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FRONT END ANALYSIS OF COMBAT FIELD FEEDING SYSTEM WASTE DISPOSAL

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A front end analysis (FEA) was conducted to define the best solutions to the Army's Combat Field Feeding System (CFFS) waste disposal problem. Industrial and military technologies and procedures compatible with the CFFS operational concept and applicable to waste management were identified and evaluated. Waste generated from each ration mix of the Army Wartime Feeding Policy was quantified, indicating that the capacity of the transportation asset (5-ton tactical truck) allocated to the CFFS would not be exceeded when only food service waste is backhauled for disposal. CFFS waste data from field exercises and demonstrations were collected and analyzed. Results showed that, with undisciplined field waste management, the average regular T Ration waste volume per person per meal for five exercises was 0.23 ft^3. Relative to logistics and annual costs, a battlefield analysis of CFFS waste disposal was conducted. Alternative waste management solutions were developed and evaluated.
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A combination of alternatives involving procedures, material action, and exploitation of technological advances will provide as much as a 70% time savings and a 68% cost reduction in CFFS waste management. Conclusions and recommendations for CFFS apply equally to the emerging Army Field Feeding System (AFFS) when deployed on a battlefield.

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PREFACE

This project was conducted by the Advanced Systems Concepts Directorate of the U.S. Army Natick Research, Development and Engineering Center as part of the Department of Defense Food and Nutrition Research and Engineering Program under Joint Services Requirement AMAF 87-19 from November 1984 to October 1987.

The authors extend special appreciation to Mr. J. Prifti for data collection; Mr. S. Holt, Mr. P. Peter, Mr. W. Chevalier, Dr. D.P. Leitch Dr. G. Hertweck and Mr. P. Bolan for technical review, Mr. M. Statkus for editorial review, and Ms. M. Severance and Ms. Katrina Schuh for report production.

SUMMARY

A Front End Analysis (FEA) was conducted to define the best solutions to the Army's Combat Field Feeding System (CFFS) waste disposal problem. Industrial and military technologies and procedures compatible with the CFFS operational concept and applicable to waste management were identified and evaluated. Waste generated from each ration mix of the Army Wartime Feeding Policy was quantified, indicating that the capacity of the transportation asset (5-ton tactical truck) allocated to the CFFS would not be exceeded when only food service waste is backhauled for disposal. CFFS waste data from field exercises and demonstrations were collected and analyzed. Results showed that, with undisciplined field waste management, the average regular T Ration waste volume per person per meal for five exercises was 0.23 ft^3. Relative to logistic and annual costs, a battlefield analysis of CFFS waste disposal was conducted. Alternative waste management solutions were developed and evaluated. A combination of alternatives involving procedures, material action, and exploitation of technological advances will provide as much as a 70% time savings and a 68% cost reduction. The following recommendations for CFFS that apply equally to the emerging Army Field Feeding System (AFFS) on a battlefield are made:

- To improve field sanitation, the Army should reestablish waste discipline in field food service operations.
- To reduce the wartime on-site manual excavation for trash bags of messgear, the Army should allocate a manual, mechanical compactor to each designated feeding unit.
- To reduce the wartime battlefield smoke and heat signature, the Army should use forced air incinerators as an alternative to field expedient incineration.
- To provide cost-effective field waste disposal operations, the Army should develop doctrine to provide integrated combat engineer excavation support to wartime CFFS on-site and backhaul waste disposal.

FRONT END ANALYSIS OF COMBAT FIELD FEEDING SYSTEM WASTE DISPOSAL

INTRODUCTION

BACKGROUND

Future Army combat scenarios will be characterized by highly mobile operations on integrated battlefields. The Army of Excellence (AOE) force design initiative is the vehicle that allows for increased combat mobility, flexibility, and responsiveness. The Combat Field Feeding System (CFFS) is a direct outgrowth of AOE. This project was initiated to address CFFS wartime solid waste management.

The CFFS concept replaces the permanent mess kit with disposable messgear that is logistically beneficial but accentuates the field feeding solid waste disposal problem. To manage increased solid waste associated with CFFS, the Army needs to improve wartime waste disposal doctrine, to include responsibility for large-scale excavation/burial.

THE CFFS CONCEPT

As outlined in Field Circular, FC 21-150, the CFFS has three main elements, the feeding standard, unitized rations, and the designated feeding unit concept.[1]

The feeding standard determines the ration mix to include two hot meals (usually Unitized T Rations) when possible and a Meal, Ready-to-Eat (MRE). Ration mix has a direct impact on the amount of shipping volume and weight of rations delivered to the field. However, field waste discipline determines the relative expansion or reduction of waste volume. The Unitized T Ration module configuration offers potential for increased sanitation and reduction of waste volume (cube) in field waste management if the boxes are used to dispose of nested tray cans, lids, disposable messgear, and packaging waste. The designated feeding unit concept organizes small combat groups into feeding units and determines the equipment-feeding strength ratio, where the Mobile Kitchen Trailer (MKT) and Modular Field Kitchen (MFK) feed 300 each meal (350 each, consolidated) and the Kitchen Company Level (KCLFF/KCL) feeds 200 each meal. Therefore, the capacity of the feeding unit equipment and the ration mix determine the daily amount of food service waste to be disposed by each feeding unit whether deployed in divisions, or echelons above division (EAD).

For the purpose of CFFS waste disposal, FC 21-150 guidance provides for on-site disposal, if permitted, and also coordinates waste backhaul for disposal with Class I pickup at the supply point.

Emerging AFFS Concept

Several months after the completion of this project a refinement of CFFS as the Army Field Feeding System (AFFS) concept emerged. The AFFS concept was developed to fix shortfalls in the CFFS. Refinements to increase commander flexibility included increased equipment and food service personnel to support the battalion managed Area Feeding Concept (smaller feeding groups) and a change in the feeding standard to serve two A Ration meals per week. Review of AFFS guidance that will be documented in Field Manual 10-23 in the year 1992 indicated no significant change in doctrine for combat waste management.

OBJECTIVE

The project objective was to define the best solutions to the Army's CFFS waste disposal problem.

SCOPE

Only wartime CFFS solid waste (trash) management solutions will be addressed in this report. While peacetime field exercises and demonstrations were observed, peacetime CFFS waste management solutions may be different due to strict national and international environmental protection rules.

TECHNICAL APPROACH

The technical approach (see Figure 1) used in this project was a Front End Analysis (FEA) modified to include field data collection, nondevelopment item (NDI) demonstrations for users, informal and formal user evaluations/feedback, prototype development, and studies and analyses as outlined below:

1. Identify and evaluate alternative civilian and military technologies, products, and procedures compatible with the CFFS operational concept and applicable to CFFS waste management.

2. Analyze and quantify rations (B, T, MRE) packaging material and disposable messgear.

3. Collect and analyze waste data from field exercises.

4. Perform quantitative analysis of the CFFS waste disposal problem.

5. Conduct battlefield analysis relative to CFFS subsistence waste disposal.

6. Develop alternative waste management solutions based on the CFFS concept of operation and the Army wartime feeding plan.

7. Evaluate alternatives and make recommendations for wartime field food service waste management.

8. Prepare a technical report detailing project-related efforts relative to the field waste management problem, alternative solutions, and final recommendations.

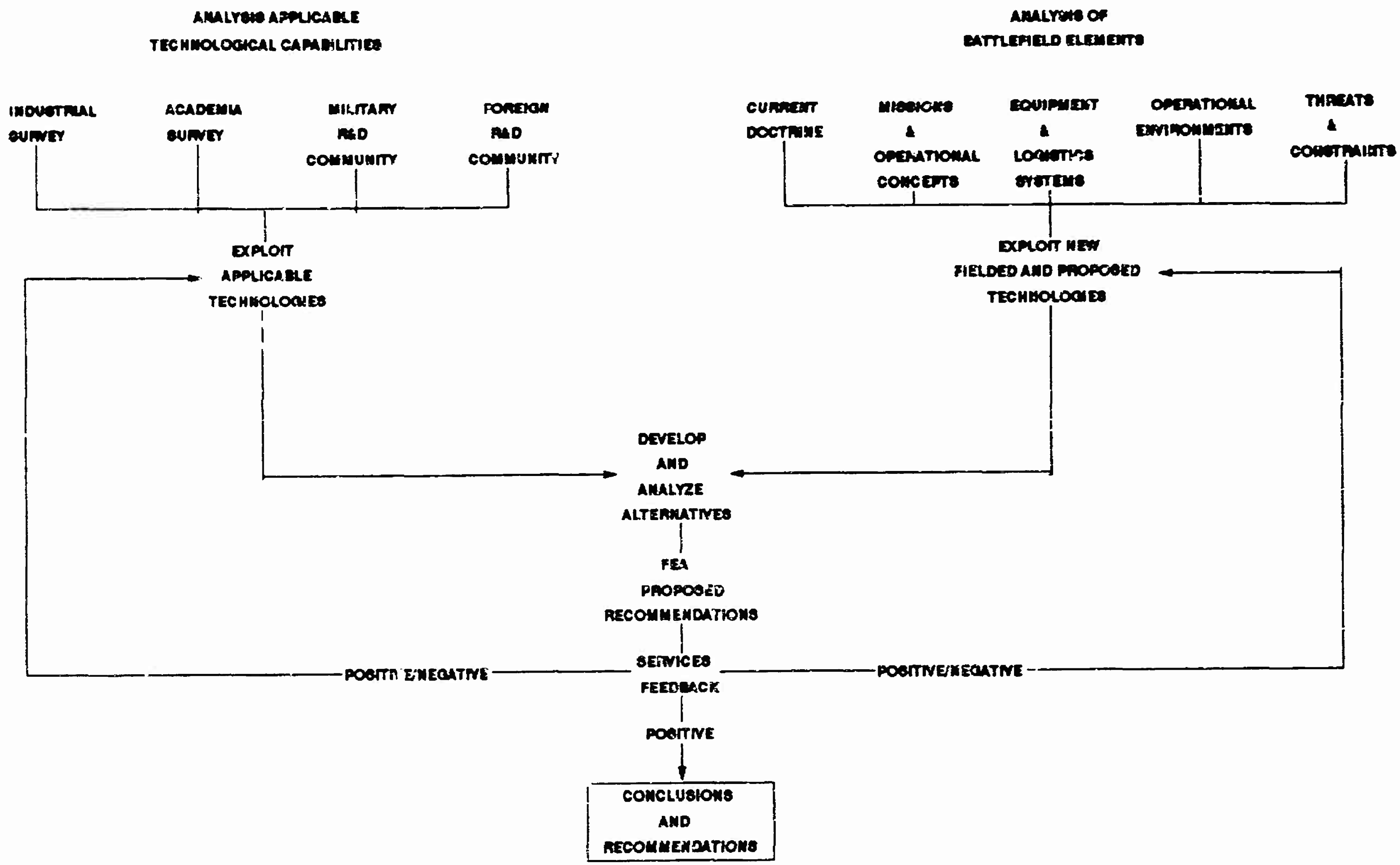

Figure 1. Modified Levesque diagram of protocol for front end analysis (FEA) study.

TECHNOLOGICAL AND PROCEDURAL FINDINGS

With reference to the FEA approach (Figure 1), findings of industrial and military materiel and procedural developments were evaluated for exploitation in support and improvement of CFFS waste management. When a trash compactor suitable for use by the CFFS designated feeding unit was not found in the industrial search, a manual, mechanical compactor was developed in-house (see Appendix A). Equipment/systems descriptions of applicable technological findings are detailed in Appendix B.

TECHNOLOGICAL FINDINGS

Equipment/systems, both industrial and military, that have potential application to CFFS waste management problems are shown in Table 1. The equipment/systems can be divided into two groups: 1) for use by designated feeding units for on-site or backhaul disposal and; 2) for use by combat engineers to support unit level (battalion) on-site excavation and consolidated excavation for brigade and divisions or their numerical equivalents in EAD. The small, portable forced air incinerator, the manual, mechanical compactor, and the portable, mobile trailer/compactor transporter have potential for on-site use to support the designated feeding units. The D-7 and ACE Dozers, SEE Tractor, Air Curtain Destructor, and Palletized Load System[2] (PLS) have potential for support of large-scale field waste management. Note that the SEE Tractor has greater potential to support designated feeding units but is ideal for excavating a trench required to operate the Air Curtain Destructor.

TABLE 1. Industrial and Military Equipment Applicable to Field Waste Disposal

INDUSTRIAL EQUIPMENT	MILITARY EQUIPMENT
Portable, Forced Air Incinerator (Small)	D-7 Dozer[a]
	ACE Dozer[b]
Portable, Air Curtain Destructor (Large Incinerator)	SEE Tractor[c]
Portable, Trailer/Compactor Transporter	Compactor, Manual, Mechanical (In-house Development)
	Palletized Load System (PLS)

[a]D-7 - Conventional 50,000-lb dozer.
[b]ACE - Armored Combat Excavator.
[c]SEE - Small Emplacement Excavator.

Waste Management Systems Consideration Criteria

The criteria for consideration of applicable waste management equipment/systems were as follows:

1. Compatible with current operational concept,
2. Does not increase transportation requirements,
3. Portable, small, rugged, and self-contained (powered),
4. Flexible enough to operate in a variety of military scenarios,
5. Adaptable to new combat support technology and equipment,
6. Amenable to operation and maintenance with minimum field skills and manpower,
7. Cost-effective,
8. Maintains sanitary conditions.

Screening of Technological Findings

The above criteria were not used as a yard stick to strictly measure each equipment/system but they were used as a general guide for considering potential waste disposal systems that may be compatible with the CFFS operational concept.

Noncompatible Equipment/Systems. For waste management equipment that requires feeding unit hauling/towing, the first and second criteria were critical. Under AOE austere force design, the CFFS transportation asset (5-ton tactical truck) is already stressed by having to haul the sanitation center and tow both the MKT and the water trailer. Regardless of how efficient a waste management system may be, if there is an existing feeding unit tow requirement, the waste management system may not be proposed as an improvement to the CFFS backhaul disposal alternatives. For example, the portable, trailer/compactor transporter is very efficient in managing waste in remote national parks, where it reduced the staffing requirements from four waste management people to one; however, it has a tow requirement and therefore may not be considered for CFFS waste management alternatives.

In an Olympic National Park demonstration of the trailer/compactor transporter for two 9ID Officers (users) with field experience (Forward Support Battalion), evaluations were mixed. One officer indicated that while the equipment could be used to compact and backhaul food service waste, it required a tow vehicle, and he already has six pieces of equipment without tow vehicles. The other officer indicated that on the battlefield total waste has to be managed, and the equipment did not have the capacity to compact and haul both food service and other waste.

The palletized load system concept, currently being evaluated in a cost and operational effectiveness analysis by the U.S. Army Transportation School for transport of all classes of military supplies, is used extensively in private industry to manage waste. However, until there is a change in the Class I/feeding operational concepts, PLS does not meet criterion number 2.

Compatible Equipment/Systems. The 5-ton tactical truck (520 ft^3 hauling capacity) has space to include the manual, mechanical compactor (5 ft^3) and portable incinerator, small (10 ft^3) with the sanitation center (338 ft^3), the troop (cooks) field gear (40 ft^3) and 300 rations (600 Unitized T and 300 MRE meals) occupying 76^3 ft. The total cube (469 ft^3) of the above items can also be hauled on the 2.5-ton truck (470 ft^3 hauling capacity), if discipline is used to load the truck. While the 5-ton tactical truck is the CFFS concept tow vehicle, most combat units currently own and train with 2.5-ton tactical trucks.

The portable, Air Curtain Destructor, with potential to support waste disposal for brigade or division size troop populations, requires only 1 tow vehicle per 3,000-18,000 soldiers.

The recently developed ACE Dozer and SEE Tractor, together with the D-7 type dozer, are allocated to the combat engineers (see Table 2). The combat engineer deployment throughout the theater is shown in Figure 2. Under the combat engineer umbrella proponency, all battlefield requirements for SEE Tractors are being evaluated. While the ACE Dozer has not been evaluated for support to battlefield waste disposal, in many divisions it is the only equipment with capacity to excavate for consolidated backhaul disposal on the battlefield.

In summary, the portable, mobile compactor/transporter and PLS should be held for later consideration. The large and small incinerators, the manual, mechanical compactor, and the dozers, D-7, ACE, and the SEE Tractors should be evaluated for their potential to increase efficiency of alternative CFFS waste management.

PROCEDURAL FINDINGS

With AOE force design emphasis on streamlining combat support personnel strength, field waste management will be best served by studying all potentially applicable military and industrial waste disposal procedures. Numerous procedural changes have brought the Army to this point in time where field waste discipline is not always practiced. A study of the elements of the operational battlefield may provide insight to improved waste management doctrine and procedures.

