IMPROVING RURAL SOLID WASTE MANAGEMENT PRACTICES

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FOREWORD

This report surveys what has been done and can be done to raise the quality of solid waste management in rural America through existing technology. The aspects covered include planning for solid waste management; types of collection, processing, and disposal methods; means of financing systems; and citizen support. Although the priority in the report deals with handling wastes from rural residences, any methods discussed can be incorporated into handling commercial, industrial, or institutional wastes in rural counties and communities. Two problem wastes--agricultural wastes and abandoned vehicles--are not covered. Sources providing more detailed information on many of the topics discussed are included in the bibliography.

We hope that this report will guide rural governments and concerned citizens in exploring and implementing acceptable, workable solutions to solid waste problems in the areas where poor practices still persist.

--Arsen J. Darnay
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ACKNOWLEDGMENT

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The line drawings of equipment prepared by Newell J. Mastin included in this report deserve particular commendation.

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THE RURAL PROBLEM...

Until recently, residential solid wastes were seldom considered a problem in most rural areas. Rural residents burned much of their rubbish, fed garbage to the farm animals, and dumped or buried other types of solid waste on remote sections of their land. If the rural resident was reluctant to deface his own property, an abundance of neighboring ravines, creekbeds, or roadsides provided convenient disposal sites. Once an easily accessible dump site emerged, other people in the area would frequent the location and within a short time a fair-sized open dump would be in operation. The consequence of such disposal practices today is a rural America pockmarked with more than 25,000 active promiscuous dumps.

In addition, more than 10,000 authorized disposal sites have been developed to serve both commercial collectors and private householders. The vast majority of these are, in actuality, dumps. Open burning was, and still is, a common method of volume reduction at these sites.

In small communities the dump often has been a popular gathering place for the townspeople. Witness one individual's description of a community dump:

> The dump serves not only as a disposal site for the public's garbage, but also as a social gathering place for people of all ages. The young kids seem to enjoy driving back and forth over the narrow suspension bridge, and the dump makes a convenient turning-around place. They also like to gather there to talk, drink beer, and shoot crows and squirrels--that seems to be good sport in that town. Some of the older people seem to like these activities too;...quite often it seems that while one person is dumping, a friend will pass by on the roadway and stop to talk for a while. The dump's location makes this social gathering place possible; it's just slightly

> out of town and there's a big wide spot in the road where several cars can pull over at one time.[1]

This social relationship between a dump and its tributary population is not necessarily typical of all rural areas. Where such a relationship does exist, however, citizen support for improved solid waste practices is more difficult to achieve. Fortunately, with more stringent National, State, and local legislation, together with increased land values and a new environmental awareness, people are beginning to demand changes in the old practices. User comments about their dumps such as "this has always been the dump"; "it's a fine dump"; "good the way it is" are changing to complaints such as "it's an eyesore"; "remove off road"; "it's a bad mess--been there too long--County is way behind the times."[2] Perhaps the changing attitudes of people can be best exemplified by one dump user who queried, "who'd complain about a dump?" and then added, "it is an eyesore though."

Indeed dumping does create an eyesore in the rural areas of our country. The more than 35,000 active sites also mean rodent infestation; vector generation; health, fire, and safety hazards; air and water pollution, and decreased land values. In addition to these sites, numerous, though uncounted, abandoned dumps are waiting to be cleaned up.

Even with the new awareness of environmental problems pervading the Nation, the enthusiasm and the improvements being initiated in urban areas have not, for the most part, extended to the pollution problems in rural America. A comparison of statistics from the 1968 National survey substantiate this fact all too vividly.[3]

Forty-two percent of the individuals in rural areas, versus 3 percent in urban areas, have no household collection by either public or private sources. Based on population, 48 percent of the rural communities exercise no jurisdiction over collection; 39 percent exercise no jurisdiction over disposal practices. Comparative figures for urban areas are 5 percent and 22 percent, respectively. According to the

survey, for collection and disposal of wastes, urban communities budget (per resident) four times the funds allocated by rural communities. The survey further showed that the overall number of active promiscuous dumps within a rural community's boundaries is 11 times greater than that for an equivalent population in an urban area—rural areas average slightly more than one active promiscuous dump for every 2,000 residents. Some of the wastes dumped in the rural areas probably are generated in the urban areas.

Why are solid waste management practices in rural areas a seriously neglected problem? Possible reasons include the following:

1. Citizens fail to recognize the need for improvements. Their attitudes range from indifference to outright resistance to change. The user comments quoted previously illustrate this range of opinions.

2. Adequate or equitable financing for improved practices is difficult to obtain. Average family incomes and governmental tax bases often are low; sparse population results in a correspondingly higher per capita cost for adequate service; and, the lack of complete accounting data on solid waste expenditures precludes the determination of total existing costs.

3. Legislation and ordinances necessary to authorize and enforce good practices are either so badly fragmented, unenforceable, or nonexistent that operational standards for most rural solid waste management practices are inadequate.

4. Authority for solid waste handling is fragmented among many governmental entities and agencies. This fragmentation is compounded by the lack of cooperation among the municipalities, counties, and regions, and among different governmental agencies.

5. Acceptable disposal operations to serve an area do not exist. Rather, disposal is often at numerous, scattered sites that cannot be acceptably operated.

6. The number of personnel properly trained to plan, implement, or operate a satisfactory solid waste system is not adequate.

7. Solid waste collection systems are not available to transfer waste to an acceptable disposal site.

8. Information on sources, types, and volumes of waste being generated in a particular area is not available.

9. Physical constraints such as terrain and road and bridge conditions can limit collection equipment usage and disposal site selection.

PLANNING AND ORGANIZING SOLID WASTE MANAGEMENT SYSTEMS

Planning is the initial step in any improved solid waste system. Planning poses such basic questions as: What do we have now and how well does it work? What do we need? What is the best way to achieve our goals?

For many rural localities an informal planning process—where one or a few individuals develop a workable plan to propose to the governing authority—may be sufficient. In other areas it may be necessary to designate a certain agency to develop a formal solid waste plan. A county road department, health department, public works department, or the county commissioners themselves may be assigned the task. Or a special board or ad hoc committee may be set up to develop a plan. This committee may comprise volunteer members from the communities to be included in the plan, as well as public officials and members of private industry.

Whatever the institutional framework, specialized assistance from private consulting firms and professional planners is sometimes obtained. Members of the planning organization also sometimes specialize or assign different subgroups with the responsibility for studying specific tasks such as data collection, legislation, technical practices, finance mechanisms, and public information.

One of the first decisions in developing a rural solid waste plan is the geographical area to be included. The most economical systems probably should ignore political boundaries to regionalize the solid waste system and minimize per capita costs. Realistically, however, the boundaries of a region often coincide with the jurisdictional boundaries of the governing agencies; solid waste planning for a single county is most common.

When a plan is being designed for a single county, the county's governing agency should assume responsibility for implementation. In multijurisdictional regions, special districts, authorities, or private nonprofit corporations might

be established as functional organizations, depending upon the State's enabling legislation. The degree of actual participation by the governing bodies can vary considerably. For instance, many incorporated communities within an area often will participate in developing a regional plan wherein the communities maintain autonomous collection systems, while the entire region is served by a central disposal site. Another alternative would be a centralized public or private agency to provide both collection and disposal services for incorporated and unincorporated areas.

No matter who does the actual planning, whether a single individual or a formal planning group, these tasks must be considered:

- Determine objectives.
- Evaluate existing conditions and practices.
- Evaluate alternatives for improved practices.
- Recommend preferred systems.
- Implement the system.

Determining Objectives

The planner's first responsibility is to decide what is to be accomplished. Possible objectives include reducing costs of present systems, providing a better level of services, conforming with State or Federal legislation, or simply "closing dumps." Initially, the actual solid waste management needs of the planning area, or the potential objectives, may be only vaguely conceptualized.

Evaluating Existing Conditions and Practices

To determine what is occurring, whether changes are actually needed, and, if so, specifically what these changes are, an inventory of current practices can be valuable. It answers the question "What do we have now?" and also provides a data base for comparing solid waste management alternatives. Surveys of public opinions are occasionally used

during this planning stage to ascertain what the citizens consider their needs to be. The following checklist is a useful guide to additional information beneficial to planning.[4]

- Determine the amount, character, and sources of solid wastes, including special solid wastes such as abandoned motor vehicles, diseased trees, water and waste treatment sludge, dead animals, and hazardous industrial and chemical wastes. Identify the proportions of wastes coming from residential, commercial, industrial, and agricultural areas.
- Determine the existing solid wastes management service areas, seasonal variations, and other local peculiarities of solid wastes generation.
- Determine the quality of storage practices from all solid wastes sources and identify practices that need improvement.
- Identify and determine the capacity, extent of service, quality, and other attributes of all collection systems (public, private, and individual).
- Determine the extent, acceptability, number, and type of on-site disposal and reduction methods, including at least residential backyard burning, other open burning, on-site incineration, and garbage grinding.
- Identify all disposal, reclamation, reduction, and transfer sites and facilities. Determine the remaining life, cost, and acceptability of these facilities, both public and private.
- Account by weight for all solid wastes generated, transported, and disposed within the study area and for the movement of solid wastes into and out of the area.
- Identify legal rules, regulations, ordinances, administrative structures, and other local conditions that affect solid wastes management systems.

- Determine local political, economic, and social factors affecting solid wastes management.
- Describe and assess the existing solid wastes management systems and summarize the existing problem areas.
- Project future solid wastes management needs for the study area. For this projection, collect data on such items as population projections, future land use, zoning, industrial growth, recreation development, agricultural needs, and development of adjacent urban areas.

Evaluating Alternatives for Improved Practices

If, after existing practices in the area have been studied, improvements are needed, the next task is to decide what alternatives are available. In deciding among alternatives, the different elements of a system—storage, collection, transportation, processing, disposal, financing—are all interrelated and a change in one can affect the others. The location and number of disposal sites, for example, affect the costs of different collection methods which in turn affect the possible methods of financing.[5] The economic and technical feasibility, the political acceptability of the different alternatives, and the alternative's capacity to accommodate future needs are the major determining factors in selecting an alternative.

Recommending Preferred Systems

Once the planner decides upon a solid waste program to meet the needs of the region, both the governmental agencies involved and the citizens involved must approve the plan. Agency approval is needed to make the plan a legal reality; citizen approval, to make the plan a physical reality. Without citizen acceptance, lasting improvements of solid waste management practices are impossible to achieve.

Implementing the System

Problems to resolve when implementing a new solid waste management system include:

- Determining whether additional State or local legislation is needed.
- Deciding who will be responsible for regulating the new system.
- Deciding whether the different elements of the system will be publicly or privately operated.
- Choosing appropriate financing mechanisms.
- Informing the general public of the new program.
- Reviewing and updating the system.

If legislative authority does not exist or is inadequate, new State, regional, or local legislation may be necessary to permit implementation. A plan for a multicounty solid waste authority, for example, dictates that counties are legally empowered to form joint authorities to handle solid waste. Many plans also recognize a need to pass local ordinances which set minimum operational standards for solid waste practices where no adequate standards exist.

Regardless of who operates the solid waste system, some public authority must be responsible for regulating and maintaining adequate practices. This agency's responsibility can vary from licensing private contractors to actually operating the entire solid waste system for an area. The governing officials who approved the plan may delegate this responsibility to an existing agency, such as a county health department or road department, or a special organization may be created specifically to regulate the solid waste management function.

In the past, private operators have provided the majority of the available collection services for rural areas. At least one half of these services have been relatively unsupervised by any public agency. As a result, system inadequacies exist, such as competitors with overlapping routes, inadequate equipment,

varying qualities of services, and no service available to the more sparsely populated regions. A number of local authorities now are trying to extend solid waste service to more residents by franchising or licensing private operators to serve specific regions. Other local officials are operating the services for their jurisdictions as a public agency. A third organizational alternative is to develop a private nonprofit organization to provide services. A combination of efforts also frequently occurs where, for instance, private contractors collect the waste and dispose of it in a publicly-operated landfill. Using a public agency for operating a solid waste system has certain advantages: (1) efficient public operation should be less expensive than private operation because there is no profit factor; (2) levels of service can be more easily adjusted to community needs; and (3) operating procedures can be more closely regulated.

