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Evaluation of HRI Role in Managing Solid Waste

The Potential Role of Heat Recovery Incineration (HRI) in Managing Army Installation Solid Waste

by
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As landfill space becomes more scarce and the costs of both landfilling and energy rise, the Army has begun to consider heat recovery incineration as a possible alternative for solid waste disposal. This report presents the findings of an investigation into the Army's solid waste disposal problem at the installation level, and the potential role of heat recovery incineration (HRI) in the management of installation solid wastes.

The authors found that little data on installation waste disposal amounts and costs have been compiled. Furthermore, much of the data that do exist are not reported appropriately or in enough detail for thorough analysis. Detailed studies at the installation level cannot be made, nor can conclusive site-specific recommendations be made, until accurate data are logged and analyzed. Based on the available data, however, 12 of the 48 installations studied might benefit from integrating HRI into their waste management programs. Seven of these have disposal needs that must be addressed within the next 5 years -too soon to be considered in the normal Military Construction, Army (MCA) budgeting process.

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FOREWORD

This research was performed for the U.S Army Engineering and Housing Support Center (USAEHSC) under the Facilities Investigations and Studies (FIS) program; Work Unit title, "Evaluation of HRI Role in Managing Solid Waste." The USAEHSC technical monitor is Mr. B. Wasserman, CEHSC-FU.

The study was performed by the Energy and Utility Systems Division (FE) of the Infrastructure Laboratory (FL) of the U.S. Army Construction Engineering Research Laboratories (USACERL). The USACERL principal investigator was Kenneth E. Griggs. Dr. David M. Joncich is Division Chief, CECER-FE and Dr. Michael J. O'Connor is Laboratory Chief, CECER-FL. The USACERL technical editor was Gordon L. Cohen, Information Management Office.

COL Daniel Waldo Jr. is Commander and Director of USACERL, and Dr. L.R. Shaffer is Technical Director.

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THE POTENTIAL ROLE OF HEAT RECOVERY INCINERATION (HRI) IN MANAGING ARMY INSTALLATION SOLID WASTE

1 INTRODUCTION

Background

Reduction of landfill availability and increases in both energy prices and landfill costs have stimulated interest in the use of heat recovery incineration (HRI) as a method of managing solid waste disposal problems on U.S. Army installations. However, few data have been compiled on the number of installations with waste disposal problems, the severity of their problems, or whether HRI plants may be an economical solution. Such data are important not only to the affected installations, but also for higher commands to direct and coordinate solutions to solid waste disposal problems. The U.S. Army Construction Engineering Research Laboratories (USACERL) has been tasked to research Army solid waste management issues with a focus on the possible role of HRI.

Purpose

The purpose of this study was to evaluate the potential role of HRI in installation solid waste management, including consideration of waste disposal amounts and costs, landfill expansion and construction costs, and projected HRI life-cycle costs. This information is intended to help the U.S. Army Corps of Engineers (USACE) and Major Army Commands (MACOMs) establish policies on waste management and HRI project development.

Approach

Data on location, base population, waste generation and disposal, and landfill availability for U.S. Army installations were analyzed to identify installations with current or potential solid waste disposal problems. Where data were incomplete or appeared to be in error, the researchers compiled the best information available from interviews with installation personnel and supplemented with pertinent national statistics. The resulting data were processed through USACERL-developed computer programs for conducting HRI economic feasibility and life-cycle cost analyses. The economic implications of HRI technology for each installation were quantified to the extent permitted by the data, and installations that could potentially benefit from HRI technology were identified.

Scope

Of the 124 U.S. Army installations available for study, detailed analysis was limited to the 48 considered to be the highest priority in terms of solid waste management needs. This report considers disposal issues and costs for municipal solid waste (MSW) only, not toxic or hazardous wastes as defined by the U.S. Environmental Protection Agency (USEPA).

Mode of Technology Transfer

The findings of this research may impact Corps of Engineers Guide Specifications (CEGS) 11181, *Incinerators, General Purpose*, and CEGS 11182, *Incinerators, Medical Waste*. Technology transfer will include publication in the *DEH Digest* of an article summarizing the findings of this work.

2 RESEARCH PROCEDURE

Selection of Study Sites

To focus this research on the areas of greatest need, USACERL developed a prioritized list of 48 Army installations from the 124 under U.S. Army Training and Doctrine Command (TRADOC), Forces Command (FORSCOM), and Army Materiel Command (AMC). The first criterion considered was geographic location, with priority assigned to east of the Appalachian Mountains and the West Coast. As can be seen on the map in Figure 1, these areas are known to have the most severe landfill shortage problems. This is generally due to higher population densities and longer histories of landfilling. Base population and waste disposal amounts, as reported in the "Red Book,"* were the other main criteria considered in prioritization. Each factor was given equal maximum possible weight of 10 points, with a total maximum of 30 points possible. Installations rating 15 points or more were assumed to have the highest probability of waste disposal problems. For TRADOC installations, data from TRADOC's files on landfill life expectancy were factored into the prioritization because short life expectancy would aggravate any solid waste disposal problems. Landfill life expectancy data for non-TRADOC installations had to be obtained by contacting each installation separately.

Some installations were dropped from the study if their principal fuel was coal because the potential energy savings from an HRI plant in such settings are greatly reduced compared to where more costly fuels are used. However, several coal-burning installations were retained (e.g., Tobyhanna Army Depot, PA, with a disposal cost of $116/ton**) if their disposal costs were unusually high. Installations that already have incinerator plants were also excluded from the study. Appendix A lists all installations excluded from the study, including the reason they were dropped.

Table 1 lists the 48 Army installations studied in detail for this investigation, including a significant point of interest about each. Data were obtained directly from each of these 48 installations on landfill life expectancy, disposal amounts, disposal costs, and local energy costs. These data were analyzed using the HRI Feasibility (HRIFEAS) and Life Cycle Cost in Design (LCCID) microcomputer programs, both developed by USACERL. Tabulations of that data and the results of the analysis comprise the bulk of this report.

Data Analysis Tools and Assumptions

HRIFEAS is being developed as part of USACERL's standard HRI design package. The program prompts the user for the required waste disposal and energy information, provides default values if the information is not known, flags values that appear unreasonable, provides technical design and cost information, and interfaces with LCCID. HRIFEAS determines the optimum economic size of the plant, including the number of incinerator units, based on the waste generation rate, an assumed 7-day-per-week operating schedule, and one redundant incinerator unit for backup. Where reported waste amounts seemed unusually large or small, HRIFEAS used default values based on effective population figures and a generation rate of 5 lb per person per day—the high end of the U.S. national average, based on USEPA data.[1]

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* Facilities Engineering and Housing Annual Summary of Operations, published by the U.S. Army Housing and Engineering Support Center (USAEHSC).

** U.S. standard units of measure are used throughout this report. A table of metric conversion factors can be found on page 27.

[1] Franklin, M., *Characterization of Municipal Solid Waste in the United States, 1960-2000*, REPT-15-3490-00 (USEPA, 25 July 1986).