Military Recruitment

The volunteer Army recruitment policy promises the soldier that civilians will do the kitchen police (KP) duties. This procedure deprives the soldiers (E 1-3) of monthly practice in food service waste management. The drafted Army of the 1960s provided frequent practice in waste discipline (flattening boxes and cans) while performing KP duty in garrison in peacetime. Today's soldiers go to the field with little or no continuous waste discipline training.

TABLE 2. Comparison of Excavation Equipment for Light and Mechanized Division Engineer Battalions*

	Engr Bn (Armored/Mech Div) (TOE 5-145H)	Engr Bn (Inf Div) (TOE 5-155H)	Engr Bn (Abn Div) (TOE 5-25H)	Engr Bn (Air Assault Div) (TOE 5-215J)	Engr Bn (Inf Div Lt) (TOE 5-155L)
Combat Engineer Companies	4	3	3	4	3
Armored Combat Earthmover (ACE)	25	19	4	0	5
Dozer	0	0	6	12	0
Small Emplacement Excavator (SEE)	8	30	3	12	18

*Table extracted from Engineer Combat Operations, FM 5-100, page 9-3.

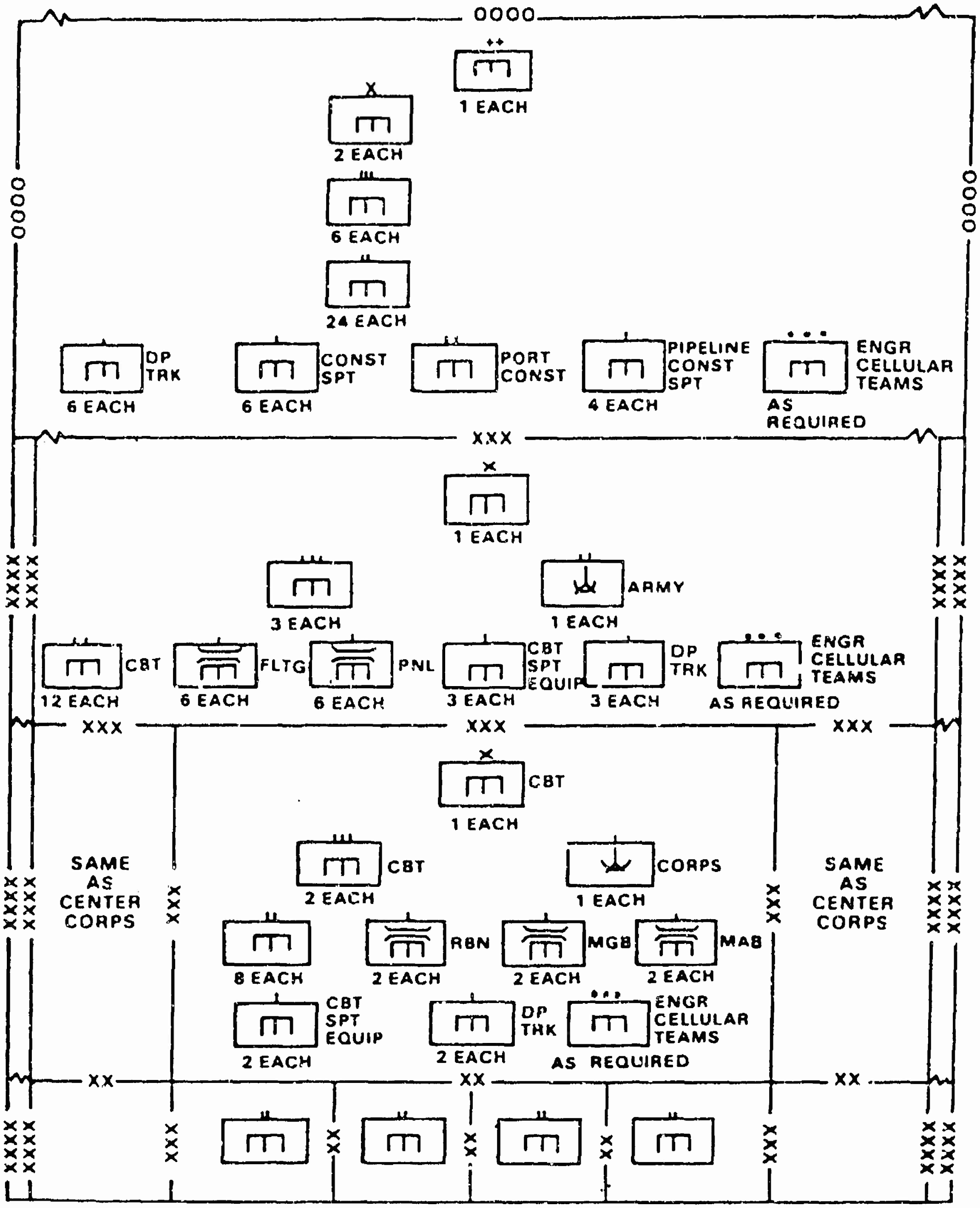

Figure 2. Deployment of combat engineer units within a theater.*

*Figure extracted from Field Manual 5-100, Engineer Combat Operations pg 33.

Impact of Environmental Protection

Field food service field manuals, FMs 21-10, 10-23, and Technical Manual (TM) 8-250 outline procedures for field sanitation and field waste discipline. However, due to environmental protection requirements, many of the procedures are not practiced. For example, on-site burning and burial of food service waste is not permitted in peacetime exercises. If on-site burial was allowed and food service personnel were required to manually excavate/bury food service waste after each meal, then there would be more inclination to reduce waste volume in order to minimize the daily excavation/burial requirement.

Current Doctrine for Field Food Service Waste Management

A review was made of field waste management doctrine in current and dated field manuals, FMs 21-10, 10-23, 63-3, and TM 8-250. Doctrine in FM 63-3 (1983) holds commanders at all theater levels responsible to enforce field waste management and sanitation standards. While doctrine in the current issue of FM 10-23 (1986) does address field expedient disposal procedures, the important operating details of earlier FMs have been left out. Doctrine for garbage/rubbish disposal in FM 21-10 (1983) is stated in only two words: BURIAL and INCINERATION. For example, FM 10-23 (1974) and TM 8-250 (1974) give detailed on-site burial requirements (trench dimensions per 100 meals) and incineration capability relative to feeding strength.

Since current FMs do not have doctrine for disposal of individual ration (MRE) waste, the "cat hole" latrine procedure (FM 21-10, TM 8-250) should be used (see Figure 3).

Doctrine Deficiencies

To meet the waste disposal requirements of CFFS and the highly mobile Army, new doctrine needs to be developed that is inclusive of the detailed tasks of all involved battlefield players, including the combat engineers.

Starting at the feeding site, new CFFS waste doctrine should stress a setup plan for waste reduction, for reasons of sanitation, safety (sharp tray can lids), and efficiency. All module boxes should be filled with ration packaging waste and drained nested empty tray cans. Trash bags of disposable messgear can be forced into module boxes. When boxes are filled, they should be closed (interlock box flaps) and, as an added measure, boxes can be placed in trash bags. If there are empty boxes remaining, they should be flattened. With a minimum degree of waste discipline, most of the ration packaging waste materials of each Unitized T module can be reduced to fit into the original box for disposal.

If on any given wartime day on-site disposal is the waste management decision, then the new doctrine needs to determine who excavates/buries or who operates the incinerators, if that is the option, and what is the time required to perform these tasks. If on-site or backhaul excavation/burial support is to

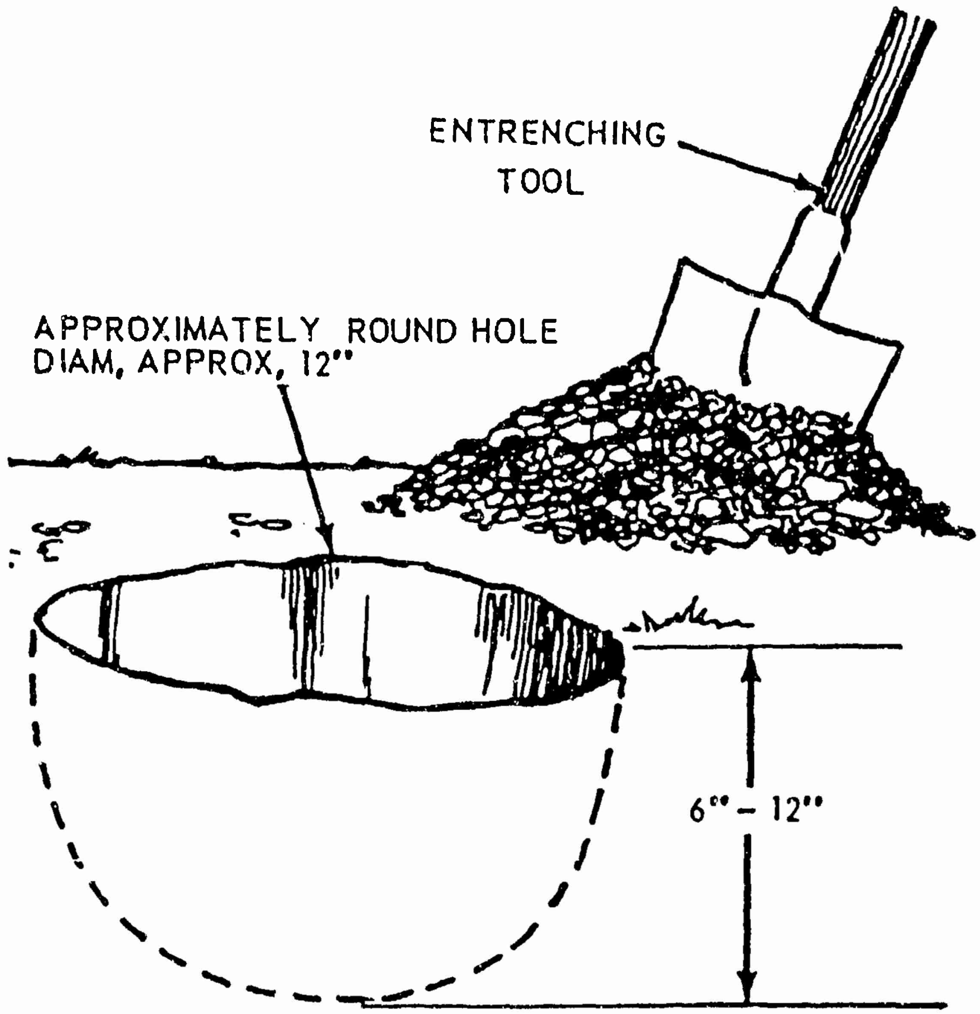

Figure 3. "Cat hole" procedure is proposed for disposal of individual MRE waste.

be provided by the combat engineers, then both the food service and combat engineers doctrine (FMs) should include that information.

In the case of the waste backhaul, doctrine is needed to determine the combat engineers responsibilities in support to CFFS waste management. In review of "Engineer Combat Operations," FM 5-100, there is no doctrine that addresses field waste management. Considering the new combat engineering operational concepts and equipment developed and fielded in response to the highly mobile AOE force design, the combat engineers may be able to provide on-site excavation/burial as well as consolidated landfill support to CFFS waste disposal.

Even though combat engineers have other high priority battlefield missions, there are no other units on the battlefield that have the equipment and expertise to operate consolidated waste disposal landfill sites.

Preliminary guidance for CFFS waste management has been provided in Field Circular, FC 21-150. However, a more detailed, integrated doctrine needs to be developed. After all applicable industrial and developing/fielded battlefield support technologies have been evaluated, doctrine should be developed for battlefield waste management that is inclusive of all tasks and what combat support group will perform those tasks. With AOE austere force design in combat support, efficient waste management will be realized only if there is an integrated doctrine to complete disposal of trash on-site or provide support for disposal of waste that is backhauled.

Historical Missions

Waste management lessons learned in past missions and field exercises may provide insight into current field waste management solutions. Waste disposal operational concepts, equipment, and logistical systems used in past wars and field exercises differ from waste disposal guidance suggested in FC 21-150 for CFFS. Field exercises provide practice of missions and operational concepts in a variety of operational environments where threats and operational constraints are evaluated. For this project, wartime mission-oriented information was provided through interviews and eyewitness accounts.

Operational Concepts. World War II veterans indicated that food service waste was disposed of mostly by on-site manual excavation/burial. In the Korean and Vietnamese conflicts as well as the Grenada Rescue (Urgent Fury), Host Nation Support played a major role in field waste management. Korea also provided Host Nation Support to the 9ID Team Spirit '86 Exercise.

In the Korean and Vietnamese conflicts and the Brimfrost '85 Exercise in Alaska, field expedient incineration was used to dispose of battlefield waste. In the Korean Conflict, pit burning was used in large dozer-excavated landfills to reduce waste cube and destroy intelligence-sensitive materials. A University of Wisconsin study[3] (see Appendix B) of landfill management used dozer landfill compaction as a procedure to reduce waste cube. This procedure could be used by the military as an alternative to pit burning. Despite threat of detection by thermal imagers, incineration can provide for disposal of waste in rocky and frozen environments.

In the case of the Grenada Rescue, the deployment did not include excavation equipment. As a result, trash piled up for more than 2 weeks. The solution to the disposal problem included capturing an enemy dozer and two trucks, establishing landfill sites, and using 21 local hires to manage the battlefield waste disposal. After establishing a waste disposal procedure, Grenada After Action Reports indicated that a waste discipline problem still existed, where the troops were reluctant to use the landfill disposal sites (see Appendix C).

With reference to the Grenada Rescue, the U.S. Army Logistics (LOG) Center (currently the Combined Arms Support Command or CASCOM) has conducted a Host Nation Support study[4] relative to combat service support in high and mid-intensity worldwide conflicts.

Logistical Systems. While tactical trucks are used most frequently to backhaul battlefield waste, in Vietnam and at the Brimfrost '85 Exercise helicopters were used to deliver hot rations to troops in remote sites not accessible to trucks and to backhaul trash for disposal.

In a number of brigade level field exercises, the 4th, 7th and 9th IDs have formed transportation details to backhaul trash. In a National Training Center '86 Exercise, the 4th ID used four supply and pickup (S&P) transport trucks to provide a daily hauling capacity of 3560 ft^3 to backhaul battlefield trash to a landfill for disposal. At the 9ID, 3Bde Octofoil Focus '85 Exercise, the 9ID used six 2.5-ton trucks and 1 S&P (2 trips daily) and a staff of 18 to provide a 4600 ft^3 daily battlefield trash backhaul capability for 2500 troops. In an interview, the 7ID food service officer indicated that at their exercises battlefield trash backhaul did not include food service personnel. At the "Project Show" demonstration in Europe, a backhaul capability of 4970 ft^3 was required daily for total trash, including Unitized T Ration trash for 2440 troops.

Battlefield Threats. Battlefield equipment and procedures have a relative threat with respect to battlefield signature. Generally, there is a trade-off of benefit of the equipment or procedure vs. the signature threat. In the case of field food service waste management, the trade-off has historically been troop disease casualties.

A Marine Corps battlefield waste management report points to documented data on the cause of Vietnam Conflict casualties[5]. Two in every three (67%) hospital admissions were due to poor waste management and field sanitation procedures, while one in every six (17%) were due to battlefield injuries. For example, in Vietnam between 1967 and 1970 cases of Viral Hepatitis, related to field sanitation, averaged 92,000 per year. In the same report, the authors assessed that the signature from incineration was not a serious threat since the enemy already knew their positions as a result of other battlefield activities.

Quantitative Assessment of Incineration Threat. Keeping in mind that incineration has battlefield signatures of heat and smoke over a relative period of time provides a basis to compare field expedient incineration to the technologically more efficient forced air incineration.

In the mathematical model where the threat components of heat (H), smoke (S), and time (T) are equally weighted (w) and equal to 1 with efficiency (e) of the baseline (field expedient) also being assigned a value of 1, and the relative known efficiency of forced air incineration expressed as a decimal fraction of 1, the reduced threat of new forced air incineration, can be assessed by the equation:

$$H(w)(e) + S(w)(e) + T(w)(e) = 1$$

Field expedient (baseline) incineration threat equals:

$$H(0.33)(1) + S(0.33)(1) + T(0.33)(1) = 1.0$$

Forced air incineration threat equals:

$$H(0.33)(1) + S(0.33)(0.1) + T(0.33)(0.38) = 0.5$$

OR

$$0.33 + 0.03 + 0.13 = 0.5$$

Based on the rationale that heat remains relatively constant and forced air incinerators reduce smoke (a signature visable from a distance) by 90% and time of burn by 62% (significant reduction of thermal imager detection time), the assessment is that battlefield threat is reduced by about 50% if field expedient incineration is replaced by state-of-the-art forced air incineration.

Battlefield Constraints. The constraint on battlefield incineration is that it should be deployed in rear division or EAD. This constraint also holds true for large-scale landfill operations that have a large battlefield signature. Camouflage should be used to the utmost degree possible for all field waste management operations to constrain battlefield signature. An example of this procedure was observed in a recent 7ID field exercise, where camouflage nets were used to hide the field kitchen trash waiting to be backhauled to a landfill disposal site.

