepared, served, leftover, and disposed (Appendixes A and B). A correlation study between the weight of the actual waste collected and the weight of individual entrees, vegetables, desserts, etc. that were noted as disposed in this report would be useful in validating the accuracy of this report.

Studies to validate the concept of waste efficiency factors using an input/output model as a tool to compare the management practices of U.S. Army dining facilities would be valuable in the reduction of costs associated with waste.

Cost feasibility studies related to recycling and composting would facilitate decision making, planning, and implementation of these programs at other installations.

Conclusions

In the United States Army Posture Statement for fiscal year 94 (Shannon & Sullivan, 1993), Army leadership outlined eight goals for the next century of Army excellence. One of those goals was: "Be a model steward of America's resources that are entrusted to the Army". These resources include people, dollars, material, infrastructure, and the environment. In the cold war era, the U.S. Army is in a unique position that enhances its ability to focus on economic and social issues and support both military and civil objectives. These objectives include two of the pillars of the Army Environmental Strategy into the 21st Century (Shannon & Sullivan, 1993) which are prevention and conservation. Army managers who are flexible, demonstrate initiative and innovation, and are committed to change must apply these objectives to the processes and procedures that currently waste resources. The U.S. Army must establish goals for waste management that reflects the philosophy of the EPA's waste management hierarchy of source reduction, recycling including composting, incineration and as a last resort, landfilling. These goals must be applied to every level of Army business including foodservice. Changing procurement policies, encouraging recycling and composting initiatives, updating foodservice regulations to include waste reduction methods and goals, and educating soldiers about the importance of conserving resources are examples of initiatives which could facilitate goal attainment.

The federal government, which is the purchasing agent for the U.S. Army, can facilitate the achievement of these goals by regulating the procurement of products to insure they contain recycled content and that they are packaged in recycled materials. These actions would create and stimulate markets for these products, and enhance the public image of the U.S. Army and the Department of Defense.

The foodservice industry and the Army share many concerns about managing solid waste in the future including the diminishing number of landfills, the increased costs of waste disposal, and increased regulation. Meeting these challenges will require management at every level of Army operations that emphasizes solid waste reduction and the gathering of accurate data concerning solid waste characteristics. By obtaining these objectives, the U.S. Army can reduce liability and compliance costs, save natural resources, preserve the environment, and enhance its public image.

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APPENDIXES

APPENDIX A

NCO Academy Dining Facility

Sample Daily Menu

DATE: 30 Jul 93

DINING FACILITY OPERATIONS
MEAL PRODUCTION PLANNING
PRODUCTION HISTORY REPORT

PCN AJK-LV1

Meal date: 29 Jul 93 Serving period: Adjusted headcount: 175

Meal type: BREAKFAST 0600 - 0730 Actual headcount : 186

RECIPE NUMBER	RECIPE NAME	ESTIMATED PORTIONS	ACTUAL PORTIONS	LEFT TO BE USED	TO DISCARD
F00400	COOKED EGGS (HARD)	25	12	0	0
F00700	GRIDDLE FRIED EGGS (COOKE	30	14	0	0
F00807	OMELET (INDIVIDUAL)	70	100	0	0
L00200	OVEN FRIED BACON	55	33	0	0
L00200	OVEN FRIED BACON	30	50	0	1
L03000	CREAMED GROUND BEEF	38	38	0	0
L08903	BAKED SAUSAGE PATTIES (PR	30	24	0	0
L08903	BAKED SAUSAGE PATTIES (PR	22	24	0	0
S00204	OMELET INGREDIENTS	70	100	0	0
D02200	FRENCH TOAST	40	26	0	0
D02200	FRENCH TOAST	40	39	0	2
D02505	PANCAKES (MIX)	30	20	0	0
D02505	PANCAKES (MIX)	30	10	0	2
E00200	BUTTER HOMINY GRITS	30	25	0	0
E00200	BUTTER HOMINY GRITS	30	12	0	3
Q04700	HOME FRIED POTATOES	40	50	0	0
Q04700	HOME FRIED POTATOES	40	50	0	4
C00500	COFFEE (AUTOMATIC URN)	150	50	0	0
S00100	ASSORTED FRUIT	25	0	0	0
S00200	ASST FRZ JUICES	175	0	0	0
S00400	BULK MILK	30	0	0	0
S00401	HALF PINT MILK	12	0	0	0
S00601	ASST DRY CEREAL	75	0	0	0
S00602	IND INSTANT OATMEAL	25	0	0	0
S00700	SYRUP	140	0	0	0
S00800	ASST. BREADS	45	0	0	0
S00801	ENGLISH MUFFIN	45	0	0	0
S00803	HOT TOAST	45	0	0	0
S00900	BUTTER/MARGARINE	50	0	0	0
S00901	MELT. BUTTER/MARGARINE	70	0	0	0
S01000	JAMS/JELLIES	30	0	0	0
S02601	PEANUT BUTTER	15	0	0	0
S02900	INDV. DRESSINGS/CONDIMENT	175	0	0	0
S03200	YOGURT	12	0	0	0
D00100	BAKING POWDER BISCUITS	60	60	0	0