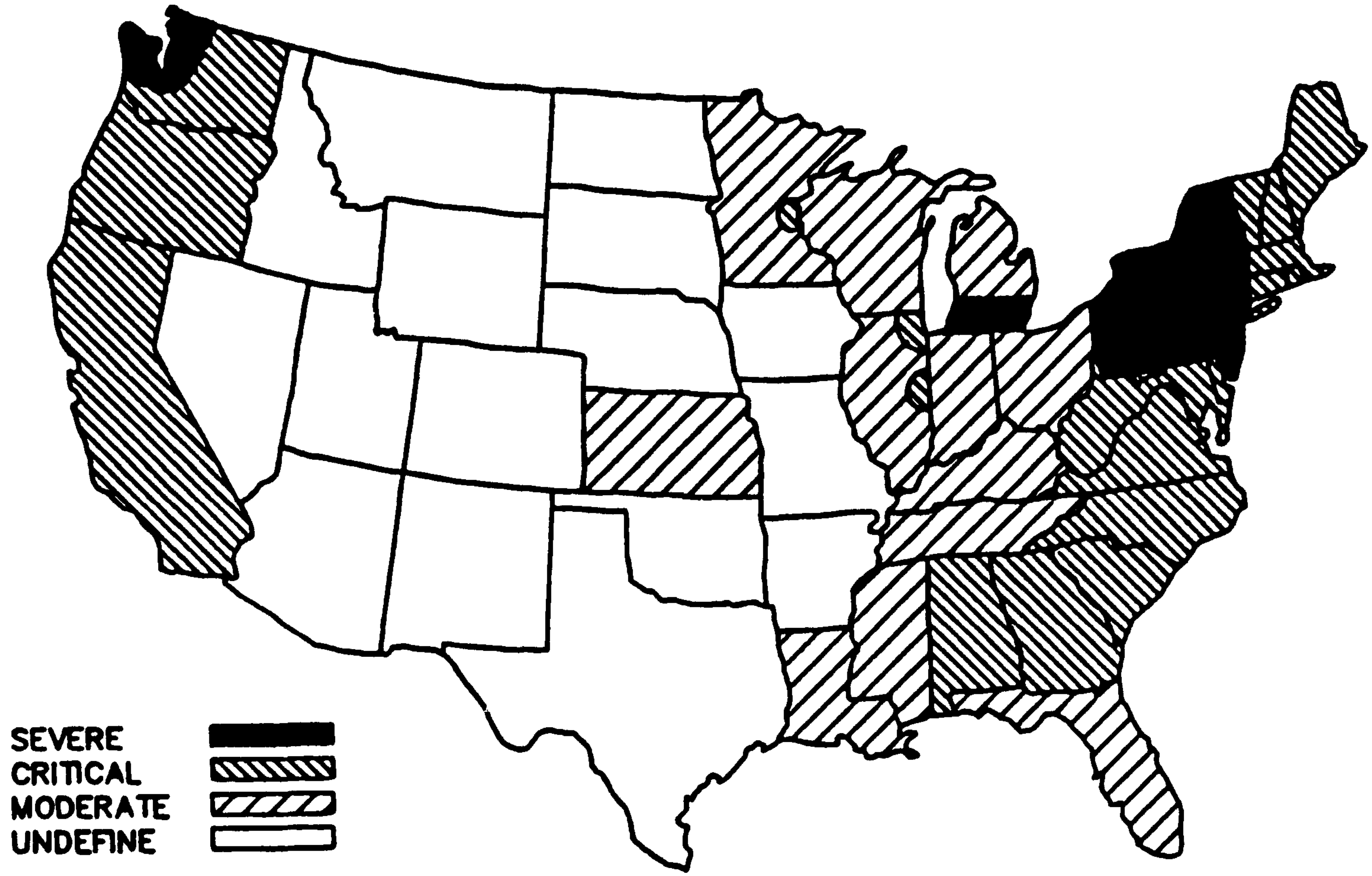

Figure 1. Landfill Shortage Areas.

Table 1

Installations Studied in Detail

INSTALLATION	STATE	MACOM	COMMENTS
Ins:allations with no landfill			
Tobyhanna AD	PA	AMC	Actual weight for FY86
Presidio, San Francisco	CA	FORSCOM	Fort Ord handles waste disposal
Sheridan, FT	IL	FORSCOM	None
Carlisle Barracks	PA	TRADOC	Off-post landfill
Picatinny Arsenal	NJ	AMC	Regional facility being planned
New Cumberland AD	PA	AMC	None
Detroit Arsenal	MI	AMC OMA	Contractor collects & disposes
Ord, FT	CA	FORSCOM	95% of refuse goes off post
Sharpe AD	CA	AMC	Interested in cogeneration
Sacramento AD	CA	AMC	Off-site disposal
Huachuca, FT	AZ	USAISC	Yuba City Regional Landfill
Indiantown Gap FT	PA	FORSCOM	Local landfill
Ritchie, FT	MD	USAISC	Refuse goes to landfill in PA
Houston, FT Sam	TX	FORSCOM	Off post disposal
Monmouth, FT	NJ	AMC	$28/ton tipping fees
Watervliet Arsenal	NY	AMC	
Installations with 1 to 5 years landfill life expectancy			
McCoy, FT	WI	FORSCOM	May dispose to county landfill
Jackson, FT	SC	TRADCO	Study conducted 5 years ago
Devens, FT	MA	FORSCOM	Regional incinerator is proposed
Belvoir, FT	VA	TRADOC	Planning a study, possible regional
Harrison, FT Benjamin	IN	TRADOC	Main fuel is coal
Riley, FT	KS	FORSCOM	Two landfills
US Military Academy	NY	TRADOC	Hospital infectious waste incin.
Drum, FT	NY	FORSCOM	New landfill in 2 years
Leavenworth, FT	KS	TRADOC	Started work on new landfill
Bayonne MOT	NJ	MTMC	Going to county landfill
Lake City AAP	MO	AMC (GOCO)	New landfill is in planning
Installations with 6-10 years landfill life expectancy			
Campbell, FT	KY	FORSCOM	Westinghouse is doing study
Bragg, FT	NC	FORSCOM	2 landfills, sanitary, demolition
Polk, FT	LA	FORSCOM	None
Hill, FT A.P.	VA	TRADOC	Has open burning permit
Gordon, FT	GA	TRADOC	Problems in future landfill approval
Pickett, FT	VA	TRADOC	Problems in future landfill approval
Sierra AD	CA	AMC	No landfill problem

Note: FT = Fort; AD = Army Depot; AAP = Army Ammunition Plant; MOT = Military Ocean Terminal; MR = Missile Range; USAISC = U.S. Army Information Systems Command; GOCO = government owned, contractor operated.

Table 1 (Cont'd)

INSTALLATION	STATE	MACOM	COMMENTS
Installations with over 10 years landfill life expectancy			
Red River AD	TX	AMC	Main heating plant also uses wood
Mead, FT George	MD	FORSCOM	Proposed 3rd party regional inciner
Carson, FT	CO	FORSCOM	Recycle cardboard & paper
Tooele AD	UT	AMC	None
Benning, FT	GA	TRADOC	New landfill in 88
Bliss, FT	TX	TRADOC	Small pathological incinerator
Sill, FT	OK	TRADOC	New landfill
Hood, FT	TX	FORSCOM	New landfill
McClellan, FT	AL	TRADOC	None
White Sands MR	NM	AMC	No problems on landfill expansion
Chaffee, FT	AR	TRADOC	City wants joint landfill
Dugway Proving Ground	UT	AMC	Contractor handles refuse
Pine Bluff Arsenal	AR	AMC	New hazardous waste landfill
Yuma Proving Grounds	AZ	AMC	No landfill problems

The information passed from HRIFEAS to LCCID includes an estimate of HRI plant capital construction cost, plant operations and maintenance (O&M) cost, amount and cost of auxiliary fuel used, amount and cost of electricity consumed, the amount and cost of fuel displaced (assuming full use of the steam produced), and an estimate of savings on landfill O&M costs. HRIFEAS also produces a rough estimate of landfill construction costs if landfill life expectancy falls short of the 15-year economic life of the HRI plant. Since Headquarters, USACE (HQUSACE) defines the life cycle of an HRI plant as 15 years, total landfill costs must be projected over that period of time to constitute a valid life-cycle cost comparison between an HRI plant and a landfill. However, in the case of installations using commercial offsite disposal, the life of any specific landfill need not be considered. In such cases it is assumed that the contractor's capital costs are factored into the service fee charged to the installation.

HRIFEAS cost estimates are based on a typical modular starved-air incinerator system as illustrated in Figure 2. This system uses a modular dual-chamber incinerator, with the primary chamber operating under substoichiometric (starved air) conditions. The secondary chamber, operating under excess air conditions, completes the combustion of the gases from the primary chamber and destroys most potential pollutants. Under the current regulations in most states, no supplemental air pollution control equipment would be needed. However, new regulations in some states (e.g., New Jersey, New York, Illinois, Oregon, California, Washington) would require additional equipment, primarily an acid gas scrubber and a baghouse for fine particulates. Furthermore, many other states are also considering such regulations. The impact of such regulations would have to be evaluated on a case-by-case basis.

LCCID provides life-cycle cost analysis and comparative economic evaluation of construction alternatives. The appropriate economic criteria, including DOE fuel price escalation rates and present value calculations are included in LCCID. Analysis by this program produces the life-cycle cost of each alternative (in this case, continuing to landfill versus constructing and operating an HRI plant), the savings-to-investment ratio (SIR), and the discounted payback period (DPP).*

* For more information about LCCID, see L.K. Lawrie, *Development and Use of the Life Cycle Cost in Design Computer Program (LCCID)*, Technical Report (TR) E-85/07/ADA162522 (USACERL, November 1985).