SUMMARY

Equipment/systems with potential for more efficient waste management and compatible with the CFFS operational concept are included in a comparative cost analysis of alternatives in the next section of this report.

Assessment of battlefield waste management indicates that procedural deficiencies are numerous. Doctrine for CFFS waste disposal needs to be improved. The lack of waste discipline observed in field exercises was manifested in the Grenada Rescue effort, a real battlefield situation.

Traditionally in industry, a reduction in manpower (AOE austere Combat Service Support [CSS] design) requires more efficient procedures and integration with more efficient equipment to maintain or increase production. Considering the increased CFFS battlefield waste cube and no Table of Organization and Equipment (TOE) allocation of personnel for waste disposal, more efficient planning and increased use of combat engineer equipment is required for current Army battlefield waste disposal.

Host Nation Support (HNS) has played a major role in support of battlefield waste management in past wartime missions. Future missions should plan for and use HNS whenever feasible.

The benefit of state-of-the-art field incineration may outweigh the thermal image detection threat, particularly in rocky and frozen environments where waste burial would be next to impossible.

ANALYSIS OF ALTERNATIVES FOR CFFS WASTE MANAGEMENT

ANALYSIS APPROACH

Waste management systems/equipment considered to be compatible with the CFFS operational concept and to have potential to increase efficiency in disposal of CFFS waste were selected for inclusion in the CFFS waste management alternatives. Based on the Army Wartime Feeding Plan, the alternatives are measured (costed in FY88 dollars) against the most frequently used ration discipline, namely the MKT feeding 600 Unitized T/300 MRE meals (see Table 3).

A logistics analysis of CFFS waste disposal was conducted to evaluate waste management requirements and to determine if additional transportation assets are required to backhaul the waste generated by the expected overall worst waste cube. The logistical impact of backhaul with the 5-ton tactical truck within division and EAD is assessed in a cost analysis. The analysis does not address directly remote site or light forces Kitchen Company Level Field Feeding/Kitchen Company Level (KCLFF/KCL) feeding using the Highly Mobile Multipurpose Wheeled Vehicle (HMMWV) or Commercial Utility Cargo Vehicle (CUCV) backhaul of trash after delivery of hot meals; however, a cost equivalency factor was derived. HMMWVs and CUCVs are not allocated to the CFFS, but they may be used instead of 5-ton trucks when available for transporting rations and KCLFF/KCLs to remote feeding sites.

Cost analyses were conducted for comparison of all alternative options of on-site and backhaul waste disposal. Also, efficiency of on-site options was assessed, relative to current baseline waste management practice. In addition, battlefield annual costs, relative to worst case vs. best case of on-site and backhaul, were determined.

CFFS waste management alternatives were evaluated relative to the Mission Area Analysis (MAA) approach used by Training and Doctrine Command (TRADOC) planners and decision makers. Efficiency of procedural (doctrinal, organizational, and training) and material development solutions were evaluated against currently observed baseline field waste management practices.

LOGISTICS ANALYSIS

Field Circular, FC 21-150, 8-5, h., under CFFS sanitation, provides doctrinal guidance for on-site and backhaul waste disposal. Both on-site and backhaul disposal have associated baseline tasks that can be improved by procedural and material developments. Also, new excavation equipment, developed in response to an AOE highly mobile Army and fielded by the combat engineers, could provide excavation support to both on-site and backhaul waste disposal.

<u>On-Site Disposal</u>

Management and disposal of CFFS waste on-site require two steps of gathering waste with or without volume reduction (current Army practice) and excavation/burial. While on-site disposal is not practiced in peacetime exercises, it most likely will be used during wartime. Waste reduction is critical to on-site disposal, especially if excavation/burial is accomplished manually.

TABLE 3. Waste Cube Per 300 Rations
(MKT Feeding Capacity)

			Waste Volume (Ft³)[c]				
Ration Discipline[a]	Total Days Fed	Waste Discipline	MRE	B	Unitized T	Mess-Gear	Ration Total
3MRE	18	Reduced	53				53
		Worst Case	107				107
1T/2MRE	41	Reduced	35		29	16	80
		Worst Case	71		58	48	177
2T/1MRE	56	Reduced	18		58	32	108
		Worst Case	36		115	97	248
T/B/MRE	50	Reduced	18	4	29	32	83
		Worst Case	36	22	58	97	213
3B[b]	15	Reduced		12		48	60
		Worst Case		66		144	210
or							
3T	15	Reduced			87	48	135
		Worst Case			174	144	318

[a]Ration discipline for the first 60 days of the Army Wartime Feeding Plan.

[b]Ration discipline 3B or 3T (highest reduced and undisciplined waste cube) is planned for only 15 days in the COMMZ.

[c]Based on waste data from Appendix D, Tables D1-D3.

Waste Reduction

With the fielding of Unitized T Rations and disposable messgear, field food service waste has increased. Guidance in FC 21-150 and doctrine in FM 10-23 instruct that field food service waste will be reduced by flattening boxes and round cans and nesting tray cans, but in current field exercises and demonstrations the doctrine is not followed. Flattening a Unitized T Ration case will reduce its cube from 1.72ft^3 to 0.23ft^3 with a reduction in waste cube of 87%. Or in the case of manually compacting trash bags of disposable messgear by 67%, wartime manual excavation can be decreased by 67% (see Figure 4).

Backhaul Disposal

Field Circular FC 21-150, 1-3.,b(1), provides guidance for the CFFS trash backhaul/Class I pickup at the supply point cycle (see Figure 5). The backhaul distances of 10 miles for within divisions and 20 miles within EAD are based on a notional battlefield laydown provided to the Army QM School and the LOG Center for study and development of EAD designated feeding units by the Combined Arms Combat Development Activity, Force Design Directorate.

Over a 2-year period, field food service waste data were collected by Natick, U.S. Army Test and Evaluation Command (TECOM), and U.S. Army Combat Development Experimentation Center (CDEC) but the data reduction was in terms of pounds and/or cubic feet per soldier per meal (see Table 4). U.S. Army Office of the Deputy Chief of Staff for Logistics (ODCSLOG) and the QM School evaluated the data and determined that cube per soldier per meal did not provide data on truck loads/trips relative to the CFFS transportation requirements. With the Natick CFFS Project Officer concurring, ODCSLOG and the QM School directed that the truck loads/trips backhaul issue be tested at the "Project Show" in Europe. This issue marked a change in direction for evaluation of CFFS waste.

Reduction of CFFS waste is not critical if other battlefield waste is not added to the backhaul load or if the truck is not already loaded with items like the sanitation center or rations. Data in Table 3 show that no worst case undisciplined waste cube exceeds the capacity of the allocated 5-ton or the 2.5-ton truck hauling capacity of 520 or 470 ft^3, respectively. However, the "Project Show" demonstration backhaul data in Table 5 clearly show that addition of other battlefield trash with CFFS waste will exceed the CFFS truck allocation.

COST ANALYSIS OF FIELD WASTE MANAGEMENT ALTERNATIVES

Cost Assumptions

Cost analysis of battlefield waste management alternatives was based on the CFFS model expected to be the most widely used throughout the battlefield and expected to generate the largest overall cube of food service trash. The trash cube (248 ft^3), due to undisciplined waste management, was based on two times the ration shipping cube and the cube of uncompacted disposable messgear (disposable paper and plasticware) for 300 (2 Unitized T/1 MRE) rations.

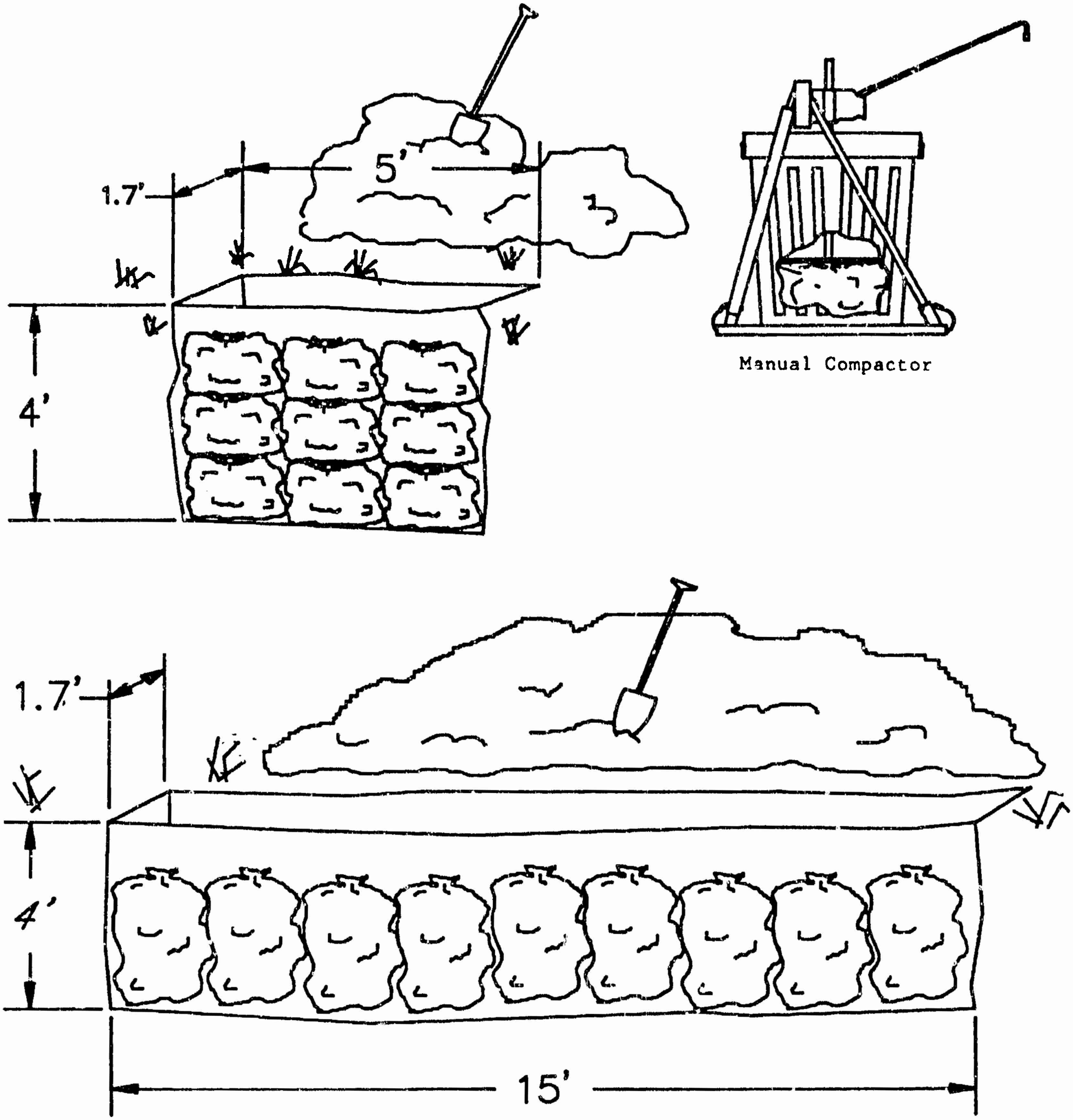

Figure 4. Comparison of wartime manual excavation/burial requirements for 300 sets of compacted (34 ft^3) vs. uncompacted (102 ft^3) disposable messgear waste.

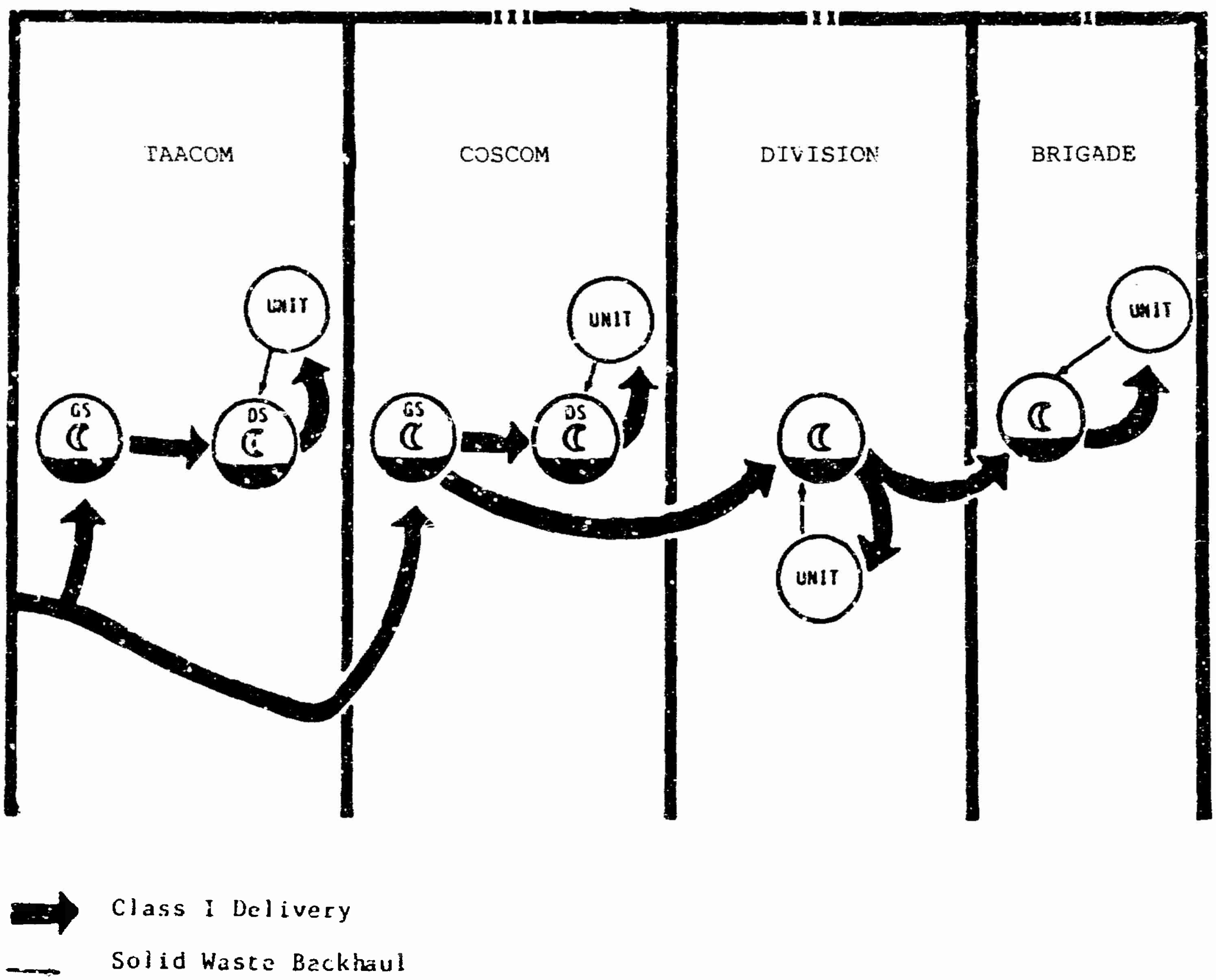

Figure 5. Theater Army Class I Supply and solid waste backhaul.

TABLE 4. Field Exercise Food Service Waste Weight and Cube (Per Soldier Per Meal)

Groups Tested	T Ration			B Ration			A Ration		
	No. Fed	Lbs	Ft^3	No. Fed	Lbs	Ft^3	No. Fed	Lbs	Ft^3
Natick RD&E Center Tests									
36 Medical Bn	267	0.96	0.26	282	0.87	0.35			
9th ID, 3 Bde	360	0.87	0.26						
TECOM Tests[a]									
Modular Field Kitchen, DT IA	1613	1.19	0.18	3273	1.01	0.14	70	1.98	0.15
KCLFF, DT II	580	0.9	0.2						
Modular Field Kitchen DT II	1201	1.15	0.25						
CDEC Test[b]									
CFFS-FDTE (Hawaii)	900	0.8	___	140	0.8	___	382	0.4	___
Average		0.98	0.23		0.89	0.25		1.19	0.15

[a] Data extracted from Test and Evaluation Command (TECOM) reports number USATTC 850902 (1985); 8-ES-765-MFK-005 (1986); and 8-ES-765-FFK-002 (1986).

[b] Data extracted from U.S. Army Combat Developments Experimentation Center (CDEC) report number CDEC-TR-85-006A (1986).