Utilizing the private sector for operation of a solid waste system can be desirable if:

- Well equipped private operators are already working in the area or will come to the area to provide the needed services.
- The public authority responsible for the service does not have sufficient manpower or equipment to operate an adequate solid waste system. Some counties, for instance, do not have road departments and use State road services.
- Capital financing for a public system is difficult to achieve.
- Local politics impede public operations.
- Public operation is highly inefficient.

Once the agency responsible for supervision is chosen and the work effort is assigned to the public and/or private sector, the next question to be resolved is that of financing the system. Even assigning the entire work effort to the private sector does not eliminate this question.

Should the private operator charge the governmental authority or the individual directly? If the public authority pays the private operator or operates the system itself, should the funds come from the general tax fund, from special tax levies, or from a user charge paid by the individuals? If a user charge is levied by either a publicly or privately operated system, should it be a flat rate or a varied rate scale? Should the capital required to initiate the system come from private sources, general obligation bonds, or revenue bonds?

The final task in planning a new solid waste system is that of assuring citizen support. If a public education program has been adequately pursued during the planning stage, the public will have had input into the planning decisions. During actual implementation, residents must be thoroughly educated to changes which directly affect them to secure their cooperation.

ELEMENTS OF SOLID WASTE MANAGEMENT SYSTEMS

Solid waste management systems have five basic operational elements: storage, collection, transportation, processing, and disposal.

Storage

Storage is concerned with handling solid waste at the source of generation—the residence, commercial establishment, industry, or institution. Rural storage facilities presently cover the spectrum from 209-l (55-gal) burn barrels, old wash tubs, and wooden boxes to standard galvanized cans, plastic bags, and mechanically-emptied bulk containers. Studies indicate that poor facilities predominate.[6-8] Enforcement regulations governing on-site storage are available for approximately 35 percent of the households and commercial establishments in rural areas. This is not surprising when one considers that 42 percent of the rural households and 38 percent of the commercial establishments have no collection services.

The sparsity of adequate on-site storage facilities is a consequence of both public apathy and lenient regulatory enforcement by governmental agencies. Considering the public health and safety hazards posed by poor storage practices, and the increased handling required where collection is provided, proper storage obviously is a major determinant in an adequate solid waste management system. It makes little sense to close community or promiscuous dumps in an area, if households and businesses are allowed to maintain mini-dumps in their backyards.

The governing agency of an area can help improve storage practices in two ways: (1) by instituting a good public information program to generate positive citizen action; and (2) by developing a solid waste ordinance which incorporates strong enforcement of adequate storage practices.

Collection and Transportation

Active promiscuous dumps are visual evidence that many unincorporated areas have inadequate or no collection systems. Prevailing practices include:

- Resident responsibility for hauling and disposing of his own waste.
- Private collectors using pickup or dump trucks to collect small routes.
- Private or public collectors using modern compaction vehicles.
- Combinations of resident responsibility and private or public collection mechanisms.

Presently, the first two procedures appear to predominate in rural areas, and both have proved inadequate. Increasing citizen awareness and improved legislation have fostered dramatic moves toward the latter two collection methods in many areas across the country. This impetus is expected to increase at an ever-expanding rate as still more areas recognize the need for solid waste management improvements and realize that solutions do exist. Figure 1 indicates who presently performs the rural collection service for various types of waste.

Collection practices which have proved successful in rural areas include: (1) house-to-house collection; (2) small containerized systems; (3) transfer stations; and (4) combinations of the above systems. Several criteria are used to evaluate different collection alternatives:

- Ability of the alternative to provide the level of services needed or desired.
- Initial capital costs of each alternative, including land acquisition, construction of facilities, equipment purchases, and site improvements.
- Annual operating and maintenance costs, including a sinking fund for replacement of equipment and disposal sites.

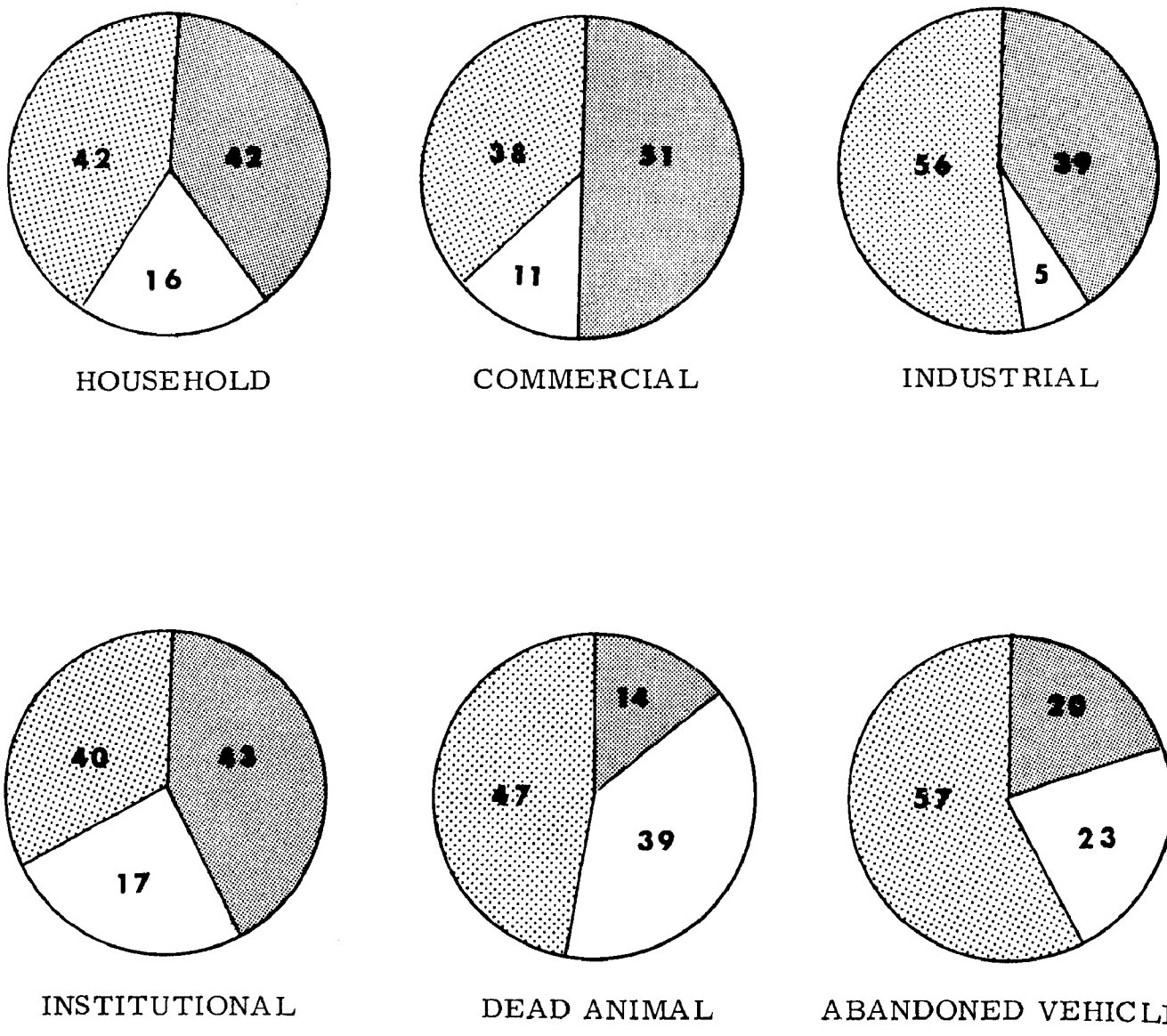


Figure 1. The percentages (by type of waste) of privately and publicly operated collection services in rural areas are compared with the percentage of individuals handling their own waste.

- Dynamic ability of the alternative to accommodate changes in population and waste generation rates. (This is especially important in areas with large seasonal fluctuations.)
- Public support which the collection alternative can generate.
- Public health, legal, safety, and aesthetic acceptability of the alternative.

House-to-House Collection. Where collection service is available in rural areas, house-to-house collection is most frequently used (Figure 2). Variations of this method often are

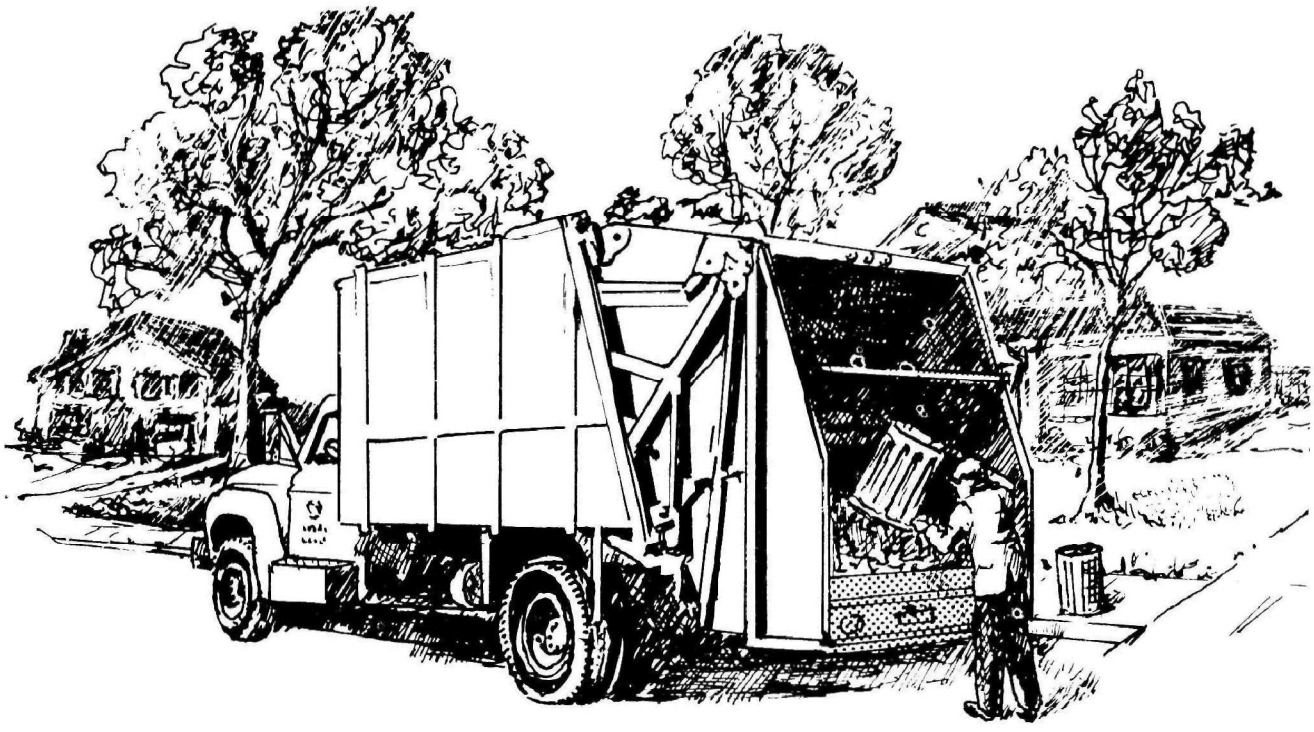


Figure 2. House-to-house service is the most common type where collection service is available.

labelled according to the location where the storage container is serviced, such as alley, backyard, or curb collection, or according to the procedures used such as set out-set back service. Since low population densities are a distinguishing factor of rural areas and costs are a major consideration, the most prevalent collection variation seems to be the least expensive form—usually curb service where the containers are placed alongside the road which the collection vehicle travels. The average frequency of collection is once weekly. A 121.6-l, or 32-gal. can is the maximum size container desirable; some areas require plastic or paper bags be used to permit faster collection.

In some areas of the country, roadside service is commonly referred to as "mailbox" collection. As the name implies, the residents are required to place their wastes next to their mailboxes. This system assumes that: (1) if a mail truck can travel the road, a collection vehicle can travel the same route; (2) over the years the post office has probably developed the most efficient routes for traveling the region; and (3) since all mailboxes on a rural route are required to be accessible to a driver and on the same side of the road, containers will only have to be picked up from one side of the road. For households that do not have mailboxes on the postal routes, the customer and collection agency must agree on a mutually acceptable collection site. Any house-to-house routes, such as "mailbox", require that collection days and times be predesignated so that residents know when to set out their waste. Because, in northern climates, scheduled collection can be difficult to maintain during the winter months, the householders must maintain a larger number of storage containers than would otherwise be needed.