The 48 installations selected for detailed study were grouped into four categories: (1) off-site contractor disposal (no landfill), (2) 5 years or less of landfill life, (3) 5 to 10 years of landfill life, and (4) more than 10 years of landfill life. Installations with no landfill generally have no suitable on-site location for a landfill. If local commercial landfill space is limited, contractor disposal costs are sure to rise sharply because the waste will have to be hauled farther when local space is exhausted. This trend in private-sector waste disposal costs is reflected in Figure 3. Installations were categorized on the basis of landfill life to represent distinct levels of severity of the waste disposal problem. Installations with no landfill life have an immediate problem. Those with less than 5 years of life may have a disposal problem looming,

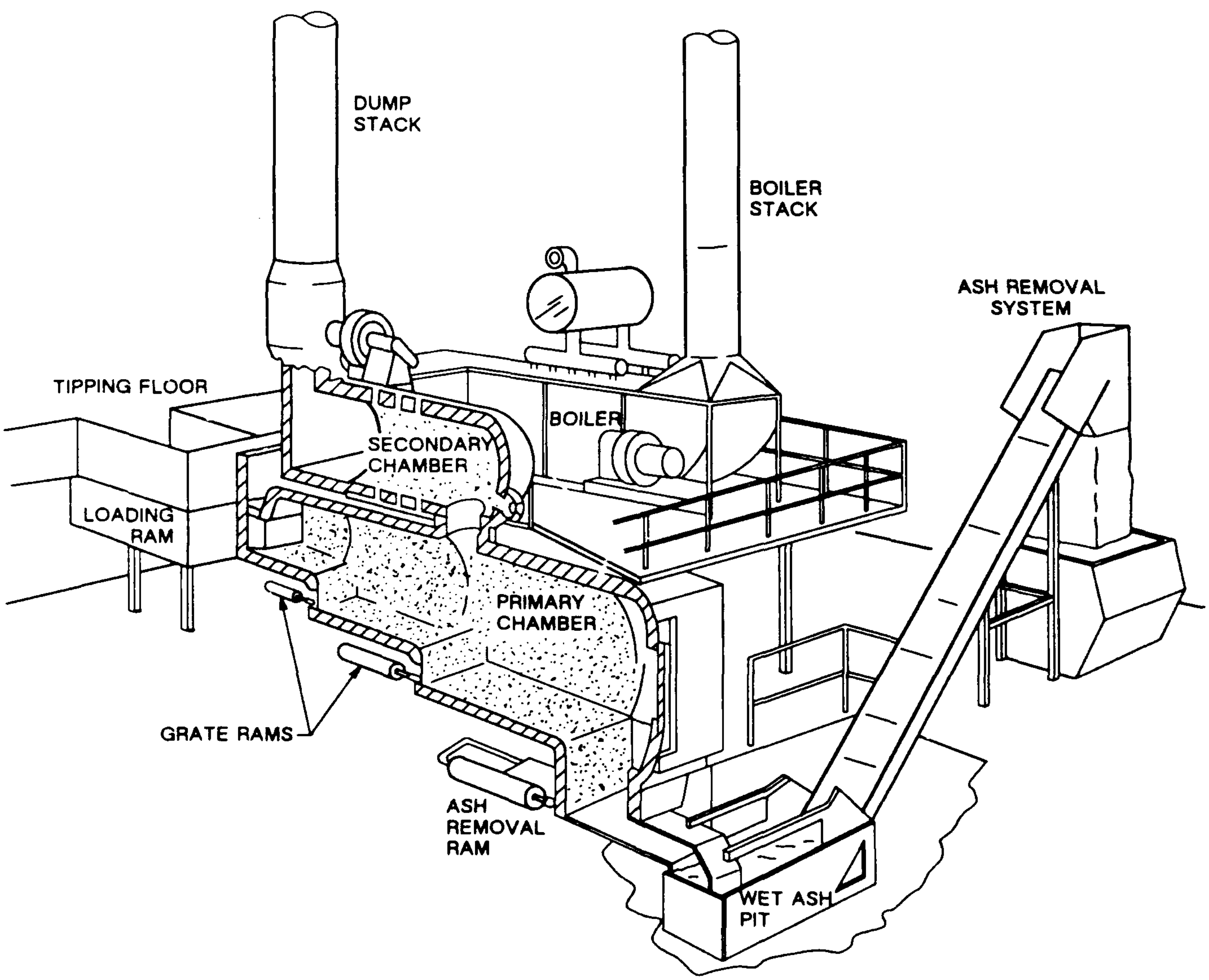

Figure 2. Typical Starved-Air Incinerator system.

but it cannot be addressed in the normal economic planning cycle for Military Construction, Army (MCA) funding. Installations with 5 to 10 years of landfill life can be included in the normal MCA economic planning cycle, and those with more than 10 years of landfill life are not considered to have a waste disposal problem. A base with a 5-year landfill life expectancy may have a larger SIR and a shorter payback period than one with a 1-year landfill life expectancy, but the shorter life expectancy would make the second project more urgent.

During this study, followup contacts were made and additional work was done for a few specific installations. Also, revisions have been made to LCCID, and energy-related projects are now evaluated under different criteria. Initially, the default waste generation rate noted previously (USEPA maximum) was applied only to certain installations on a case-by-case basis. Later, for reasons discussed in Chapter 3, it was decided to apply the default rate to all installations reported to be generating more than four times the default amount. The authors believe that this handling of the data eliminates the most extreme overestimations of installation waste production but still leads to a good "ballpark" estimate of the actual impact of installations that generate unusually large amounts of waste.

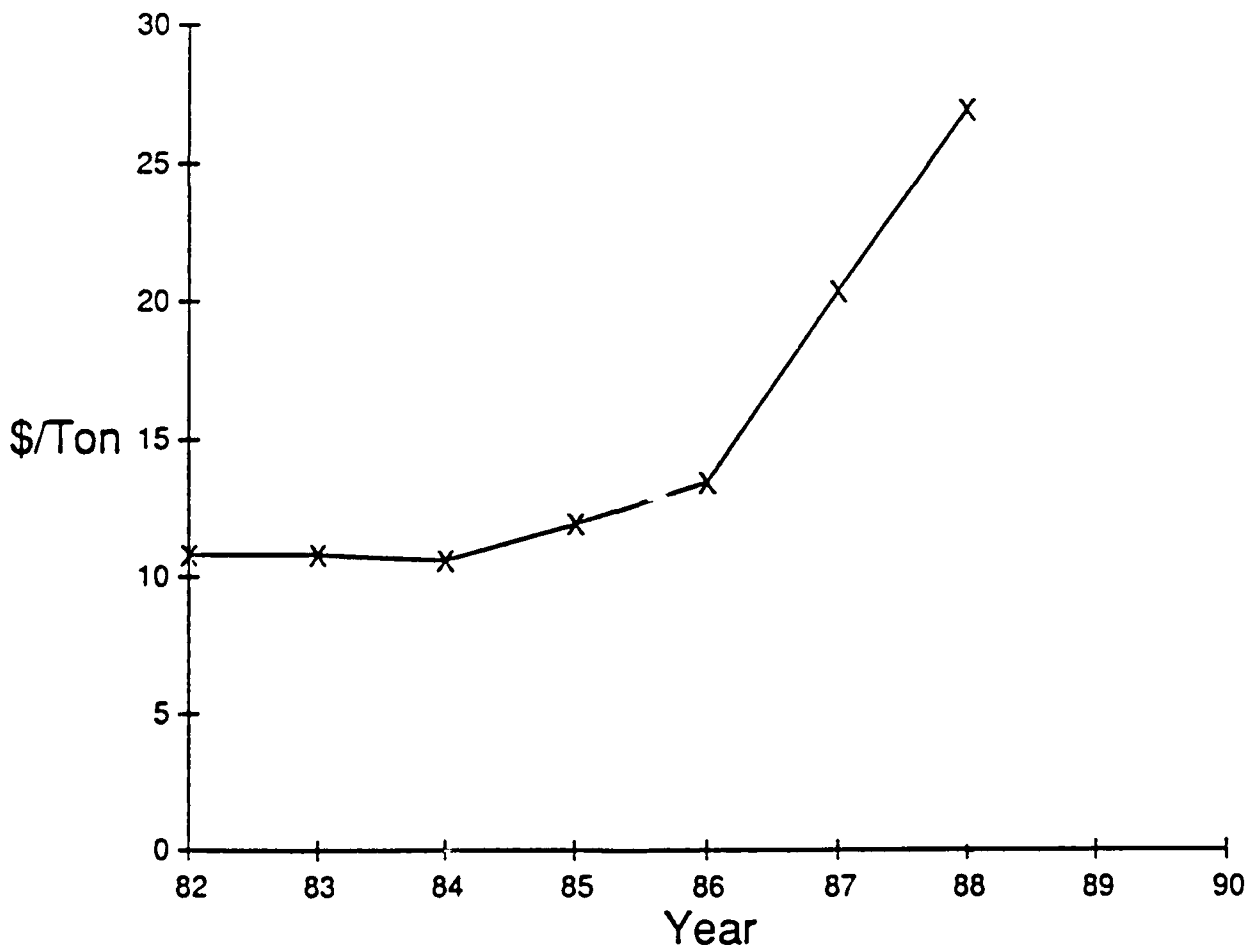

Figure 3. National Landfill Tipping Fee Trend. (Source: *Waste Age*, 1983-1989.)