TABLE 5. Truck Loads/Trips of Trash Backhauled Daily From MKTs Feeding 2T/MRE Rations at "Project Show"

Groups Tested	Troop Strength	CFFS Truck Allocation	2.5-Ton Truck Loads: Food Service[a]	Nonfood Service	Total Loads
HHC, 3rd Bde	200	1	0.35	1.65	2
4/8 INF Bn	770	3	1.35	2.65	4
5/77 Armor Bn	520	2	1	0	1[b]
3/7 Cavalry	650	3	2	0	2
3rd FSB	300	1	0.53	1.47	2

[a] Estimate of food service waste is based on 248 ft^3 per 300 rations (2T/MRE).

[b] The 5/77 Armor Bn used the Heavy Expandable Mobile Tactical Truck (HEMTT) to backhaul only food service waste.

The model was applied to both on-site and backhaul disposal. Using the allocated 5-Ton Tactical Truck, the average waste backhaul enroute to pick up rations at the supply points within divisions and EAD were 10 and 20 miles, respectively.

Costs for deploying KCLFF/KCL on a CUCV/HMMWV, feeding 200 rations, 400 Unitized T meals (hot) and 200 MRE meals, were higher by a factor of 1.23 than the costs of the MKT model, based on data extracted from Table 11. The KCLFF/KCL, originally designed for light forces (infantry, airborne, and air assault), is now a small part (8%) of overall theater feeding but is being considered for deployment where required throughout the battlefield, to include EAD.

Since no table of organization and equipment (TOE) personnel and equipment are allocated to CFFS waste management, all associated costs were sunk costs. The baseline and other alternatives were defined as CFFS sanitation subsystems for the purpose of comparative cost analysis. Commercial equipment proposed for improvement of baseline CFFS waste management constituted real costs to the Army; however, those equipment costs were offset by the economy of improved efficiency of operation.

Evaluation Criteria

Proposed alternative options shall increase efficiency of operation by a reduction in time, cost, or provide for operating in unusual environments.

CFFS Waste Management Costs

Waste management costs were defined in terms of tasks related to equipment operating costs and personnel (manual) costs per hour. Daily disposal costs were derived by summing the cost of each task times the hours required daily. Baseline on-site and backhaul disposal alternatives and their suboptions were compared for relative efficiency of time and costs.

Equipment Operating Costs. The elements that make up the equipment operating hourly costs included capital and operating and supporting (O&S) maintenance (Table 6), fuel (Table 7), and personnel costs (Table 8). Hours required to perform a task were based on equipment or manual rates (Tables 9 & 10). The capital and O&S (10% of the capital cost) hourly costs were based on the number of hours (87,600 hours) in a 10-year equipment life. Military equipment, capital costs, and fuel consumption rates were provided by U.S. Army Tank and Automotive Command. Industrial equipment capital costs (based on an estimated buy size) and fuel consumption rate were provided by the companies marketing those items. Fuel (diesel) cost was provided by U.S. Army General Material Petroleum Activity.

TABLE 6. Equipment Capital and Operating & Supporting (O&S) Maintenance Costs($)

EQUIPMENT	EQUIPMENT COSTS		O&S COSTS	
	CAPITAL	HOURLY	TOTAL	HOURLY
5-Ton Truck	70,000	0.80	7,000	0.07
CUCV/HMMWV	20,000	0.23	2,000	0.02
D-7 Dozer	200,000	2.28	20,000	0.23
ACE Dozer	600,000	6.85	60,000	0.68
SEE Tractor	70,000	0.80	7,000	0.07
Portable Incinerator W/Generator	4,500	0.05	450	0.01
Air Curtain Destructor	25,000	0.29	2,500	0.03

The capital and O&S (10% of the capital cost) hourly costs are based on the number of hours (87,600) in a 10-year equipment life.

TABLE 7. Equipment Operating Fuel Costs

EQUIPMENT	MILES PER HOUR	GALLONS PER HOUR	COST PER HOUR
5-Ton Truck	10(in Div.)	2.0	1.50
	20(in EAD)	4.0	3.00
CUCV/HMMWV	10(in Div.)	1.0	0.75
	20(in EAD)	2.0	1.50
D-7 Dozer		4.0	3.00
ACE Dozer		17.5	13.13
SEE Tractor		4.0	3.00
Portable Incinerator W/Generator		0.3	0.23
Air Curtain Destructor		2.0	1.50

Average worldwide cost of diesel is $0.75 per gallon, provided by the U.S. Army General Materiel Petroleum Activity.

TABLE 8. Personnel Costs

MILITARY RANK	JOB	SALARY COSTS YEARLY	SALARY COSTS HOURLY
E-2	Kitchen Police	19,088	4.36
E-4	Equipment Operator	23,461	5.36

Salary costs are based on guidance from the Office of the Comptroller of the Army Finance and Accounting Policy Division.

TABLE 9. Daily Excavation/Burial Costs per 300 Rations
(600 Unitized T/300 MRE)

EVACUATION/BURIAL	RATE PER HOUR[a] FT^3	YD^3	COST PER HOUR ($)	HOURS[b] REQUIRED	COST PER DAY ($)
D-7 Dozer	16,200	600	10.87	0.1	1.09
ACE Dozer	16,200	600	26.02	0.1	2.60
SEE Tractor	1,350	50	9.23	0.25	2.31
Manual	108	4	4.36	4.0	17.44

[a] Military volume is measured in ft^3 while the waste industry measures trash in yd^3.

[b] Hours required are based on 248 ft^3 of trash generated by undisciplined waste management of 300 rations.

TABLE 10. Daily Incineration Costs per 300 Rations
(600 Unitized T/300 MRE)

INCINERATION EQUIPMENT	INCINERATION RATE (lb) PER HOUR	COST PER HOUR ($)	HOURS REQUIRED	COST PER DAY ($)
Portable, Forced Air Incinerator (Small)	75	4.65	4.5	20.93
Portable, Air Curtain Destructor	6000	7.18	0.1	3.03*
(Required Excavation)		9.23	0.25	2.31

*Air Curtain Destructor cost per day includes required SEE Tractor excavation cost per day ($2.31).

Personnel Costs. Personnel costs were based on guidance from the Office of Comptroller of the Army, Finance and Accounting Policy Division. Annual salaries were a composite of base pay, allowances, billeting, subsistence, and training. The hourly rate was based on the wartime workday of 12 hours per day, 365 days per year. Two grades were considered for waste disposal: E-2 for the labor rate and E-4 for the equipment operator rate (see Table 8). Daily and annual costs for all waste disposal tasks (equipment and manual) are summarized in Table 11.

Comparative Cost Analysis of Waste Disposal Alternatives

CFFS on-site and backhaul waste disposal alternatives 1-4 were compared for time and cost efficiency. On-site disposal alternatives 1 and 2 were grouped into two sets of operations to bury, options 1A - 1E, and to burn/incinerate and bury, options 2A and 2B. Backhaul disposal alternatives 3 and 4 were grouped into options 3A - 3C and alternative 4 without options. The options are made up of tasks required to perform the steps to manage field waste.

On-Site Disposal (Burial) Alternative 1. Baseline option 1A (see Table 12) and 1B represent disposal without and with manual reduction, respectively. Using option 1A as a base for comparisons, Table 12 shows the time and cost efficiency of manual reduction (option 2B) can reduce time and cost by 29% when compared to undisciplined waste management. A further gain in efficiency (43%) is obtained by using the manual compactor (option 1C). The combination of undisciplined waste management with excavation provided by the SEE Tractor (option 1D) has an efficiency rating of 54% and 50% for reduction of time and cost for waste disposal. Option 1E is proposed and preferred, where manual waste reduction, manual compaction, and excavation by the SEE Tractor provide the best efficiency (70% and 68% for time and cost reduction for waste disposal).

On-Site Disposal (Burning/Incinerating/Burial) Alternative 2. Baseline option 2A (see Table 13) represents disposal with manual reduction required for field expedient incineration. Option 2B using manual compaction, forced air incineration, and SEE Tractor excavation/burial is proposed and preferred. Three compacted trash bags occupy the same incinerator space as one uncompacted bag, permitting a 3 to 1 savings in burn and refill time. With about 20% moisture weight (plate waste) in the trash, forced air incineration will support rapid burning while field expedient incineration will require intensive labor to keep the wet trash burning. Table 13 shows an efficiency of 59% time and 56% cost reduction of option 2B over the baseline option 2A.

Backhaul Disposal (Burial) Alternative 3. Three baseline backhaul options are compared in Table 14. When comparing heavy division (option 3A) to light division (option 3B), the very slight difference in cost is attributed to the higher cost of excavation/burial by the ACE Dozer allocated to the light divisions. Backhaul in EAD shows a slightly higher cost ($1.50 fuel cost per day) over heavy division backhaul but about the same cost when compared to light division backhaul.

TABLE 11. Equipment Operating Costs (OC) and Personnel Costs for Disposal of Waste From 300 Rations (MKT Feeding Capacity)

ITEM/TASK	EQUIPMENT COSTS CAPITAL	O&S COSTS HOURLY	O&S COSTS HOURLY	FUEL COSTS, HOURLY	PERSONNEL COSTS, HOURLY	TOTAL COSTS, HOURLY	FEEDING UNIT DAILY & YEARLY DISPOSAL COSTS HOURS/ DAY	COST/ DAY	ANNUAL COSTS
5 Ton Truck									
OC in Div.	70,000	0.80	0.07	1.50	5.36	7.73	1.0	7.73	2,822
OC in EAD	70,000	0.80	0.07	3.00	5.36	9.23	1.0	9.23	3,369
CUCV/HMMWV									
OC in Div.	20,000	0.23	0.02	0.75	5.36	6.36	1.5[a]	9.54	3,482
OC in EAD	20,000	0.23	0.02	1.50	5.36	7.11	1.5[a]	10.67	3,895
D-7 Dozer	200,000	2.28	0.23	3.00	5.36	10.87	0.1	1.09	398
ACE Dozer	600,000	6.85	0.68	13.13	5.36	26.02	0.1	2.60	949
SEE Tractor	70,000	0.80	0.07	3.00	5.36	9.23	0.25	2.31	843
Portable Incinerator W/3K Generator	4,500	0.05	0.01	0.23	4.36	4.65	4.5	20.93	7,640
Air Curtain Destructor	25,000	0.29	0.03	1.50	5.36	7.18	0.35[b]	3.03	1,106
Manual Compactor	400	0.005	0.0005	-	4.36	4.37	1.0	4.37	1,595
Manual									
Reduction					4.36	4.36	3	13.08	4,774
Excavation/ Burial					4.36	4.36	4	17.44	6,366
Load/Unload					4.36	4.36	1	4.36	1,591

[a]The factor 1.5 hours is used to equalize KCLFF/KCL (200 rations) vs. MKT (300 rations).

[b]Time includes 0.25 hr of SEE Tractor time at a rate of $9.23 per hr.

TABLE 12. Comparison of Cost and Efficiency for On-Site Disposal (Burial) of Waste From 300 Rations (Alternative 1)

WASTE DISPOSAL TASKS	MAN/ HOURS PER DAY	COST PER HOUR	COST PER DAY	ANNUAL COSTS	EFFICIENCY (%) REDUCTION IN TIME	COST
BASELINE, OPTION 1A						
Gathering WO/Reduction (Manual)	3.0	4.36	13.08	4,774		
Excavation/Burial (Manual)	4.0	4.36	17.44	6,366		
Baseline, Option 1A, Total Hours and Costs	7.0		30.52	11,140		
BASELINE, OPTION 1B						
Gathering W/Reduction (Manual)	3.0	4.36	13.08	4,774		
Excavation/Burial (Manual)	2.0	4.36	8.72	3,183		
Baseline, Option 1B, Total Hours and Costs	5.0		21.80	7,957	29	29
Proposed Option 1C						
Gathering W/Reduction and Compaction (Manual)	2.0	4.36	8.72	3,183		
Excavation/Burial (Manual)	2.0	4.36	8.72	3,183		
Proposed, Option 1C, Total Hours and Costs	4.0		17.44	6,366	43	43
Proposed Option 1D						
Gathering WO/Reduction (Manual)	3.0	4.36	13.08	4,774		
Excavation/Burial (W/SEE Tractor)	0.25	9.23	2.31	843		
Proposed, Option 1D, Total Hours and Costs	3.25		15.39	5,617	54	50
Proposed, Preferred, Option 1E						
Gathering W/Reduction & Compaction (Manual)	2.0	4.36	8.72	3,183		
Excavation/Burial (W/SEE Tractor)	0.13	9.23	1.20	438		
Proposed, Preferred, Option 1E Total Hours and Costs	2.13		9.92	3,621	70	68

TABLE 13. Comparison of Cost and Efficiency for On-Site Disposal (Burning or Incinerating/Burial) of Waste From 300 Rations (Alternative 2)

WASTE DISPOSAL TASKS	MAN/ HOURS PER DAY	COST PER HOUR	COST PER DAY	ANNUAL COSTS	EFFICIENCY(%) REDUCTION IN TIME	COST
BASELINE, OPTION 2A						
Gathering W/Reduction	3.0	4.36	13.08	4,774		
(Manual)	3.0	4.36	13.08	4,774		
Burn (Field Expedient is Labor Intensive)	12.0	4.36	52.32	19,097		
Excavation Burial (Manual)	1.0	4.36	4.36	1,591		
Baseline, Option 2A, Total Hours and Cost	16.0		69.76	25,462		
Proposed, Preferred, Option 2B						
Gathering W/Reduction & Compaction (Manual)	2.0	4.36	8.72	3,183		
Burn (Portable, Forced-Air Incinerator)	4.5	4.65	20.93	7,640		
Excavation/Burial	0.13	9.23	1.20	438		
Proposed, Preferred, Option 2B, Total Hours and Costs	6.63		30.85	11,261	59	56

Backhaul Disposal (Incinerating/Burial) Alternative 4. The Air Curtain Destructor provides for consolidated backhaul disposal without large-scale excavation/burial. The proposed alternative 4 (see Table 15) allows for large-scale disposal in rocky or thick forest areas, at only a slightly higher cost than conventional backhaul, burial disposal.

Theater Battlefield Waste Management Costs (M$)

An analysis of battlefield waste disposal annual costs (M$) compares on-site worst and best cases and average backhaul waste disposal (see Table 16). Battlefield costs are based on annual unit costs per option/alternative, times the number of estimated designated feeding units. Using the theater troop strength divided by the average designated feeding unit (220 personnel) developed by the QM School (FC 21-150), the number of theater designated feeding units were determined.

A 68% cost savings is realized when comparing on-site disposal option 1E to the baseline option 1A. On-site burn/bury is a more expensive alternative than on-site bury; however, the proposed use of forced air incineration (option 2B) instead of field expedient incineration (option 2A) will provide a 56% cost savings. Backhaul/bury is a more expensive alternative than on-site bury, but considering that backhaul/bury is the only alternative used in peacetime exercises and was used in the Grenada Rescue, together with international environmental concerns, it may be the most frequently used alternative in wartime, regardless of the higher cost.

TABLE 14. Comparison of Cost for Backhaul Disposal (Burial) of Waste From 300 Rations (Alternative 3)

WASTE DISPOSAL TASKS	MAN/ HOURS PER DAY	COST PER HOUR	COST PER DAY	ANNUAL COSTS
BASELINE, OPTION 3A FOR HEAVY DIV				
Gathering WO/W/Reduction (Manual)	3.0	4.36	13.08	4,774
Backhaul for Heavy Div (10 miles at 10 MPH)	1.0	7.73	7.73	2,822
Load/Unload	1.0	4.36	4.36	1,591
Excavation/Burial (D-7 Dozer)	0.1	10.87	1.09	398
Baseline, Option 3A, Total Hours and Cost	5.1		26.26	9,585
Baseline, Option 3B for Light Div				
Gathering WO/W/Reduction (Manual)	3.0	4.36	13.08	4,774
Backhaul for Light Div (10 miles at 10 MPH)	1.0	7.73	7.73	2,822
Load/Unload	1.0	4.36	4.36	1,591
Excavation/Burial (ACE Dozer)	0.1	26.02	2.60	949
Baseline, Option 3B, Light Div, Total Hours and Costs	5.1		27.77	10,136
Baseline, Option 3C for EAD				
Gathering WO/W/Reduction (Manual)	3.0	4.36	13.08	4,774
Backhaul for EAD (20 miles at 20 MPH)	1.0	9.23	9.23	3,369
Load/Unload	1.0	4.36	4.36	1,591
Excavation/Burial (D-7 Dozer)	0.1	10.87	1.09	398
Baseline, Option 3C, EAD, Total Hours and Costs	5.1		27.76	10,132

SUMMARY

Using the MAA approach of applying solutions to battlefield deficiencies, a procedural (doctrinal, organizational, and training) improvement in manual waste reduction discipline (see Table 12, baseline option 1B) will result in only a 29% increase in efficiency of time and cost. In contrast, a combination of procedural (manual waste reduction), material actions (development and use of the manual, mechanical compactor), and exploitation of technological advancements (SEE Tractor) will provide a high efficiency, namely 70% time savings and 68% cost reduction (see Table 12, option 1E).