One of the main arguments against rural house-to-house service is that a sparse population cannot economically support such a method. Some estimates of the minimum number of collections required per day to support the service range from 200 to 250. The tendency then is toward collection routes that serve small communities together with very remotely located households. For instance, where 300 community services might be collected on one day, the next day's route might handle under 100 isolated services. The critical population density necessary

to support the service will vary considerably for different areas and is determined by comparing the labor costs, equipment costs, and system's efficiency with the financial capabilities of the area.

Mandatory Collection. Some States empower local authorities to require mandatory collection throughout their jurisdiction. The governing agencies must provide adequate services and residents must accept and pay for the service. Exceptions are allowed where the householder can prove that he is privately disposing of his waste in a satisfactory manner—usually regularly burying the waste on his property in a location approved by the governing agency. There are three requisites for instituting mandatory collection:

- State enabling legislation must exist to allow local governing agencies to enact ordinances requiring mandatory collection.
- An economically feasible system must be available to provide collection service to all residents.
- The governing agencies must have the capability, or private collectors must be available, to operate the system.

A mandatory house-to-house collection system for an entire area can offer several advantages.

- It collects the largest percentage of generated household waste of any system.
- It permits a high level of scheduled service to the rural resident and business establishments.
- It establishes uniform fees for rural areas.
- It provides a system by which user charges can be collected.
- It allows for development of a reliable budget to pay operating and capital expenses.
- A centralized sanitary landfill can be used which incorporates economies of scale.

Disadvantages of the system include:

- Costs are usually higher than those for container systems or transfer stations.
- Homeowners must cooperate in setting out containers and following scheduled service.
- Litter problems may occur if bags are torn or if containers are upset along the road.
- Travel may be difficult for collection vehicles when servicing very isolated areas or when bad weather conditions exist.
- Only limited types and amounts of bulky wastes can be collected without a special collection crew.

Voluntary Collection. Although mandatory collection is desirable, legal, political, or economic reasons preclude its use in most rural areas. Usually house-to-house collection is a voluntary service. The advantages and disadvantages are similar to those for the mandatory routes with one major difference. The percentage of generated waste collected will drop considerably from the theoretical 100 percent collection of mandatory system and costs per capita served will correspondingly rise. One area, after a year of offering countywide voluntary collection to the rural population, has a 30 percent usage rate. Other areas expect a voluntary house-to-house system to eventually collect up to 60-85 percent of the generated waste. A second difference is the fact that voluntary systems do not have the guaranteed revenue base of mandatory collection. In voluntary systems, a residential user charge based on the actual amount and type of waste collected is desirable. Otherwise one homeowner may join a voluntary service at the fixed rate and several neighbors may place their waste with the paying customer for free disposal.

Setting the user fee by the amount of waste collected can have negative effects. People may be tempted to illegally burn or promiscuously dump excess waste not covered by the basic charge.

Typical charges for either mandatory or voluntary once-a-week collection service range from $2 to $4 per month.

Collection Equipment. Where adequate house-to-house systems are operating, side-loading and rear-loading compactors are the most commonly used vehicles. Load capacities for either vehicle typically range from 7.6 to 22.9 m^3, or 10 to 30 yd^3. Such factors as type of terrain, road and bridge conditions, limitations of gross vehicle or axle weights, haul distances, and amounts of waste to be collected determine vehicle size.

In purchasing a collection vehicle, the following questions should be considered.[9]

- What routine maintenance is required?
- How often do major parts have to be repaired or replaced and at what cost?
- Where is the nearest facility for having major repairs made?
- Where can parts be obtained and what kind of delivery schedule can be expected?
- How complex is normal operation of the vehicle?
- What type of operator training program is needed and who will provide training and at what cost?
- What are expected operational and maintenance costs?
- What kind of trade-in value can be expected?
- Will obtaining standby equipment present a problem?

Small Containerized Systems. Where house-to-house collection is not economically or politically feasible, two other methods successfully being used are small containerized

systems and transfer stations. Although both alternatives are often termed transfer stations, here they are differentiated by size and method of handling. The small containers (.8 to 8 m^3, or 1 to 10 yd^3) are emptied into a collection vehicle; the transfer station containers (11.5 to 38.2 m^3, or 15 to 50 yd^3) or trailers (up to 57.3 m^3 or 75 yd^3) are hauled directly from the transfer site to the disposal area to be emptied.

The first nationally publicized rural small containerized system was a project supported by the Environmental Protection Agency in Chilton County, Alabama. In the 4 years since the project's inception, the small container alternative has been implemented in at least 150 rural counties in 14 other States. The advantages of a small container system are that:

- A collection system is provided where no other method has existed.
- Promiscuous dumps are reduced and community dumps are eliminated.
- Public acceptability is usually relatively high.
- There is considerable operational flexibility to adjust to population and waste generation changes by changing the number of containers and the site locations.
- Costs for developing individual container sites are relatively low.
- A centralized sanitary landfill can be used which incorporates economies of scale.
- The system is well adapted to servicing commercial stops.
- It is well adapted to serving recreational areas.
- Multiple container site locations provide close proximity between containers and users.

Disadvantages of small container systems are that:

- Initial capital equipment cost is high.
- Unsanitary conditions are created at sites unless they are properly maintained.
- Containers are often abused.
- Financing with user charges cannot be utilized except for commercial services.
- User cooperation is required to carry waste to container sites.
- A substantial number of small accessible sites must be available for containers.
- Period of time waste is stored at residence cannot be controlled.
- Existing private house-to-house collection in area of container sites could be decreased.
- Residents with no means of transportation have difficulty utilizing the containers.
- Containers located near municipalities, though intended to serve only rural areas, may be used by town residents if inadequate city service exists.
- Only limited types and amounts of bulky wastes can be collected without a special collection crew.

Not more than 75 percent of the rural residents will probably use the containers for several reasons—some individuals have no means for transporting their waste; others prefer dumping on their own property; and still others continue to promiscuously dump even after the improved alternative is implemented. Commercial establishments, small industries, and institutions desiring service on their premises, are either provided containers by the operating agency or required to purchase and maintain their own containers.

Types of Containerized Systems. Three basic types of small containerized systems are being used in rural areas—front-,

rear-, and side-loading (Figures 3, 4, 5). Each has certain specific characteristics itemized below:

Front-Loading Containerized System

- Vehicle crew size: one driver
- Typical container servicing time: 1 to 2 min
- Container site development: requires pull-off area from main road; gravel or paved surface is common
- Container sizes: .8 to 8 m^3, or 1 to 10 yd^3
- Typical packer body sizes: 15.3 to 27.5 m^3, or 20 to 36 yd^3
- Site maintenance: usually a special crew cleans sites periodically
- Type of wastes collected: any wastes which will fit inside container
- Vehicle flexibility: can service only front-loading containers; rarely used for house-to-house collection

Rear-Loading Containerized System

- Vehicle crew size: 2 or 3 persons
- Typical container servicing time (for 4.6-m^3, or 6-yd^3, container): 2 to 6 min, including some litter cleanup
- Container site development: requires area for truck to back up to container; gravel or paved surface is common
- Container sizes: .8 to 8 m^3, or 1 to 10 yd^3
- Typical packer body sizes: 12.2 to 22.9 m^3, or 16 to 30 yd^3
- Site maintenance: collection crew cleans up as containers are emptied

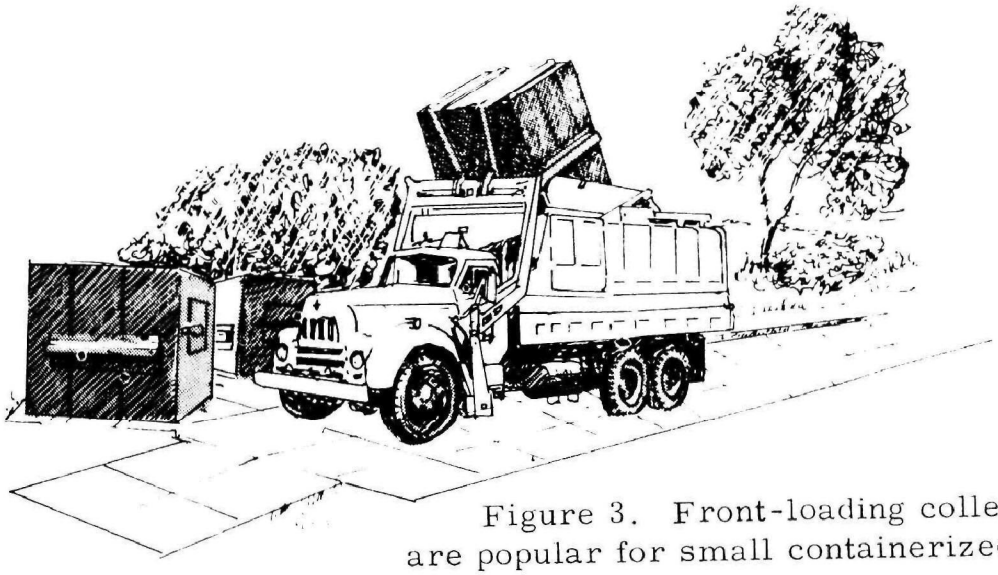


Figure 3. Front-loading collection vehicles are popular for small containerized systems.

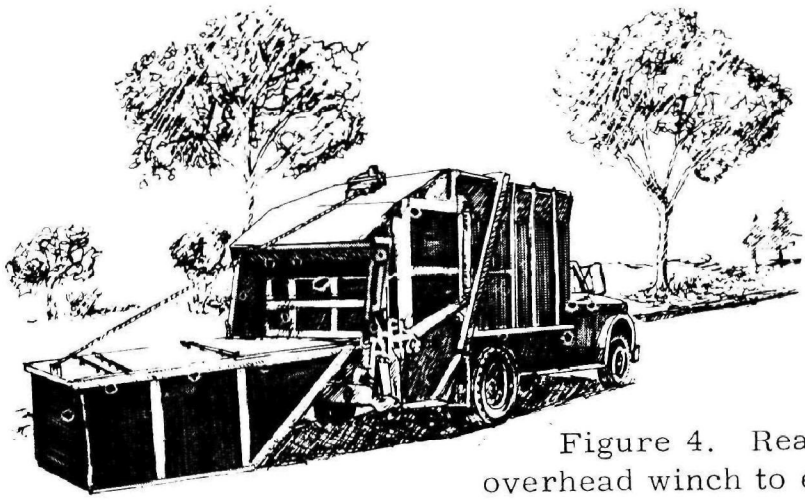


Figure 4. Rear-loading packers use an overhead winch to empty containers.

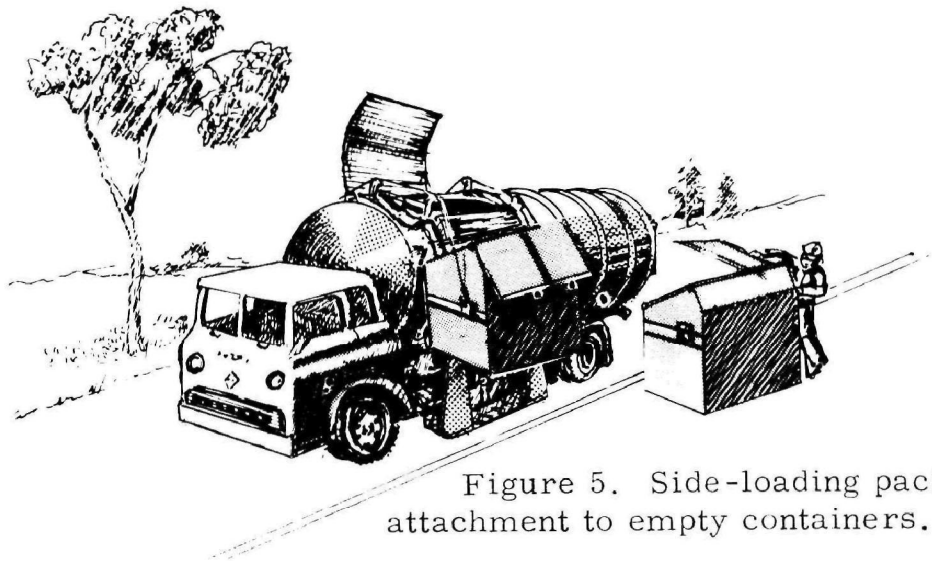


Figure 5. Side-loading packers use a special attachment to empty containers.