3 FINDINGS

The data gathered in this research and the results of the analysis are contained in Tables 2 through 5, which are found at the end of this chapter. As noted in Chapter 2, the installations are grouped in each table according to landfill life expectancy to define distinct categories of severity by which to evaluate each one.

Installation Disposal Volumes and Costs

Table 2 shows that 27 bases, or about 22 percent of the Army's 124 installations, have less than 5 years of remaining landfill life. Of these, 16 have no landfill and depend on disposal contractors. Their ability to control waste disposal costs is seriously limited. Since data were collected from only 48 installations, the actual number of bases facing this situation is certainly higher. Army policy is to dispose of solid waste off post, where feasible.[2] However, economic considerations are ultimately the criteria that govern whether an installation builds a new landfill or uses a private-sector disposal facility.

The previously cited USEPA figure for daily individual solid waste generation (5 lb per day) translates into about 0.9 tons per year. Table 2 shows that almost all of the installations studied greatly exceed this figure (based on available waste disposal and population figures). A few are significantly lower, however. In cases where the discrepancy seemed the most serious, a different amount, based upon the USEPA figure, was calculated and used in the analysis. In five cases where a commercial landfill was being used (zero landfill life), the person contacted at the installation did not know the annual disposal cost.

In those cases, the default value generated by HRIFEAS was used. Unit disposal costs varied widely among installations. Based on the annual amounts and costs reported, some installations claimed to pay less than $1 per ton for disposal. Fort Bliss, whose reported annual quantity of waste was cut almost 90 percent for this analysis, paid a mere $0.21 per ton. Another look at the tipping fee trends in Figure 3 makes it clear that such low disposal costs cannot be accurate. All this tends to indicate that most Army installations do not have good information on how much waste they generate or how much disposal of it costs.

Energy Costs

Table 3, energy data for the 48 installations analyzed, shows that 22 of the bases (46 percent) do not have natural gas service available. Gas generally costs less than fuel oil—about $3.00/MBtu for gas compared to $4.28/MBtu for oil. The unavailability of gas on these installations would adversely affect the economics of an HRI plant because the plant would not have the less expensive fuel as an alternative for a backup fuel; it would have to use oil.

The units for reporting the price of natural gas differed among the installations studied, with values being expressed in dollars per therm by some instead of the usual dollars per thousand cubic feet (Kcf). Reported costs of electricity ranged from a high of 11.70 cents to a low of 2.2 cents per kilowatt-hour. During this study, the stock fund price of both residual and distillate changed, with distillate oil dropping

[2] Draft revision of AR 420-47, *Solid and Hazardous Waste Management* (Headquarters, Department of the Army [HQDA], 1 January 1985).

from $0.75 per gallon to $0.56 per gallon. In cases where oil is the fuel displaced by HRI, falling oil prices would have a negative impact on the economic benefits of HRI.

Basic HRI Design Assumptions

HRI design data, produced by the automated management tools discussed in Chapter 2, are presented in Table 4. The data indicate that the Army might have to build plants with capacities ranging anywhere from 20 tons per day (TPD) to 220 TPD. Any HRI plant with individual units having capacities larger than 50 TPD would be subject to Federal regulations and need air pollution control (APC) equipment. All but the very smallest plants—less than 20 TPD—would also need APC equipment if located in New Jersey, Illinois, Oregon, California, and Washington. And in New York, all HRI plants are regulated. Carlisle Barracks, Fort Devens, Fort Drum, Fort Monmouth, Fort Ord, Fort Polk, Sacramento Air Depot, Presidio of San Francisco, Sharpe Army Depot, the U.S. Military Academy, and Watervliet Arsenal were analyzed with the assumption that APC equipment would be required. This does have an adverse impact on potential project economics. The impact will tend to be greater on the smaller plants.

Economic Viability of HRI

Any potential HRI project with a life-cycle cost (LCC) less than the LCC of the landfill alternative and an SIR greater than 1.0 is considered to be economically justified. The economic analysis by LCCID, summarized in Table 5, shows that two installations with no landfill, five installations with less than 5 years of landfill life, and five installations with 6 to 10 years of landfill life may benefit economically from an HRI plant. The seven plants in the first two categories may be needed sooner than possible for economic planning through the regular MCA funding process. The five remaining potential projects (landfill life greater than 5 years) could be put into the normal economic planning and evaluation cycle.

Some installations show a negative SIR for building an HRI plant. As mentioned above, the payback period for these would be less than 1 year. Not only would these projects create an energy savings, but the capital cost of the HRI plant would be lower than the cost of constructing the additional landfill space that would otherwise be required.

Fort Benjamin Harrison and Red River Army Depot were included in the analysis even though their main fuel, at the begining of the study, was coal. While economic analysis confirms that HRI plants attempting to displace coal usage cannot usually be economically justified, this may not be true if the waste disposal cost is high enough. This is illustrated by the case of Tobyhanna Army Depot, which reported a disposal cost of $116 per ton.

Table 5 also shows that plant size is not the primary determining factor in the economic viability for an HRI installation. The most potentially viable HRI projects range in size from 20 TPD (Tobyhanna) to 200 TPD (Fort Polk). Any size plant can be justified under the right conditions of energy usage and waste disposal costs.

Table 2

Solid Waste Disposal Information on the 48 Installations Studied

INSTALLATION	BASE POP.	LAND-FILL LIFE YEARS	DISPOSAL AMOUNT TON/YEAR	TON/YR USED FOR ANALYSIS	TON/ PERSON/ YEAR	ANNUAL DISPOSAL COST	DISPOSAL COST /TON
INSTALLATIONS WITH NO LANDFILL							
Tobyhanna AD	5,058	0	3,679		0.727	$425,345	$115.61
Presidio, San Francisco	14,305	0	198,000†	13,018	13.841	$466,764	$35.86
Sheridan, FT	6,826	0	15,925		2.333	†	
Carlisle Barracks	2,265	0	30,712		13.559	†	
Picatinny Arsenal	6,567	0	130,000†	5,910	19.796	$181,249	$30.67
New Cumberland AD	5,048	0	51,000†	4,594	10.103	$96,708	$21.05
Detroit Arsenal	6,310	0	10,300		1.632	†	
Ord, FT	32,279	0	48,000		1.487	$150,938	$3.14
Sharpe AD	2,126	0	8,026		3.775	†	
Sacramento AD	3,597	0	11,812		3.284	$42,828	$3.63
Huachuca, FT	16,807	0	9,245		0.550	$30,693	$3.32
Indiantown Gap, FT	5,941	0	32,000†	5,406	5.386	$20,337	$3.76
Ritchie, FT	8,897	0	18,000		2.023	$31,789	$1.77
Houston, FT Sam	25,594	0	28,000		1.094	$128,556	$4.59
Monmouth, FT	11,125	0	18,000		1.618	$28,002	$1.56
Watervliet Arsenal	3,079	0	63,371†	6,407	20.582	$63,371	$9.89
INSTALLATIONS WITH 1 TO 5 YEARS LANDFILL LIFE EXPECTANCY							
McCoy, FT	5,292	1	20,000		3.779	$17,224	$0.86
Jackson, FT	25,174	5	18,191		3.059	$37,235	$2.05
Devens, FT	15,132	2	1,300†	13,770	0.086	$85,728	$6.23
Belvoir, FT	8,904	5	20,280		2.278	$47,363	$2.34
Harrison, FT Benjamin	12,656	5	138,000†	11,517	10.904	$72,567	$6.30
Riley, FT	51,913	5	14,000		0.270	$125,336	$8.95
US Military Academy	15,643	5	7,014		0.447	$128,341	$18.30
Drum, FT	11,526	3	7,800†	10,489	0.677	$68,783	$6.56
Leavenworth, FT	15,499	5	282,000†	14,104	18.195	$106,732	$7.57
Bayonne MOT	3,245	1	864†	2,953	0.266	$136,688	$46.29
Lake City AAP	3,131	5	13,397†	2,849	4.279	$221,935	$77.90

Note: FT = Fort; AD = Army Depot; AAP = Army Ammunition Plant; MOT = Military Ocean Terminal; MR = Missile Range.
† = questionable amount reported by installation; amount used in analysis is shown next column to right.