PAGE 1

DATE: 30 Jul 93 | DINING FACILITY OPERATIONS | PCN AJK-LV1

MEAL PRODUCTION PLANNING
PRODUCTION HISTORY REPORT

Meal date: 29 Jul 93 | Serving period: | Adjusted headcount: 175

Meal type: BREAKFAST | 0600 - 0730 | Actual headcount : 186

RECIPE NUMBER	RECIPE NAME	ESTIMATED PORTIONS	ACTUAL PORTIONS	LEFT TO BE USED	TO DISCARD
D03700	QUICK COFFEE CAKE (BISCUI	108	54	15	0
F01000	SCRAMBLED EGGS	25	60	0	0

FOOD SERVICE SERGEANT SIGNATURE: ______________________________

END PAGE

2

DATE: 30 Jul 93 | DINING FACILITY OPERATIONS | PCN AJK-LV1

MEAL PRODUCTION PLANNING

PRODUCTION HISTORY REPORT

Meal date: 29 Jul 93 | Serving period: | Adjusted headcount: 175

Meal type: LUNCH | 1130 - 1300 | Actual headcount : 193

RECIPE NUMBER	RECIPE NAME	ESTIMATED PORTIONS	ACTUAL PORTIONS	LEFT TO BE USED	TO DISCARD
L12400	BAKED FISH PORTIONS	25	24	0	0
L16700	FRENCH FRIED FISH PORTION	50	60	0	0
E00500	STEAMED RICE	100	75	40	0
Q00700	LYONNAISE GREEN BEANS (FR	50	50	35	0
Q00700	LYONNAISE GREEN BEANS (FR	25	20	0	0
Q02702	MEXICAN CORN	25	50	0	0
Q02702	MEXICAN CORN	50	25	0	5
M01200	COTTAGE CHEESE SALAD	25	50	0	6
M02600	JELLIED FRUIT COCKTAIL SA	25	25	0	8
M04000	POTATO SALAD	25	35	0	10
S00403	IND ICE CREAM	25	0	0	0
S01300	SALAD BAR	175	175	0	15
G05200	VANILLA FROSTING (ICING M	54	54	0	3
H01003	CHOC.,CHOC CHIP COOKIES	50	30	0	2
I02801	CHOCOLATE CREAM PIE (DESS	48	32	0	0
C00500	COFFEE (AUTOMATIC URN)	50	25	0	5
S00100	ASSORTED FRUIT	25	0	0	0
S00300	BEVERAGE BASE PWDR	100	0	0	0
S00301	INSTANT TEA	75	0	0	0
S00400	BULK MILK	30	0	0	0
S00401	HALF PINT MILK	12	0	0	0
S00800	ASST. BREADS	45	0	0	0
S00802	BROWN & SERV ROLLS	45	0	0	0
S00900	BUTTER/MARGARINE	50	0	0	0
S01200	CRACKERS	30	0	0	0
S01500	ASST SALAD DRESSING BTL	175	0	0	0
S02800	CARBONATED BEVERAGES	45	0	0	0
S02900	INDV. DRESSINGS/CONDIMENT	175	0	0	0
S03200	YOGURT	12	0	0	0
D01601	GARLIC CROUTONS	75	50	0	0
N03501	HOT ROAST BEEF SANDWICH (	100	103	53	0
O01300	TARTER SAUCE	75	75	0	8
O01600	BROWN GRAVY	175	175	0	15
P00300	CREOLE SOUP	75	75	40	0
F00100	BAKED MACARONI AND CHEESE	75	75	0	10