- Type of wastes collected: any wastes that will fit into rear-loading hopper
- Vehicle flexibility: can service combination of rear-loading containers and house-to-house collection

Side-Loading Containerized System

- Vehicle crew size: normally 2 persons
- Typical container servicing time: 1 to 3 min (including some litter cleanup)
- Container site development: if users and collection vehicle can stop safely along road, site needs to be only slightly larger than containers; otherwise pull-off area is common with gravel or paved surface
- Container sizes: .8-3.1 m^3, or 1 to 4 yd^3
- Typical packer body sizes: 9.9-24.5 m^3, or 13 to 32 yd^3
- Site maintenance: collection crews clean up as containers are emptied
- Types of wastes collected: any wastes that will fit in containers, plus any bulky wastes that can be placed in the side or rear doors of collection vehicle
- Vehicle flexibility: can service combination of side-loading containers and house-to-house collection

Because it requires the minimum crew size and has the fastest servicing time, the front-loading containerized system is a very popular type for rural areas. The flexibility of combining house-to-house service with containerized collection, however, affords the other two methods a strong advantage. The following design criteria are applicable to any of the three types.

Locating Container Sites. User convenience and suitable land availability dictate container locations. User convenience requires establishing a maximum driving distance to a container, ideally 1 or 2 miles. Unfortunately, economics may require this maximum to be 5 or 6 miles. An alternative would be to establish a maximum driving time to a container for any user. This is more difficult because driving times depend on local terrain, vehicle type, and individual driving characteristics. A one-way driving time of 8 to 10 minutes is a reasonable objective.

The procedure for establishing preliminary container locations is as follows:

1. Identify the collection system area using county highway maps, topographic maps, air photos, on-site surveys by automobile or other means. If possible, break population densities down into detailed locations of individual residences, schools, businesses, and any other sources of waste generation.
2. Select a maximum distance or maximum driving time criterion to be used for the collection system.
3. Identify groups of potential users, based on the criteria selected in item 2, to be served by separate container locations (i.e., all users are within X miles or X minutes of a container).

Ideally, each container storage unit should be located as close as practicable to the center of the group of houses it will serve. This is not always possible because a suitable container site may not be available at this location. Attempts should be made, however, to have the individual transfer his waste no further than the distance he previously had to travel for disposal. Locating containers close to old dump sites takes advantage of the user's operational habits; but the container should be located at least a short distance away for two reasons:

1. Too frequently, users revert to previous practices and tend to use the dump rather than the containers when they are located next to each other.

2. Dump sites were originally located using the "out of sight, out of mind" concept and, as a result, are often situated in remote areas. Container sites, conversely, should be located to afford maximum accessibility and convenience to the user.

In addition to areas near old dump sites, other container locations which should be considered include:

- Schools
- Service stations
- Grocery stores and other commercial establishments
- Churches
- Community centers
- Parks and recreation sites
- Litter-barrel sites
- Road intersections

Containers are frequently located on the shoulders of roads and highways, but they must be placed where they do not cause hazardous conditions for people depositing wastes or for the driving public. The appropriate State agency (usually the Department of Highways) must approve any container location on rights-of-way under their jurisdiction. Many private property owners will allow free usage of their land in exchange for the convenience of a nearby container.

Container Site Requirements. The type of containerized system used determines container location layouts. Side-loading systems require that the collection vehicle be driven alongside the containers; rear-loading systems require maneuvering space to back up to the containers; front-loading systems require that the vehicle drive forward to the containers. (See Figures 3, 4, and 5.) Any container site must have a sufficiently large area to permit waste unloading, container servicing, and vehicle maneuverability without causing hazardous traffic conditions. The

area required for the sites varies considerably with type of container used and the roads along which the containers are placed. In a side-loading system where the users or collection vehicle do not have to pull off the road, the site needs to be just large enough for placement of the containers (approximately 9 m^2, or 100 ft^2 for one side-loading container). Most sites for all three systems will require a pull-off and turn-around area. A minimum area of 360 m^2 (4000 ft^2) with a 9-m (30-ft) clear distance between the container and the roadway is usually adequate. (See diagram in Figure 6.)

(SITE NO.)

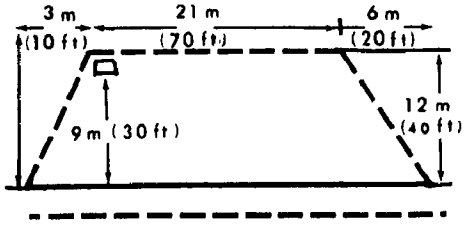
In _____ County on Highway _____ Headed _____ Toward _____

_____ km(mi) _____ of _____

_____ km(mi) _____ of Container Site No. _____ Route No. _____

Sight Distance: _____ m(ft) Ahead; _____ m(ft) Back.

SITE REQUIRES: ( ) No work – can be used as is; ( ) Gravel; ( ) Fill;



( ) Cut; ( ) Grading; ( ) Drainage pipe; ( ) Other.

No. of Containers _____ Size of Containers _____

REMARKS: _____

_____

_____

_____

Figure 6. Description form for a container site is useful in comparing potential sites. (From Parrott, Ely, and Hunt, Consulting Engineers, Lexington, Kentucky.)

The container site must be usable under all weather conditions and should be adequately graded for drainage. To avoid muddy conditions and erosion, the site may need to be surfaced with gravel, asphalt, or concrete. Initially, only minimum container site preparation should be performed. If, after operations begin, the site is not used effectively, it may be necessary to move the container. The final preparation cost can range from zero to more than $200 per site depending upon the amount of development needed to allow adequate site usage.

A form (Figure 6) is useful for recording descriptions of potential locations and needed site preparation. Site preparation may require special equipment and labor which are not readily available to the collection agency. Often county road crews or private contractors are utilized. Furthermore, an arrangement should be considered whereby the State highway Department provides equipment, materials, and labor necessary to prepare and maintain container sites on their rights-of-way in lieu of operating and maintaining a highway litter-barrel collection system.

Selecting Collection Equipment. The size of a containerized system vehicle is subject to the same selection factors as those used for house-to-house collection equipment--type of terrain, road and bridge conditions, limitations of gross vehicle or axle weights, haul distances, and amounts of waste to be collected. Once the sizes of the collection vehicles are decided, the approximate number of containers that these vehicles can collect in a single trip can be determined using the following formula:

$$\frac{\text{truck capacity } m^3\ (yd^3)}{\text{container capacity } m^3\ (yd^3)} \times \text{truck compaction ratio} \times \frac{100}{\text{fullness of container}} = \text{No. containers collected}$$

As an example: How many 4.6-m^3 (6-yd^3) containers can be collected by a 23-m^3 (30-yd^3) collection vehicle without returning to the disposal site? Assume that the containers are normally 70 percent full and that the loader has a compaction ratio of 4.5 to 1:

$$\frac{23\ m^3\ (30\ yd^3)}{4.6\ m^3\ (6\ yd^3)}\ X\ 4.5\ X\ \frac{100}{70}\ =\ 32\ containers$$

Determining the required container capacity at a given location is based upon: (1) the number of users of the site; (2) the quantity of waste generated by the users; and (3) the frequency of container collection (Figure 7).

WORKSHEET USED FOR SIZING CONTAINER UNITS

(1) Highway identification	(2) Collection point	(3) Number of waste sources	(4) Weight of waste (lb or kg)	(5) Volume of waste (m^3 or yd^3)		(6) Number & size of containers
				Uncompacted	Compacted	

Column

(1) Identify highway name or number
(2) Identify collection point by letter or number
(3) Number of users served by container location
(4) Weight of waste handled at container location per collection
(5) Volume of waste handled at container location per collection
(6) Number and size of containers required to hold uncompacted volume at each location

Figure 7. A worksheet is useful for calculating container requirements. (From G. A. Ross. Rural Collection System Requirements. Frankfort, Division of Solid Waste Disposal, Kentucky State Department of Health, 1971. p. 21.)

The residential population served by container sites is estimated by multiplying the number of residences by an average occupancy rate. The average number of persons per household in a specific county is available from the U.S. Bureau of the Census. In addition to residences, businesses and other waste generators may use the site and have to be considered.

The most satisfactory method for gathering the data is to actually survey present amounts of waste being disposed of. Seasonal fluctuations and estimates of the waste being promiscuously dumped or burned should also be evaluated. Surveys and estimates of rural household waste generation range from .45 kg (1 lb)/capita/day to over .9 kg (2 lb)/capita/day. These surveys do not usually consider bulky wastes, agricultural wastes, or wastes from commercial, industrial, or institutional sources.

To estimate waste generation, if no other design data are available, an average of .15 m^3 (.20 yd^3)/family/week or .7 kg (1.5 lb)/capita/day for household waste can be used. The waste generated daily per person is multiplied by the number of people who will use the site and added to the volumes or weights of waste from other site-users, such as schools or small businesses. If weights are used, they must be divided by the expected waste density to determine the volume generated. Typical loose densities for residential waste range from 74.1 to 118.5 kg/m^3 (125 to 200 lb/yd^3). Multiplying the daily volume by the number of days between collection, gives the required container volume.

Here is a typical example. Calculate the container volume required at a rural location which is serving 35 residential units with once-a-week collection. An average occupancy rate of 4.0 has been obtained from the Census; no other waste generators are expected to use this site. The waste density is expected to average 89 kg/m^3 (150 lb/yd^3).

Where:

waste generation rate = .7 kg (1.5 lb)/capita/day
(from survey or estimate)

weight of waste = 98 kg (210 lb)/day
[35 units x 4 people x .7 kg (1.5 lb)/capita/day]

volume of waste = 1.1 m^3 (1.4 yd^3)/day
[(98 kg/day ÷ 89 kg/m^3) or (210 lb/day ÷ 150 lb/yd^3)]

average weekly volume = 7.7 m^3 (9.8 yd^3)
[seven days x 1.1 m^3 (1.4 yd^3)]

Then,

required container volume = 8 m^3 (10 yd^3)

Possible container combinations that will satisfy the required container volume are:

three 3.1 m^3 (4 yd^3) side-loading containers
two 4.6 m^3 (6 yd^3) rear-loading containers
two 4.6 m^3 (6 yd^3) front-loading containers

Since some containers are not always filled to their rated capacity and since users do not adjust their waste disposal to the collection vehicle schedule, a sufficient excess storage capacity must be designed into a container system. Increasing the volume capability of a site to 120 to 125 percent of intended volume should be sufficient.

Occasionally this excess design capacity will be exceeded during peak load periods, such as after holiday weekends or during spring cleanups. If the peak load periods can be anticipated, increased collection frequencies or additional containers should be utilized.

In rural collection systems, the sizes of containers commonly used are:

- Side-loading: 2.3 and 3.1 m^3 (3 and 4 yd^3)
- Rear-loading: 3.1, 4.6, and 6.1 m^3 (4, 6, and 8 yd^3)
- Front-loading: 3.1, 4.6, and 6.1 m^3 (4, 6, and 8 yd^3)

In addition to the number of users and the waste generation used in the sample calculation, the frequency of container collection is a third factor affecting the required container storage capacity of a site. For instance, if collection had been twice, rather than once, a week, in the calculation, a single 4.6-m^3 (6-yd^3) container would have been sufficient. Collection frequency is governed by: (1) the demands of the users; (2) health and safety requirements; (3) the ability to provide the service; (4) State laws and regulations; and (5) local ordinances. Container service varies from daily to once a week; two or three times a week collection is common.

More frequent collection may be required during the fly season. Since residents store garbage at their houses for varying lengths of time before bringing it to a container, this lengthens the period during which the waste is available for fly propagation. Even with frequent collection, the containers must be maintained in a sanitary condition.

Collection Routes. After the containers have been located, collection routes should be established so that all containers are collected with a minimum of expenditure by the collection agency. A collection system may consist of a single route which is collected in one day or several routes which are collected over a period of days. Typically a proposed rural collection area is traversed by a complex system of roads and selection of the best possible routes from this road network is not always a simple task. It may be necessary to study numerous trial routes before the best arrangement is found (Figure 8).