Table 2 (Cont'd)

INSTALLATION	BASE POP.	LAND-FILL LIFE YEARS	DISPOSAL AMOUNT TON/YEAR	TON/YR USED FOR ANALYSIS	TON/ PERSON/ YEAR	ANNUAL DISPOSAL COST	DISPOSAL COST /TON
INSTALLATIONS WITH 6 TO 10 YEARS LANDFILL LIFE EXPECTANCY							
Campbell, FT	41,295	10	504,000†	37,578	12.205	$141,182	$3.76
Bragg, FT	50,790	7	443,000†	46,219	8.722	$198,185	$4.29
Polk, FT	27,308	8	60,000		2.197	$20,000	$0.33
Hill, FT A.P.	25,503	10	265,000†	23,208	10.391	$153,719	$6.62
Gordon, FT	23,874	10	14,128		0.592	$66,943	$4.74
Pickett,FT	3,024	6	11,829		3.912	$16,389	$1.39
Sierra AD	1,463	10	32,448†	1,331	22.179	$9,996	$7.51
INSTALLATIONS WITH OVER 10 YEARS LANDFILL LIFE EXPECTANCY							
Red River AD	7,136	15	145,000†	6,494	20.320	$58,527	$9.01
Mead, FT George	45,640	18	462,000†	41,532	10.123	$120,947	$2.91
Carson, FT	50,687	11	316,000†	46,125	6.234	$117,837	$2.55
Tooele AD	4,317	50	47,000†	3,928	10.887	$43,622	$11.11
Benning, FT	46,049	20	341,000†	41,905	7.405	$58,500	$1.40
Bliss, FT	42,212	15	370,000†	38,413	8.765	$8,101	$0.21
Sill, FT	35,387	30	152,000†	32,202	4.295	$108,553	$3.37
Hood, FT	64,404	40	458,000†	58,608	7.111	$136,705	$2.33
McClellan, FT	19,016	15	195,000†	17,305	10.255	$91,825	$5.31
White Sands Missile Range	9,273	20	22,464		2.423	$69,593	$3.10
Chaffee, FT	1,698	13	40,000†	1,545	23.557	$46,117	$29.85
Dugway Proving Ground	2,576	30	11,000†	2,344	4.270	$70,023	$29.87
Pine Bluff Arsenal	2,525	30	32,340†	2,298	12.808	$32,340	$14.07
Yuma Proving Grounds	2,041	20	26,780†	1,857	13.121	$26,780	$14.42

Table 3

Energy Sources and Costs

INSTALLATION	MAIN FUEL	MAIN FUEL COST	AUX FUEL	AUX FUEL COST	ELECT. CENTS/KWH
INSTALLATIONS WITH NO LANDFILL					
Tobyhanna AD	Coal	$58.50/ton	Fuel Oil	$.56/gal	6.20
Presidio, San Francisco	Nat Gas	$.755/therm	Nat Gas	$.755/therm	11.00
Sheridan, FT	Nat Gas	$.50/therm	Nat Gas	$.50/therm	9.00
Carlisle Barracks	Nat Gas	$6.00/kcf	Nat Gas	$6.00/kcf	5.50
Picatinny Arsenal	Fuel Oil	$.56/gal	Fuel Oil	$.56/gal	7.00
New Cumberland AD	Fuel Oil	$.56/gal	Fuel Oil	$.56/gal	5.50
Detroit Arsenal	Nat Gas	$4.22/kcf	Nat Gas	$4.22/kcf	6.40
Ord, FT	Nat Gas	$.51/therm	Nat Gas	$.51/therm	8.64
Sharpe AD	Nat Gas	$5.66/ktherm	Nat Gas	$5.66/ktherm	4.50
Sacramento AD	Nat Gas	$5.75/kcf	Nat Gas	$5.75/kcf	4.76
Huachuca, FT	Nat Gas	$.433/Therm	Nat Gas	$.433/Therm	5.20
Indiantown Gap, FT	Fuel Oil	$.56/gal	Fuel Oil	$.56/gal	9.47
Ritchie. FT	Fuel Oil	$.56/gal	Fuel Oil	$.56/gal	5.00
Houston, FT Sam	Nat Gas	$4.30/kcf	Nat Gas	$4.30/kcf	5.20
Monmouth, FT	Fuel Oil	$.56/gal	Fuel Oil	$.56/gal	7.03
Watervliet Arsenal	#6 Oil	$.53/gal	Fuel Oil	$.56/gal	6.00
INSTALLATIONS WITH 1 TO 5 YEARS LANDFILL LIFE EXPECTANCY					
McCoy, FT	Propane	$.588/gal	Fuel Oil	$.56/gal	3.20
Jackson, FT	Nat Gas	$5.51/mbtu	Nat Gas	$5.51/mbtu	3.89
Devens, FT	Fuel Oil	$.56/gal	Fuel Oil	$.56/gal	5.00
Belvoir, FT	Fuel Oil	$.56/gal	Fuel Oil	$.56/gal	4.86
Harrison, FT Benjamin	Coal	$35.50/ton	Fuel Oil	$.56/gal	3.50
Riley, FT	Nat Gas	$2.81/kcf	Nat Gas	$2.81/kcf	4.83
US Military Academy	Fuel Oil	$.56/gal	Fuel Oil	$.56/gal	9.00
Drum, FT	Fuel Oil	$.56/gal	Fuel Oil	$.56/gal	6.00
Leavenworth, FT	Nat Gas	$2.70/kcf	Nat Gas	$2.70/kcf	5.52
Bayonne MOT	#6 oil	$.53/gal	Fuel Oil	$.56/gal	6.00
Lake City AAP	Nat Gas	$3.50/kcf	Nat Gas	$3.50/kcf	5.80

Note: FT = Fort; AD = Army Depot; AAP = Army Ammunition Plant; MOT = Military Ocean Terminal; MR = Missile Range.

Table 3 (Cont'd)

INSTALLATION	MAIN FUEL	MAIN FUEL COST	AUX FUEL	AUX FUEL COST	ELECT. CENTS/KWH
INSTALLATIONS WITH 6 TO 10 YEARS LANDFILL LIFE EXPECTANCY					
Campbell, FT	Nat Gas	$.466/Therm	Nat Gas	$.466/Therm	5.27
Bragg, FT	Res Oil	$.53/gal	Nat Gas	$4.64/kcf	5.87
Polk, FT	Fuel Oil	$.56/gal	Fuel Oil	$.56/gal	6.00
A.P. Hill, FT	Fuel Oil	$.56/gal	Fuel Oil	$.56/gal	7.48
Gordon, FT	Nat Gas	$.56/Therm	Nat Gas	$.56/Therm	5.00
Pickett, FT	Fuel Oil	$.56/gal	Fuel Oil	$.56/gal	6.00
Sierra AD	Fuel Oil	$.56/gal	Fuel Oil	$.56/gal	11.70
INSTALLATIONS WITH OVER 10 YEARS LANDFILL LIFE EXPECTANCY					
Red River AD	Coal	$55/ton	Fuel Oil	$.56/gal	4.00
Mead, FT George	Nat Gas	$.529/Therm	Nat Gas	$.529/Therm	4.48
Carson, FT	Nat Gas	$3.50/kcf	Nat Gas	$3.50/kcf	3.50
Tooele AD	Fuel Oil	$.56/gal	Fuel Oil	$.56/gal	6.64
Benning, FT	Nat Gas	$4.51/kcf	Nat Gas	$4.51/kcf	5.00
Bliss, FT	Nat Gas	$3.43/kcf	Nat Gas	$3.43/kcf	5.25
Sill, FT	Nat Gas	$4.43/kcf	Nat Gas	$4.43/kcf	2.63
Hood, FT	Nat Gas	$2.71/kcf	Nat Gas	$2.71/kcf	4.50
McClelan, FT	Nat Gas	$2.50/kcf	Nat Gas	$2.50/kcf	2.20
White Sands MR	Nat Gas	$3.00/mbtu	Nat Gas	$3.00/mbtu	5.64
Chaffee, FT	Nat Gas	$3.48/kcf	Nat Gas	$3.48/kcf	10.05
Dugway Proving Ground	Fuel Oil	$.56/gal	Fuel Oil	$.56/gal	4.20
Pine Bluff Arsenal	Nat Gas	$3.65/kcf	Nat Gas	$3.65/kcf	6.00
Yuma Provirg Grounds	Fuel Oil	$.56/gal	Fuel Oil	$.56/gal	7.79