Realizing that manual waste reduction discipline may never be fully utilized on the battlefield, we must consider option 1D in Table 12, where use of SEE Tractor excavation/burial without waste reduction, provides a time savings of 54% and cost reduction of 50% compared to baseline manual excavation/burial (option 1A).

TABLE 15. Cost for Backhaul Disposal (Incinerating/Burial) of Waste From 300 Rations (Alternative 4)

WASTE DISPOSAL TASKS	MAN/ HOURS PER DAY	COST PER HOUR	COST PER DAY	ANNUAL COSTS
PROPOSED, ALTERNATIVE 4 FOR EAD AND DIV, REAR				
Gathering WO/W/Reduction (Manual)	3.0	4.36	13.08	4,774
Backhaul for EAD (20 miles at 20 MPH)	1.0	9.23	9.23	3,369
Load/Unload	1.0	4.36	4.36	1,591
Incinerate with Air Curtain Destructor*	0.1	7.18	0.72	263
Excavate/Burial (SEE Tractor)	0.25	9.23	2.31	843
Proposed, Alt 4, EAD and DIV, Rear Total Hours and Costs	5.35		29.70	10,840

*The Air Curtain Destructor is a powerful tool that can, at the rate of 3 tons per hour, incinerate all daily food service waste of a light division or equivalent in 3.5 hours or a heavy division or equivalent in 6 hours. In either case, the excavations required are two trenches, 8′ width by 10′ length by 12′ depth.

TABLE 16. Two Army Mature Theater Battlefield (CFFS) Waste Management Costs (M$)

European (NATO) Theater (5 Corps)	Troop Strength	Number of Feeding Units	Annual Costs of Alternatives: Disposal Option	Annual Costs of Alternatives: Unit Cost ($)	Battlefield Costs (M$) of Alternatives: On-Site Waste Disposal: Bury: Worst	Bury: Best	Burn/Bury: Worst	Burn/Bury: Best	Average Backhaul Disposal
Divisions	296,200	1,346	1A	11,140	14.99				
			1E	3,621		4.87			
			2A	25,462			34.27		
			2B	11,261				15.16	
			3A-Alt 4	10,173					13.69
Echelons Above Division (EAD)									
Corps, Non-Div	357,000	1,623	1A	11,140	18.08				
			1E	3,621		5.88			
			2A	25,462			41.33		
			2B	11,261				18.28	
			3A-Alt 4	10,173					16.51
Echelons Above Corps (EAC)	164,000	746	1A	11,140	8.31				
			1E	3,621		2.70			
			2A	25,462			18.99		
			2B	11,261				8.40	
			3A-Alt 4	10,173					7.59
NATO Theater Totals:	817,200	3,715			41.38	13.45	94.59	41.84	37.79
Southwest Asia (SWA) Theater									
Divisions	69,200	315	1A	11,140	3.51				
			1E	3,621		1.14			
			2A	25,462			8.02		
			2B	11,261				3.55	
			3A-Alt 4	10,173					3.20
EAD Corps, Non-Div	93,800	426	1A	11,140	4.75				
			1E	3,621		1.54			
			2A	25,462			10.85		
			2B	11,261				4.80	
			3A-Alt 4	10,173					4.33
EAC	50,800	231	1A	11,140	2.57				
			1E	3,621		0.84			
			2A	25,462			5.88		
			2B	11,261				2.60	
			3A-Alt 4	10,173					2.35
SWA Theater Totals:	213,800	972			10.83	3.52	24.75	10.95	9.88

CONCLUSIONS AND RECOMMENDATIONS

Based on FEA findings and analyses applicable to field waste management, alternative waste disposal solutions compatible with the CFFS and AFFS (during wartime) operational concepts have been proposed. The AOE force design initiative and the TRADOC MAA approach were considered when developing the following conclusions and recommendations.

1. To meet the need for improved field sanitation and the threat of spread of disease with subsequent battlefield casualties, recommend that field waste discipline be reestablished in field food service operations.

2. With the increase of CFFS waste as a result of using disposable messgear to replace permanent messgear, recommend that the manual, mechanical compactor be allocated to each designated feeding unit to decrease the wartime on-site manual excavation requirement for trash bags.

3. To reduce the wartime battlefield smoke and heat signature by a significant reduction in smoke production and burn time, recommend the portable, forced air incinerators (can be used in frozen environments) be used as an alternative to on-site field expedient incineration. For the same reasons above, recommend the Air Curtain Destructor (large incinerator) as an alternative to consolidated landfill for rocky and heavy forest environments. Incinerators should be deployed in rear division, corps, and COMMZ areas.

4. To provide cost-effective field waste disposal operations, recommend that doctrine be developed to provide integrated combat engineer SEE Tractor and dozer (conventional or ACE) support to wartime CFFS on-site and backhaul excavation/burial.

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Zum Brunnen, R.L., and M.I. Hutton, Front End Analysis (FEA) Methodology CRDEC-TR-87058, U.S. Army Chemical Research and Development Center, Aberdeen Proving Ground, MD, 1987. (Former Technical Note TN 85-5, 1986).

ABBREVIATION AND ACRONYMS

ACD	Air Curtain Destructor
ACE	Armored Combat Excavator
AFFS	Army Field Feeding System
AOE	Army of Excellence
Bde	Brigade
Bn	Battalion
CDEC	U.S. Army Combat Developments Experimentation Center
CFM	Cubic Feet per Minute
CFFS	Combat Field Feeding System
COMMZ	Communication Zone
COSCOM	Corps Support Command
CSS	Combat Service Support
CUCV	Commercial Utility Cargo Vehicle
Div	Division
DS	Direct Support
EAC	Echelon Above Corps
EAD	Echelon Above Division
FC	U.S. Army Field Circular
FEA	Front End Analysis
FM	U.S. Army Field Manual
GS	General Support
HEMTT	Heavy Expandable Mobile Tactical Truck
HMMWV	Highly Mobile Multipurpose Wheeled Vehicle
HNS	Host Nation Support

ABBREVIATIONS AND ACRONYMS (cont'd)

ID	Infantry Division
KCLFF/KCL	Kitchen Company Level Field Feeding/Kitchen Company Level
KP	Kitchen Police
LOG	Logistics
Lt	Light and Light (small) Division
MAA	Mission Area Analysis
MFK	Modular Field Kitchen
MKT	Mobile Kitchen Trailer
MRE	Meal, Ready-to-Eat
NDI	Nondevelopment Item
ODCSLOG	U.S. Army Office of the Deputy Chief of Staff for Logistics
O&S	Operating and Supporting
PLS	Palletized Load System
QM	U.S. Army Quartermaster (School)
R&D	Research and Development
SEE	Small Emplacement Excavator
S&P	Supply and Pickup (truck)
TAACOM	Theater Army Area Command
TECOM	U.S. Army Test and Evaluation Command
TM	U.S. Army Technical Manual
TOE	Table of Organization and Equipment
TRADOC	U.S. Army Training and Doctrine Command

APPENDIX A.

Development of the Manual, Mechanical Compactor

APPENDIX A.

Development of the Manual, Mechanical Compactor

RATIONALE FOR DEVELOPMENT

A manual, mechanical compactor requiring no mobile or under-the-hood power was conceptualized, designed, fabricated, and tested by the senior author and project engineer with assistance from the Aero-Mechanical Engineering, Prototype Shop, Natick. The development of the manual compactor is in response to a need to manage increased battlefield trash resulting from replacement of permanent messgear with disposable messgear.

Ration packaging waste cube can be reduced by flattening boxes and round cans and nesting tray cans. However, randomly filled trash bags of disposable messgear, which increase the trash cube more than tenfold when compared to messgear shipping cube, require compaction to reduce the waste cube.

The on-site wartime manual excavation/burial requirement for trash bags can be reduced by 67%, if trash bags are manually compacted (see Figure 5 of the main report).

EQUIPMENT/SYSTEMS DESCRIPTION

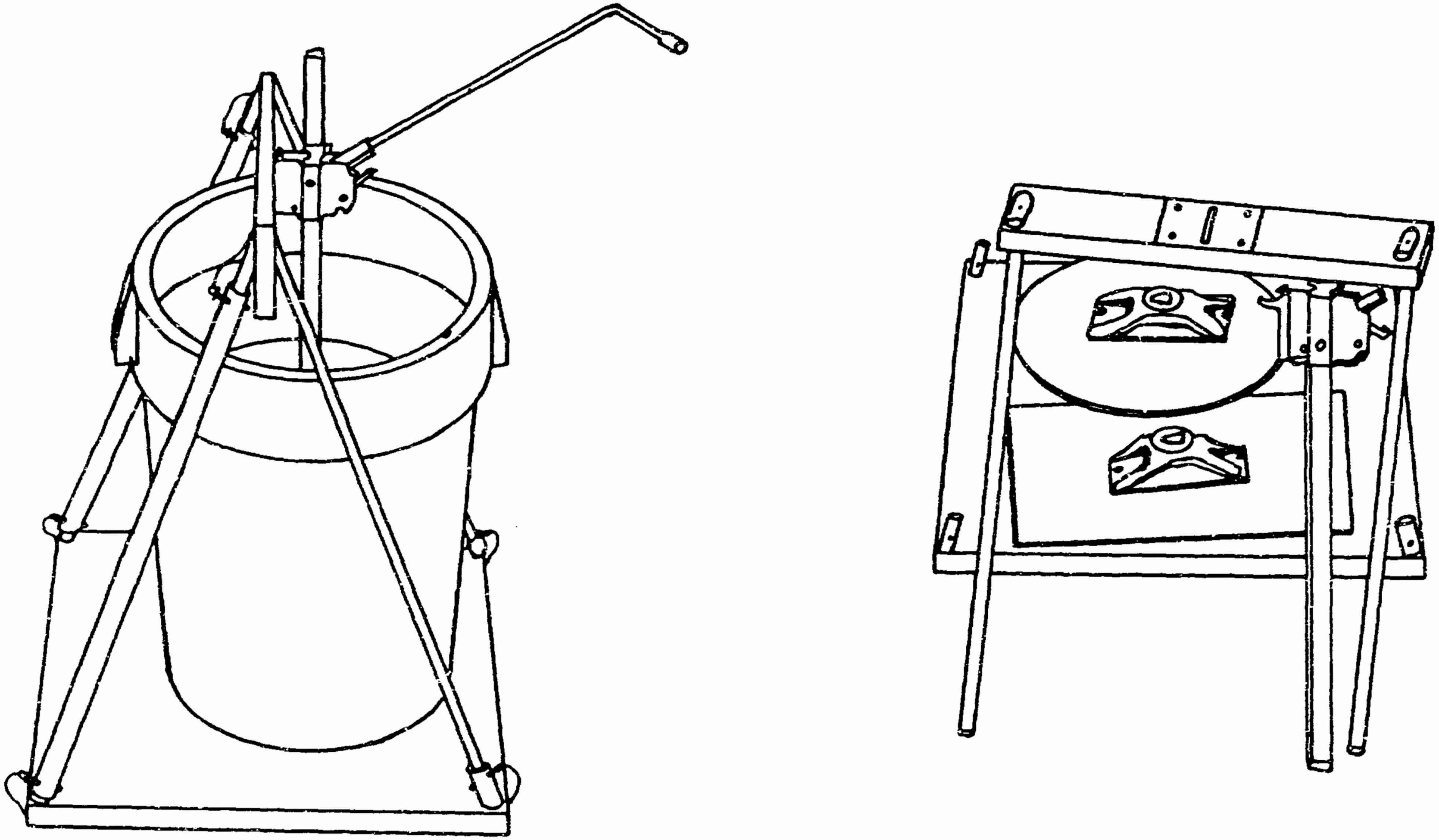
The manual, mechanical compactor consists of a bumper jack (1-ton or 3.5-ton) and aluminum (6061 grade) compactor plates and frame. Three prototype frames were fabricated: the A Frame, T Frame, and I Frame (see Figures A-1 thru A-3). The frames setup/operating configurations average about 16 ft^3 and the foldup/storage configurations are about 5 ft^3. The manual compactor weight ranges from 50 lb with the 1-ton jack to 70 lb with the 3.5-ton jack. All three frames perform (compact) equally; however, the A Frame requires more effort to set up and fold up. The system was also designed to compact trash bags of disposable messgear into Unitized T Module boxes using a rectangular compaction plate.

MEASUREMENT OF COMPACTOR OPERATING PARAMETERS

The parameters of compaction time, volume reduction, and rupture rate were determined. Trash compaction memory (springback) was also evaluated. In both the time and volume compaction tests sample size (95% confidence) was determined. All tests were conducted on the A Frame prototype.

Compaction Time Test

Table A-1 shows the compaction time data where the average time for compacting a trash bag was determined to be 2 minutes with a standard deviation of 0.27 minutes and a sample size of five bags.



OPERATING
CONFIGURATION

STORAGE/TRANSPORT
CONFIGURATION

Figure A-1. Prototype A compactor frame.

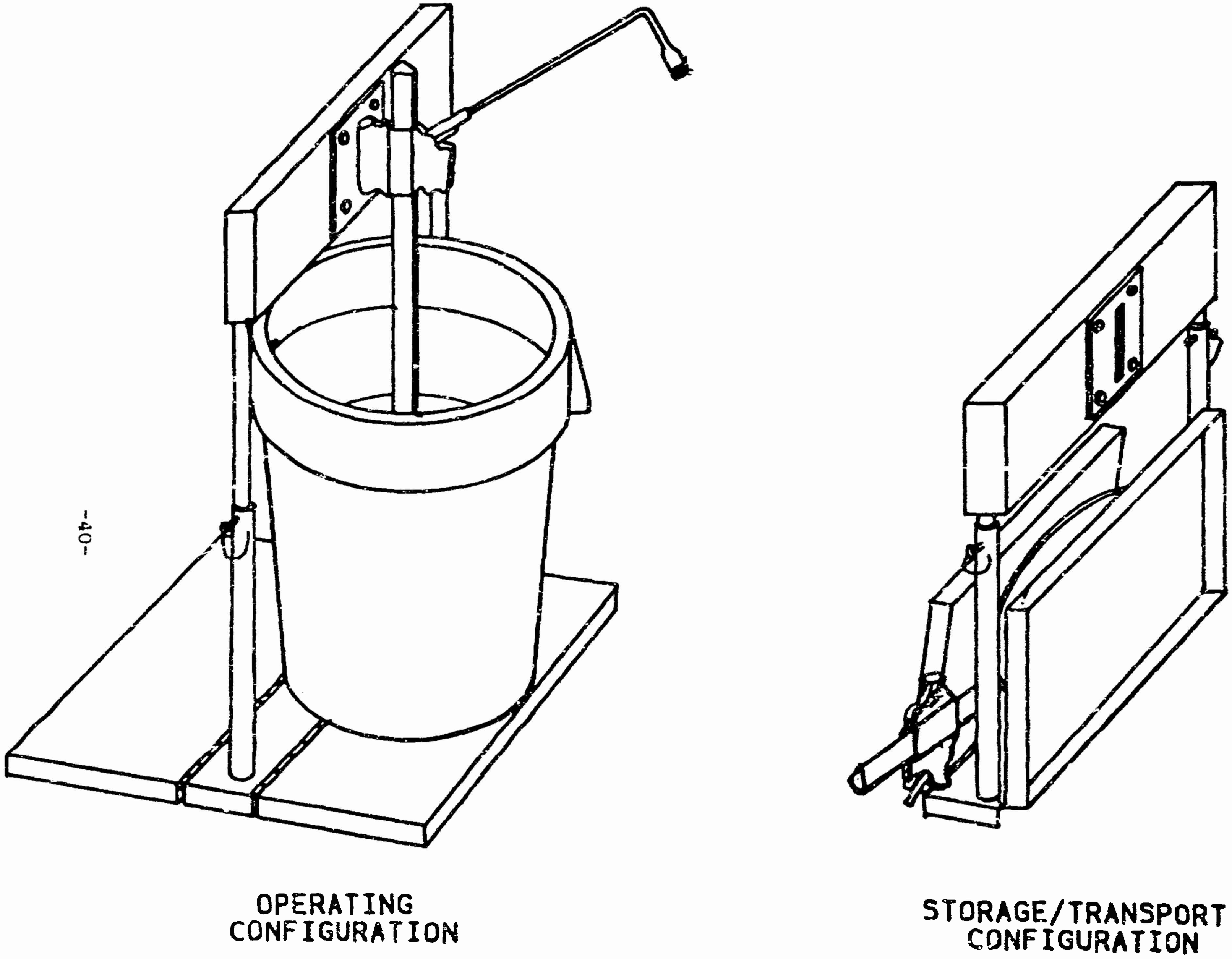


Figure A-2. Prototype T compactor frame.