The total collection time is used for comparing alternative routes and is directly related to the collection cost. Some costs, however, are not necessarily related to the total collection time. Travel on congested or hazardous roads increases the probability of vehicle accidents; use of roads requiring frequent stops or negotiation of steep grades can cause increased maintenance and

WORKSHEET USED TO ESTIMATE ROUTE COLLECTION TIMES

(1) Route	(2) Collection point	(3) Distance (km or mi)	(4) Avg speed (mi or km/hr)	(5) Travel time (min)	(6) No. of containers	(7) Compacted volume collected (m^3 or yd^3)	(8) Container collection time (min)	(9) Total collection time (min)

Column

(1) Identify route by letter or number
(2) Identify collection point by letter or number
(3) Distance between collection points
(4) Average speed traveled between collection points
(5) Column (3) ÷ Column (4) X 60
(6) Indicate number of containers at each collection point
(7) Compacted volume of waste collected at container site
(8) Time that collection vehicle is at the container site
(9) Column (5) + Column (8)

Figure 8. A worksheet is useful for estimating route collection times. (From G. A. Ross. Rural Collection System Requirements. Frankfort, Division of Solid Waste Disposal, Kentucky State Department of Health, 1971. p. 23.)

operation costs. Consequently, the shortest route may not be the most economical.

Analysis of the collection routes connecting the container sites requires the use of detailed highway maps which indicate distances and road types. If possible, the collection equipment should be road-tested to determine expected average travel speeds. By adding the total expected travel time to the on-site collection time, one can determine the total time on the collection routes. Approximate on-site collection times for the three systems are:

	min
Front-loading container	1-2
Rear-loading container (4.6 m^3, 6 yd^3)	2-6
Side-loading container	1-3

The route length is adjusted depending on the time required for collection and the quantity of waste collected. Depending on the size of the collection system, more than one route and/or collection vehicle may be required. The time-estimating procedure is repeated using alternative routes until a set of routes is found with a minimum total collection time for the entire system. More than one collection vehicle may be required to service the routes with the desired frequency, or working overtime hours or additional days may have to be considered.

Problems of Containerized Systems. Although small container systems are being successfully used in many areas of the country, planners of new containerized systems should be aware of certain drawbacks or problems involved with this alternative. The first and most obvious constraint involves handling bulky wastes.

Disposal of bulky goods—refrigerators, stoves, furniture—is a prominent solid waste problem for rural areas. At most present dump sites, numerous bulky items are thrown out with the rest of the family waste. It is a type of waste that has to be disposed of properly if a solid waste system is to provide complete service. The small containerized methods can deal with bulky wastes only to a limited extent.

Front-loading systems are designed to handle only bulky wastes that fit into the containers. A pickup or open-bed truck is sometimes used periodically to clean the sites and collect bulky items illegally placed alongside the containers. Rear-loading and side-loading vehicles can handle limited amounts of bulky wastes, but they too are primarily intended to handle normal residential wastes.

Overloading bins with bulky or special wastes, such as brush, yard wastes, fence or baling wire, tires, and demolition debris can be a major problem for small containerized collection systems. Potential solutions for handling these wastes include:

- Providing the user access to authorized disposal sites (sanitary landfills).
- Providing, upon request, and for an additional charge, a pickup service for bulky or special amounts of waste.
- Encouraging private haulers to provide a bulky or special waste pickup service.
- Having biannual, quarterly, or even monthly cleanup days when wastes can be set out at a predesignated location and time for special collection.
- Utilizing transfer stations in combination with a small containerized system to handle special or bulky wastes.

This same problem of how to handle bulky wastes also prevails in the house-to-house collection system, and any of the suggested solutions could also apply to that collection alternative as well as to the small container alternatives.

A variety of operational problems also can be encountered with small containerized systems.

1. Vandalism—Rural containers have been burned, shot at, turned over, and dynamited. Reasons

range from mischievousness to sheer dislike of the container system. Strong public support before system startup and prosecution of vandals are two means of alleviating the problem. In some areas portable hidden cameras have been recommended to identify and apprehend vandals. Locating sites near residences, businesses, and well-lighted areas is also advantageous.

2. Fires—Vandals who set intentional fires should be prosecuted. Unintentional fires are caused by placing "hot loads," such as hot ashes, into the containers. Publicizing the need for precaution in dumping burned waste or other incendiary materials can decrease unintentional fires. In addition to ruining the paint and warping the containers, there is always the danger that a hot load can be emptied into the collection vehicle and set an entire packer truck load on fire. Container sites should be designed so that, even if fires occur, danger of the fire spreading to the adjacent area is eliminated.

3. Misuse—Leaving waste beside or on top of near-empty containers indicates poor public support and a serious problem. Once waste is placed on the outside, other users often assume the container is filled and the site rapidly degenerates into a dump. Filling the containers with a few bulky wastes or setting wastes beside the container with no means of easy collection also results in improper dumping.

4. Over-utilization—Although this may appear desirable, in an underdesigned system overusage of the containers has the same practical effect as misuse. Waste is delivered faster than it is removed and dumps are started. This problem can easily occur in totally adequate systems during the initial startup. When a new collection

method begins in an area, especially if it has been well publicized, a much larger tonnage of waste is often deposited during the initial two weeks of the system than the tonnage which the system will eventually average for several reasons: (a) when people learn of the new collection system, they may save their waste in anticipation of the new program; (b) people come to see and use the system out of curiosity although they may not continue to use it; (c) those who might want to show the system is a failure will try to overload it. To handle this initial influx, collection may have to be more frequent at system start-ups.

5. Scavenging—In one incident, a woman stood up inside a container just as it was about to be emptied. Fortunately the compactor vehicle driver saw her and a major tragedy was avoided. Scavenging, a major problem of containerized systems, is both a dangerous practice and a contributor to litter, and there is no easy solution. Strictly enforced ordinances against salvaging and adequate citizen education can be of some value in reducing this problem.

6. Weather—A complaint in many areas is that, in the spring or fall, there is a mud problem at the site locations; in the summer there is a dust problem; and in the winter there is snow to contend with. The weight of snow can warp container lids, and sites must be snow plowed to allow access to both the user and the collection vehicle. Paving the sites can control the dust and mud problems.

7. Maintenance and Cleaning—The sites will always require some minor cleanup around the containers, picking up spillage and litter. The collectors in rear-loading and side-loading containerized systems usually clean up the sites when they empty the containers. Front-loading systems require

someone in a follow-up vehicle, usually a pickup, to periodically clean the sites. Most small containers are not regularly cleaned, but steam cleaning or washing, when it is periodically done, usually occurs at the container sites. Portable steam cleaners on a pickup or washwater tanks on a collection vehicle are often used. A container's life is largely a function of the handling and maintenance it has received. Burned containers which are not repaired and painted, can have useful lives of less than 3 years. Many well-maintained containers are over 11 years old and still in usable condition.

Transfer Stations. A third major collection alternative for rural areas is to locate large roll-on/roll-off containers, or transfer trailers for waste material, at centrally located sites. This transfer station concept has become very popular in urban communities in the last 10 years, and scaled-down versions are now starting to be used in more sparsely populated areas. Rural transfer stations differ significantly from their urban counterparts not only in size but also in purpose. An urban transfer station's major function is to provide shorter hauling distances for commercial vehicles; most rural stations serve as a central collection location for local residents who bring their wastes to the site. Although commercial collection vehicles may utilize rural transfer stations (especially those sites that provide compaction of the waste), the primary users of the sites are the local families that have no other collection service. Some advantages of transfer stations are:

- A collection system is provided where no other method has existed.
- Promiscuous dumps are reduced and community dumps are eliminated.
- Large fluctuations of generated waste can be handled.

- A collection mechanism is provided for almost all wastes including bulky wastes.
- Disposal fees and/or tax revenues can be used to finance the system.
- Compaction units can be used to increase density of transported waste.
- Limited processing, such as metal salvage, paper baling, and glass recovery, is possible.
- A centralized sanitary landfill can be used which incorporates economies of scale.

The disadvantages of transfer stations include:

- User cooperation is required to carry waste to transfer sites.
- Residents with no means of transportation have difficulty utilizing the sites.
- Unsanitary conditions are created at sites unless properly maintained.
- The average user has to travel longer distances than those required by small containerized systems.
- Site relocation is expensive because of high construction costs or lack of available land.
- Period of time waste is stored at residence cannot be controlled.
- Existing house-to-house collection in area near transfer site could be decreased.

Types of Transfer Stations. The two basic types are the direct dump system and the compaction transfer system. Each of these systems can be further subdivided into the following categories:[10]

Direct dump transfer systems

1. Gravity dumping from one vehicle to another with no compaction.
2. Gravity dumping from one vehicle to another followed by load leveling and compaction with a backhoe.
3. Compaction pit method—waste is unloaded into a storage pit or onto a floor area and crushed under crawler tractor treads before being pushed over a ledge into an open trailer below. Load leveling is usually performed with a backhoe.

Compaction transfer systems

1. Internal compactor system—waste is placed in the trailer through a door located on top and near the front. Waste may be dumped directly from the collection vehicle through the door or it may be pushed over a ledge and into the trailer by a front-end loader working from a storage area. The internal hydraulic compactor pushes the waste toward the rear of the trailer in cycles.
2. Stationary compactor system—waste is unloaded into compactor hopper and then pushed horizontally into transfer trailer or container.

Unlike most urban or commercial applications, many of the rural transfer stations use direct dumping into open top containers or transfer trailers with no type of compaction. Where a stationary compactor is used at a transfer station, a hopper is often built on top of the charging box to increase storage capacity (Figure 9). An option to bypass the compaction unit is desirable during emergencies; otherwise equipment breakdowns could require closing the transfer station.

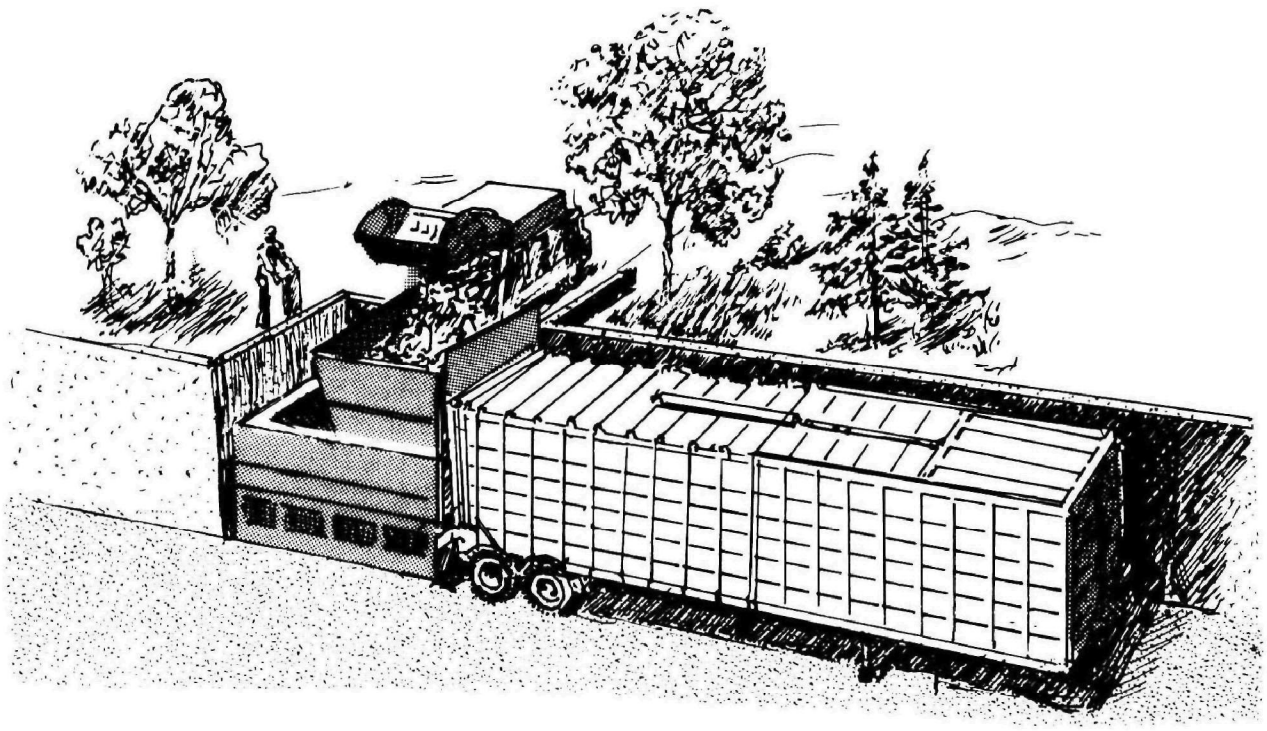


Figure 9. Collection truck discharges waste into stationary packer for loading into transfer trailer.

