ANALYZING ECONOMIC FEASIBILITIES OF RURAL SOLID WASTE MANAGEMENT SYSTEMS IN OKLAHOMA

A GUIDEBOOK FOR LOCAL DECISIONMAKERS

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Preface

This bulletin was prepared for use by persons from such organizations as Cooperative Extension, Sub-State Planning Districts and Oklahoma State Health Department as they work with rural decisionmakers to examine solid waste service needs and conduct preliminary evaluations of alternative systems to meet such needs. Parts of the publication can be utilized as a workbook. Cost data and work forms are presented which can be utilized to facilitate the above specified applications. Blank copies of these forms can be obtained by writing the authors of this bulletin.

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Analyzing Economic Feasibilities of Rural Solid Waste Management Systems in Oklahoma:

A Guidebook for Local Decisionmakers

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INTRODUCTION

For many years, it has been assumed that the responsibility for proper collection and disposal of solid wastes rests with municipal governments. Wastes were generally collected and disposed of in a manner which was satisfactory to community residents. Due to rapid population growth and increasing affluence of the nation, the volume of solid waste being handled by municipalities has grown from a national average of 2.75 pounds per capita per day in 1920 to over 5.0 pounds per capita per day in 1970 for urban residents, a trend which is also indicative of rural waste generation patterns. Growing awareness of the pattern of increasing waste generation and potentially decreasing environmental quality resulting from improper disposal of these wastes prompted the 91st Congress to enact Public Law 91-512 of 1970 which set guidelines for proper waste disposal.

By 1971, most states had also enacted legislation which met or exceeded the standards set by PL91-512. Many communities in rural areas are still working to comply with these regulations. Compliance with may be expensive. This prompts local decisionmakers to investigate methods to bring their systems in line with present quality requirements at the lowest possible cost given certain local physical and political restrictions.

OBJECTIVES

The primary objective of this study is to develop information useful to decisionmakers in evaluating the economic feasibilities of various alternative solid waste systems in small communities and rural areas of Oklahoma. The specific objectives of the study include:

1. developing a procedure to estimate current local needs for solid waste service;
2. developing information to enable local decisionmakers to establish complete capital and operating budgets for alternative methods of solid waste collection, transfer and landfill disposal systems;
3. developing a methodology to enable local decisionmakers to evaluate alternative solid waste management systems by comparing revenues and costs.

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ORGANIZATION OF STUDY

A simplified procedure to estimate local needs for solid waste service is presented in the following section of this report. General information about solid waste collection, transfer and disposal systems, including capital and operating costs, is presented in the next three sections. Methodologies are then presented which may be used to estimate capital and operating costs associated with alternative solid waste management systems and to compare these costs with potential revenues. These methodologies are specified in forms which can be used by local decisionmakers or personnel providing technical assistance to such decisionmakers. Finally, a summary and some concluding remarks are given which may be useful to users of the materials presented.

DETERMINING SOLID WASTE SERVICE NEEDS

The initial step decisionmakers face in structuring an appropriate solid waste management system is that of determining solid waste service needs. Fifty-two solid waste systems in Oklahoma were selected for use in this phase of the study. Information obtained by interviews with system managers, collection workers and city officials was utilized in determining needs for solid waste services.

For purposes of this study, the term "user" was employed to describe any residence or establishment for which solid waste service was available. The number of users per system for the fifty-two systems sampled ranged from 287 to 4,896. Weekly solid waste generated per user was estimated to be 0.1948 cubic yards.[1] This estimate can be used to determine collection and disposal equipment needs for solid waste management systems.

SOLID WASTE COLLECTION

Selecting Collection Equipment

Collection equipment consists of packer bodies and truck cabs and chassis. It is important to select equipment which is tailored to each local situation. Some factors which should be considered are: (1) determination of weekly waste generation; (2) type and frequency of collection; (3) desired crew size per vehicle; (4) labor prices and availability; (5) layout of streets and alleys; (6) density of users; (7) identification

[1]The effects of many factors on solid waste generation were examined using ordinary least squares regression analysis. Factors considered included population, number of users (total and by user types), per capita income, education, frequency of collection, type of pick-up, percentage rural population and per capita manufacturing employment. Models in which population or total number of users was included as the only independent variable explained almost as much variation in volume of waste as the more complex models. Based on comparison of ratios of error mean squares to mean values of the dependent variable for models including and excluding intercept terms, an intercept term was found to have little effect on the results of the models tested. For ease of application and understanding by rural decisionmakers, the following model is used:

$$\text{VOLC} = \underset{(.0001)}{0.1948}\ \text{USERS}$$

where:

VOLC = Total volume (cubic yards) solid waste collected per week

USERS = Total number of users served

The number appearing in parentheses represents the observed significance level of the independent variable as determined by the "student-t" value. This model seems to be adequate and appropriate for use in estimating solid waste generation for small towns and rural areas in the study area. Care should be exercised in its application in other situations.

of heavy users; (8) labor management methods (task vs. daily collection); (9) location of disposal site; (10) disposal method; (11) availability of equipment servicing; (12) degree of maintenance desired on equipment and (13) financial situation of the system regarding initial capital outlay for equipment.

To assist decisionmakers in selecting collection equipment, an inventory of the equipment complements in some existing systems in the study area is given in Table 1. Systems shown in Table 1 are listed in order of total number of users.

There are three common types of packer bodies—rear-load, side-load and front-load. Rear-loaders are the most popular in residential and small to medium commercial collection. They can handle small bulk containers (2 and 3 cubic yard sizes), brush and larger loose waste. Rear-loaders are popular in high-density areas for two- or three-man crews where refuse is collected on both sides of the street. Availability of

Table 1. Inventory of solid waste collection equipment systems in use, Oklahoma Study Area

Number of users[1]	Weekly vol. collected	Vehicle type[2]	Crew size[3]	Collection Pick-Up type[4]	Collection Per week[5]	Avg. users served per day per crew
	Cubic yards		*Persons*			
287	80	(1)-16r	2	c	1	144
400	50	(1)-18s	1	c	2	160
424	48	(1)-16r	2	c	1	141
750	45	(1)-20r	2	c	1	231
831	160	(2)-16r	3	o	2	166
1017	180	(1)-18r	3	o	2	406
1055	100	(1)-20r	4	o	1	211
1100	130	(1)-13r	3	c	1	220
1156	252	(1)-23r	3	o	2	462
1302	325	(2)-20r	3	c	2	260
1522	285	(2)-16r	3	c	1	152
1564	540	(2)-18r	2	o	2	313
1684	375	(2)-20r	3	c	2	337
1720	235	(2)-18r	2	c	2	430
2216	415	(1)-18s	2	o	2	220
		(3)-16r	2	o	2	
2330	360	(3)-18r	3	o	2	311
2400	162	(1)-16r	3	c	2	320
		(2)-18r	3	c	2	
3180	480	(5)-18r	2	o	2	254
3300	240	(3)-16r	2	o	1	220
3406	295	(1)-16r	3	c	1	341
		(1)-18r	3	c	1	
4002	752	(4)-16r	3	c	2	400
4070	861	(1)-20f	2	o	2	408
		(2)-16r	2	o	2	
		(1)-18r		o	2	
4100	325	(1)-20r	3	c	1	410
		(1)-25r	3	c	1	
4896	768	(4)-16r	3	o	2	490

[1]Includes residential, commercial and industrial users.

[2]Refers to capacity in cubic yards and packer body type (r= rear-loader, s= side-loader, f= front-loader). Numbers in parenthesis refer to number of vehicles or crews of a specific type or size.

[3]Number of workers per crew.

[4]c = curbside pick-up, o = alley or backporch pick-up.

[5]Number of residential collections per week. Commercial collections vary from twice weekly to daily.

maintenance is not a problem. Side-loaders are gaining popularity in residential collection systems where labor is a major concern. One man can operate this type of collection vehicle. Constraints on the use of side-loaders include problems of availability of maintenance, limited use for larger loose waste pickup, and collection type used in the community (same side of street curbside type of collection is the most efficient for side-loaders). Front-loaders are restricted to bulk container pick-up. This limits their use largely to heavy users, such as large commercial and industrial users and apartment complexes. Under conditions of normal usage and routine maintenance, the approximate life of packer bodies is between five and seven years, according to dealer representatives.

In selecting the appropriate truck cab and chassis for a packer body, it is important to pay particular attention to the recommended performance specifications concerning gross vehicle weight (GVW), transmission, front and rear axle limitations, body length and engine size. Selection of an undersized chassis will result in poor performance, high repair costs and premature chassis replacement. Gasoline or diesel powered engines can be used in the collection trucks. Gasoline engine trucks have lower initial capital costs than diesel trucks. Their estimated useful life is 125,000 miles as compared to 200,000 miles useful life for diesel engine trucks, according to dealer representatives. Considerable differences exist in operating costs as well, as discussed below.

Capital Costs of Collection Equipment

Average capital costs for various types of packer bodies, truck cabs and chassis and disposal containers appear in Table 2. These costs were obtained from interviews with dealer representatives of various manufacturers of packers, trucks and containers. Packer body prices are for installed packer bodies shipped to Tulsa and Kansas City.

Table 2. Average capital costs for solid waste collection equipment, October, 1979[1]

Item	Cubic Yard Capacity				
	16	18	20	25	30
			Dollars		
Packerbodies, Installed					
Rear loaders, 600 lbs./yd.[2]	13,135	13,645	14,190	15,335	
Rear loaders, 750 lbs./yd.[2]	14,300	14,550	14,850	15,450	16,150
Rear loaders, 1000 lbs./yd.[2]			18,000	18,600	20,200
	Cubic Yard Capacity				
	17		21	25	28-30
			Dollars		
Side loaders, manual load[3]	10,000		10,400	10,800	
Side loaders, mechanical load[3]	16,000		16,200	16,800	17,950
Truck Cabs and Chassis					
Gasoline engine	15,760	21,802	28,997	29,333	
Diesel engine	20,000	26,000	26,000	46,895	53,159
	Cubic Yard Capacity				
	1	2	3	4	8
			Dollars		
Containers	190	370	455	580	865

[1]Price data obtained from eight major manufacturers.
[2]Density of compacted waste in packerbody.
[3]Density of compacted waste in side loaders is 500 pounds per cubic yard.