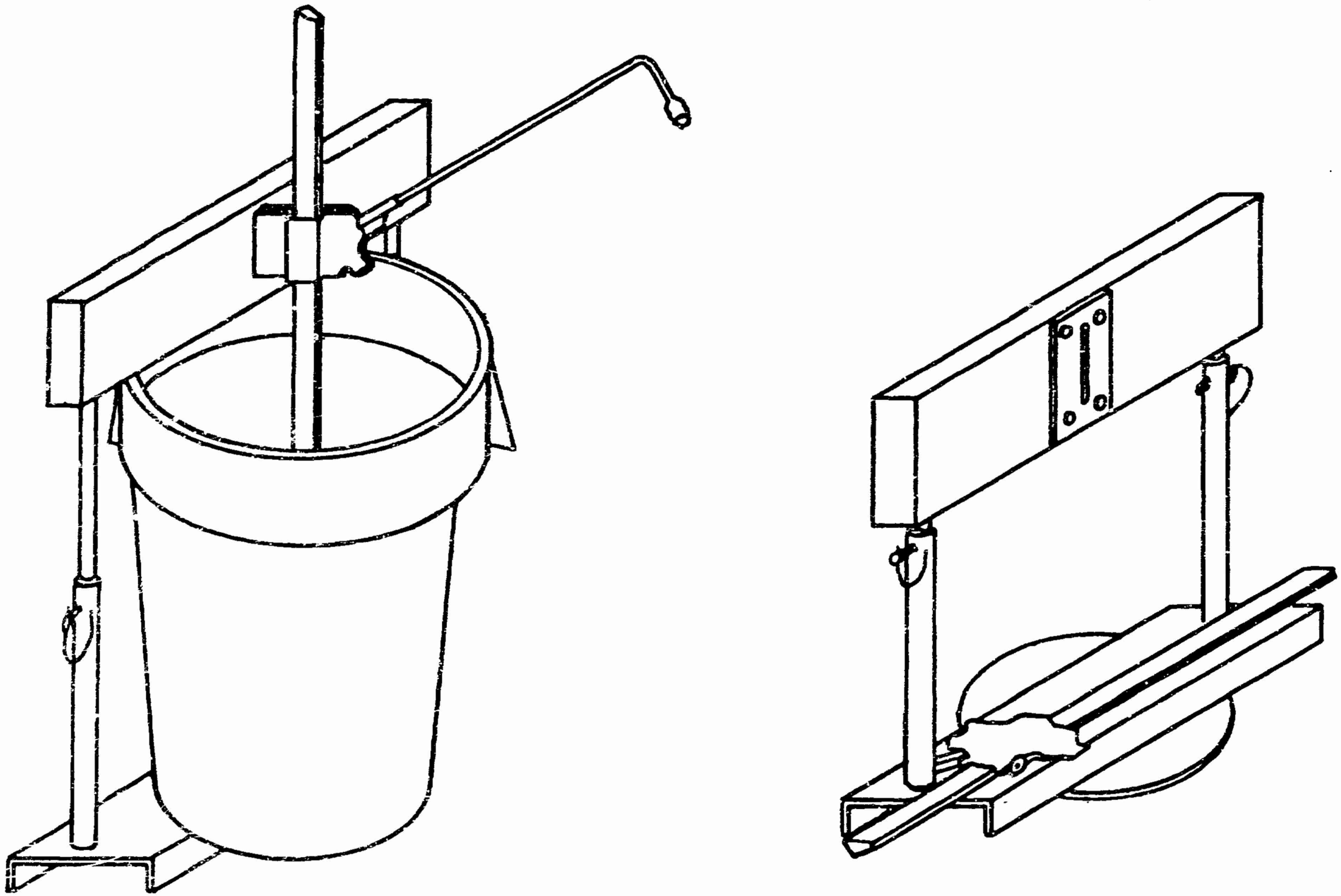


Figure A-3. Prototype I compactor frame.

TABLE A-1. Determination of Compaction Time

No. of Repeats	Minutes to Compact
1	2.00
2	1.73
3	1.68
4	2.40
5	2.58
6	2.07
7	2.12
8	1.93
9	1.95
10	2.02
11	1.83
12	1.75
$\bar{x}$	2.01 min
s	0.27 min

Compacted Volume Tests

The percent compacted volume reduction data is shown in Table A-2 where the average reduced volume is 67% with standard deviation of 3.4% and a sample size of 12 bags. Trash memory (springback) after compaction relative to trash bag initial cube and content (1/4, 1/2, 3/4, and full bags) was measured as well as trash bag rupture rate (see Table A-3 and Figure A-4).

TABLE A-2. Determination of Compacted Volume (%)

No. of Repeats	Compaction (%)
1	67.0
2	60.5
3	60.5
4	64.7
5	67.8
6	73.7
7	68.0
8	68.0
9	70.7
10	70.2
11	68.4
12	65.0
13	68.4
14	65.0
15	66.9
16	66.3
$\bar{x}$	66.94%
s	3.4 %

TABLE A-3. Comparison of Disposables Compacted Volumes Before and After Memory (Springback) Relative to Initial Trash Bag Cube

Initial Trash Bag Fill	Ft^3	Reduction On Compaction (%)	Reduction After Springback (%)	Observed Ruptures*
1/4	0.75	80	67.0	
1/4	0.75	80	60.5	
1/4	0.75	80	60.5	
$\bar{x}$	0.8	80	63	
1/2	1.70	82.5	64.7	
1/2	1.86	84.0	67.8	
1/2	1.70	82.5	73.7	x
$\bar{x}$	1.8	83	69	
3/4	2.36	81	68	
3/4	2.36	81	68	
3/4	2.53	79.3	70.2	
$\bar{x}$	2.4	80.4	69	
1	3.04	75.2	70.2	x
1	3.04	79.1	68.4	x
1	2.86	80.3	65.0	x
$\bar{x}$	3.0	78.2	68	

* Small ruptures were due to plastic flatware punctures.

<u>Volume Measurement Procedure.</u> Using a 32 gallon trash can calibrated in 1-inch increments, the volume of each compacted or uncompacted bag of trash was determined by the Frustum of Right Circular Cone equation*:

$$\text{Volume} = \text{pi}(r^2+rR+R^2)h/3$$

where pi equals 3.142, r is the radius of the bottom of the trash can, R is the radius at the top of the compacted or uncompacted bag, and h is the height of the compacted or uncompacted bag. Cubic inches are converted to ft^3 by division with the conversion factor 1728 cubic inches per ft^3.

LESSONS LEARNED AT "PROJECT SHOW"

At the "Project Show" demonstration of the CFFS in Europe, trash bags contained disposable messgear and tray cans. When these bags were compacted, using a 32 gallon plastic trash can or Unitized T module box, the compacting containers deformed. The field demonstration indicates that 32 gallon metal trash cans are required with a 1 or 3.5-ton jack to compact trash bags with a mixture of cans and paper.

*Larson, R.E., and R.P. Hostetler, Calculus, 1979.

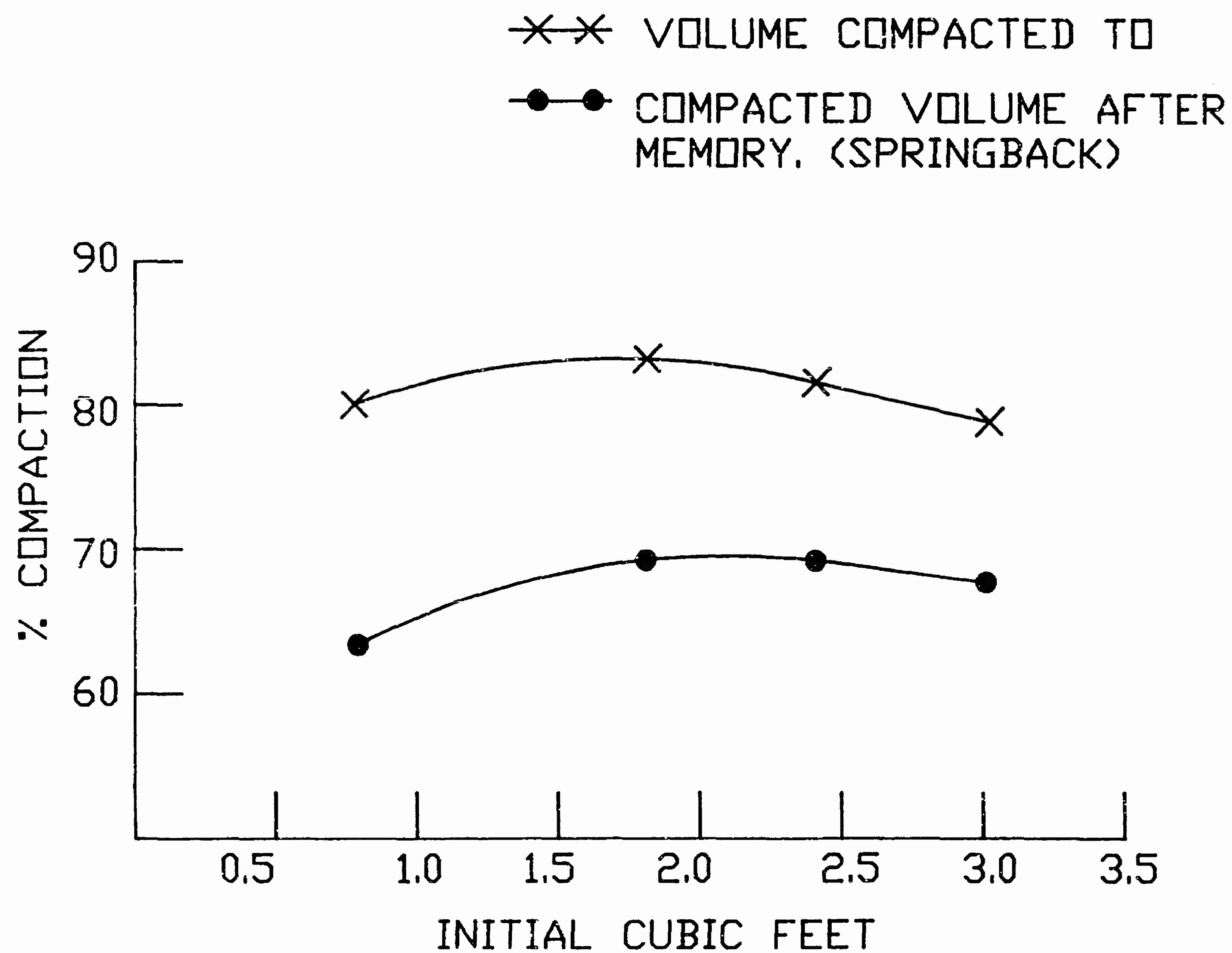


Figure A-4. Comparison of disposable messgear compacted volumes before and after trash memory.

APPENDIX B.

Study of Waste Management Technologies and Procedures Applicable to Army Field Food Service Waste Management

APPENDIX B.

Study of Waste Management Technologies and Procedures Applicable to Field Food Service Waste Management

Studies of waste management technologies and battlefield elements applicable to Army field food service waste management were conducted concurrently (see Figure 1 main report).

STUDY OF APPLICABLE TECHNOLOGICAL CAPABILITIES

Surveys and literature searches of domestic and foreign industry, academia, and military research and development (R&D) communities were conducted to identify and characterize technologies, products, and procedures applicable to CFFS waste management.

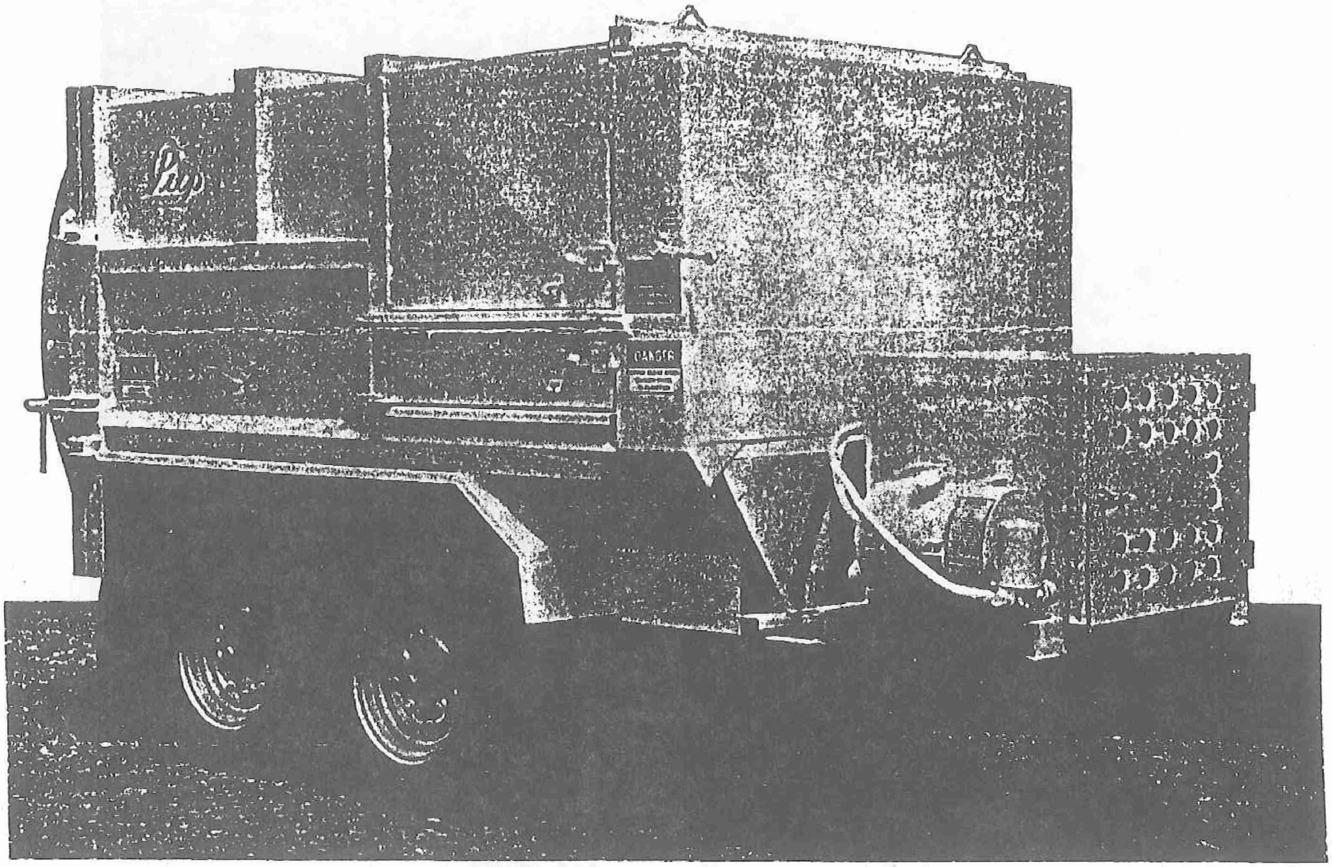
Industrial Survey

There is very little interest in the industrial R&D community for managing waste in remote sites. The thrust of waste management R&D in domestic and foreign industry is in large-scale waste-to-energy conversion, as evidenced by the entire November 1986 issue of the journal Waste Age being dedicated to the subject. Largely, the focus is on energy from incineration in the form of steam and/or electricity. Interestingly, the Army's Technical Manual, TM 8-250, Environmental Health Technician, recommends using heat from field expedient incinerators to heat water for food service sanitation and showers. There is some interest in large-scale compaction/baling to conserve landfill space and in commercial development of methane from landfills. Commercial compactors available fall in two categories--large to medium for industrial use, and small for restaurant use--neither of which are applicable to military field feeding.

Of the 100 waste equipment/systems companies surveyed, 3 companies make trailer compactors/transporters (see Figure B-1) used to manage waste in municipal, state, and remote national parks. In parks, use of compactor/transporters have resulted in manpower reductions of 4 to 1. Two other companies make large and small portable incinerations (see Figures B-2 and B-3) that are applicable to remote site waste management. Details of equipment/systems descriptions are addressed later in this Appendix. Unit costs and sources of equipment/systems are shown in Table B-1.