PAGE 1

DATE: 30 Jul 93

DINING FACILITY OPERATIONS
MEAL PRODUCTION PLANNING
PRODUCTION HISTORY REPORT

PCN AJK-LV1

Meal date: 29 Jul 93 Serving period: Adjusted headcount: 175

Meal type: LUNCH 1130 - 1300 Actual headcount : 193

RECIPE NUMBER	RECIPE NAME	ESTIMATED PORTIONS	ACTUAL PORTIONS	LEFT TO BE USED	TO DISCARD
G00600	BANANA CAKE	54	54	0	0

FOOD SERVICE SERGEANT SIGNATURE: ______________________________

END PAGE

2

DATE: 30 Jul 93 DINING FACILITY OPERATIONS PCN AJK-LV1

MEAL PRODUCTION PLANNING

PRODUCTION HISTORY REPORT

Meal date: 29 Jul 93 Serving period: Adjusted headcount: 0

Meal type: LUNCH SO 1130 - 1300 Actual headcount : 0

RECIPE NUMBER	RECIPE NAME	ESTIMATED PORTIONS	ACTUAL PORTIONS	LEFT TO BE USED	TO DISCARD
N00100	TOASTED BACON, LETTUCE AN	2	4	0	0
N00600	GRILLED CHEESE SANDWICH	1	0	0	0
N00603	GRILLED CHEESE AND HAM SA	1	0	0	0
N01000	EGG SALAD SANDWICH	1	1	0	0
N01102	HAM AND CHEESE SANDWICH	2	22	0	0
N01500	TUNA SALAD SANDWICH	2	4	0	0
N02900	GRILLED HAMBURGERS (BF PA	5	4	0	0
N02902	CHEESEBURGERS	5	20	0	0
N03004	GRILLED FRANKFURTER ON RO	1	0	0	0
Q04501	FRENCH FRIED POTATOES (FR	25	57	0	6
S02000	POTATO CHIPS	15	0	0	0
S02900	INDV. DRESSINGS/CONDIMENT	25	0	0	0
N02102	BURRITOS (BEEF AND BEAN F	5	0	0	0

FOOD SERVICE SERGEANT SIGNATURE:____

END PAGE

1

DATE: 30 Jul 93

DINING FACILITY OPERATIONS
MEAL PRODUCTION PLANNING
PRODUCTION HISTORY REPORT

PCN AJK-LV1

Meal date: 29 Jul 93 | Serving period: | Adjusted headcount: 165

Meal type: DINNER | 1630 - 1800 | Actual headcount : 169

RECIPE NUMBER	RECIPE NAME	ESTIMATED PORTIONS	ACTUAL PORTIONS	LEFT TO BE USED	TO DISCARD
L03800	SPAGHETTI SAUCE	100	50	0	0
L14600	BARBECUED CHICKEN	45	50	25	0
E00400	BOILED PASTA (SPG)	100	50	0	0
Q04900	O'BRIEN POTATOES	40	40	0	0
Q05700	MASHED POTATOES (INSTANT)	25	15	0	3
Q91002	SEASONED LIMA BEANS CANNE	50	50	0	6
Q91010	BLACKEYED PEAS AND BACON	25	0	0	0
Q91010	BLACKEYED PEAS AND BACON	50	0	0	0
Q93004	SEASONED LIMA BEANS (FRZ)	25	0	0	0
Q93004	SEASONED LIMA BEANS (FRZ)	50	0	0	0
M01200	COTTAGE CHEESE SALAD	25	25	0	6
M02600	JELLIED FRUIT COCKTAIL SA	25	25	0	5
M04000	POTATO SALAD	25	25	0	8
S00403	IND ICE CREAM	25	0	0	0
S01300	SALAD BAR	150	125	0	6
G05200	VANILLA FROSTING (ICING M	54	54	17	0
H01003	CHOC.,CHOC CHIP COOKIES	40	30	0	0
I02801	CHOCOLATE CREAM PIE (DESS	36	32	0	0
C00500	COFFEE (AUTOMATIC URN)	25	13	0	2
S00100	ASSORTED FRUIT	25	0	0	0
S00300	BEVERAGE BASE PWDR	100	0	0	0
S00301	INSTANT TEA	65	0	0	0
S00400	BULK MILK	30	0	0	0
S00401	HALF PINT MILK	12	0	0	0
S00800	ASST. BREADS	45	0	0	0
S00802	BROWN & SERV ROLLS	45	0	0	0
S00900	BUTTER/MARGARINE	50	0	0	0
S01200	CRACKERS	30	0	0	0
S01500	ASST SALAD DRESSING BTL	150	0	0	0
S02800	CARBONATED BEVERAGES	45	0	0	0
S02900	INDV. DRESSINGS/CONDIMENT	165	0	0	0
S03200	YOGURT	12	0	0	0
D00700	TOASTED GARLIC BREAD	100	50	0	10
O01602	CHICKEN GRAVY	65	50	0	6
G00600	BANANA CAKE	54	54	17	0