Truck cab and chassis prices are for properly specified trucks for each size of packer at the dealer. Container prices are averages of both custom-built and premanufactured steel bulk containers at the plant.

Operating Costs of Collection Equipment

Fuel, lubricants, tires, maintenance, labor, administration and miscellaneous expenditures comprise the operating costs for collection systems. Average expenditures for these categories are shown in Table 3. As can be seen, considerable differences exist between gasoline and diesel trucks in fuel and repair costs. Fuel cost differences can be explained by greater fuel efficiency for diesel trucks and lower costs per gallon for diesel fuel as opposed to gasoline. Differences in repair costs can be attributed to savings on tune-ups and routine maintenance, increased durability of parts and longer time intervals between servicing for diesel as opposed to gasoline engine trucks. Consumption of lubricants and estimated tire life are equivalent for the two types of trucks. For ease of application, all expenditures are presented as costs per mile.

Labor and administrative costs make up a large portion of operating costs of the collection components. Wage figures shown in Table 3 are averages of 52 systems in the study area, and include a 20 percent fringe benefit allowance. Administrative costs represent 30 percent of labor costs and miscellaneous costs include insurance, fees, licenses and inspections.

TRANSFER STATIONS

During the past few years, transfer stations have gained increasing popularity as a means of intermediate solid waste handling between the collection and disposal phases. Transfer stations may be adequately described as a method of waste movement after the waste has left the collection vehicle. The waste is generally transferred from

Table 3. Annual operating costs for solid waste collection vehicles October, 1979[1]

Item	Cost/Unit
Fuel	
Gasoline engine[2]	$.2375/mile
Diesel engine[3]	$.1125/mile
Maintenance[4]	
Gasoline engine	$.7345/mile
Diesel engine	$.3575/mile
Labor[5]	
Driver	$4.08/hr.
Helper	$3.58/hr.
Administration	30% direct labor
Miscellaneous[6]	$3000/year

[1]Fuel, maintenance and labor costs were derived from dealer and manufacturer information, city records of Stillwater, Nowata and Ponca City and local input prices. Labor, administration and miscellaneous costs are based on information collected from 52 systems in the study area.

[2]4.0 MPG @ $.95/gallon

[3]8.0 MPG @ $.90/gallon

[4]Includes oil and filters, grease, labor, parts for tune-ups, brake and transmission maintenance, belts and other general maintenance.

[5]Includes 20% fringe benefits.

[6]Includes insurance, fees and licenses, and inspections.

collection vehicles to transfer vehicles for hauling to some local or county disposal site to save on time and/or operating costs of the collection system or to allow for location of the disposal site further away from the collection system. The waste may also be hauled to some other locality for disposal on a contract basis. There are two common types of transfer stations—the transfer trailer system and the roll-off box system. Brief explanations of these systems appear in the following sections.

Transfer Trailer Systems

A transfer trailer system consists of an unloading dock or ramp, the transfer trailer and a vehicle to pull the trailer. Some systems also employ a stationary compactor to increase the volume of waste which can be hauled per load in the transfer trailer. Collection vehicles unload into the transfer trailer via a hopper and a blade compacts the waste into the back of the trailer. When the trailer is full, the transport vehicle pulls it to the disposal facility and a blade pushes the compacted waste out the back of the trailer. A tandem axle diesel tractor rig of adequate power and GVW rating is recommended for transporting the transfer trailer to and from the disposal facility.

Advantages of transfer trailers include increased payload per disposal trip, fewer disposal trips and elimination of the necessity of a stationary compactor. Stationary compactors may be used with a transfer trailer, but their use may cause the trailer gross weight to exceed that permitted by law. Initial costs of a trailer and the tractor may exceed costs of other alternatives.

Roll-Off Box Systems

Roll-off box systems are comprised of an unloading dock, waste hopper, stationary compactor, roll-off boxes and a truck cab and chassis, equipped with a hydraulic hoist mechanism, for hauling the boxes. Like the transfer trailer system, collection vehicles unload off the dock, but must either unload into a hopper or a push-pit. The stationary compactor then pushes the waste into the roll-off box, which is clamped to the end frame. Waste is commonly compacted up to 800 pounds per cubic yard. (Some systems may achieve a compaction rate of 1000 pounds per cubic yard.) The truck bed is then tilted to ground level and the hydraulic hoist loads the box. Unloading of the box is accomplished by tilting the truck bed again to ground level and driving away, leaving the waste behind.

A roll-off box system usually entails lower initial costs of both transfer containers and vehicles than does a transfer trailer system. One box may be moved into place and filled while another is being emptied to avoid time lost due to unloading delay of the collection vehicles. Once again, care must be taken not to exceed payload limitations for over-the-road travel to the disposal site. "Bridging" of brush or other light, bulky material over the top of the hopper may cause problems in unloading. Also, timbers, pipes or other extremely rigid materials cannot be emptied into the roll-off box system due to the possibility of puncturing the roll-off box sides or damaging the compactor.

Transfer Station Sites

Whether the transfer trailer or roll-off box system is selected, a transfer station site must be developed. There are as many station site construction styles as there are systems. Several transfer systems in Oklahoma were contacted as to the specific structures they use. Brief explanations of some components of these station sites follow.

Natural topographical characteristics of an area can be utilized to achieve the elevation necessary for the unloading of collection vehicles into the transfer containers. Such features as hillsides and abandoned pits, ponds and sewage facilities have been made suitable for unloading purposes. The unloading dock area on top may be constructed to accommodate multiple truck unloading set-ups or to provide space for turning the vehicles around to prevent some of the problems caused by backing on or off the ramp. Shelters for unloading areas should be constructed to minimize problems caused by blowing trash and inclement weather. These range from three-sided sheds to enclosed buildings. Of course, vast differences exist in the cost of the alternative transfer station sites.

Capital Costs of Transfer Station Equipment

Average capital costs for various sizes of transfer trailers, trucks or tandem diesel tractors and optional compactors may be found in Table 4. These costs were obtained from interviews with dealer representatives for the various equipment items and are for equipment shipped to Tulsa, Bartlesville, Oklahoma City and St. Louis. There may be considerable savings if used equipment is utilized. Truck and trailer dealers indicate that there is often adequate equipment in good repair which may be obtained in lieu of new equipment.

Table 4. Average capital costs for solid waste transfer equipment, transfer trailer systems, October, 1979[1]

Equipment	Description	Cubic Yard Capacity, Trailers				
		50	60	65	75	
		Dollars				
Trailers[2]	self-emptying	32,000	33,200	34,000	35,000	
Trucks[3]	diesel engine	39,200	51,870	51,870	51,870	
		Cubic Yard Capacity, Hoppers				
		1	2	3	5.5	7
		Dollars				
Compactors[4]						
110 Cubic yds/hr[5]		7,010				
180 cubic yds/hr[5]			10,910			
245 cubic yds/hr[5]				14,020		
410 cubic yds/hr[5]					19,065	
570 cubic yds/hr[5]						20,800

[1]Price data obtained from seven major manufacturers.

[2]Trailers are front loading with push blade for compacting and emptying. Such units compact at approximately 650 pounds/cubic yard.

[3]Transfer trailers require tandem diesel tractors. The 50-yard trailer (54,500 pounds gross) can be marginally handled with a mid-range diesel, but all trailers larger (63,500-77,500 pounds gross) require a big bore diesel tandem tractor.

[4]Includes installation, hoppers, walk-on and dock ramps and heater. Units compact at approximately 800 pounds/cubic yard in a transfer trailer. These are optional.

[5]Total yards of waste processed per hour, ideal conditions.

Average cost figures for roll-off boxes, trucks with hoist units and compactors appear in Table 5. Considerable savings are possible if a system can locate acceptable used equipment which will meet their needs.

Transfer station sites have widely varying capital costs depending upon the size of the solid waste management system and the desired degree of facility sophistocation. The amount of earth work required, availability of appropriate construction materials and amount of labor involved will, to a large extent, determine the cost of the site. Several of the systems sampled received free or low cost materials and labor from some

Table 5. Average capital costs for solid waste transfer equipment, roll-off system October, 1979[1]

Equipment	Description	28	32	36	40	44
		Cubic Yard Capacity, Boxes				
				Dollars		
Containers	covered	3,899	4,223	4,438	4,540	4,800
Containers	open-top	2,958	3,168	3,290	3,470	3,610
Truck	40,000 pound hoist	53,760	55,910	60,130	64,190	
Truck	50,000 pound hoist	54,790	56,940	60,250	64,310	64,310
		Cubic Yard Capacity				
		110	180	245	410	570
				Dollars		
Compactors[2]		7,010	10,910	14,020	19,065	20,800

[1]Price data obtained from eight major manufacturers.

[2]Includes installation, hoppers, walk-on and dock ramps, and heater. Units compact at approximately 800 pounds/cubic yard in roll-off box.

[3]Total yards of waste processed per hour, ideal conditions.

cooperating local entity and thereby lowered costs substantially. In some cases, resourceful decisionmakers in the study area have used city and county equipment and surplus materials to develop adequate transfer station sites for as little as $12,000 to $15,000. Conventional development of such sites, utilizing new materials and professional contractors can be accomplished for about $30,000. These figures include the water connections and drainage areas required for washing hoppers, push pits, unloading ramps and areas surrounding the site.