Academic and Military R & D Literature Searches

Efficient Landfill Operations. With focus on the operational concept guidance outlined in U.S. Army Field Circular, FC 21-150, Combat Field Feeding System (CFFS) Operations as related to CFFS waste backhaul to a landfill, a University of Wisconsin paper[3] analyzed the parameters of efficient landfill operations. There are two analyses of interest to CFFS waste management studies. The equipment needed, relative to a division size population of 18,000, based on 5.5 pounds of waste per person per day, is one D-7 type dozer operating 8 hours a day. Also of interest to the study is the analysis of efficiency of



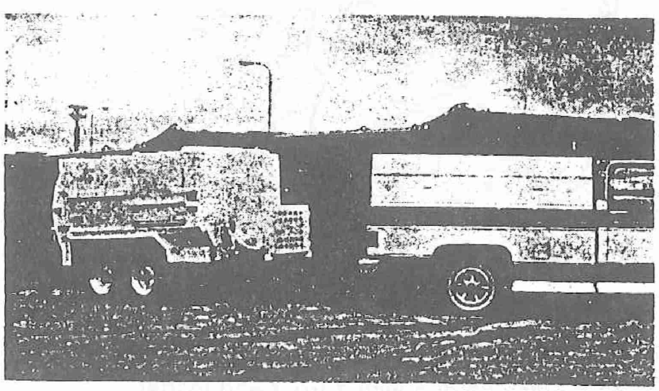
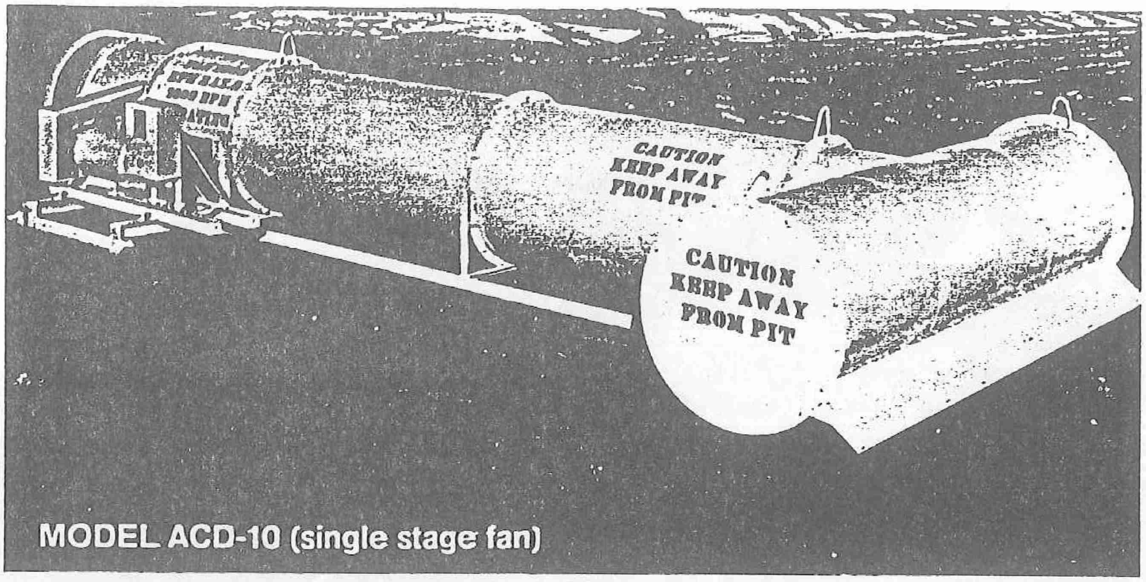
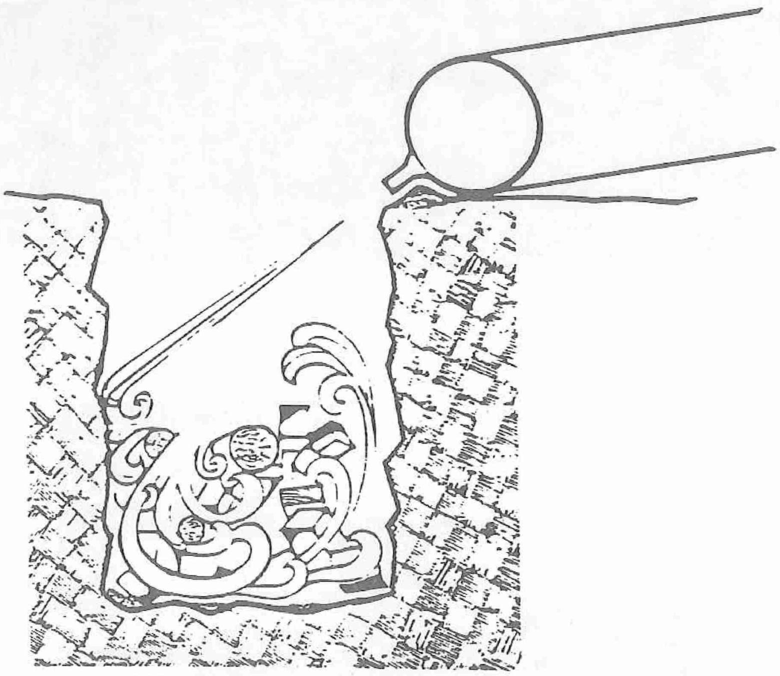


Figure B-1. Trailer compactor/transporter with potential to backhaul waste with a CUCV.



MODEL ACD-10 (single stage fan)



SITE PREPARATION

The burning pit may be dug with a front-end loader or backhoe to an 8-foot width and a length of 10, 21 or 42 feet, depending on the model used. Optimum depth of the pit should be 12 to 15 feet, but can be as deep as 20 feet. In areas where rock or water occurs, the sides of the pit can be built up above ground level to obtain proper pit depth. The Destructor is positioned with the nozzle end 3 to 6 inches back from the pit. The air curtain is directed diagonally downward across the pit and this provides the high turbulence for combustion.

Figure B-2. Air Curtain Destructor (ACD) has potential for brigade and division level waste disposal.

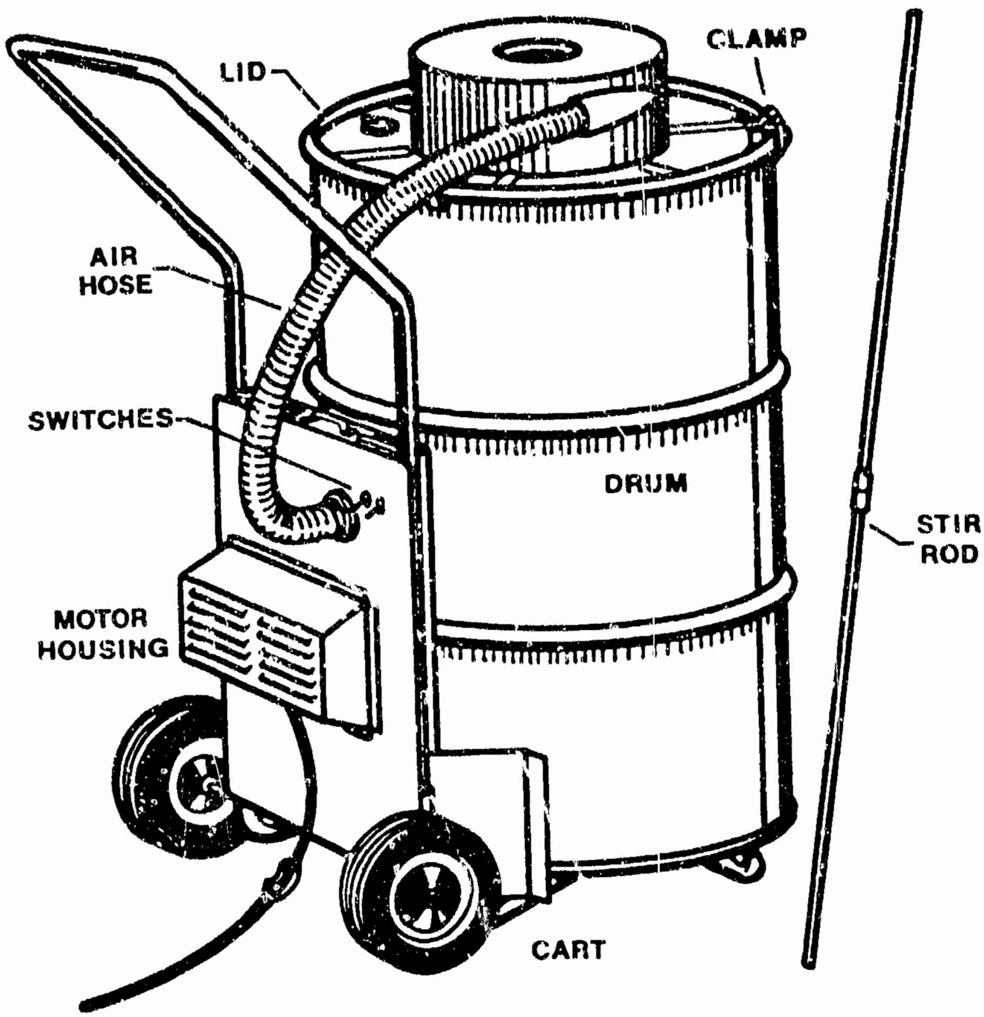


Figure B-3. Forced air incinerator with potential for on-site waste reduction.

TABLE B-1. Waste Management Systems Sources

Equipment/Systems	Unit Cost ($1000)	Sources
Mobile Compactor Trailer		
6 yd^3	10	Wayne Engineering Corp. Cedar Falls, Iowa
8 yd^3	16	International Compactors, Inc. Trenton, Michigan
10 yd^3	24	Martco Waste Systems Equipment Dallas, Texas
Air Curtain Destructor (Large Incinerator)	25	DRIALL, Inc. Attica, Indiana
Trash-Away Incinerator (Small Incinerator)	0.8	Crossbow, Inc. Cincinnati, Ohio
w/Diesel Generator	3.7	
Palletized Load System (PLS) (PLS Truck, 10 Ton)		Government Contract Possible Candidates: MARREL, KENWORTH, GMC, MACK, PETERBILT
Small Emplacement Excavator (SEE)	70	Government Contract Freightline Corp. Charlotte, N. Carolina
Armored Combat Excavator (ACE)	600	Government Contract BMY Division of Harsco Corp. York, Pennsylvania

compaction in the landfill trench to achieve high (50%) in-place waste reduction. With the waste spread 2 ft in depth, three to five passes of the dozer result in the highest density of compacted waste and extended capacity of the landfill. In military operations, landfill compacting can reduce excavation requirements by about 50%.

Palletized Load System (PLS) Study. The Army Logistics Center has conducted a cost and operational effectiveness analysis (COEA)[2] on tactical PLS (see Figure B-4) vehicles to transport ammunition, but ultimately the transport of all classes of supplies may be included. If PLS is fielded for all classes of supplies in the 1992-95 time frame, then there is the potential to introduce a nondevelopment item (NDI) dumpster system on the battlefield and centralize landfills by division for CFFS rather than by brigade as currently practiced. For future consideration, the exploitation of efficient landfill operations integrated with a PLS dumpster system may greatly improve battlefield waste management. The PLS system would require only one dozer per division or equivalent compared to four presently required.

New Combat Excavation Equipment. To meet the requirements of a highly mobile AOE designed Army, two highly mobile excavators have been fielded by the combat engineers.

The small emplacement excavators (SEE) tractor (see Figure B-5) has been fielded to provide a highly mobile excavation capability to support combat operations in the forward battlefield, especially in a light forces deployment. The SEE tractor has the capability to excavate a small on-site trench for burial of trash for 300 rations in 15 minutes or less, while the same operation, using manual excavation, will require about 4 hours.

The highly mobile Armored Combat Excavator (ACE) was also fielded to provide battlefield forward area excavation (see Figure B-6). Though less likely to provide on-site excavation support to CFFS, the ACE should not be ruled out entirely. For example, six ACEs are the only dozers deployed in the AOE light division force concept and will be required to support burial of food service trash, especially if commanders order trash to be backhauled to the rear supply point area.

Host Nation Support (HNS). Having assumed HNS proponency on behalf of TRADOC, in an on-going study[4], the Logistics Center has been tasked to include HNS considerations in the Combat Service Support (CSS) doctrine development process and incorporate policies and procedures in training publications. HNS has gained fresh impetus following the AOE emphasis on CSS austerity in new force structures.

Furthermore, recent operational experiences in Grenada and Honduras have highlighted the importance of taking full advantage of local infrastructures and available resources in both the planning and execution stages of an operation. For example, in the Grenada Rescue Mission (Operation Urgent Fury), local hires and captured equipment (a dozer and two trucks) were used to dispose of battlefield waste (see Appendix C).

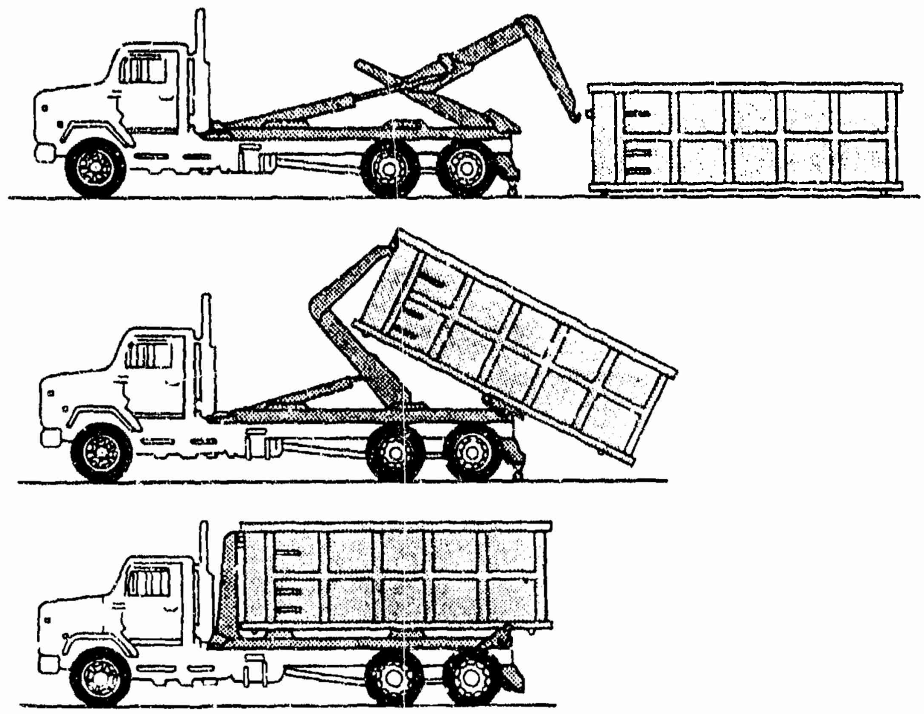
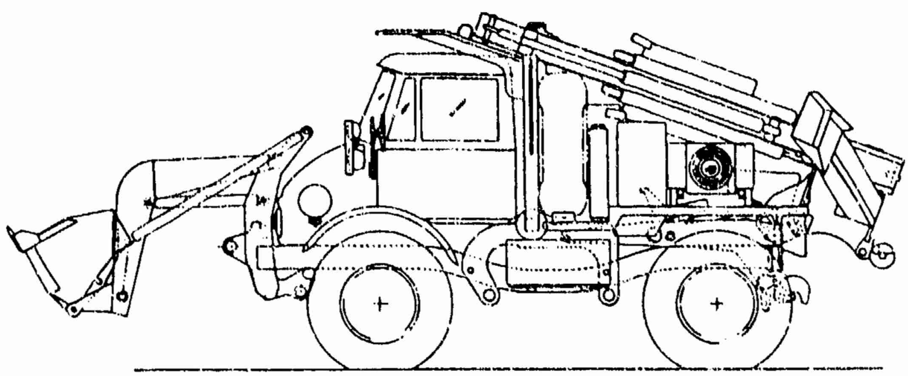


Figure B-4. Palletized Load System (PLS) being studied by the Logistics Center for transport of all classes of supplies.

Travel Position



Operating Position

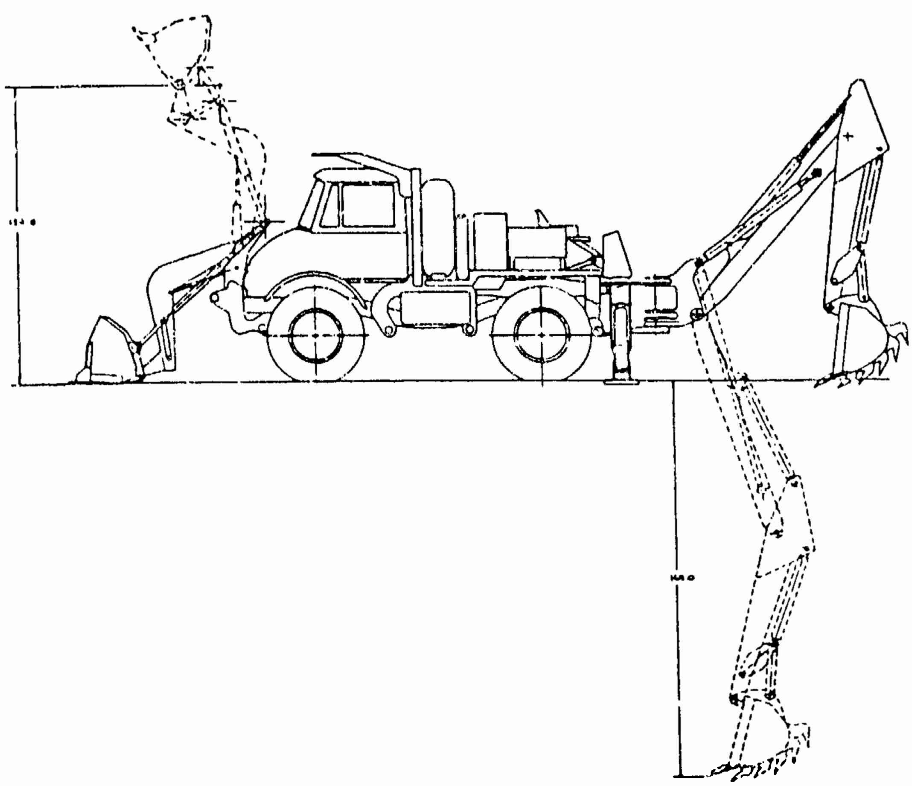


Figure D-5. Small Emplacement Excavator (SEE) Tractor with mission to provide support to the forward combat area.