Equipment. Transfer trailers or roll-on/roll-off containers are the two main types of storage bins used for transferring waste from the stations. Typical transfer trailer capacities used range from 38.2 to 57.3 m^3 (50 to 75 yd^3) for both enclosed and open-top trailers. The back of the enclosed trailers are attached to stationary packers for loading, and a built-in hydraulic pushing mechanism in the trailer unloads the solid waste at the disposal site. A somewhat similar enclosed unit, a compaction trailer, uses an auxiliary engine mounted on the front of the trailer to operate a hydraulic compaction system. All compaction trailers are designed to be used as small independent compactors.

The open-top trailers use either no compaction or a backhoe for load-leveling and compaction. At the disposal site they can be emptied using a hydraulic hoist, a tipper platform, or an extrusion plate and cables which are attached to the landfill equipment. Open-top tractor-trailer rigs have empty weights ranging from 11,700 to 14,900 kg (26,000 to 33,000 lb). The initial purchase price is usually lower than that of the heavier compaction trailer rigs,

which weigh from 17,600 to 18,900 kg (39,000 to 42,000 lb). On roads with a maximum gross vehicle weight of 32,400 kg (72,000 lb), the open-top vehicles can carry a maximum legal payload of about 17,200 to 20,900 kg (19 to 23 tons). The enclosed compactor rigs are limited to about 13,600 to 15,400 kg (15 to 17 tons).[11] For uncompacted loads the maximum gross vehicle weight will not approach the limits of the best grade of highways. On many rural roads and bridges, however, the legal load-carrying capacity is a major factor in choosing transfer station locations and dictating routes to the disposal site.

Roll-on/roll-off containers are somewhat similar to the body unit on transfer trailers (Figure 10). The major characteristics are: (1) the containers are smaller than transfer trailers; (2) the units are designed to be picked up by a truck with a roll-off chassis; and (3) solid waste is discharged at the disposal site by tilting the container. When the truck carrying a filled container reaches the disposal site, the rear door of

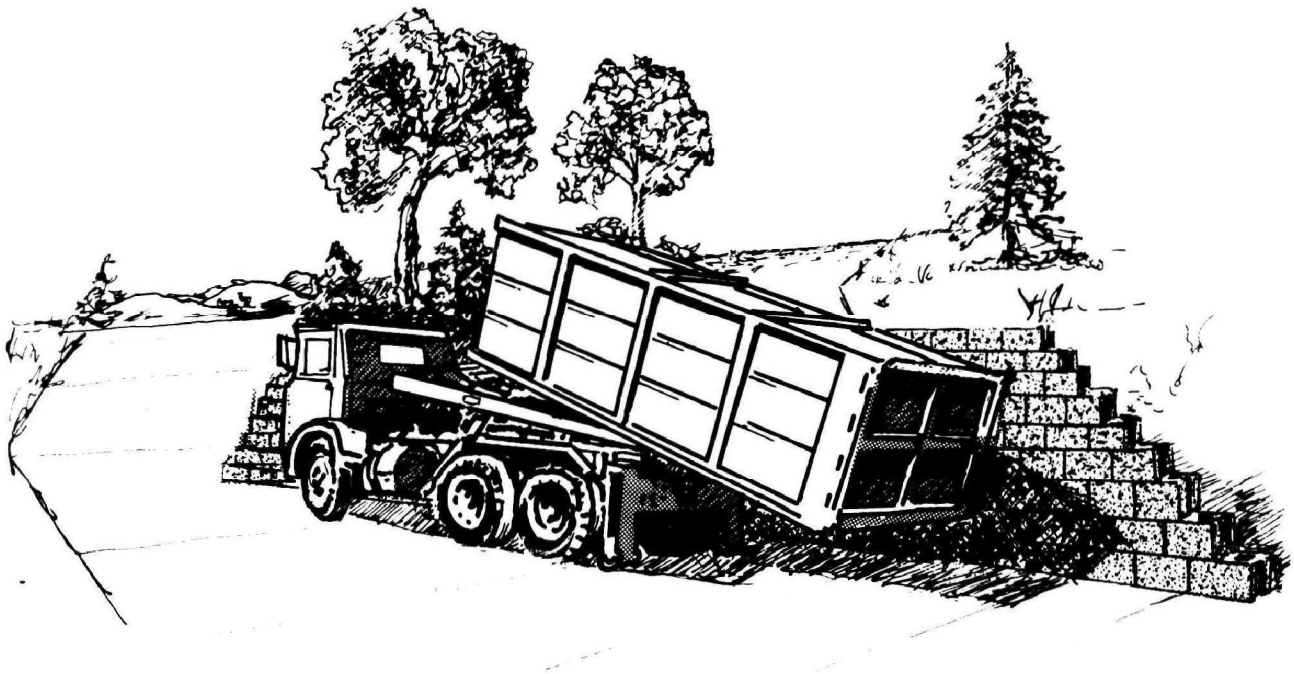


Figure 10. Unloading containers requires adequate maneuvering space at transfer stations.

the container is opened, the container is hydraulically lifted and the waste slides out. Considering the weight of the truck and the container, most of these vehicles can legally carry a maximum of about 9,000 kg (10 tons) of waste on the best grade of highways. Typical capacities are 11.5 to 38.2 m^3 (15 to 50 yd^3) for open-top, roll-off containers and 19.1 to 34.4 m^3 (25 to 45 yd^3) for enclosed roll-off containers which are used in conjunction with stationary packers.

A pull trailer can be attached to a truck carrying a container or a single semitrailer can be used to haul two containers simultaneously (Figure 11). For containers up to 15.3 m^3 (20 yd^3), a gooseneck trailer hauled by a pickup truck can be used (Figure 12).

Figure 11. Pull-trailer attached to a truck allows a combined load of 61.2m^3 (80 yd^3).

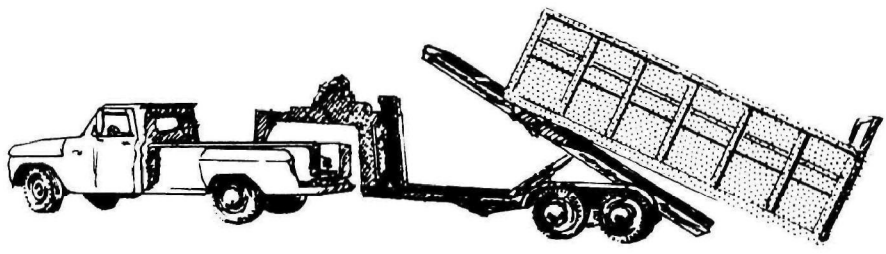


Figure 12. Gooseneck trailer lifts a 15.3-m^3 (20-yd^3) container.

Locating Transfer Stations. Site locations are influenced by the population density of the area, the road system to the site, the land use of the area, and the public's acceptance of the site.

A procedure similar to that described for establishing small container systems can be used for transfer stations.

1. Identify the population densities and other waste generation sources for the area to be served.
2. Select maximum distance or maximum driving time criteria for the users of the collection system.
3. Identify groups of potential users, based on the criteria selected in item 2, to be served by different transfer stations (i.e., all users are within a prescribed distance or time of a station).

As noted in the discussion of equipment, legal load-carrying capacities of roads and bridges leading to the transfer station are extremely important. These will determine the kinds of user vehicles and transfer equipment that can use the station. If the roads' load-carrying capacity is low, then smaller trucks must be used or larger trucks will have to operate with partial loads. In both cases, equipment efficiency is reduced. Equally important, roads leading to the transfer station will determine the average speed of the vehicles which travel to the site, thereby affecting both efficiency and operating costs.

The third factor affecting transfer site locations is land use in the collection system area. Land requirements of more than one acre for a typical site decrease the number of feasible site locations. It can be much easier to obtain a number of 360 m^2 (4,000 ft^2) sites for small containers than a few 3,600 m^2 (40,000 ft^2) or larger, sites required for transfer stations.

The fourth factor, public acceptance of the location, is necessary both to minimize land acquisition problems and to maximize citizen support of the system.

A critical factor in selection is the high capital cost for constructing sites. Basic site development costs range from $4,000 to more than $20,000; stationary packers and buildings

add to this cost. As a result, it is very expensive to change transfer locations once the site has been constructed. In addition, the substantial capital investment restricts the number of locations that an area can reasonably afford.

Since costs limit the number of sites, user convenience is decreased in the sense that average travel distances for the residents and other users is greatly increased over that of the small container system. Ideally, transfer stations should be located no further away than the distance an individual previously had to travel for disposal.

A study of rural dump sites in Humboldt County, California, indicated that permanent residents utilizing the dumps on a regular basis were willing to travel up to 8 to 10 miles one-way on paved rural mountainous roads, approximately 30 min, one-way travel time. The norm among the rural citizens surveyed at the sites appear to be in the range of 10- to 15-min travel time. When transfer stations replaced the dumps, the residents still were willing to travel up to 10 miles to dispose of their wastes.

Locating transfer stations near old dump sites is desirable to take advantage of the user's operational habits. The disadvantages of locating immediately at the old dump site, however, are the same as were described for the small containers.

In addition to locations near old dump sites, other transfer site locations which should be considered include:

- Small towns with a central collection point convenient to residents.
- Road intersections or along heavily traveled roads.
- Parks and recreation sites.
- Commercial establishments.
- Population centers of an area.

Sites should be located where a fire would be visible to some residence or fire tower.

Site Requirements. A number of alternatives are possible for designing rural transfer stations. The first design considera-

tion is site capacity. Rural transfer stations can serve a similar function as either house-to-house service or small container systems—they provide a collection function for their area. There is, therefore, a propensity to design many rural sites to be used by private residents or small businesses rather than commercial collectors. As might be expected, usage varies at different sites from 100 percent private sources to almost 100 percent commercial collection vehicles.

The type of user is a major factor in site design. For instance, 500 families each bringing .2 m^3 (.25 yd^3) of waste to the site weekly are equivalent to approximately two loads of a 15.3-m^3 (20-yd^3) packer. Although a 38.2-m^3 (50-yd^3) open-top transfer station would probably be justified as a collection point for 500 families, it would be completely unacceptable as a transfer site for the 15.3-m^3 (20-yd^3) packer loads.

Once the number and type of potential users to be served by a given site are decided upon, the amounts of waste generated by the various sources must be determined. The average amounts of household wastes generated would be the same as the amounts collected were small containers used. The overall quantity expected for the transfer station system will be greater, however, since the bulky waste that house-to-house service or small containers cannot handle can be delivered to the large containers or trailers.

Actual surveys of waste volumes being disposed of in an area provide the most adequate method for determining needed container capacity. Where no other data are available, .2 m^3 (.25 yd^3) per family per week can be used as a rough estimate of residential waste. In addition to individuals and commercial collectors, nearby industries, commercial establishments, and institutions may use the site. The amounts and types of wastes generated by all these sources have to be considered in any survey and in the design stage of a transfer station. Just as with the small containers, the volume capability of the transfer site should be 120 to 125 percent than expected volumes to allow for adequately handling peak loads.

Although transfer stations can handle much greater fluctuations in waste generation than either of the other two collection

methods, transfer sites can also suffer from large overloads. For instance, unexpected loads of demolition, industrial, farm or other special waste will overload an otherwise adequately designed station. It cannot be overemphasized that early in the design stage of any system the types of waste to be handled and projected amounts to be generated must be decided upon.

Sites receiving volumes of less than 38.2 m^3 (50 yd^3) of uncompacted waste per day would usually use open-top containers with no compaction. If commercial packer trucks unload at a site, usually a stationary packer, backhoe, or compactor trailer must be provided at the transfer site.

Collection frequency of the transfer trailers or containers will dictate the required waste storage capacity of the site. Servicings vary from a number of collections per day to pick-ups only upon call. For sound sanitation, a minimum of once-a-week service should be provided.