Operating Costs of Transfer Station Equipment[2]

Operating costs for transfer station systems include labor costs and vehicle (truck) costs. Truck operating costs for a mid-range diesel can be estimated at $.1287 per mile for fuel and $.2629 per mile for maintenance. These costs for a diesel tandem tractor can be estimated at $.2059 per mile for fuel and $.3681 per mile for maintenance. Very little maintenance or operating expense is involved in the transfer containers or transfer station sites. System managers estimate that a figure of $1000 annually per transfer trailer will cover tire costs and maintenance to the trailer (lubrication, rust prevention and painting). Roll-off boxes may be adequately maintained for $200 per year. Stationary compactors require only minimal maintenance if attended properly, with miscellaneous parts, lubricants and fluids costing approximately $150 per year, according to system operators.

LANDFILL DISPOSAL

Selecting Landfill Disposal Equipment

There is a wide variety of equipment which can be used to handle landfill disposal of solid waste. Selection of the appropriate equipment will depend upon local considerations, such as: (1) amount and kind of waste disposal; (2) operational procedures at the landfill; (3) skill level of the equipment operator; (4) fiscal limitations of the local

[2]Costs presented in this section are based on information obtained from operating transfer systems in Oklahoma and from dealer/manufacturers of equipment utilized in transfer station operation and represent costs as of October, 1979.

solid waste management system; (5) availability of suitable landfill sites; (6) availability of service to equipment; (7) versatility desired in equipment capabilities; and (8) availability of support functions from local entities in landfill activities.

To assist local decisionmakers in selecting appropriate landfill equipment to meet their needs, an inventory of existing equipment complements in use by solid waste management systems in the study area is presented in Table 6. In order to provide additional information which could be useful in the selection of landfill equipment, a brief discussion of alternative equipment items available for landfill use is presented in the following paragraphs.

Track-Type Tractors. The track-type tractor, or dozer is excellent for grading and excavation. It can adequately handle maneuvering of waste materials when equipped with a U-shaped blade. Being designed for flotation, dozers cannot achieve the degree of compaction that can be accomplished by wheeled machines or specialized compactors. The density of waste compacted by track-type vehicles usually ranges

Table 6. Inventory of existing landfill collection equipment complements, Oklahoma study region.

Number of users[1]	Weekly volume disposed[2]	Disposal Equipment		Time required for disposal[3]
		Type	Horsepower	
	cubic yards			*hours per week*
287	80	dozer	105	—
550	50	dozer	105	15
750	55	dozer	105	20
831	320	loader	80	45
1017	200	dozer	105	30
1055	190	dozer	105	48
1100	250	compactor	145	
1156	360	dozer	140	20
		loader	85	
1302	325	loader	95	40
1522	470	loader	95	
1564	900	loader	85	40
		compactor	145	
1684	500	dozer	210	40
1720	285	dozer	300	20
2216	457	dozer	140	18
2330	396	dozer	140	40
2800	610	dozer	140	40
		dozer	210	
3180	960	dozer	410	40
3300	240	dozer	145	40
3406	675	dozer	140	40
		dozer	300	
3829	760	dozer	140	40
4070	861	dozer	145	35
		loader	80	
4100	382	dozer	140	40
4896	1526	loader	210	48

[1]Number of users refers to all residential and commercial users on the respective collection system.

[2]Indicates total number of cubic yards of waste disposed at the landfill site. Many systems, institutions and industries dispose of their waste by hauling to some of the systems shown in this table. In these instances, the cubic yards of waste is included as "Weekly volume disposed."

[3]Disposal here refers to final landfill disposal, including burying and spreading of cover material.

from 800 to 1,000 pounds per cubic yard [4]. The track-type tractor is the most versatile of all equipment and the most popular in one-machine systems. When operated under conditions which normally exist in landfill use, the approximate life is 10,000 hours for tractors of less than 260 horsepower and 12,000 hours for those of sizes greater than 260 horsepower.

Track-Type Loaders. Crawler loaders are excellent for excavation and are adequate in spreading cover material. They have the added feature of being able to lift materials. However, they cannot handle as much waste in the same period of time as track-type tractors due to the narrower "buckets" with which they are equipped. The compaction rate, 800 to 1,000 pounds per cubic yard under ideal conditions, is equal to that of a track-type tractor [4]. Useful life of a track-type loader in landfill application is approximately 10,000 hours.

Wheel-Type Loaders. Wheel-type loaders have the advantage of being able to cover ground at higher rates of speed than track-type machines. They generally do not excavate as well, however, and have less flotation and traction. Compaction is somewhat higher (1,150 pounds/cubic yard) than the 1,000 pounds per cubic yard achieved by track-type loaders, but because of the rough, spongy surface at a landfill, grading ability is less than that of track-type equipment. Wheel type loaders can usually compact waste from 900 to 1,100 pounds density per cubic yard [4]. Approximate lives under these operating conditions are 10,000 hours for loaders of less than 185 horsepower and 12,000 hours for loaders of greater than 185 horsepower.

Scrapers. Scrapers are used largely for excavation and the moving and grading of cover material. Scrapers cannot function alone in a landfill situation and are generally used in large solid waste management systems. The useful life of a self-powered scraper under conditions of sanitary landfill use is approximately 12,000 hours [4].

Compactors. Landfill compactors are excellent for spreading and compacting on flat or level surfaces and operate fairly well on moderate slopes. Landfill compactors operate at high speeds and produce high inplace densities. Compactors usually achieve waste densities ranging from 1,400 to 1,500 pounds per cubic yard [4]. They are best applied in combination systems where excavation is performed with a second machine or contracted out, as they have poor excavating ability. Specialized compactors have a useful life of approximately 10,000 hours.

Graders. Graders are generally used only for spreading cover material, work which can often be performed by equipment owned by other entities. When operated under conditions which normally exist in landfill use, a grader can be expected to have a useful life of about 10,000 hours [4].

Capital Costs of Landfill Disposal Equipment. Average capital costs for various types of landfill disposal equipment appear in Table 7. These costs were obtained from interviews with dealer representatives of the various manufacturers of heavy equipment and from literature provided by these manufacturers. Average capital costs appearing in Table 7 do not include delivery costs of the equipment from the dealership to the solid waste management system. It was assumed that transportation of the more common types of equipment from Tulsa, Oklahoma City, Joplin, Kansas City and St. Louis could be provided in cooperation with some other local entity, and that freight costs of other equipment could be added as necessary.

Capital Costs of Buildings, Land and Fencing

Buildings, land and fencing comprise additional capital costs for a solid waste management system. Each of these components will be discussed separately in the following paragraphs.

Table 7. Capital costs for solid waste disposal equipment items, October, 1979[1]

Equipment description	Average price
	Dollars
A. Tractors, track-type	
1. D4 equivalent (75 HP)	55,000
2. D5 equivalent (105-110 HP)	75,900
3. D6 equivalent (130-145 HP)	94,250
4. D7 equivalent (200-210 HP)	143,033
5. D8 equivalent (260-310 HP)	187,767
6. D9 equivalent (410 HP)	330,500
B. Front end loaders, track-type	
1. 80 HP	54,400
2. 95-110 HP	66,100
3. 130-145 HP	77,500
4. 190-200 HP	144,225
C. Front end loaders, wheel-type	
1. 80-85 HP	57,900
2. 105-110 HP	66,800
3. 130-145 HP	87,650
4. 170-185 HP	110,000
5. 240-290 HP	181,300
D. Scrapers, self-powered	
1. 11 cubic yard capacity	97,000
2. 15 cubic yard capacity	130,700
3. 20 cubic yard capacity	190,433
E. Compactors	
1. 145 HP (46″ pass)	103,800
2. 170-186 HP (68″ - 80″ pass)	104,000
3. 300-330 HP (80″ - 96″ pass)	162,333
4. 425 HP (96″ pass)	250,000
F. Graders, 12′ Blade	
1. 85 HP	63,100
2. 125 HP	79,950
3. 150 HP	91,600

[1]Prices obtained from dealer representatives of 8 major manufacturers.

Buildings. Buildings are recommended for housing of collection and landfill disposal equipment, but are not required. After selecting the equipment complements for the solid waste system, floor space for housing the equipment can be determined (Table 8). Capital costs were obtained from various construction companies which handle prefabricated metal buildings. Constructed metal buildings with ventilation, lighting and wiring, overhead doors with 14 foot clearance, foundation and dirt floor have per square foot costs ranging from $13 to $18 (October, 1979). Office costs for these buildings may be calculated at $28 to $35 per square foot, (October, 1979) including heating, floor covering and electrical and toilet facilities.

Land. Many factors are involved in determining the capital costs attributable to the land component of a solid waste management system. Prices for suitable landfill sites will vary widely in different areas depending upon availability of the land and its location relative to communities, roads, businesses and other developments. Local decisionmakers should determine the local land price for their area and use this price in the cost analysis to follow. The approximate amount of land used annually may be determined by following a procedure presented later in this report.

Table 8. Maximum bay sizes for storage of solid waste collection and disposal equipment[1]

Equipment	Width	Length	Floor Space
		-----Feet[2]-----	*Sq. Ft.*
Collection vehicles	16	40	640
Track-type tractors	18	32	576
Track-type loaders	18	28	504
Wheel-type loaders	18	38	684
Self-powered scrapers	20	50	1,000
Compactors	20	36	720
Graders, 12′ blade	16	36	576

[1]Derived from equipment dimensions as given by manufacturers.
[2]Height of bays are 14 feet at doors. Width and length dimensions of bays allow a minimum of 4 feet clearance on all sides of equipment.

Fencing. State and federal laws require limited access to landfill sites. This may be achieved by using any number of various fencing methods with locked gates on the access road. Barbed wire, cyclone fencing, hog wire and cable, as well as other materials are possible for enclosing the landfill. Barbed wire fencing is usually the least expensive alternative. Materials and construction for a four-strand fence with metal posts costs about 47 cents per linear foot.[3] Costs will vary according to the fencing method selected and the corresponding local material and labor prices.

Law also requires a "blow screen" be constructed around the working face of the landfill to diminish litter problems caused by blowing trash. Mobile "blow screens" constructed in sections seem to be most popular, as they provide for easy movement and arrangement around the various working face sites during landfill disposal. Many different materials (some even use shrub plantings to assist in land reclamation) can be used for the "blow screen", and costs will vary depending upon the type of screen selected and local material and labor prices.