PAGE 1

DATE: 30 Jul 93 DINING FACILITY OPERATIONS PCN AJK-LV1

MEAL PRODUCTION PLANNING

PRODUCTION HISTORY REPORT

Meal date: 29 Jul 93 Serving period: Adjusted headcount: 165

Meal type: DINNER 1630 - 1800 Actual headcount : 169

RECIPE NUMBER	RECIPE NAME	ESTIMATED PORTIONS	ACTUAL PORTIONS	LEFT TO BE USED	TO DISCARD
L14300	BAKED CHICKEN (QUARTERED)	20	25	12	0

FOOD SERVICE SERGEANT SIGNATURE: ______________________________

END PAGE

2

DATE: 30 Jul 93 — DINING FACILITY OPERATIONS — PCN AJK-LV1

MEAL PRODUCTION PLANNING

PRODUCTION HISTORY REPORT

Meal date: 29 Jul 93   Serving period: Adjusted headcount: 0

Meal type: DINNER SO   1630 - 1800   Actual headcount : 0

RECIPE NUMBER	RECIPE NAME	ESTIMATED PORTIONS	ACTUAL PORTIONS	LEFT TO BE USED	TO DISCARD
N00600	GRILLED CHEESE SANDWICH	1	0	0	0
N00603	GRILLED CHEESE AND HAM SA	1	0	0	0
N01102	HAM AND CHEESE SANDWICH	1	0	0	0
N02900	GRILLED HAMBURGERS (BF PA	1	1	0	0
N02902	CHEESEBURGERS	1	31	0	0
N03004	GRILLED FRANKFURTER ON RO	1	0	0	0
Q04501	FRENCH FRIED POTATOES (FR	10	65	0	8
S02000	POTATO CHIPS	5	0	0	0
S02900	INDV. DRESSINGS/CONDIMENT	10	0	0	0
N02102	BURRITOS (BEEF AND BEAN F	4	0	0	0

FOOD SERVICE SERGEANT SIGNATURE:______________________________

END PAGE

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APPENDIX B

1-34 Armor Dining Facility

Sample Daily Menu

DATE: 30 Jul 93

DINING FACILITY OPERATIONS
MEAL PRODUCTION PLANNING
PRODUCTION HISTORY REPORT

PCN AJK-LV1

1-34

1-34 ARMOR DINING FACILITY

Meal date: 29 Jul 93

Serving period: 0530 - 0700

Adjusted headcount: 150

Meal type: BREAKFAST

Actual headcount : 0

RECIPE NUMBER	RECIPE NAME	ESTIMATED PORTIONS	ACTUAL PORTIONS	LEFT TO BE USED	TO DISCARD
F00400	COOKED EGGS (HARD)	25	0	0	0
F00700	GRIDDLE FRIED EGGS (COOKE	25	0	0	0
F00807	OMELET (INDIVIDUAL)	150	0	0	0
L00200	OVEN FRIED BACON	100	200	0	0
L03000	CREAMED GROUND BEEF	50	0	0	0
L08903	BAKED SAUSAGE PATTIES (PR	75	0	0	0
S00204	OMELET INGREDIENTS	150	0	0	0
D02200	FRENCH TOAST	100	100	0	0
D02505	PANCAKES (MIX)	100	100	0	0
E00200	BUTTER HOMINY GRITS	75	75	0	0
Q04600	HASHED BROWN POTATOES	150	175	0	0
C00500	COFFEE (AUTOMATIC URN)	100	100	0	0
S00100	ASSORTED FRUIT	100	200	0	0
S00200	ASST FRZ JUICES	150	200	0	0
S00400	BULK MILK	150	150	0	0
S00601	ASST DRY CEREAL	150	0	0	0
S00700	SYRUP	100	0	0	0
S00800	ASST. BREADS	100	0	0	0
S00900	BUTTER/MARGARINE	100	0	0	0
S01000	JAMS/JELLIES	100	0	0	0
S01100	INDV. DRESSINGS/CONDIMENT	100	0	0	0
S02601	PEANUT BUTTER	100	100	0	0
S02900	INDV. DRESSINGS/CONDIMENT	100	0	0	0
S03200	YOGURT	50	0	0	0
S03200	YOGURT	50	0	0	0
F01000	SCRAMBLED EGGS	50	0	0	0