Table 4

HRI Design Specifications for Installations Studied

INSTALLATION	STATE	MACOM	DISPOSAL AMOUNT	SIZE OF UNITS	NO. OF UNITS	PLANT SIZE	CAPITAL COST	O & M COST/YEAR
INSTALLATIONS WITH NO LANDFILL								
Tobyhanna AD	PA	AMC	3,679	10	2	20	$1,390,196	$91,975
Presidio, San Francisco	CA	FORSCOM	13,018	20	3	60	$3,939,009	$371,666
Sheridan, FT	IL	FORSCOM	15,925	15	4	60	$3,347,905	$398,125
Carlisle Barracks	PA	TRADOC	30,712	30	4	120	$6,628,538	$834,365
Picatinny Arsenal	NJ	AMC	5,910	10	3	30	$1,922,867	$147,750
New Cumberland AD	PA	AMC	4,594	5	4	20	$1,390,196	$114,850
Detroit Arsenel	MI	AMC	10,300	10	4	40	$2,420,473	$257,500
Ord, FT	CA	FORSCOM	48,000	45	4	180	$9,016,480	$1,281,289
Sharpe AD	CA	AMC	8,026	10	4	40	$2,420,473	$276,412
Sacramento AD	CA	AMC	11,812	20	3	60	$3,939,009	$337,234
Huachuca, FT	AZ	USAISC	9,245	10	4	40	$2,420,473	$231,125
Indiantown Gap, FT	PA	FORSCOM	5,406	5	4	20	$1,390,196	$135,150
Ritchie, FT	MD	USAISC	18,000	25	3	75	$4,002,222	$450,000
Houston, FT Sam	TX	FORSCOM	28,000	40	3	120	$5,829,042	$700,000
Monmounth, FT	NJ	AMC	18,000	25	3	75	$4,653,678	$505,789
Watervliet Arsenal	NY	AMC	2,802			7.7*		
INSTALLATIONS WITH 1 TO 5 YEARS LANDFILL LIFE EXPECTANCY								
McCoy, FT	WI	FORSCOM	20,000	20	4	80	$4,884,321	$555,478
Jackson, FT	SC	TRADOC	18,191	25	3	75	$4,002,222	$454,775
Devens, FT	MA	FORSCOM	13,770	20	3	60	$3,939,009	$393,135
Belvoir, FT	VA	TRADOC	20,280	20	4	80	$4,214,287	$507,000
Harrison , FT Benjamin	IN	TRADOC	11,517	20	3	60	$3,347,905	$287,925
Riley, FT	KS	FORSCOM	14,000	20	3	60	$3,347,905	$350,000
US Military Academy	NY	TRADOC	7,014	10	3	30	$2,359,896	$175,350
Drum, FT	NY	FORSCOM	10,489	10	4	40	$2,915,859	$306,856
Leavenworth, FT	KS	TRADOC	14,104	20	3	60	$3,347,905	$352,600
Bayonne MOT	NJ	MTMC	2,953			8.1*		
Lake City AAP	MO	AMC (GOCO)	2,849			7.8*		

Note: FT = Fort; AD = Army Depot; AAP = Army Ammunition Plant; MOT = Military Ocean Terminal; MR = Missile Range; USAISC = U.S. Army Information Systems Command; GOCO = government owned, contractor operated. *Less then 10 TPD and not analyzed further.

Table 4 (Cont'd)

INSTALLATION	STATE	MACOM	DISPOSAL AMOUNT	SIZE OF UNITS	NO. OF UNITS	PLANT SIZE	CAPITAL COST	O & M COST/YEAR
INSTALLATIONS WITH 6 TO 10 YEARS LANDFILL LIFE EXPECTANCY								
Campbell, FT	KY	FORSCOM	37,578	35	4	140	$6,594,086	$939,450
Bragg, FT	NC	FORSCOM	46,219	45	4	180	$8,062,508	$1,155,475
Polk, FT	LA	FORSCOM	60,000	55	4	220	$9,466,518	$1,500,000
Hill, FT A.P.	VA	TRADOC	23,208	25	4	100	$5,037,930	$580,200
Gordon, FT	GA	TRADOC	14,128	20	3	60	$3,347,905	$353,200
Pickett, FT	VA	TRADOC	11,829	20	3	60	$3,357,318	$295,725
Sierra AD	CA	AMC	1,331			3.7*		
INSTALLATIONS WITH OVER 10 YEARS LANDFILL LIFE EXPECTANCY								
Red River AD	TX	AMC	6,494	10	3	30	$1,922,867	$162,350
Mead Ft. George	MD	FORSCOM	41,532	40	4	160	$7,337,501	$1,038,300
Carson, FT	CO	FORSCOM	46,125	45	4	180	$8,062,508	$1,153,125
Tooele AD	UT	AMC	3,928	5	4	20	$1,390,196	$98,200
Benning, FT	GA	TRADOC	41,905	40	4	160	$7,337,501	$1,047,625
Bliss, FT	TX	TRADOC	38,413	35	4	140	$6,594,086	$960,325
Sill FT	OK	TRADOC	32,202	30	4	120	$5,829,042	$805,050
Hood, FT	TX	FORSCOM	58,608	55	4	220	$9,466,518	$1,465,200
McClelan, FT	AL	TRADOC	17,305	25	4	100	$4,002,222	$432,625
White Sands MR	NM	AMC	22,464	25	4	100	$5,037,930	$561,600
Chaffee, FT	AR	TRADOC	1,545			4.2*		
Dugway Proving Ground	UT	AMC	2,344			6.4*		
Pine Bluff Arsenal	AR	AMC	2,298			6.3*		
Yuma Proving Grounds	AZ	AMC	1,857			5.1*		

*Less then 10 TPD and not analyzed further.

Table 5

HRI Life-Cycle Cost Data

INSTALLATION	LAND-FILL LIFE	DISPOSAL AMOUNT	PLANT SIZE (TPD)	CAPITAL COST	HRI LCC X K$	LANDFILL LCC X K$	SIR	DPP
INSTALLATIONS WITH NO LANDFILL								
Tobyhanna AD	0	3,679	20	$1,394,105	2,192	3,272	1.9	7
Presidio, San Francisco	0	13,018	60	$3,950,083	8,175	8,996	1.2	12
Sheridan, FT	0	15,925	60	$3,357,318	7,396	6,758	0.8	19
Carlisle Barracks	0	30,712	120	$6,647,174	15,130	13,520	0.7	20
Picatinny Arsenal	0	5,910	30	$1,928,273	3,302	2,580	0.6	34
New Cumberland AD	0	4,594	20	$1,394,105	2,448	1,764	0.5	76
Detroit Arsenel	0	10,300	40	$2,427,278	4,892	3,538	0.4	44
Ord, FT	0	48,000	180	$9,041,830	22,738	17,991	0.4	30
Sharpe AD	0	8,026	40	$2,924,057	5,163	3,627	0.4	44
Sacramento AD	0	11,812	60	$3,950,083	7,204	4,854	0.3	57
Huachuca, FT	0	9,245	40	$2,427,278	4,593	3,002	0.3	>99
Indiantown Gap, FT	0	5,406	20	$1,394,105	2,735	1,565	0.1	>99
Ritchie, FT	0	18,000	75	$4,013,474	8,248	5,070	0.1	>99
Houston, FT Sam	0	28,000	120	$5,845,430	12,426	6,750	N/A	***
Monmounth, FT	0	18,000	75	$4,666,762	9,794	4,965	N/A	***
Watervliet Arsenal	0	2,802	7.7*					
INSTALLATIONS WITH 1 TO 5 YEARS LANDFILL LIFE EXPECTANCY								
McCoy, FT	1	20,000	80	$4,898,054	9,840	13,284	N/A	<1
Jackson, FT	5	18,191	75	$4,013,474	8,244	9,530	N/A	<1
Devens, FT	2	13,770	60	$3,950,083	7,742	7,766	N/A	???
Belvoir, FT	5	20,280	80	$4,226,136	9,019	10,384	N/A	<1
Harrison , FT Ben.	5	11,517	60	$3,357,318	5,797	6,206	2.0	10
Riley, FT	5	14,000	60	$3,357,318	6,563	6,616	0.7	>99
US Military Academy	5	7,014	30	$2,366,531	4,628	3,723	0.6	36
Drum, FT	2	10,489	40	$2,924,057	5,978	5,789	N/A	???
Leavenworth, FT	5	14,104	60	$3,357,318	6,617	6,447	N/A	???
Bayonne MOT	1	12,757	8.1*					
Lake City AAP	3	13,397	7.8*					

Note: FT = Fort; AD = Army Depot; AAP = Army Ammunition Plant;
MOT = Military Ocean Terminal; MR = Missile Range.

*Less then 10 TPD and not analyzed further.