Operating Costs of Landfill Disposal Equipment

Operating expenses for landfill disposal components are shown in Table 9. In Table 9, approximate hourly consumptions of fuel and lubricants, as well as filter replacement, repair, undercarriage and tire replacement cost estimates are presented on a per hour of operation basis. Costs are presented for various sizes of alternative landfill disposal equipment. It should be noted that "filters" refers to all filters required of the equipment and "repairs" includes routine maintenance of equipment as well as other repairs, excluding undercarriage, tire replacement, compactor feet, ground engaging tools, body liners and repair welding.

[3]Based on July, 1979 Oklahoma price infromation.

Table 9—Estimated hourly operating costs for landfill disposal equipment, October 1979

Equipment Description	Fuel, oil, fluids, grease[1]	Filters, repairs, track, tires[2]
	Dollars	
A. Track-type tractors		
1. 75 HP	3.18	5.13
2. 105 HP	4.28	6.57
3. 140 HP	5.66	7.75
4. 200 HP	7.99	8.78
5. 300 HP	11.52	10.93
6. 410 HP	15.93	13.88
B. Track-type front end loaders		
1. 80 HP	3.91	6.71
2. 95 HP	4.70	7.75
3. 130 HP	6.08	8.99
4. 190 HP	8.02	11.16
C. Wheel-type front end loaders		
1. 80 HP	3.52	3.12
2. 100 HP	4.21	3.60
3. 130 HP	5.10	4.23
4. 170 HP	7.11	4.91
5. 270 HP	9.40	6.14
D. Scrapers		
1. 11 cubic yards	5.55	5.81
2. 20 cubic yards	11.77	7.44
E. Compactors		
1. 170 HP	9.80	3.76
2. 300 HP	16.07	5.33
F. Graders		
1. 125 HP	4.98	3.10
2. 150 HP	5.64	3.84
3. 180 HP	6.58	4.71

[1]Derived from data in reference [6].

[2]Derived from source above; excludes repair or replacement of compactor feet, ground engaging tools, body liners, and repair welding.

EXAMINING THE ECONOMICS OF ALTERNATIVE SOLID WASTE MANAGEMENT SYSTEMS

In the following pages of this report methodologies are presented which may be used to evaluate capital and operating costs associated with alternative solid waste management systems. Application of the information in preceeding sections regarding the structure and costs of various collection, transfer and landfill disposal systems, in combination with certain local information, will provide information useful to decisionmakers in evaluating economic feasibilities of solid waste management systems of their choice.

In order to develop an understanding of the components of capital and operation and maintenance budgets for use in decisionmaking, sample budgets for some alternative systems of collection, transfer and landfill disposal are shown. An example community with 3,180 solid waste system users was selected for use in this sample analysis. Two example collection alternatives, two transfer alternatives and two landfill disposal alternatives are examined. Special summary forms employing information from these collection, transfer and landfill disposal sub-sections are provided to facilitate cost and revenue comparisons of total solid waste management systems. Blank copies of the form demonstrated in the following sub-sections may be obtained by writing the authors.

Determining Collection Budgets

Estimation of capital and operating budgets for collection systems can be made by following the procedure in Form 1. Spaces for indicating general information regarding packer size and type, crew size, collection method and disposal method, all specified by decisionmakers, appear at the top of the form. Prior to calculating actual dollar amounts involved in the budget estimation, it is necessary to identify such things as number of collection trucks required, total on- and off-route time and mileage and estimated truck life. Section A of Form 1 deals with determining the number of truckloads of waste and off-route hours per week. These are obtained by applying local information and information specified at the top of the form to the methodology in Section A. Collection hours per truckload and number of trucks needed for collection service are determined in Section B. This section is completed by applying local information, information in Section A and collection performance rates given in Appendix A. Please note, however, that the collection performance rates shown in Appendix A are suggested as guidelines only. If collection performance rates are known for the particular community their use would be more appropriate. (These rates may be obtained by observing number of collections per hour for each collection route within the community.) Section C determines the total mileage per year of collection vehicles, a figure which is vital in calculating vehicle operating costs and years of life of each vehicle in use.

To account in some way for the constantly escalating costs faced by communities due to inflation, two inflation indices are developed in Section D. The first, a capital equipment inflation adjustment factor, is used to update capital cost estimates for collection equipment. The second, a general inflation adjustment factor, can be used to adjust operation and maintenance costs for many items employed in the operation of the collection system. Both these indices are used in Forms 2 and 3, which estimate capital and operating costs for transfer and landfill disposal systems, respectively.

Form 1—Estimation of Capital and Operating Costs for Collection Systems

Collection alternative	I
Packer type & size	18 yd. rear
Crew size	2 man
Collection method	curb, twice/wk.
Disposal method	landfill

A. Determine number of truck loads and off-route hours

1. Enter number of users		3180
2. Multiply by cu. yds. per user per week	(×)	.1948
3. Total cubic yards per week		619
4. Divide by vehicle size	(÷)	18
5. No. of truck loads per week		34.4
6. Multiply by round-trip hours to disposal facility	(×)	.6
7. Total hours off-route		20.64

B. Determine hours required to collect truck load and number of trucks needed

1. Enter packer size		18
2. Divide by cubic yards collected per hour, Appendix A	(÷)	5.88
3. On-route hours per truck load		3.06
4. Multiply by number of truckloads per week (A5)	(×)	34.4
5. Total on-route hours		105.26
6. Add total hours off-route (A7)	(+)	20.64
7. Total hours working		125.9
8. Divide by working hrs. per week, eg., 30	(÷)	30
9. No. of trucks and crews (rounded up to nearest whole number)		5

C. Determine mileage per year

1. Enter total route mileage, locally determined		60
2. Multiply by frequency of collection per week	(×)	2
3. Total route mileage per week		120

4. Enter round-trip mileage to disposal		10
5. Multiply by number of truck loads per week (A5)	(×)	34.4
6. Total off-route mileage per week		344
7. Add (C3) and (C6)		464
8. Multiply by 52 weeks per year	(×)	52
9. Total mileage per year, all vehicles		24128

D. Determine inflation adjustment factors

1. Enter current Construction Equipment index[1]		271.5
2. Divide by base period index[2]	(÷)	269.9
3. Inflation adjustment factor for capital equipment		1.0555
4. Enter current Consumer Price index[3]		236.5
5. Divide by base period index	(÷)	225.6
6. General inflation adjustment factor		1.0483

E. Determine annual capital costs of collection equipment

1. Enter packer body price, Table 2		$ 13645.00
2. Add chassis costs, Table 2	(+)	$ 21802.00
3. Per vehicle capital costs		$ 35447.00
4. Multiply by number of vehicles (B9)	(×)	5
5. Total vehicle capital costs		$ 177235.00
6. Multiply by capital equipment adjustment factor (D3)	(×)	$ 1.0555
7. Total adjusted vehicle capital costs		$ 187071.54
8. Multiply by amortization rate for 7 years, Appendix B[4]	(×)	.1728
9. Annual capital costs, vehicles		$ 32325.96
10. Enter number of containers		100
11. Multiply by price of container, Table 2	(×)	$ 370.00
12. Total costs of containers		$ 37000.00
13. Multiply by capital equipment adjustment factor (D3)	(×)	1.0555
14. Total adjusted container capital costs		$ 39053.50

15. Multiply by amortization rate for 10 years, Appendix B[5]	(×)	.1295
16. Annual capital costs, containers		$5057.43
17. Total annual capital costs, add E9 and E16		$37383.39

F. Determine annual operating costs

1. Enter persons per truck crew, locally determined		2
2. Multiply by number of crews (B9)	(×)	5
3. Multiply by average annual wage, locally determined	(×)	7965.00
4. Total annual labor costs		$79650.00
5. Enter vehicle fuel costs per mile, Table 3		$.2375
6. Multiply by total annual mileage (C9)	(×)	24128
7. Total annual fuel cost		$
8. Enter vehicle maintenance cost per mile, Table 3		$.7345
9. Multiply by total annual mileage (C9)	(×)	24128
10. Total annual maintenance costs		$17722.02
11. Add miscellaneous vehicle costs ($3000/vehicle)	(+)	$15000.00
12. Total annual non-fuel vehicle costs		$32722.02
13. Multiply by general inflation factor (D6)	(×)	1.0483
14. Total annual adjusted non-fuel vehicle costs		$34302.49
15. Add total annual labor costs (F4)	(+)	$79650.00
16. Add total annual fuel costs (F7)	(+)	$5730.40
17. Total annual operating costs		$119682.89

G. Determine total annual capital and operating costs

1. Enter total annual capital costs (E17)		$37383.39
2. Add total annual operating costs (F17)	(+)	$119682.89
3. Total annual collection system costs		$157066.28

[1]Use Producer Index, Construction Machinery, *Survey of Current Business* or *Monthly Labor Review.*
[2]Base period is July, 1979.
[3]Use Consumer Price Index, *Survey of Current Business* or *Monthly Labor Review.*
[4]Farmers Home Administration can fund solid waste equipment at 5 percent interest over a seven year payback period. Alternative interest rates and payback periods may be considered depending upon local conditions and credit sources.
[5]Assumes a useful life for containers of 10 years and a 5 percent Farmers Home Administration loan.

Form 1—Estimation of Capital and Operating Costs for Collection Systems

Collection alternative II

Packer type & size 20 yd. rear

Crew size 3 man

Collection method curb, once/wk.