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DATE: 30 Jul 93 DINING FACILITY OPERATIONS PCN AJK-LVI
MEAL PRODUCTION PLANNING
PRODUCTION HISTORY REPORT

Meal date: 29 Jul 93 Serving period: Adjusted headcount : 200

Meal type: LUNCH 1200 - 1330 Actual headcount : 0

RECIPE NUMBER	RECIPE NAME	ESTIMATED PORTIONS	ACTUAL PORTIONS	LEFT TO BE USED	TO DISCARD
L02500	LASAGNA	100	100	0	0
L11907	CAJUN BAKED FISH	100	100	0	15
E00701	FRIED RICE (GRIDDLE METHO	100	100	0	0
Q05700	MASHED POTATOES (INSTANT)	100	75	0	0
Q08400	CARROTS AMANDINE	100	0	0	0
Q93006	SEASONED CAULIFLOWER FROZ	100	75	0	0
M00800	COLE SLAW	50	50	0	0
M02500	JELLIED FRUIT SALAD	50	50	0	0
S01300	SALAD BAR	150	200	0	0
G02001	PEANUT BUTTER CAKE (CAKE	50	0	0	0
G04900	PEANUT BUTTER CREAM FROST	50	0	0	0
H02300	OATMEAL COOKIES	50	0	0	0
I01702	BLUEBERRY PIE (PIE FILLIN	50	0	0	0
C00500	COFFEE (AUTOMATIC URN)	100	0	0	0
S00300	BEVERAGE BASE PWDR	100	250	0	0
S00301	INSTANT TEA	100	0	0	0
S00400	BULK MILK	100	100	0	0
S00800	ASST. BREADS	1000	150	0	0
S00900	BUTTER/MARGARINE	100	0	0	0
S01200	CRACKERS	100	0	0	0
S01500	ASST SALAD DRESSING BTL	150	0	0	0
S02700	SOFT SERVE ICE CREAM	100	0	0	0
S02800	CARBONATED BEVERAGES	100	75	0	0
D03302	HOT ROLLS (ROLL MIX)	50	64	0	0
O01600	BROWN GRAVY	100	100	0	0

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DATE: 30 Jul 93 | DINING FACILITY OPERATIONS | PCN AJK-LV1

MEAL PRODUCTION PLANNING

PRODUCTION HISTORY REPORT

Meal date: 29 Jul 93 | Serving period: | Adjusted headcount: 0

Meal type: LUNCH SO | 1200 - 1330 | Actual headcount : 0

RECIPE NUMBER	RECIPE NAME	ESTIMATED PORTIONS	ACTUAL PORTIONS	LEFT TO BE USED	TO DISCARD
L02800	CHILI CON CARNE	10	25	10	0
N00600	GRILLED CHEESE SANDWICH	10	10	0	0
N00603	GRILLED CHEESE AND HAM SA	10	0	0	0
N01500	TUNA SALAD SANDWICH	15	10	0	0
N02900	GRILLED HAMBURGERS (BF PA	10	12	0	0
N02902	CHEESEBURGERS	25	0	0	0
S03001	CHILI DOG	10	10	0	0
Q04501	FRENCH FRIED POTATOES (FR	75	75	0	0
S02900	INDV. DRESSINGS/CONDIMENT	50	0	0	0
N03000	SIMMERED FRANKFURTERS ON	10	10	0	0
N04202	CORN DOGS (FROZEN)	10	18	8	0