A second design consideration is available land. For most small transfer stations, a land area of .4 or .8 ha (1 or 2 acres) is usually adequate for site layout and construction. However, because of the need for central locations with access to main roads and public skepticism over the aesthetics of a transfer site, the relative cost of the land may be high. Almost all sites use a dual elevation incorporating a ramp and a retaining wall (Figures 13-14). The most typical type of site layout utilizes a straight line retaining wall (Figure 15). The length of the retaining wall dictates the number of containers or trailers which can be accessible for filling at one time. A second type of retaining wall layout is the Z-shape (Figure 15) where empty containers are placed on one side of the Z, and filled containers are picked up from the other side. A third type of layout being used is the L-shape design (Figure 15).

Assuming that only one container is to be filled at a time, design alternatives such as the following are possible: a one-stall design that requires dragging the filled container out of position to permit unloading the empty container into the only available space; a two-stall design where the collection vehicle unloads the empty container into one stall and collects the full one from the

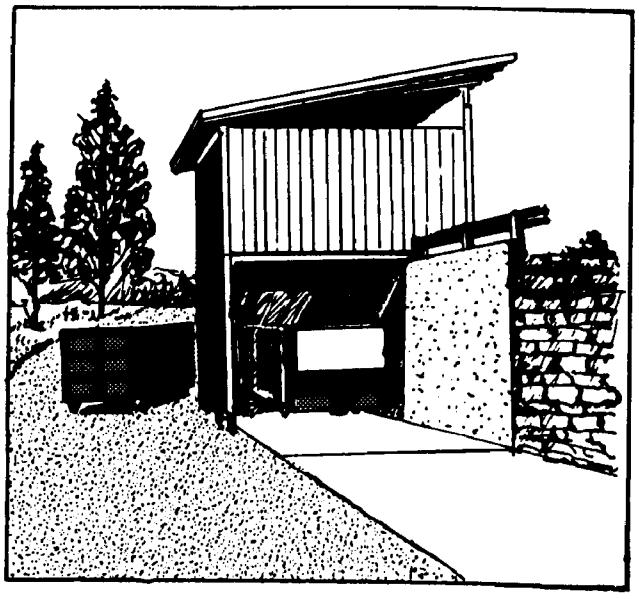
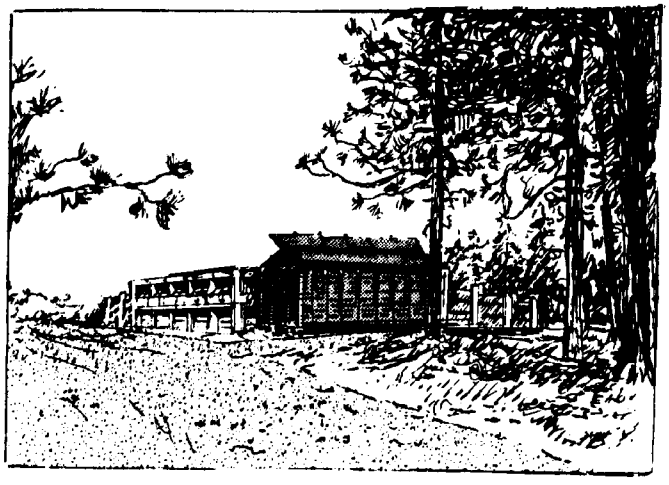


Figure 13. The site construction used at different transfer stations can vary considerably.



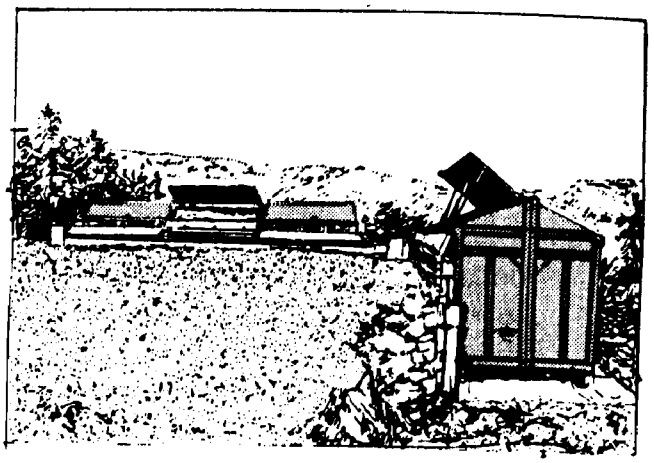
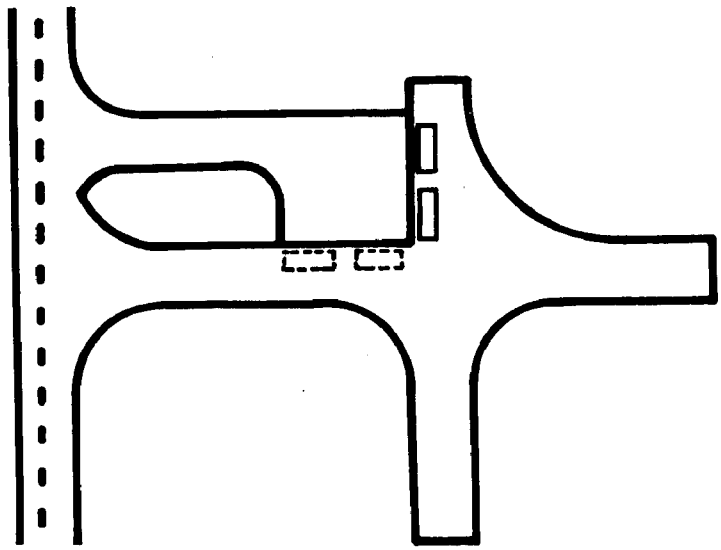
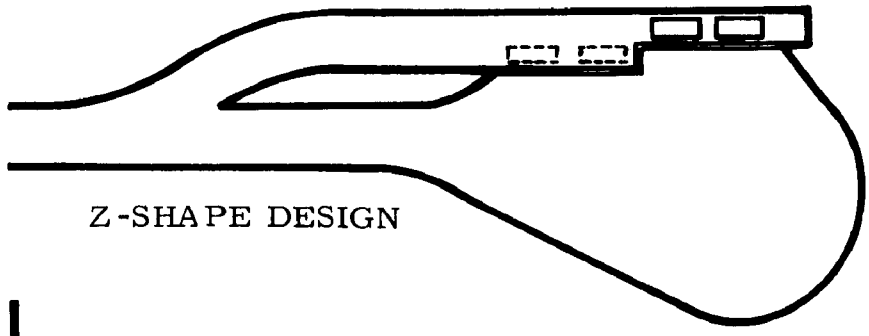


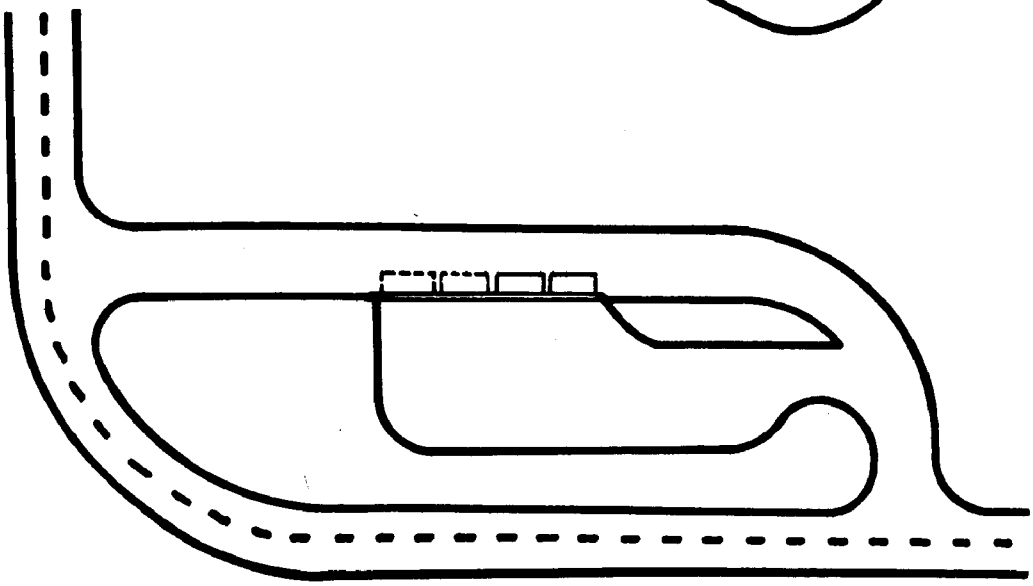
Figure 14. L-shaped retaining walls minimize the container maneuvering required.



L-SHAPE DESIGN



Z-SHAPE DESIGN



STRAIGHT-LINE DESIGN

Figure 15. The choice of wall design is influenced by construction costs and the size and shape of the land used for the transfer station site.

other; and a $1\frac{1}{2}$ stall design which is a compromise between the other two designs with a shorter maneuvering time than the one-stall design and a lower construction cost than the two-stall design. With a stationary packer, only the one-stall design is used and waste is unloaded at a hopper or charge pit. For open-top containers or trailers the loading ramp should allow dumping along the length of the bin.

The retaining walls are commonly built of either wood or concrete. Wooden walls are less expensive but less durable than concrete. If fires occur, the wooden walls can be badly damaged. Also any protrusions on the side of the wall facing the container can damage the container sides. Wooden walls do have flexibility in that they can be moved if a transfer station site has to be changed. Lane County, Oregon, has built its retaining walls from 1.2 m by 5.5 m (4 ft by 18 ft) concrete slabs secured by H-beams; the slabs can be moved if a site location is changed.

Retaining walls that are higher, lower, and level with container heights are used. A retaining wall height level with or slightly below the height of the containers is preferable so that pickup trucks can easily dump into the containers. Curbing is needed to prevent a vehicle from backing over the end of the retaining wall. Putting tire stops several feet from the end of the wall should be avoided, however, since it prevents vehicles with large loads from dumping directly into the containers. A wooden or metal overhang will prevent waste from falling between the container or trailer and retaining wall (Figure 16).

The site should be large enough that both the user vehicles and the transfer equipment have adequate access and maneuvering room. Additional space for possible future expansion is also desirable. A transfer station must be usable under all weather conditions. The site should be adequately sloped to provide proper drainage; construction of ditches or installation of drainage pipe may be desirable. Surfacing the site with gravel, asphalt, or concrete should be done where necessary to prevent mud and erosion. Public access ramps and the location where the container or trailer is placed are the most important areas where adequate surfacing is needed.

Unloading ramps, compaction units, and open-top containers are sometimes housed in a shelter. If the transfer station has limited operating hours, buildings can be kept closed to the public during other times to reduce illegal use or vandalism. In constructing a building, the ceiling must be high enough to allow the largest vehicles anticipated to unload, and enough space should be provided for planned future expansion.

Container lids are used to cover the waste at some rural transfer stations which have no buildings or shelters. Properly used, container lids can help reduce wind-blown litter and animals feeding on the waste and provide protection against the weather. Easily opened container lids are valuable in areas with heavy snowfall unless a shelter of some type is used.

One type of container lid (used in heavy snow areas) is a tepee-shaped lid which opens up 1/3 the length of a 30.6 m^3 (40 yd^3) container (Figure 16). Another type uses spring-loaded hinges (Figure 17) with two lids covering a 30.6 m^3 (40 yd^3) container. A third type has a wire mesh screen mounted on a metal frame which extends across the entire length of the container and protects against blowing litter (Figure 18). A problem with all lids is that people frequently fail to close them after using the containers; too, heavy lids are a potential safety hazard.

Operating the Transfer Station. Where stationary packers, scales, or disposal fees are used at a transfer station, an attendant is required whenever the station is open. Some areas are considering an unattended coin-operated transfer station using a stationary packer, but so far this method has not become operational. The attendant also performs necessary cleaning and general maintenance, prevents scavenging and calls for an empty container or trailer when required. At some sites the attendant can double as driver of a transfer vehicle. Where no compaction equipment is used, the attendant can use a pole to better distribute the waste load in the containers and increase storage capacity. A manned station requires gates or some other means of closing the sites to the public when the attendant is not on duty.