Disposal method transfer/landfill

A. Determine number of truck loads and off-route hours

1. Enter number of users		3180
2. Multiply by cu. yds. per user per week	(×)	.1948
3. Total cubic yards per week		619
4. Divide by vehicle size	(÷)	20
5. No. of truck loads per week		31
6. Multiply by round-trip hours to disposal facility	(×)	.3
7. Total hours off-route		9.3

B. Determine hours required to collect truck load and number of trucks needed

1. Enter packer size		20
2. Divide by cubic yards collected per hour, Appendix A	(÷)	11.24
3. On-route hours per truck load		1.78
4. Multiply by number of truckloads per week (A5)	(×)	31
5. Total on-route hours		55.18
6. Add total hours off-route (A7)	(+)	9.3
7. Total hours working		64.48
8. Divide by working hrs. per week, eg., 30	(÷)	30
9. No. of trucks and crews (rounded up to nearest whole number)		3

C. Determine mileage per year

1. Enter total route mileage, locally determined		60
2. Multiply by frequency of collection per week	(×)	1
3. Total route mileage per week		60

4. Enter round-trip mileage to disposal		2
5. Multiply by number of truck loads per week (A5)	(×)	31
6. Total off-route mileage per week		62
7. Add (C3) and (C6)		122
8. Multiply by 52 weeks per year	(×)	52
9. Total mileage per year, all vehicles		6344

D. Determine inflation adjustment factors

1. Enter current Construction Equipment index[1]		277.5
2. Divide by base period index[2]	(÷)	269.9
3. Inflation adjustment factor for capital equipment		1.0555
4. Enter current Consumer Price index[3]		236.5
5. Divide by base period index	(÷)	225.6
6. General inflation adjustment factor		1.0483

E. Determine annual capital costs of collection equipment

1. Enter packer body price, Table 2		$14190.00
2. Add chassis costs, Table 2	(+)	$28997.00
3. Per vehicle capital costs		$43187.00
4. Multiply by number of vehicles (B9)	(×)	3
5. Total vehicle capital costs		$129561.00
6. Multiply by capital equipment adjustment factor (D3)	(×)	$1.0555
7. Total adjusted vehicle capital costs		$136751.63
8. Multiply by amortization rate for 7 years, Appendix B[4]	(×)	.1728
9. Annual capital costs, vehicles		$23630.68
10. Enter number of containers		100
11. Multiply by price of container, Table 2	(×)	$370
12. Total costs of containers		$37000.00
13. Multiply by capital equipment adjustment factor (D3)	(×)	1.0555
14. Total adjusted container capital costs		$39053.50

15. Multiply by amortization rate for 10 years, Appendix B[5]	(×)	.1295
16. Annual capital costs, containers		$5057.43
17. Total annual capital costs, add E9 and E16		$28688.11

F. Determine annual operating costs

1. Enter persons per truck crew, locally determined		3
2. Multiply by number of crews (B9)	(×)	3
3. Multiply by average annual wage, locally determined	(×)	7965.00
4. Total annual labor costs		$71685.00
5. Enter vehicle fuel costs per mile, Table 3		$.2375
6. Multiply by total annual mileage (C9)	(×)	6344
7. Total annual fuel cost		$1506.70
8. Enter vehicle maintenance cost per mile, Table 3		$.7345
9. Multiply by total annual mileage (C9)	(×)	6344
10. Total annual maintenance costs		$4659.67
11. Add miscellaneous vehicle costs ($3000/vehicle)	(+)	$9000.00
12. Total annual non-fuel vehicle costs		$13659.67
13. Multiply by general inflation factor (D6)	(×)	1.0483
14. Total annual adjusted non-fuel vehicle costs		$14319.43
15. Add total annual labor costs (F4)	(+)	$71685.00
16. Add total annual fuel costs (F7)	(+)	$1506.70
17. Total annual operating costs		$87511.13

G. Determine total annual capital and operating costs

1. Enter total annual capital costs (E17)		$28688.11
2. Add total annual operating costs (F17)	(+)	$87511.13
3. Total annual collection system costs		$116199.24

[1]Use Producer Index, Construction Machinery, *Survey of Current Business* or *Monthly Labor Review*.
[2]Base period is July, 1979.
[3]Use Consumer Price Index, *Survey of Current Business* or *Monthly Labor Review*.
[4]Farmers Home Administration can fund solid waste equipment at 5 percent interest over a seven year payback period. Alternative interest rates and payback periods may be considered depending upon local conditions and credit sources.
[5]Assumes a useful life for containers of 10 years and a 5 percent Farmers Home Administration loan.

Section E of Form 1 specifies a step-by-step procedure for determining annual capital costs. Necessary information for this section is contained in Table 2, in Appendix B and in preceeding sections of Form 1. Annual operating costs (Section F) are derived in much the same fashion, again using previously determined information and operating cost figures from Table 3. Total annual capital and operating costs (Section G) are then estimated by adding the totals obtained in Sections E and F.

Three alternative collection systems were examined for illustrative purposes. Total annual costs for example Alternative I were calculated as $157,066.28, while example Alternative II had total annual system costs of $116,199.24. Before drawing any conclusions concerning least cost collection systems, specific differences in associated packer body sizes, crew sizes, collection methods and disposal methods should be evaluated in terms of physical and political feasibilities and the additional costs associated with transfer and disposal alternatives which will complete the solid waste management systems.

Determining Transfer Station Budgets

Transfer station budgets can be estimated by following the procedure presented in Form 2. Information concerning packer size and type, disposal method and transfer equipment for the system appears at the top of the form. This information can be specified by decisionmakers, depending upon the different transfer alternatives to be examined. It should be noted that the transfer systems can be examined only in conjunction with a collection alternative which provides for transfer as a method of dealing with collected solid waste. In other words, unless "transfer" is specified at the top of the Form 1 next to the blank for "disposal method", it is meaningless to evaluate transfer station alternatives. For the transfer alternatives demonstrated in the examples for Form 2, Collection Alternative II is involved.

As was the case in the collection system alternatives (Form 1), it is necessary to identify certain information before arriving at specific dollar amounts for the budgeting procedure. Sections A and B of Form 2 employ data derived in Form 1 and local information regarding transfer route miles to identify this information. Transfer container capacity, packer body capacity and transfer station location are factors which influence number of trips and annual mileage for transfer vehicles.

Annual capital costs for transfer containers and transfer vehicles are determined in Sections C and D of Form 2. Unit costs of this equipment can be found in Tables 4 and 5 for both the transfer trailer and roll-off box systems of solid waste transfer. The inflation adjustment factor calculated in Form 1, D.3 is applied to update the cost estimates, and costs are annualized by multiplying these totals by the appropriate amortization factor dependent upon the interest rate and payback period used. Section E deals with annual capital costs of the transfer station site. Cost estimation for the transfer station site is much like that for transfer containers and transfer vehicles. Reference to the text section titled "Transfer Stations" may be useful in the determination of costs for the different elements of the site. In the example systems, a lump sum bid of $30,000 was used to arrive at an annual capital cost figure for site development.

Determination of annual operating costs (Section F) is accomplished by incorporating locally determined information with data in Table 3 and in preceeding sections of Form 2. Once again the general inflation adjustment factor (Form 1, D6) is used to bring the estimated operating cost up to current levels. The total annual capital and operating costs for the alternative transfer system is determined in Section G, where totals from Section C through F are combined into a single dollar amount.

On comparison, it can be seen that Alternative I, which included the use of 40 cubic yard roll-off boxes for transfer, has a total annual cost of $41,165.68, whereas

Form 2—Estimation of Capital and Operating Costs for Transfer Stations

Transfer Alternative		I
Packer type and size		20 yd rear
Disposal method		land fill
Transfer equipment		40 yd. roll off boxes

A. Determine number of trips from transfer station to disposal site

1. Enter number of truckloads per week (Form 1, A5)		31
2. Divide by 5 work days per week	(÷)	5
3. Number of truckloads per day		6.2
4. Multiply by cu. yds. per truckload	(×)	20
5. Total cu. yds. per day		124
6. Divide by transfer trailer (roll-off box) capacity	(÷)	40
7. Total transfer loads per day		3.1
8. Multiply by 5 work days per week	(×)	5
9. Total transfer loads per week		15.5

B. Determine mileage per year and years of vehicle life

1. Enter miles per complete transfer trip locally determined		20
2. Multiply by total transfer loads per week (A9)	(×)	15.5
3. Multiply by 52 weeks per year	(×)	52
4. Total transfer miles per year		16120

C. Determine annual capital costs of transfer containers

1. Enter transfer trailer (roll-off box) price. Table 4 or 5		$ 4540.00
2. Multiply by number of transfer containers required	(×)	2
3. Total capital costs for transfer containers		$ 9080.00
4. Multiply by capital equipment inflation factor (Form 1, D3)	(×)	1.0555
5. Total adjusted capital costs for transfer containers		$ 9583.94
6. Multiply by amortization factor for 15 years Appendix B	(×)	.0963
7. Annual capital costs for transfer containers		$ 922.93

D. Determine annual capital costs for transfer vehicle

1. Enter transfer vehicle price, Table 4 or 5 — $ 64190.00
2. Multiply by capital equipment inflation factor (Form 1, D3) (×) — 1.05555
3. Total adjusted capital costs for transfer vehicle — $ 67752.55
4. Multiply by amortization factor for 15 years, Appendix B (×) — .0963
5. Annual capital costs for transfer vehicle — $ 6524.57

E. Determine annual capital costs of transfer station site[1]

1. Enter cost of earthwork at transfer site, locally determined — $ ______
2. Add surfacing cost at transfer site, locally determined (+) — $ ______
3. Add building cost at transfer site, locally determined (+) — $ ______
4. Add any miscellaneous costs, locally determined (+) — $ ______
5. Total capital costs of transfer site — $ 30000.00
6. Multiply by amortization rate for appropriate years life, Appendix B (×) — .0802
7. Annual capital costs of transfer station site — $ 2406.00

F. Determining annual operating costs

1. Enter number of employees, transfer operation, locally determined — 2
2. Multiply by average annual wage, locally determined (×) — $ 10400.00
3. Total annual labor costs — $ 20800.00
4. Enter vehicle fuel costs per mile, diesel, (text) — $ .1287
5. Multiply by total annual mileage (B4) (×) — 16120
6. Total annual fuel costs — $ 2074.64
7. Enter vehicle maintenance costs per mile, diesel, (text) — $ .2629
8. Multiply by total annual mileage (B4) (×) — 16120

[1]Transfer station sites are generally tailored for specific local conditions. For further explanation, refer to text.