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END PAGE

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DATE: 30 Jul 93

DINING FACILITY OPERATIONS
MEAL PRODUCTION PLANNING
PRODUCTION HISTORY REPORT

PCN AJK-LV1

Meal date: 29 Jul 93 Serving period: Adjusted headcount: 150

Meal type: DINNER 1530 - 1700 Actual headcount : 0

RECIPE NUMBER	RECIPE NAME	ESTIMATED PORTIONS	ACTUAL PORTIONS	LEFT TO BE USED	TO DISCARD
L02200	BEEF STEW	75	75	50	0
L16300	TURKEY NUGGETS	75	75	0	0
E00500	STEAMED RICE	75	0	0	0
Q07700	PARSLEY BUTTERED POTATOES	75	0	0	0
Q08400	CARROTS AMANDINE	75	0	0	0
Q93006	SEASONED CAULIFLOWER FROZ	75	25	0	0
M00800	COLE SLAW	75	50	0	0
M01200	COTTAGE CHEESE SALAD	75	0	0	0
M02500	JELLIED FRUIT SALAD	75	0	0	0
S01300	SALAD BAR	75	75	0	0
G02001	PEANUT BUTTER CAKE (CAKE	50	0	0	0
G04900	PEANUT BUTTER CREAM FROST	50	0	0	0
H02300	OATMEAL COOKIES	50	0	0	0
I01702	BLUEBERRY PIE (PIE FILLIN	50	0	0	0
C00500	COFFEE (AUTOMATIC URN)	75	0	0	0
S00300	BEVERAGE BASE PWDR	100	100	0	0
S00301	INSTANT TEA	100	0	0	0
S00400	BULK MILK	100	50	0	0
S00800	ASST. BREADS	100	0	0	0
S00900	BUTTER/MARGARINE	100	0	0	0
S01200	CRACKERS	100	0	0	0
S01500	ASST SALAD DRESSING BTL	100	0	0	0
S02700	SOFT SERVE ICE CREAM	100	0	0	0
S02800	CARBONATED BEVERAGES	100	0	0	0
O01600	BROWN GRAVY	75	0	0	0

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END PAGE

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DATE: 30 Jul 93

DINING FACILITY OPERATIONS
MEAL PRODUCTION PLANNING
PRODUCTION HISTORY REPORT

RCN [illegible]

Meal date: 29 Jul 93 | Serving period: | Adjusted headcount: 0

Meal type: DINNER SO | 1530 - 1700 | Actual headcount : 0

RECIPE NUMBER	RECIPE NAME	ESTIMATED PORTIONS	ACTUAL PORTIONS	LEFT TO BE USED	TO DISCARD
L02800	CHILI CON CARNE	10	0	0	0
N00600	GRILLED CHEESE SANDWICH	10	0	0	0
N00603	GRILLED CHEESE AND HAM SA	10	12	0	0
N01500	TUNA SALAD SANDWICH	10	0	0	0
N02900	GRILLED HAMBURGERS (BF PA	10	0	0	0
N02902	CHEESEBURGERS	25	0	0	0
S03001	CHILI DOG	10	10	0	0
Q04501	FRENCH FRIED POTATOES (FR	75	50	0	0
S01400	S/O RELISH TRAY	25	0	0	0
S02900	INDV. DRESSINGS/CONDIMENT	25	0	0	0
N03000	SIMMERED FRANKFURTERS ON	10	10	0	0
N04202	CORN DOGS (FROZEN)	10	0	0	0

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APPENDIX C

Device for Measuring Volume of Waste in Gallons

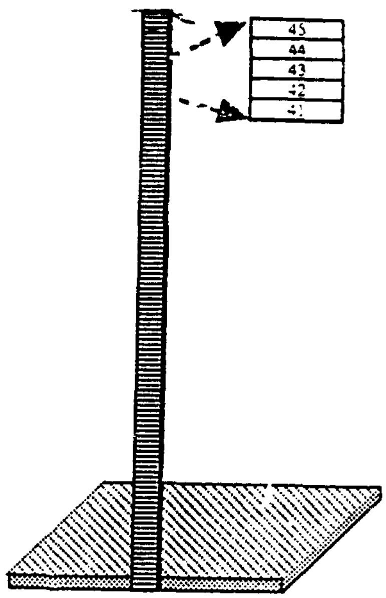

FIGURE 1. Device for measuring volume of waste in gallons.