Table 5 (Cont'd)

INSTALLATION	LAND-FILL LIFE	DISPOSAL AMOUNT	PLANT SIZE (TPD)	CAPITAL COST	HRI LCC X K$	LANDFILL LCC X K$	SIR	DPP
INSTALLATIONS WITH 6 TO 10 YEARS LANDFILL LIFE EXPECTANCY								
Campbell, FT	10	37,578	140	$6,612,625	15,626	15,846	N/A	<1
Bragg, FT	7	46,219	180	$8,085,176	18,786	22,633	N/A	<1
Polk, FT	8	60,000	200	$10,537,191	26,469	27,610	N/A	<1
Hill, FT A.P.	6	11,829	60	$3,357,318	10,726	10,859	1.2	14
Gordon, FT	10	14,128	60	$3,357,318	6,676	6,721	1.1	15
Pickett, FT	10	23,208	100	$5,052,094	6,109	5,836	0.4	22
Sierra AD	10	47,912	3.7*					
INSTALLATIONS WITH OVER 10 YEARS LANDFILL LIFE EXPECTANCY								
Red River AD	15	6,494	30	$1,928,273	3,323	2,646	0.4	35
Mead Ft. George	18	41,532	160	$7,358,130	17,262	14,190	0.3	27
Carson, FT	11	46,125	180	$8,085,176	18,871	18,460	0.2	18
Tooele AD	50	3,928	20	$1,394,105	2,290	1,307	0.2	>99
Benning, FT	20	41,905	160	$7,358,130	17,337	10,844	N/A	***
Bliss, FT	15	38,413	140	$6,612,625	15,716	10,214	N/A	***
Sill, FT	30	32,202	120	$5,845,430	13,221	7,766	N/A	***
Hood, FT	40	58,608	220	$10,537,191	25,291	8,580	N/A	***
McClelan, FT	15	17,305	75	$4,013,474	7,786	4,268	N/A	***
White Sands MR	20	22,464	100	$5,052,094	10,332	5,708	N/A	***
Chaffee, FT	13	40,000	4.2*					
Dugway Proving Ground	30	11,000	6.4*					
Pine Bluff Arsenal	30	10,683	6.3*					
Yuma Proving Grounds	20	7,687	5.1*					

*Less then 10 TPD and not analyzed further.

4 FOLLOW-ON STUDIES

The widespread lack of reliable disposal amount and cost data for Army installations was not anticipated by the authors. When this data problem surfaced, however, it appeared necessary to conduct some *ad hoc* follow-on studies to gain insight into the situation. Several installations were contacted to further investigate waste disposal reporting problems and their relationship (if any) to the economic potential of HRI plants. Although these investigations were not explicitly within the scope of the original study, they were prompted by the findings of the study and they support the objective of the study. Consequently, the results are appropriate to report here.

Contract Waste Volume Versus Actual Waste Volume

It was found at the Presidio of San Francisco and Fort Monmouth that the installation waste disposal contract was based on the volume of all dumpsters on each site, not the volume of the trash actually collected. The waste amounts were reported and the fees were paid regardless of whether the dumpsters were only half or one-quarter full. Two problems arise from such a situation: (1) the installation may be paying more than necessary for waste disposal and (2) waste generation records based on this payment arrangement may over-report the amount of waste potentially available for HRI, which in turn may over-estimate the economic benefit of HRI in that setting. This kind of situation suggests the need to base collection and disposal contracts on waste amounts actually collected, not on the volume of dumpsters on the installation.

Amendment to Fort Riley Analysis

A quick study was done for Fort Riley, KS, in which actual weight data were made available. However, due to the lack of available land, it is not possible to construct another landfill on the post. The extended impact area resulting from tank gunnery frequently requires troops to be sent to other training areas for field exercises. Several counties surrounding Fort Riley are developing a regional waste management plan including a regional landfill. A very rough preliminary estimate by a consultant put the tipping fee for the new regional landfill at $25/ton. The analysis in this report for Fort Riley was based on constructing and operating a new landfill there. The analysis shows a lower LCC for the incinerator plant, but an inadequate SIR. A new analysis was run specifically for Fort Riley, based on zero capital cost for a new landfill and a disposal cost of $25/ton. Based on this revised scenario, neither a plant built specifically for Fort Riley nor a larger third party plant built at nearby Kansas State University would be economically justifiable. However, current waste disposal trends indicate it is highly unlikely that a new regional landfill, constructed in compliance with new Subtitle D regulations, could afford to charge a tipping fee as low as $25/ton. Examination of the data would lead to the expectation of a tipping fee of $50/ton or higher. This information was communicated in a letter to Fort Riley officials, along with a recommendation that they reevaluate the situation as plans for the regional landfill progress.

Waste Management Study for West Point

A detailed waste management study, including an analysis of HRI feasibility, was recently completed by USACERL for the U.S. Military Academy (USMA) at West Point, NY.[3] Orange County, where USMA is located, is also formulating a waste management plan. The new extension of the county landfill has significantly raised disposal costs, and a future new landfill will probably have to charge over $100/ton. Both commercial and Government-owned HRI options were studied. The requirement for APC equipment would eliminate the economic benefits of a plant built specifically for USMA. However, the high cost of disposing of medical waste from Keller Army Hospital at USMA would make a plant burning both types of waste economically viable and offset the cost of required APC equipment. The HRI option offering the greatest economic advantage to USMA would be the construction of a larger contractor-operated plant, but local residents and government officials there oppose waste incineration. Because the solid-waste situation is changing in the country and in West Point itself, guidance is being supplied to USMA to help decisionmakers determine when and what type of an incinerator plant may be appropriate in the future.

Lima HRI Study

Although the results are not included in this study, a solid waste disposal study related to this HRI study was conducted for Lima Army Tank Plant (LATP).[4] However, the Lima study is limited to the issue of burning wood and paper scrap for energy recovery.

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[3] Kenneth E. Griggs and Micnael R. Kemr ıe. *Solid Waste Disposal Alternatives for the U.S. Military Academy*, Draft Technical Report (USACERL, March 1991).

[4] Kenneth E. Griggs, *Solid Waste Incineration at Lima Army Tank Plant*, OH, Technical Report E-92/06/ADA250748 (USACERL, April 1992).

5 CONCLUSIONS AND RECOMMENDATIONS

Conclusions

This study identifies Army installations that currently have, or will soon have, waste disposal problems, and it verifies that HRI is a potential solution for a number of installations. The factor that seems to have the greatest impact on whether to build an HRI plant is whether new landfill construction could be avoided if an HRI plant is built. Changes in energy prices have a significant effect on the economic viability of an HRI plant. However, changes in economic criteria can also have an important effect on a potential project. Although large plants are generally easier to justify economically, smaller plants can also be justified under certain conditions. This is especially true where waste disposal costs are very high, as in the case of certain nonhazardous but difficult industrial and medical wastes (e.g., tires).

A prerequisite for determining the potential role of HRI on any Army installation is accurate data on landfill life expectancy, waste generation amounts, and waste disposal costs. The lack of such data makes it more difficult to assess how effective and economical HRI may be in a specific situation.

Of the three MACOMs studied, only TRADOC maintainted any centralized data on landfill life expectancy. Therefore, a substantial amount of data had to be gathered from individual installations. These data should help the MACOMs identify installations with the most serious waste disposal problems—especially those among the 48 studied here in detail. The facilities with zero landfill life must depend on commercial disposal services, and recent national data show that cost increases for these services can occur suddenly and drastically.

Many useful data on waste generation and disposal were gathered or constructed as a result of this study. However, uncertainties remain about the figures for many installations. The researchers often had to estimate waste quantities and costs on the basis of installation population, location, and national statistics on waste generation and disposal. Even installations that own or operate a landfill were frequently found not to have good data on its operating costs. Furthermore, most of these bases had not looked at closure or postclosure costs. Where waste generation amounts were uncertain, overestimation of quantities available for incineration poses a problem for justifying an HRI project since available volume is a key factor in HRI economics. Even in cases where large estimated amounts of waste are confirmed through improved tracking, waste-reduction procedures such as recycling should be considered and implemented (if appropriate) before an HRI project is begun.

Although the findings of this study are not quantitatively conclusive for many of the installations studied, they will be valuable in helping the Army decide which installations should be examined more closely.

Recommendations

It is recommended that detailed studies be made of those potential projects with less than 5 years of landfill life and an indication of favorable economics. These studies should also include an examination of the potential for a third-party project. Also, plans should be made to conduct detailed studies in the near future for all other bases with less than 10 years of landfill life and a favorable projected SIR (greater than 1.0 or a negative value) for an HRI plant.

It is recommended that the bases which report generating an unusually large amount of waste (more than 5 lb per person daily or 0.9 tons per person annually), should be studied specifically to determine whether they actually produce that quantity of waste and whether recycling and waste generation reduction measures would be beneficial. This information is crucial to reliably asses the need for an HRI plant. If a recycling program were found to be appropriate, for example, the change in waste available to burn could change the economic justification for an HRI plant. Also, such data would substantially refine the Army's ability to estimate the amount of waste typically generated by different types of military installations.

It is recommended that the U.S. Army Engineering and Housing Support Center (USAEHSC) and all MACOMs issue policy and guidance requiring Army installations to periodically weigh their waste. All installations with a dedicated landfill should also be required to identify and quantify operating costs, expected closure, and postclosure costs. Installations should be encouraged to obtain technical assistance from either USAEHSC or USACERL. Installations that use commercial disposal services should require the contractor to bill collection charges and disposal charges separately, basing the latter only on actual tonnage collected. Contractors should also be required to report actual measured weight with each billing. Bases could then effectively review and optimize their collection program in terms of placement of dumpsters and frequency of collection. Under such an arrangement, installations would be billed for disposal of the actual amount of waste collected instead of a flat fee. This would make the cost avoidance impact of recycling and waste reduction programs easier to evaluate. These installations should also ask their contractors about the life expectancy of the disposal facilities they are using and whether any cost increases are anticipated. USAEHSC, USACERL, and the MACOMs could develop a standard commercial waste disposal contract to help implement the above commercial disposal recommendations.