9. Total annual maintenance costs $ 4231.95

10. Add miscellaneous vehicle costs, Table 3 (+) $ 3000.00

11. Total annual non-fuel vehicle costs $ 7231.95

12. Multiply by general inflation factor (Form 1, D6) (×) 1.0483

13. Total annual adjusted non-fuel vehicle costs $ 7587.54

14. Add total annual labor costs (F3) (+) $ 20800.00

15. Add total annual fuel costs (F6) (+) $ 2074.64

16. Add container and site maintenance,

locally determined (+) $ 850.00

17. Total annual operating costs $ 31312.18

G. Determine total annual capital and operating costs

1. Enter annual capital costs, transfer containers (C7) $ 922.93

2. Add annual capital costs, transfer vehicle (D5) (+) $ 6524.57

3. Add annual capital costs, transfer station site (E7) (+) $ 2406.00

4. Add total annual operating costs (F17) (+) $ 31312.18

5. Total annual capital and operating costs $ 41165.68

Form 2—Estimation of Capital and Operating Costs for Transfer Stations

Transfer Alternative	II
Packer type and size	20yd. rear
Disposal method	landfill
Transfer equipment	75 yd. trailer

A. Determine number of trips from transfer station to disposal site

1.	Enter number of truckloads per week (Form 1, A5)		31
2.	Divide by 5 work days per week	(÷)	5
3.	Number of truckloads per day		6.2
4.	Multiply by cu. yds. per truckload	(×)	20
5.	Total cu. yds. per day		124
6.	Divide by transfer trailer (roll-off box) capacity	(÷)	75
7.	Total transfer loads per day		1.65
8.	Multiply by 5 work days per week	(×)	5
9.	Total transfer loads per week		8.25

B. Determine mileage per year and years of vehicle life

1.	Enter miles per complete transfer trip locally determined		20
2.	Multiply by total transfer loads per week (A9)	(×)	8.25
3.	Multiply by 52 weeks per year	(×)	52
4.	Total transfer miles per year		8580

C. Determine annual capital costs of transfer containers

1.	Enter transfer trailer (roll-off box) price. Table 4 or 5		$35000.00
2.	Multiply by number of transfer containers required	(×)	1
3.	Total capital costs for transfer containers		$35000.00
4.	Multiply by capital equipment inflation factor (Form 1, D3)	(×)	1.0555
5.	Total adjusted capital costs for transfer containers		$36942.50
6.	Multiply by amortization factor for 15 years Appendix B	(×)	.0963
7.	Annual capital costs for transfer containers		$3557.56

D. Determine annual capital costs for transfer vehicle

1. Enter transfer vehicle price, Table 4 or 5 $51870.00
2. Multiply by capital equipment inflation factor (Form 1, D3) (×) 1.0555
3. Total adjusted capital costs for transfer vehicle $54748.79
4. Multiply by amortization factor for 15 years, Appendix B (×) .0963
5. Annual capital costs for transfer vehicle $5272.31

E. Determine annual capital costs of transfer station site[1]

1. Enter cost of earthwork at transfer site, locally determined $______
2. Add surfacing cost at transfer site, locally determined (+) $______
3. Add building cost at transfer site, locally determined (+) $______
4. Add any miscellaneous costs, locally determined (+) $______
5. Total capital costs of transfer site $30000.00
6. Multiply by amortization rate for appropriate years life, Appendix B (×) .0802
7. Annual capital costs of transfer station site $2406.00

F. Determining annual operating costs

1. Enter number of employees, transfer operation, locally determined 2
2. Multiply by average annual wage, locally determined (×) $10400.00
3. Total annual labor costs $20800.00
4. Enter vehicle fuel costs per mile, diesel, (text) $.2059
5. Multiply by total annual mileage (B4) (×) 8580
6. Total annual fuel costs $1766.62
7. Enter vehicle maintenance costs per mile, diesel, (text) $.3681
8. Multiply by total annual mileage (B4) (×) 8580

[1]Transfer station sites are generally tailored for specific local conditions. For further explanation, refer to text.

9. Total annual maintenance costs		$ 3158.30
10. Add miscellaneous vehicle costs, Table 3	(+)	$ 3000.00
11. Total annual non-fuel vehicle costs		$ 6158.30
12. Multiply by general inflation factor (Form 1, D6)	(×)	1.0483
13. Total annual adjusted non-fuel vehicle costs		$ 6455.75
14. Add total annual labor costs (F3)	(+)	$ 20800.00
15. Add total annual fuel costs (F6)	(+)	$ 1766.62
16. Add container and site maintenance, locally determined	(+)	$ 2350.00
17. Total annual operating costs		$ 31372.37

G. Determine total annual capital and operating costs

1. Enter annual capital costs, transfer containers (C7)		$ 3557.56
2. Add annual capital costs, transfer vehicle (D5)	(+)	$ 5272.31
3. Add annual capital costs, transfer station site (E7)	(+)	$ 2406.00
4. Add total annual operating costs (F17)	(+)	$ 31372.37
5. Total annual capital and operating costs		$ 42608.24

Form 3—Estimation of Capital and Operating Costs for Landfill Systems

Disposal Alternative	I
Disposal method	land fill
Equipment selected	D8

A. Determine annual capital cost of land used in landfill[1]

1. Enter number of users		3180
2. Multiply by cu. yds. waste per user per week[2]	(×)	.1948
3. Total cubic yds. waste per week		619.46
4. Add total solid waste hauled to landfill from sources not on collection routes	(+)	450
5. Divide by cu. yds. per acre foot	(÷)	1613.3
6. Total acre feet waste per week		.6629
7. Multiply by 52 weeks per year	(×)	52
8. Total acre feet waste per year		34.47
9. Multiply by landfill waste compaction rate	(×)	.75
10. Total landfill acre - feet waste per year		25.85
11. Divide by depth of waste in feet	(÷)	6
12. Acre-feet of land required		4.31
13. Multiply by desired years of life at current use	(×)	20
14. Total number of acres required for landfill site		86.2
15. Multiply by price per acre, locally determined	(×)	$3000.00
16. Total land costs		$258600.00
17. Multiply by amortization rate for landfill life, Appendix B	(×)	.0802
18. Annual land costs for landfill site		$20739.72

B. Determine annual capital cost of fencing [4]

1. Enter number of linear feet of fencing required ___10560___
2. Multiply by cost per linear foot of fencing materials, (text) (×) $___.47___
3. Total fencing material costs ___4963.20___
4. Add cost of gates for landfill entrance, locally determined (+) $___400.00___
5. Add fencing labor costs, locally determined (+) $___450.00___
6. Total fencing construction costs $___5813.20___
7. Multiply by amortization rate for landfill life (×) ___.0802___
8. Annual fencing costs for landfill site $___466.22___

C. Determine annual capital cost of landfill disposal equipment

1. Enter capital cost of landfill disposal equipment, Table 7 $___187767.00___
2. Multiply by inflation adjustment factor for capital equipment (Form 1, D3) (×) ___1.05355___
3. Multiply by amortization rate for appropriate years life[5] (×) ___.1728___
4. Total annual capital costs for landfill disposal equipment $___34246.90___

D. Determine annual capital costs of buildings and blow screen

1. Enter square feet required for equipment storage, Table 8 ___540___
2. Multiply by construction costs per square foot, locally determined [4] (×) $___16.00___
3. Add construction costs for office space, locally determined [6] (+) $___3000.00___
4. Total building costs for equipment storage $___11640.00___
5. Multiply by amortization rate for estimated life of building, Appendix B (×) ___.0802___
6. Annual capital costs for equipment storage building $___933.53___

7. Enter number linear feet of blow screen required for landfill working face, locally determined[7] ___347.5___
8. Multiply by cost per linear foot, locally determined (×) $___.75___
9. Multiply by amortization rate for estimated life of blow screen, Appendix B. (×) ___1.05___
10. Annual capital cost for blow screen $___194.91___
11. Add annual capital costs for equipment storage building (D6) (+) $___933.53___
12. Total annual costs of building and blow screen $___1128.44___

E. Determine annual operating costs

Labor

1. Enter number of employees, landfill site ___1___
2. Multiply by average annual wage, locally determined (×) ___14560.00___
3. Total annual labor costs $___14560.00___

Fuel, Oil, Fluids and Grease

4. Enter hourly cost of fuel, oil, fluids and grease, Table 9 $___11.52___
5. Multiply by total annual hours of operation, locally determined (×) ___1600___
6. Multiply by general inflation adjustment factor, (Form 1, D6) (×) ___1.0483___
7. Total annual costs of fuel, oil, fluids and grease $___19322.27___

Filters, Repairs, Track and Tires

8. Enter hourly costs of filters, repairs, track and tires, Table 9 $___10.93___
9. Multiply by total annual hours of operation, locally determined (×) ___1600___

10. Multiply by general inflation adjustment factor (Form 1, D6) (×) 1.0433

11. Total annual costs of filters, repairs, track and tires $18332.61

12. Add total annual labor costs (E3) $14560.00

13. Add total annual costs of fuel, oil, fluids and grease (E7) $19322.27

14. Total annual operating costs $52214.94

F. Determine total annual capital and operating costs

1. Enter annual land costs for landfill site (A18) $20739.72
2. Add annual fencing costs for landfill site (B8) (+) $466.22
3. Add total annual capital costs for landfill equipment (C4) (+) $34246.90
4. Add total annual building and blow screen costs (D12) (+) $1128.44
5. Add total annual operating costs (E14) (+) $52214.94
6. Total annual disposal system costs $108796.22

[1]For explanation of Section A, Form 3, refer to text, pp. 12.
[2]Waste compacted at 600 pounds per cubic yard in collection vehicle.
[3]Assumes 5 percent interest and 20 year life.
[4]For explanation of Section B, Form 3, refer to text, pp. 12.
[5]To calculate estimated years of life for landfill equipment, divide total hours life for appropriate equipment by total estimated hours usage per year. See test pp. 9-10
[6]For explanation of Section D2 and D3 refer to text, pp. 11.
[7]For explanation of Section D7, refer to text, pp. 12.