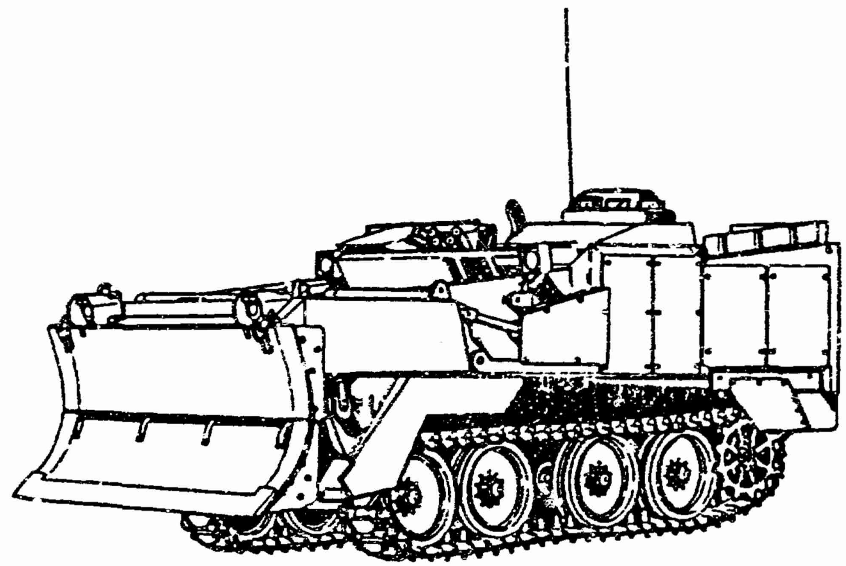


Figure B-6. Armored Combat Earthmover (ACE) battlefield forward area excavation support to combat.

Waste Management Equipment/Systems Descriptions

Mobile Compactor Trailer. The trailer compactor is a self-contained waste management system with its own power system (see Figure B-1). The system collects, compacts, stores, and transports (requires a 1.25-ton tow vehicle) waste. The 10-horsepower engine produces up to 5 tons of force to compact or eject collected waste. System capacity includes sizes of 6, 8, and 10 yd^3 and ratios of waste reduction range from 2.5:1 (60%) to 4:1 (75%). The system was designed to manage waste in remote parks, campgrounds, and truck stops.

Air Curtain Destructor (ACD). The ACD is a portable system designed for large-scale waste reduction by controlled incineration in a pit (see Figure B-2). The ACD maintains a uniform curtain of air (800 CFM) across the top of the burning pit to contain smoke and particulate matter and promote rapid burning. The ACD-10 (10 ft. wide) burns 1 to 3 tons per hour providing a rate 3 to 5 times faster than open pit burning.

Trash-Away Incinerator. Trash-Away is a small incinerator designed for disposing of trash from small business operations and households (see Figure B-3). The incinerator consists of an open head 55-gallon drum with an air blower (120 CFM) system. The incinerator system uses forced air and trash to support rapid burning. Rate of burning is 50-75 lb per hour. A portable classified document destroyer variant, being evaluated by the Air Force and Navy, burns up to 140 lb per hour using an air blower delivering 590 CFM.

Palletized Load System (PLS). The PLS is a truck with hydraulic hook system designed to on/off load containers and flatracks (see Figure B-4). The on/off load of demountable cargo beds provide for the operations without support forklifts in remote locations.

The U.S. Army Transportation School has evaluated the PLS for a Corps level ammunition distribution system as an alternative to correct mission area shortfalls in ammunition delivery for combat. Future studies will include transport of all classes of supplies.

Small Emplacement Excavator (SEE). The SEE tractor is a lightweight four-wheel drive, diesel driven, high-mobility vehicle with backhoe and bucket loader (see Figure B-5). The SEE hydraulic system operates numerous construction and material handling attachments; however, the excavation attachments are used to support combat operations in the battlefield forward area. The SEE was designed for military versatility and mobility to convoy at 45 miles per hour yet has four-wheel drive for rough terrain capability. The SEE tractor facilitates rapid deployment by helicopter sling and strategic airlift.

Armored Combat Earthmover (ACE). The ACE is a lightweight, armored, tracked dozer designed to provide excavation support to weapon systems deployed in the battlefield forward area (see Figure B-6). The ACE is designed to keep up with the highly mobile Army (30 miles per hour road speed). The ACE, deployable by strategic airlift, is the only tracked vehicle allocated to the light infantry divisions.

APPENDIX C.

Grenada Rescue (Operation Urgent Fury) Field Hygiene and Sanitation Lessons Learned

Operation Urgent Fury Lessons Learned

(U) Item: Enforcement of Field Hygiene and Sanitation at the Unit and Individual Level in Combat and Combat Support Units.

(U) Discussion:

(U) US Forces Grenada units experienced preventive medicine problems in the following areas: (1) waste and garbage disposal, (2) human waste disposal, (3) creation of arthropod and rodent harborage sites, (4) inadequate preventive medicine and hygiene supplies, (5) failure to utilize trained unit field sanitatio teams, (6) lack of personal hygiene and individual protective measures.

(U) Success of a preventive medicine program and the basics of keeping a soldier fit to fight are a command responsibility. Field hygiene and sanitation should recieve command emphasis.

(U) Recommendation: That unit commanders enforce standards of field sanitation in their units by training personnel in field sanitation and hygiene IAW AR 40-5, and by having on hand and issuing items necessary for field hygiene upon deployment.

(U) Agency/Activity: XVIII Airborne Corps Surgeon, CPT Hassett, AV 236-5772/5704.

(U) ITEM: Trash and garbage dumping created sanitation problems.

(U) COMMENTS: Open dumping of unit trash and garbage continued around the airfield after approved landfills were opened and signs erected identifying authorized dump sites. This problem was brought to the attention of all major Headquarters in the area. Civilian trash collection crews were hired; however, the problem continued. This dumping increased the filth fly population, attracted rats, feral dogs, and was unsightly. Several of these unauthorized dumps were located within one mile of the 5th MASH facilities. Command backing is necessary for this action to be successful.

(U) RECOMMENDATION: That commanders support a strong field sanitation program.

(U) RESPONSIBLE STAFF SECTION/POC: MAJ Jack R. Roden, Jr., 44th Medical Brigade, telephone 396-5202.

APPENDIX D.

Analysis of Solid Waste Generated by B, T, Unitized T, and MRE Rations

APPENDIX D.

Analysis of Solid Waste Generated by B, T, Unitized T, and MRE Rations

Analyses of solid waste generated by operational B, T, Unitized T, and MRE Rations were conducted. Disposable dinnerware (messgear) was also analyzed for solid waste generated. Weights and cubes of the operational ration packaging materials, and disposable messgear were determined. Shipping cubes of 1000 B, T, Unitized T, and MRE Rations were compared to the cubes of their waste packaging materials (paper and metal) after simulated manual reduction. Disposable messgear cube expansion was compared to shipping cube. MRE solid waste weight and cube of paper, plastic, and aluminum laminate were determined.

METHODOLOGY FOR WASTE ANALYSIS

Item descriptions for B, T, and MRE Rations including unit of issue, units per case, case dimensions, case cube, and case packaging weights were obtained from the Federal Supply Catalog, C8900-SL June 1984. Weights of cans (#10, Tpack) and boxes (V3c cases) were determined by actual weighing. Unitized T module (36 meals) packaging materials weight and cube were measured directly. MRE cases and food packaging were weighed to establish weights of paper, plastic, and aluminum-plastic laminate. MRE solid waste cube was found experimentally to be equal to the shipping cube, since the food wrappers fill the original shipping case. Disposable messgear waste cube expansion was determined experimentally by measuring the trash generated by simulating typical field exercise disposal procedures for 100 sets of disposable paper and plasticware.

In observing Army field exercises and demonstrations, disposed boxes and round cans are not flattened and tray cans are not nested. In addition, disposable messgear, packaging materials, and cans are disposed of randomly in plastic trash bags. To simulate this undisciplined waste disposal procedure (worst case), the waste cube is estimated to be two times the rations shipping cube plus the expanded cube of the disposable messgear.

Solid Waste of B Rations

Solid waste data for B Rations were determined by analyzing the packaging materials (paper, metal) of each item of the B Ration menu, SB 10-495 (10 days for 100 men or 1000 rations). Shipping cubes and packaging paper and metal (cans) weights together with manually reduced (flattened cases, cans) cubes were determined. Using the flattened cases and cans as the minimum solid waste cube, comparisons were made to both the maximum possible cube (undisciplined waste disposal) and the original shipping cube. Due to limited documentation, Unitized B Ration waste weight and cube were not addressed in this analysis.

Solid Waste of T Rations

Solid Waste data for 1000 T and Unitized T Rations were determined by analyzing the packaging materials of simulated menus for breakfast and lunch/dinner entree, starch, vegetable, dessert and fruit menu items, including all supplemental items (beverages, soups, condiments, etc.).

Solid Waste of MRE

Feeding MRE's in the field does not lend itself to a collection and waste reduction discipline. However, tests were conducted to determine solid waste generated by MRE's. Through experimentation, MRE packaging was found to fill the original case. If a field waste reduction discipline is not established (cases not flattened), then MRE & field waste will be double the shipping cube.

Solid Waste Data Base

Disposable messgear weight and cube data are detailed in Table D-1. Table D-2 compares the weights of field rations and shows the relative waste reduction that can be realized with manual reduction. Table D-3 compares the best case (manually reduced) cube to a simulation of current Army field exercise practice (worst case) that has been observed.

TABLE D-1. Disposable Messgear Weight and Cube for 3000 Servings (1000 Rations)

ITEM	CASE WT (lbs)	CASE CUBE	CASE CONTENT#	SHIPPING WT(lbs)	SHIPPING CUBE	WASTE CUBE	REDUCED CASES, FT^3
CUPS	29.0	2.6	2000	43.5	3.9		0.35
TRAYS	40.0	4.6	500	240.0	27.6	USED	2.21
FORKS	17.5	1.1	1000	52.5	3.3	MESS-	0.50
KNIVES	17.5	1.1	1000	52.5	3.3	GEAR	0.50
SPOONS	17.5	1.1	1000	52.5	3.3		0.50
NAPKINS	32.0	2.9	6000	15.9	1.5		0.15
PLASTIC BAGS	19.0	0.5	125	13.7	0.36		0.06
TOTALS FOR 3000 MEALS (1000 RATIONS)				470.6	43.3	480.0*	4.30
						484.3	

*Cube is based on simulation of undisciplined disposal for 100 sets of disposable dinnerware (messgear); plastic bags full with dimensions of 23" x 23" x 52" or 16 ft^3.

TABLE D-2. Comparison of B, T, Unitized T, and MRE Rations Solid Weight and Cube (Manually Reduced for 1000 Rations)

ITEMS	WEIGHT (lbs) PAPER	METAL	PLASTIC	TOTAL	SHIPPING CUBE	WASTE CUBE (ft^3) PAPER	METAL	TOTAL
B RATION[a]								
OPTION A	235.7	420.5		656.2	120.5	22.6	13.8	36.4
OPTION B	232.0	440.8		672.8	116.5	22.0	13.9	35.9
T RATION	502.6	613.2		1115.8	126.2	33.0	27.6	60.6
T, UNITIZED	1131.0	833.0	171.0	2125.0	287.0	287.0	--[c]	287.0
MRE	1269.0	192.0[b]	243.0	1704.0	177.5	177.5		177.5
MESSGEAR	299.4		171.2	470.6	43.3			484.3[d]

[a]B Rations option a are conventional canned rations while option b contain some freeze dried items.

[b]Aluminum - plastic laminate

[c]Tray cans are nested in T Ration cases (boxes).

[d]Disposable messgear was not manually reduced.

TABLE D-3. Comparison of Best (Manual Reduction) vs. Worst (Undisciplined) Solid Waste Cube (1000 Rations)

ITEM	SHIPPING CUBE	BEST WASTE CUBE PAPER	METAL	TOTAL	WORST WASTE CUBE PAPER	METAL	TOTAL
B RATION							
OPTION A	120.5	19.5	13.8	13.3	135.9	105.0	240.9
OPTION B	116.5	19.0	13.9	32.9	133.6	99.4	233.0
T RATION	126.2	33.0	27.6	60.6	137.4	115.0	252.4
T UNITIZED	287.0	287.0	—[b]	287.0	287.0	287.0	574.0
MRE	177.5	177.5		177.5	355.0		355.0
MESSGEAR	43.3	161.0[a]		161.0	484.3		484.3

[a]Disposable messgear compacted 67% using manual, mechanical compactor.

[b]Tray cans are nested in T Ration cases (boxes).

APPENDIX E.

Analysis of Field Food Service Plate Waste

APPENDIX E.

Analysis of Field Food Service Plate Waste

Data were collected at three field exercises to determine average plate waste for B, T, and MRE Rations. Tables E-1 through E-3 include plate waste data taken from the Nutritional Adequacy of Rations, Appendix A, Combat Field Feeding System - Force Development Test and Experimentation (CFFS-FDTE) Report, CDEC-TR-85-006A. Plate waste was obtained based on standard portion sizes served and consumed. Actual amounts (%) of waste were determined by measuring portions returned minus portions served times 100 for B and T Ration items. MRE food waste was calculated similarly, although MRE portion sizes (weights) were obtained from specification MIL-M-44074.

Table E-4 includes plate waste data collected at field exercises at Ft. Devens, MA (36th Medical Battalion) and Yakima Firing Center, WA (9th ID, 3 Bde Octofoil Focus Exercises). Average Pounds of plate waste per person were determined by measuring the weight of each trash bag of disposable messgear and plate waste, determining the average weight per troops fed, and subtracting the average weight (tare) of a messgear set (data extracted from Table D-1) to arrive at the average plate waste. Table E-4 also compares average plate waste from the three exercises.

TABLE E-1. Average Plate Waste Data for B Ration Menus

Menu/Day	(b&d gms)*	Total (b&d lbs)
1	154.0	0.34
2	157.1	0.35
3	96.5	0.21
4	160.0	0.35
5	124.9	0.28
6	205.8	0.45
7	131.1	0.29
8	130.5	0.29
9	227.1	0.50
10	191.7	0.42
avg/meal	78.9	0.17

*b=Breakfast, d=Dinner

TABLE E-2. Average Plate Waste for T Ration Menus

Menu/Day	Total (b&d gms)*	Total (b&d lbs)
1	168.7	0.37
2	225.5	0.50
3	226.8	0.50
4	275.3	0.61
5	186.0	0.41
6	238.6	0.53
7	189.3	0.42
8	244.1	0.54
9	211.5	0.47
10	247.2	0.55
11	192.5	0.42
12	247.3	0.55
13	260.5	0.57
14	196.2	0.43
avg/meal	111.0	0.24

*b=Breakfast, d=Dinner

TABLE E-3. Average Plate Waste for MRE Menus

MENU	FOOD WASTE (gms)	FOOD WASTE (lbs)
1	2.12	0.005
2	3.13	0.007
3	5.88	0.013
4	11.33	0.026
5	5.93	0.013
6	7.19	0.016
7	6.84	0.015
8	6.96	0.015
9	4.81	0.011
10	5.94	0.013
11	10.73	0.024
12	5.47	0.012
avg/menu	6.41	0.014

TABLE E-4. Plate Waste Determined by Measurement of Field Exercise Messgear Waste

Field Exercise	Number of Troops	Messgear & Platewaste		Average Messgear Tare (lb)	Average Plate Waste (lb)
		Lb Messgear	Avg Lb Messgear		
36th Medical BN	95	45			
B Ration	97	45	0.47	0.15	0.33
	90	42			
T Ration	92	39			
	87	30	0.38	0.15	0.24
	88	32			
9th ID 3rd BDE	210	64	0.34	0.15	0.20
T Ration	150	60			
CFFS-FDTE					
84th Engr Br					
B Ration	7				0.17
T Ration	16				0.24
MRE	69				0.01