It is recommended that USAEHSC and all MACOMs issue guidance encouraging all Army installations to recycle to the maximum extent that is economically feasible. Priority (based upon amount in the waste stream and ease of disposal) should be assigned to recycling aluminum first, then paper, then clear glass. The avoided cost of disposal should offset the cost of collection for recycling. Any installation considering an HRI project should initiate a recycling program before actually beginning to plan for an incinerator.

It is recommended that the Army issue guidance requiring any installation considering construction of a new landfill, expansion of an existing landfill, or construction of an incinerator to have the project reviewed by either USAEHSC or USACERL. DD Form 1391 should note that such a review has been conducted and the project recommended. Corps Districts should also seek technical assistance or, at least, technical review of any studies on potential HRI projects. This would ensure that the waste amounts have been correctly quantified, including the effects of recycling.

It was noted in Chapter 3 that many Army installations do not have natural gas available. These are the bases where natural gas is not listed as either the main or the auxiliary fuel in Table 2. The unavailability of gas would have an adverse economic impact on potential HRI projects when fuel oil, which is more expensive than gas, would have to be used for the auxiliary fuel. Because prices for gas and oil have widely fluctuated at various times from 1973 to the present, having both fuels available would allow HRI facilities to take advantage of market fluctuations by using the least expensive auxiliary fuel available. (Having access to both fuels would also have a positive economic impact on the operation of conventional boiler plants.) It is recommended that USAEHSC ask Huntsville Division to investigate the possibility of obtaining gas service through third-party energy contracting for bases that do not have it.

METRIC CONVERSION TABLE

1 lb	=	0.453 kg
1 ton	=	907.1848 kg
1 gal	=	3.78 l
1 cu ft	=	0.02832 m^3

APPENDIX: Installations Dropped From the Study

INSTALLATION	MACOM	REASON DROPPED	COMMENTS
Aberdeen Proving Grounds	AMC	Incinerator being installed	
Anniston AD	AMC	Coal Principal Fuel	Plan Study in FY88
Arlington Hall Annex	INSCOM	Cannot get data. Low Volume	
Cornhusker AAP	AMC	Small Population	
Corpus Christie AD	AMC	Small Population	
Ethan Allen Firing Range	FORSCOM	Small Population	
Fitzsimmons AMC	HSC	Health Services Command	
Detrick, FT	HSC	Health Services Command	Health Services Command
Douglas, FT	FORSCOM	Small Population	
Greely,FT	FORSCOM	Alaska	
Hamilton, FT	TRADOC	New York City	Located in New York City
McNair, FT	FORSCOM	Washington DC Area	
Gulf Outport	MTMC	Small Population	
Hawthorn AAP	AMC	Small Population	
Holston AAP	AMC	Small Population	
Hunter AAF	FORSCOM	Sub of Ft. Stewart	
Hunter Liggett, FT	FORSCOM	Sub of Ft. Ord	Under Fort Ord
Indiana AAP	AMC	Small Population	
Iowa AAP	AMC	Small Population	
Irwin FT.	FORSCOM	Small Volume	Landfill is no problem
Jefferson Proving Ground	AMC	Small Population	
Joliet AAP	AMC	Small Population	
Kansas AAP	AMC	Small Population	
Letterkenny AD	AMC	Small Volume	Also dispose 60,000 gal diesel fuel
Lexington Blue Grass AD	AMC	Small Volume	Scrap wood given to employees etc.
Lima Army Tank Center	AMC (GOCO)	Coal as Principal fuel	Expect major increase in dis. costs
Lone Star AAP	AMC (GOCO)	Small Volume	Problems with hazardous waste
Longhorn AAP	AMC	Small Population	
Louisiana AAP	AMC	Small Population	
McAlester AAP	AMC	Small Population	
McPherson, FT	FORSCOM	In city of Atlanta	Probably cannot get permit
Milan AAP	AMC (GOCO)	Coal Heating	Open buring of 50% of refuse
Mississippi AAP	AMC	Small Population	
Monroe, FT	TRADOC	Refuse now going to HRI	HRI at Langley Res. Center
Myer, FT	MDW	Mil. Dist. of Washington	
Natick Dev. Center	AMC	Small Population	
Newport AAP	AMC	Small Population	

APPENDIX (Cont'd)

INSTALLATION	MACOM	REASON DROPPED	COMMENTS
Oakland Army Base	MTMC	Refuse handled by Navy	Navy handles all Refuse disposal
Petroleum Division	AMC	Small Population	
Pres. of Monterey	FORSCOM	Sub of Ft. Ord	Fort Ord handles waste disposal
Pueblo Depot	AMC	Small Population	
Radford AAP	AMC (GOCO)	Coal is primary fuel	Generates 60% of elect. used
Ravenna AAP	AMC	Small Population	
Richardson, FT	FORSCOM	Alaska	
Riverbank AAP	AMC	Small Population	
Rock Island Arsenal	AMC	Coal is primary fuel	Steam costs are $4.73/klb
Rocky Mountain Arsenal	AMC	Small Population	
Saint Louis Area Sup Ctr	AMC	Small Population	
Savanna Depot	AMC	Small Population	
Scranton AAP	AMC	Small Population	
Selfridge Sup Center	AMC	Located on Air Force base	
Seneca AD	AMC	Small Volume	
Stewart, FT	FORSCOM	Wood fired regional heating	Wood fired regional heating
Sunflower AAP	AMC	Small Population	
Sunnypoint MOT	MTMC	Small Population	
Twin Cities AD	AMC GOCO	Small Volume	Disposal may be major problem
Umatilla AD	AMC	Small Population	
Vint Hill Farms	INSCOM	Part of MDW?	
Volunteer AAP	AMC	Small Population	
Wainwright, FT	FORSCOM	Alaska	
Walter Reed AMC	HSC	MDW	
Wingate AD	AMC	Small Population	

Note: FT = Fort; AD = Army Depot; AAP = Army Ammunition Plant; MOT = Military Ocean Terminal; MR = Missile Range; HSC = U.S. Army Health Services Command; MDW = U.S. Army Military District of Washington; INSCOM = U.S. Army Intelligence and Security Command; GOCO = Government owned, contractor operated; MTMC = U.S. Army Military Traffic Management Command.

ABBREVIATIONS AND ACRONYMS

AAP	Army Ammunition Plant
AD	Army Depot
AMC	U.S. Army Materiel Command
APC	air pollution control
DPP	discounted payback period
FIS	Facilities Investigative Studies
FORSCOM	U.S. Army Forces Command
GOCO	Government owned, contractor operated
HQUSACE	Headquarters, U.S. Army Corps of Engineers
HRI	heat recovery incineration
HRIFEAS	HRI Feasibility (software)
HSC	U.S. Army Health Services Command
INSCOM	U.S. Army Intelligence and Security Command
Kcf	1000 cubic feet
LATP	Lima Army Tank Plant
LCC	life-cycle cost
LCCID	Life Cycle Cost in Design
MACOM	Major Army Command
MDW	U.S. Army Military District of Washington
MOT	Military Ocean Terminal
MSW	municipal solid waste
MTMC	U.S. Army Military Traffic Management Command
O&M	operations and maintenance
SIR	savings-to-investment ratio

ABBREVIATIONS AND ACRONYMS (Cont'd)

TPD	tons per day
TRADOC	U.S. Army Training and Doctrine Command
USACE	U.S. Army Corps of Engineers
USACERL	U.S. Army Construction Engineering Research Laboratory
USAEHSC	U.S. Army Engineering and Housing Support Center
USEPA	U.S. Environmental Protection Agency
USMA	U.S. Military Academy

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235th Base Support Battalion
ATTN: Unit 28614 Ansbach 09177
293d Base Support Battalion
ATTN: AEUSG-MA-AST-WO-E 09086
409th Support Battalion (Base)
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412th Base Support Battalion 09630
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Frankfurt Base Support Battalion
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CMTC Hohenfels 09173
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SETAF
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Letterkenny Army Depot
ATTN: SDSLE-ENN 17201
Pueblo Army Depot 81008
ATTN: SDSTE-PUI-F
Dugway Proving Ground 84022
ATTN: STEDP-EN
Tooele Army Depot 84074
ATTN: SDSTE-ELF
Yuma Proving Ground 85365
ATTN: STEYP-EH-E
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Seneca Army Depot 14541
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Aberdeen Proving Ground
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