Form 3—Estimation of Capital and Operating Costs for Landfill Systems

Disposal Alternative	II
Disposal method	landfill/transfer (all waste)
Equipment selected	D8

A. Determine annual capital cost of land used in landfill[1]

1. Enter number of users		3180
2. Multiply by cu. yds. waste per user per week[2]	(×)	.1948
3. Total cubic yds. waste per week		619.46
4. Add total solid waste hauled to landfill from sources not on collection routes	(+)	450
5. Divide by cu. yds. per acre foot	(÷)	1613.3
6. Total acre feet waste per week		.6629
7. Multiply by 52 weeks per year	(×)	52
8. Total acre feet waste per year		34.47
9. Multiply by landfill waste compaction rate	(×)	.75
10. Total landfill acre - feet waste per year		25.85
11. Divide by depth of waste in feet	(÷)	6
12. Acre-feet of land required		4.31
13. Multiply by desired years of life at current use	(×)	20
14. Total number of acres required for landfill site		86.2
15. Multiply by price per acre, locally determined	(×)	$1000.00
16. Total land costs		$86200.00
17. Multiply by amortization rate for landfill life, Appendix B	(×)	.0802
18. Annual land costs for landfill site		$6913.24

B. Determine annual capital cost of fencing [4]

1. Enter number of linear feet of fencing required ___10560___
2. Multiply by cost per linear foot of fencing materials, (text) (×) $___.47___
3. Total fencing material costs ___4963.20___
4. Add cost of gates for landfill entrance, locally determined (+) $___400.00___
5. Add fencing labor costs, locally determined (+) $___450.00___
6. Total fencing construction costs $___5813.20___
7. Multiply by amortization rate for landfill life (×) ___.0802___
8. Annual fencing costs for landfill site $___466.22___

C. Determine annual capital cost of landfill disposal equipment

1. Enter capital cost of landfill disposal equipment, Table 7 $___187767.00___
2. Multiply by inflation adjustment factor for capital equipment (Form 1, D3) (×) ___1.0555___
3. Multiply by amortization rate for appropriate years life[5] (×) ___.1728___
4. Total annual capital costs for landfill disposal equipment $___34246.90___

D. Determine annual capital costs of buildings and blow screen

1. Enter square feet required for equipment storage, Table 8 ___540___
2. Multiply by construction costs per square foot, locally determined [4] (×) $___16.00___
3. Add construction costs for office space, locally determined [6] (+) $___3000.00___
4. Total building costs for equipment storage $___11640.00___
5. Multiply by amortization rate for estimated life of building, Appendix B (×) ___.0802___
6. Annual capital costs for equipment storage building $___933.53___

7. Enter number linear feet of blow screen required for landfill working face, locally determined [7] ______ 247.5
8. Multiply by cost per linear foot, locally determined (×) $ ______ .75
9. Multiply by amortization rate for estimated life of blow screen, Appendix B. (×) ______ 1.05
10. Annual capital cost for blow screen $ ______ 194.91
11. Add annual capital costs for equipment storage building (D6) (+) $ ______ 933.53
12. Total annual costs of building and blow screen $ ______ 1128.44

E. Determine annual operating costs

Labor

1. Enter number of employees, landfill site ______ 1
2. Multiply by average annual wage, locally determined (×) ______ 14560.00
3. Total annual labor costs $ ______ 14560.00

Fuel, Oil, Fluids and Grease

4. Enter hourly cost of fuel, oil, fluids and grease, Table 9 $ ______ 11.52
5. Multiply by total annual hours of operation, locally determined (×) ______ 1600
6. Multiply by general inflation adjustment factor, (Form 1, D6) (×) ______ 1.0483
7. Total annual costs of fue , oil, fluids and grease $ ______ 19322.27

Filters, Repairs, Track and Tires

8. Enter hourly costs of filters, repairs, track and tires, Table 9 $ ______ 10.93
9. Multiply by total annual hours of operation, locally determined (×) ______ 1600

10. Multiply by general inflation adjustment factor (Form 1, D6) (×) 1.0483

11. Total annual costs of filters, repairs, track and tires $ 18332.67

12. Add total annual labor costs (E3) $ 14560.00

13. Add total annual costs of fuel, oil, fluids and grease (E7) $ 19322.27

14. Total annual operating costs $ 52214.94

F. Determine total annual capital and operating costs

1. Enter annual land costs for landfill site (A18) $ 6913.24
2. Add annual fencing costs for landfill site (B8) (+) $ 466.22
3. Add total annual capital costs for landfill equipment (C4) (+) $ 34246.90
4. Add total annual building and blow screen costs (D12) (+) $ 1128.44
5. Add total annual operating costs (E14) (+) $ 52214.94
6. Total annual disposal system costs $ 94969.74

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[1]For explanation of Section A, Form 3, refer to text, pp. 12.
[2]Waste compacted at 600 pounds per cubic yard in collection vehicle.
[3]Assumes 5 percent interest and 20 year life.
[4]For explanation of Section B, Form 3, refer to text, pp. 12.
[5]To calculate estimated years of life for landfill equipment, divide total hours life for appropriate equipment by total estimated hours usage per year. See test pp. 9-10
[6]For explanation of Section D2 and D3 refer to text, pp. 11.
[7]For explanation of Section D7, refer to text, pp. 12.

Alternative II, using 75 cubic yard transfer trailers, has a total annual cost of $42,608.24. This indicates that for the example community analyzed, no major annual cost differences exist between the alternatives. However, this relationship may not hold for all communities. These alternatives should be investigated by decisionmakers using local data.

Determining Landfill Disposal Budgets

Estimates of capital and operating budgets for landfill disposal systems can be made by following the procedure in Form 3. Spaces for indicating general information regarding disposal method and equipment selected for disposal, both specified by decisionmakers, appear at the top of the form.

A brief explanation of both alternatives will be helpful in understanding the procedure in Form 3. Alternative I consists of a landfill located close to the community which handles solid wastes collected by the community and also solid wastes hauled in by industrial parks and other non-community users. Alternative II consists of a landfill located relatively distant from the community which receives both community collected solid wastes and industrial and non-residential solid wastes, with collected wastes transferred to the landfill site.

One of the major capital costs of any landfill system is that cost associated with the land purchase. Section A of Form 3 provides a methodology of estimating land requirements for landfill disposal of solid wastes for the example community. By applying local land prices to this land estimate and amortizing the total cost for the appropriate interest rate and payback period, annual capital costs for land used in the landfill can be determined. This will, of course, be dependent upon the volume of solid waste handled and the price of available land in the area.

Annual capital costs for fencing are determined in Section B. Annual capital costs for landfill disposal equipment are estimated in Section C. Cost figures for selected landfill equipment appear in Table 7. These costs are adjusted for inflation and amortized to arrive at an annual capital cost for landfill equipment. In Section D, information from Table 8 and the sub-section entitled "Capital Costs of Buildings, Land and Fencing" is combined with locally determined material and construction costs to determine the annual capital costs for buildings and blow-screen.

Total annual operating costs, which include labor, fuel, lubricants, grease, filters, repairs and undercarriage replacement are calculated in Section E. Local prices for labor, fuel, lubricants and grease are multiplied by consumption levels of these inputs (Table 9). Filter, repair and undercarriage replacement costs are also given in Table 9. These costs are then inflated and totaled to obtain the total annual operating costs for a landfill disposal system.

The total annual capital and operating costs (Section F) are determined by adding the totals for Sections A through E. Of the two landfill disposal systems examined, Alternative II is the lease cost alternative, having a total annual cost of $94,969.74 compared to $108,796.22 for Alternative I. It should be noted that considerable differences exist in land prices for the two alternatives, a factor which accounts for the major part of the total cost difference.

Determining Solid Waste Management System Budgets

Now that several alternatives for example collection, transfer and landfill disposal systems have been examined, it is possible to perform some comparisons of the total annual capital and operating costs for these alternative solid waste management systems. By utilizing Form 4, comparisons are made of three possible combinations of systems, to be identified as Alternatives A through C. Alternative A involves collection

Alternative I and landfill Alternative I and has an annual capital and operating cost of $265,862.50. Alternative B combines Collection Alternative II, Transfer Alternative II and Landfill Alternative II at an annual capital and operating cost of $253,777.22. The least cost alternative is C, comprised of Collection Alternative II, Transfer Alternative I and Disposal Alternative II.

Many other combinations could be evaluated within this same framework. For example, varying landfill alternatives could be examined in a complete system by altering collection alternatives to reflect differing distances to the landfill site. One important thing to be aware of is that some component costs of alternative collection and landfill systems will change as transfer systems are added or deleted or as mileage for vehicle travel changes.

Form 4 also allows the alternatives of private contracting of the collection, transfer and/or landfill systems to be considered. These costs may be incorporated easily into the form by replacing the collection alternative cost, for instance, with the cost of a contract for private collection. Use of a transfer station as a final disposal method can also be examined by adding a tipping charge for transfer disposal to some landfill not owned by the community.

Determining Annual Revenues for Solid Waste Management Systems

In order to fully evaluate the economic feasibilities of alternative solid waste management systems, revenues must be considered as well as costs. Annual revenues for alternative solid waste management systems can be estimated using Form 5. Annual revenues from residential collections can be estimated by multiplying the number of residential users served by a system times the monthly charge paid by each such user, then multiplying this product times 12. Annual revenues from normal commercial collections can be estimated in a similar manner. These two types of annual revenues can be summed with any expected system revenues from other sources to calculate estimated total annual system revenues.

Form 6 can then be used to estimate annual net revenues (profits or losses) from alternative systems considered. These estimates of annual net revenues from alternative solid waste systems should be considered by decisionmakers along with information on other factors as they evaluate alternatives to serve their constituents. Other factors which should be considered include such noneconomic considerations as differences in expected quality of service from alternative systems, special equipment operations or maintenance problems associated with specific alternatives and special management problems associated with specific alternatives.

FEDERAL AND STATE REGULATIONS

In 1970, the 91st Congress enacted PL 91-512 which established guidelines for the proper disposal of solid waste. By the end of the year, most of the states had also enacted legislation which met or exceeded the standards set by PL 91-512. Rural communities were given until July 1, 1975 to comply with new federal and state regulations.

Each state has an agency which is responsible for the administration and enforcement of solid waste disposal regulations. In Oklahoma, this responsibility rests with the Oklahoma State Department of Health.

Specific federal and state regulations dealing with proper disposal of solid wastes are quite lengthy and somewhat technical. There are certain guidelines and procedures, however, which can be outlined in a rather general fashion in order to provide

Form 4—Total Annual Costs of the Selected Solid Waste Management System

System Component	Alternative	Cost	Alternative	Cost	Alternative	Cost
Collection Alternative	I	$157066.28	II	$116199.24	II	$116199.24
Private Contract Collection		$				
Transfer System Alternative		$	II	$42608.24	I	41165.68
Landfill Alternative	I	$108796.22	II	$94969.74	II	$94969.74
Tipping Charge for Transfer Disposal		$		$		$
Total Solid Waste Management System Costs	A	$	B	$	C	$

Form 5: Estimation of Annual Revenue for Solid Waste Management Systems by Alternative Rate Schedules

Rate Schedule A

1. 3000 residential users × $ 3.00 /month x 12 months = $ 108000.00
2. 180 commercial users × $ 5.00 /month x 12 months = $ 10800.00
3. $1350 monthly revenues, other sources x 12 months = $ 16200.00

Total annual revenue $135000.00

Rate Schedule B

1. 3000 residential users x $ 4.00 /month x 12 months = $ 144000.00
2. 180 commercial users x $ 7.50 /month x 12 months = $ 16200.00
3. $________ monthly revenues, other sources x 12 months = $ 21600.00

Total annual revenue $ 181800 00

Rate Schedule C

1. 3000 residential users x $ 5.00 /month x 12 months = $ 180000.00
2. 180 commercial users x $ 10.00 /month x 12 months = $ 21600.00
3. $ 1800 monthly revenues, other sources x 12 months = $ 27000.00

Total annual revenue $ 228600 00

Form 6—Estimation of Annual Net Revenues for Alternatives Solid Waste Management Systems

Summary	System A Rate Schedule A	System B Rate Schedule B	System C Rate Schedule C
A. Total Annual Revenues (Form 5)	$135000.00	$181800.00	$228600.00
B. Total Annual Costs (Form 4)	$265862.50	$253777.22	$252334.66
C. Annual Net Revenues (A-B)	$(130862.50)	$(71977.22)	$(23734.66)

initial information concerning solid waste disposal. These general guidelines, along with information concerning who to contact for further information and assistance are given in the following paragraphs.

One of the first criteria to be met in solid waste disposal is that of locating and acquiring a suitable site for disposal and obtaining a permit to operate the facility. Assistance in finding land of suitable physical structure to quality as a solid waste disposal site may be obtained from the Soil Conservation Service, U S Department of Agriculture (U.S.D.A.). The land must meet or surpass certain minimum structural, chemical and slope criteria and the site must be approved by the appropriate state agency.

State regulations in Oklahoma specify wastes which are allowable and wastes which are not allowable under conditions of landfill disposal. Specifications are made concerning the amount of initial, intermediate and final cover material (soil) necessary to meet the standards set forth by PL 91-512 and state laws. In addition, restrictions dealing with maintaining air and water quality; control of gases generated from disposed wastes; insect, vermin and rodent control; preservation of aesthetic value of the disposal area; safety of workers and citizens at the site; and reporting to appropriate state agencies on compliance with these restrictions, are laid out in detail in Oklahoma laws. For further details concerning acceptable solid waste disposal, rural leaders should refer to The Oklahoma Solid Waste Management Act of 1970.

Assistance in site selection, planning and appropriate operation of a solid waste disposal facility may be obtained from:

Oklahoma State Department of Health
Industrial and Solid Waste Division
NE 10th and Stonewall
Room 804
Oklahoma City, Oklahoma 73152

Assistance is also available through the local offices of the Soil Conservation Service and the Farmer's Home Administration, U.S.D.A. Local extension agents with the Oklahoma Cooperative Extension Service are also available to assist rural decision-makers in the planning and operation of their solid waste disposal facilities.

SUMMARY AND CONCLUSION

Simplified procedures to estimate local needs for solid waste service and to estimate costs and evaluate economic feasibilities of alternative solid waste management systems are presented in this report. General technical and economic information about solid waste collection, transfer and disposal systems is also presented herein. This information facilitates the application of the feasibility analysis procedures.

The information and procedures presented in this report can be used by local decisionmakers concerned with the provision of solid waste management service to constituents. This report should also be useful to state agency personnel, multicounty planning district personnel and Cooperative Extension Service personnel as they work to provide technical assistance to local decisionmakers.

Any persons who use this publication as the basis for evaluating solid waste management system alternatives should keep in mind that there are considerations important to the provision of solid waste management service other than the economic factors specified here. These considerations relate to quality of service and possible management and technical problems, and may not be fully accounted for in the economic analysis procedures presented herein.

Persons analyzing the economics of solid waste management alternatives should also remember that local information generally facilitates more realistic analyses than generalized national, state or regional information. Consequently, local information should be used whenever possible in performing the analyses described in this report.

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Appendix A—Average productivity of selected residential collection systems[1]

Type of collection vehicle	Crew size	Pickups per week	Pickups per route mile	Cubic yards per crew per hour
Sideloader:	1	1	39	8.26
Sideloader:	1	2	30	3.96
Rearloader:	2	1	51	8.79
Rearloader:	2	2	73	5.88
Rearloader:	3	1	39	10.83
Rearloader:	3	2	80	11.06

[1]Assumes 600 pounds per compacted yard in collection vehicle. Calculated from information in [9] and from unpublished data at Oklahoma State University. These systems collected residential solid waste at the curb or in alleys and used the task assignment for work performed.

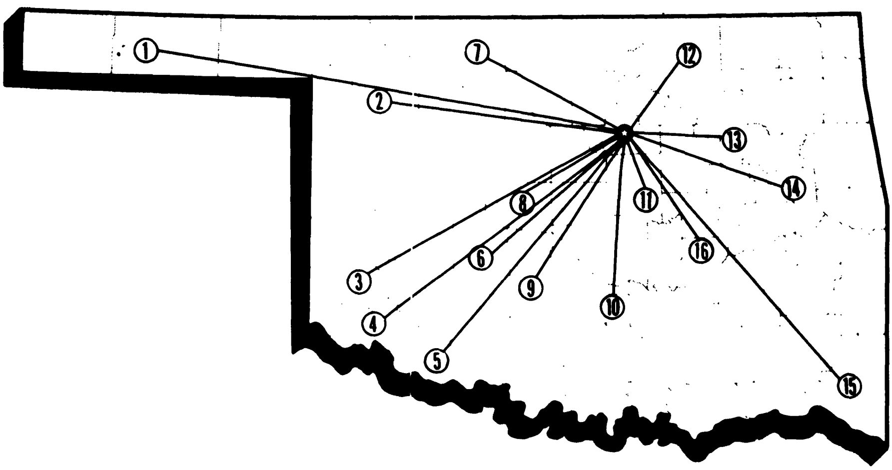
Appendix B—Amortization factors for various repayment periods and interest rates

Years for Repayment	Interest Rate 5.0	6.0	7.0	8.0	9.0	10.0
1	1.0500	1.0600	1.0700	1.0800	1.0900	1.1000
2	.5378	.5454	.5531	.5608	.5685	.5762
3	.3672	.3741	.3811	.3880	.3951	.4021
4	.2820	.2886	.2952	.3019	.3087	.3155
5	.2310	.2374	.2439	.2505	.2571	.2638
6	.1970	.2034	.2098	.2163	.229	.2296
7	.1728	.1791	.1856	.1921	.1987	.2054
8	.1547	.1610	.1675	.1740	.1807	.1874
9	.1407	.1470	.1535	.1601	.1668	.1736
10	.1295	.1359	.1424	.1490	.1558	.1627
15	.0963	.1030	.1098	.1168	.1241	.1305
20	.0802	.0872	.0944	.1019	.1095	.1175
25	.0710	.0782	.0858	.0937	.1018	.1102
30	.0651	.0726	.0806	.0888	.0973	.1061
35	.0611	.0690	.0772	.0858	.0946	.1037
40	.0583	.0665	.0750	.0839	.0930	.1023

OKLAHOMA

Agricultural Experiment Station

System Covers the State



Main Station — *Stillwater, Perkins and Lake Carl Blackwell*

1. **Panhandle Research Station — *Goodwell***
2. **Southern Great Plains Field Station — *Woodward***
3. **Sandyland Research Station — *Mangum***
4. **Irrigation Research Station — *Altus***
5. **Southwest Agronomy Research Station — *Tipton***
6. **Caddo Research Station — *Ft. Cobb***
7. **North Central Research Station — *Lahoma***
8. **Southwestern Livestock and Forage Research Station — *El Reno***
9. **South Central Research Station — *Chickasha***
10. **Agronomy Research Station — *Stratford***
11. **Pecan Research Station — *Sparks***
12. **Veterinary Research Station — *Pawhuska***
13. **Vegetable Research Station — *Bixby***
14. **Eastern Research Station — *Haskell***
15. **Kiamichi Field Station — *Idabel***
16. **Sarkeys Research and Demonstration Project — *Lamar***