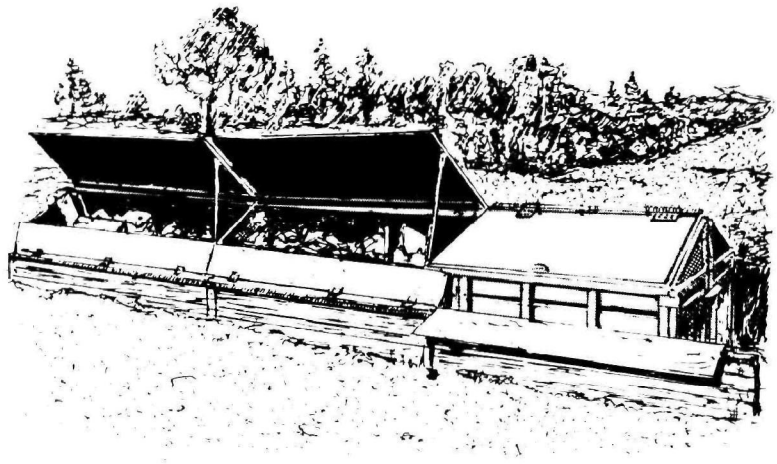


Figure 16. Tepee-shaped lids prevent rain or snow from accumulating on lids.

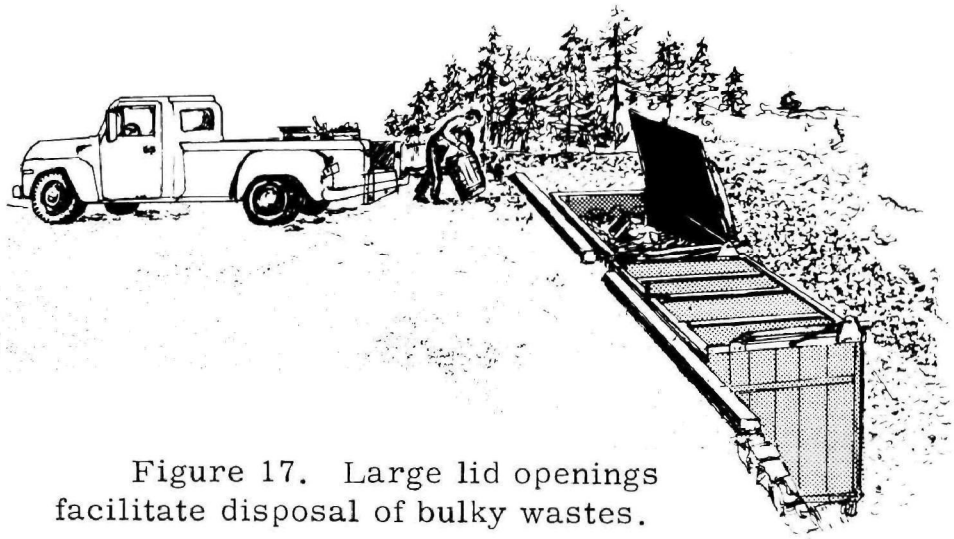


Figure 17. Large lid openings facilitate disposal of bulky wastes.

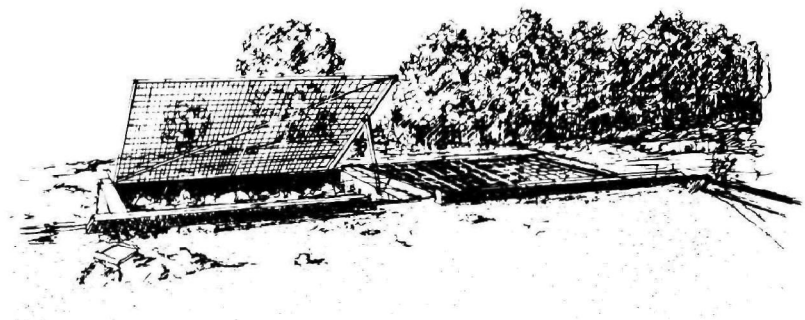


Figure 18. Lids made of wire mesh screen are lightweight and easy to open and close.

If attendants are not present to maintain the sites, the driver who picks up the waste cleans up around the site. Occasionally special site visits are made expressly for cleaning up. Lane County, Oregon, is planning to mount a backhoe on a pickup to travel to its open-top 30.6-m^3 (40-yd^3) container sites to compact the waste during cleanup visits. Clean, well maintained sites improve the public image of solid waste services and encourage users to keep the sites clean.

Large containers or trailers are washed and serviced at the disposal site or garage area where the equipment is hauled in contrast to the small container system where all the washing and most of the maintenance is done at the container site.

Most rural transfer stations do not use scales. When disposal fees are charged, the rate is based on the number of containers or estimated cubic meters (cubic yards). Compacted waste is charged at a higher rate per cubic meter (cubic yard) than loose waste, and special items, such as tires, engine blocks, or old auto bodies often have separate charges. The basic criticisms against charging at rural transfer stations are: (1) that the residents who have been dumping free for years will resist paying for disposal at a transfer site and will illegally dump their wastes; and (2) limiting operating hours provides an inconvenience to users. Both arguments are valid.

Transfer sites charging disposal fees have encountered problems with user acceptance. Incidents of illegal dumping have occurred and citizens have been angered. By achieving strong public support for improved practices and equally strong enforcement against violations, however, disposal fees are successfully levied at rural transfer sites. When the station is only open for limited periods, the hours of operation should be prominently advertised and scheduled to provide the greatest convenience to the public.

The same problems described for small containers—vandalism, fires, misuse, scavenging, weather, maintenance, and cleaning—also plague transfer systems. Even at sites that won't have permanent supervision, having an attendant at each new station during the first week or two of operation to give instructions and explain the system is advisable.

One problem which can occur at unattended locations is that large waste loads are sometimes hauled to the station by people who are unauthorized to use the sites. The illegal users can be commercial or industrial sources who should be going to the landfill. Instances have also occurred where solid wastes from one county have been illegally disposed of at the unattended sites of another county.

Collection Routes. Routing the transfer vehicle which picks up the container or trailer is relatively simple for transfer station systems, as compared to house-to-house or small container methods. For most routes, the vehicle simply leaves the garage or disposal site where it is stationed, travels to the transfer site to be serviced, picks up the filled container or trailer, deposits an empty one, and returns to the disposal site. The main criterion for route selection is road conditions, since legal weight restrictions will preclude the use of certain roads and the type of road will also affect vehicle speed.

Processing

The third element of good solid waste management, processing, is not a common centralized practice in most rural areas. Any burning, composting, or salvaging that does take place usually is done at the residence or business before the waste is taken to a disposal site.

Incineration. The 1968 National survey indicated that 85 percent of the rural households are situated in communities which practice backyard burning. More stringent pollution laws are reducing this percentage in recent years. Central incinerators serving large rural areas are not common, probably because of the high plant construction and operating costs and the fact that a disposal site is still required for the residue. In the 1968 survey, of 6,571 rural communities, 140 indicated that they used central incinerators; some of these were probably nearby municipal incinerators. For the same sample of 6,571 rural communities, 78 indicated that they used tepee burners. Other methods used to varying extents in rural areas, included open burning, open-pit incineration, and home incineration.

Some incinerator systems are designed for small communities; for instance one incinerator plant in the Grafton, Wisconsin, area serves approximately 11,000 people. This plant, built in 1970 at a cost of $350,000, has a 21,800 kg (24 ton)/day capacity. Operating and maintenance costs are approximately $25,000 annually. Figure 19 shows another 21,800 kg (24 ton)/day incinerator used for 15,000 people in Plaquemine Parish, Louisiana. The 1968 construction costs were about $290,000, and the annual operating and maintenance cost is about $36,000.

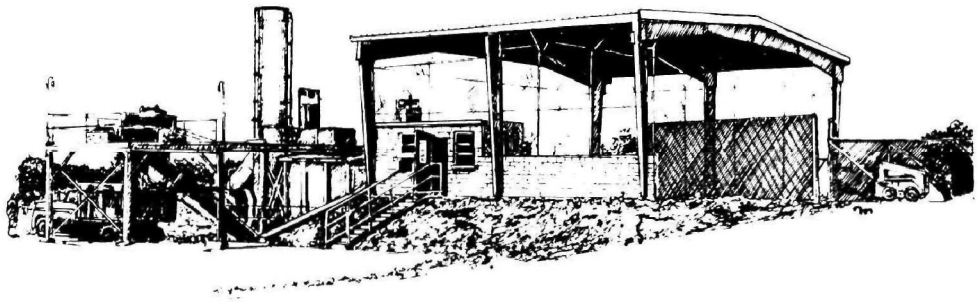


Figure 19. Incinerator with a 21,800 kg (24 ton)/day capacity is used where adequate land for disposal is scarce.

Composting. The organic material in solid waste can be decomposed into a soil conditioner. Although large scale commercial composting plants are not used for processing rural residential solid waste, some composting does occur at rural homes. Organic wastes from the homes are combined with yard or animal wastes or crop residues in a compost pile. The number of residents in most areas who can or will compost their waste is limited, and up to 30 percent of the household waste is not compostable. Although the process is advantageous in that it can decrease the amount of organic waste to be collected and a potentially valuable product results, it is at best only a partial solution for adequate solid waste disposal.

Other Process Methods. Baling and grinding of wastes are not commonly practiced in rural solid waste systems. Feeding garbage to animals is a disposal process which does occur to a

limited extent commercially and to a larger extent at the private residences in agricultural areas. State regulations requiring that the garbage be cooked before being fed to animals has limited the use of this disposal method in recent years. The 1968 National survey of 6,571 rural areas indicated that 15 publicly operated hog feeding lots and 347 privately operated lots still use garbage as a food source.

Disposal

Present Practices. There are more than 10,000 land disposal sites in rural America that are used by commercial collectors and private individuals. Approximately two-thirds are publicly operated; the other one-third are privately operated. Responsibility for regulating these disposal sites is distributed as follows: health authorities, 35 percent of the sites; operational authorities, 20 percent; the police, 3 percent; other agencies, 15 percent. Twenty-seven percent of the disposal sites have no authority responsible for regulation. Rural disposal sites include: sanitary landfills; dumps which are covered only when filled with wastes; dumps which are maintained periodically with equipment transported from site to site; and dumps which never receive any maintenance or cover. Except for sanitary landfills, all these sites encourage open burning, uncontrolled access, air and water pollution, or vector infestation.

When authorized disposal sites are inconvenient or unavailable to the public, illegal dumps occur. The absence of collection systems makes the prevalence of promiscuous dumping all the more common. In addition to the 10,000 sites mentioned above, rural America houses well over 25,000 active promiscuous dumps, or slightly more than one promiscuous dump for every 2,000 rural residents (Figure 20). This ratio of promiscuous dumps to residents is 11 times greater than that for an equivalent urban population. In the past, a disposal site has been selected largely because it was convenient to the user and concealed from the casual observer. As a result, dump sites include ravines, creekbeds, roadsides, highway litter barrels, and any other location that someone decides to use. Once waste is dumped, other

Figure 20. These types of dump sites are common in rural America.

individuals frequent the site and a new dump emerges. Sometimes communities have selected a certain location and designated it the "town dump." The bar charts in Figure 21 summarize the results of several public usage surveys conducted at rural dump sites. The charts characterize the users of the dump sites and describe dumping practices.

Most States have solid waste disposal regulations that specify certain minimum requirements, and provide authority to close unacceptable sites. Closing these sites is an especially formidable task in rural areas because of the large number of sites involved and the attitudes of many rural citizens toward their disposal practices.

Dumps have the apparent advantages of being inexpensive to operate and usually convenient to the user. Other often unconsidered "costs," however, can be substantial. It is indeterminable when highway litter becomes a roadside dump; but a substantial portion of the almost $50 million dollars spent annually for highway cleanup can probably be attributed to roadside dumps.[12] And how does one calculate the cost of sullied air, contaminated water sources, or fire hazards that have, in some instances, spread to nearby forests? What value does one place on the aesthetic effect of a dump on the surrounding area or the nuisance of rats and flies nearby residents must contend with?

In many areas the residents like having their own dump. As illustrated in the following community dump description, the disposal site often provides a social gathering place in sparsely populated areas.

The disposal site is considered "a meeting ground, a place to visit and chat with neighbors, drink beer, and shoot a few crows and squirrels. It provides amusement for the children, an excuse to take a late afternoon drive to town, and an opportunity for the whole family to work together on a common task."[13]

One New England radio station supposedly plays "Going to the Dump" music for its listeners on Saturday mornings.

For communities with this concept of "their dump," improving solid waste practices can be exceedingly difficult. For this

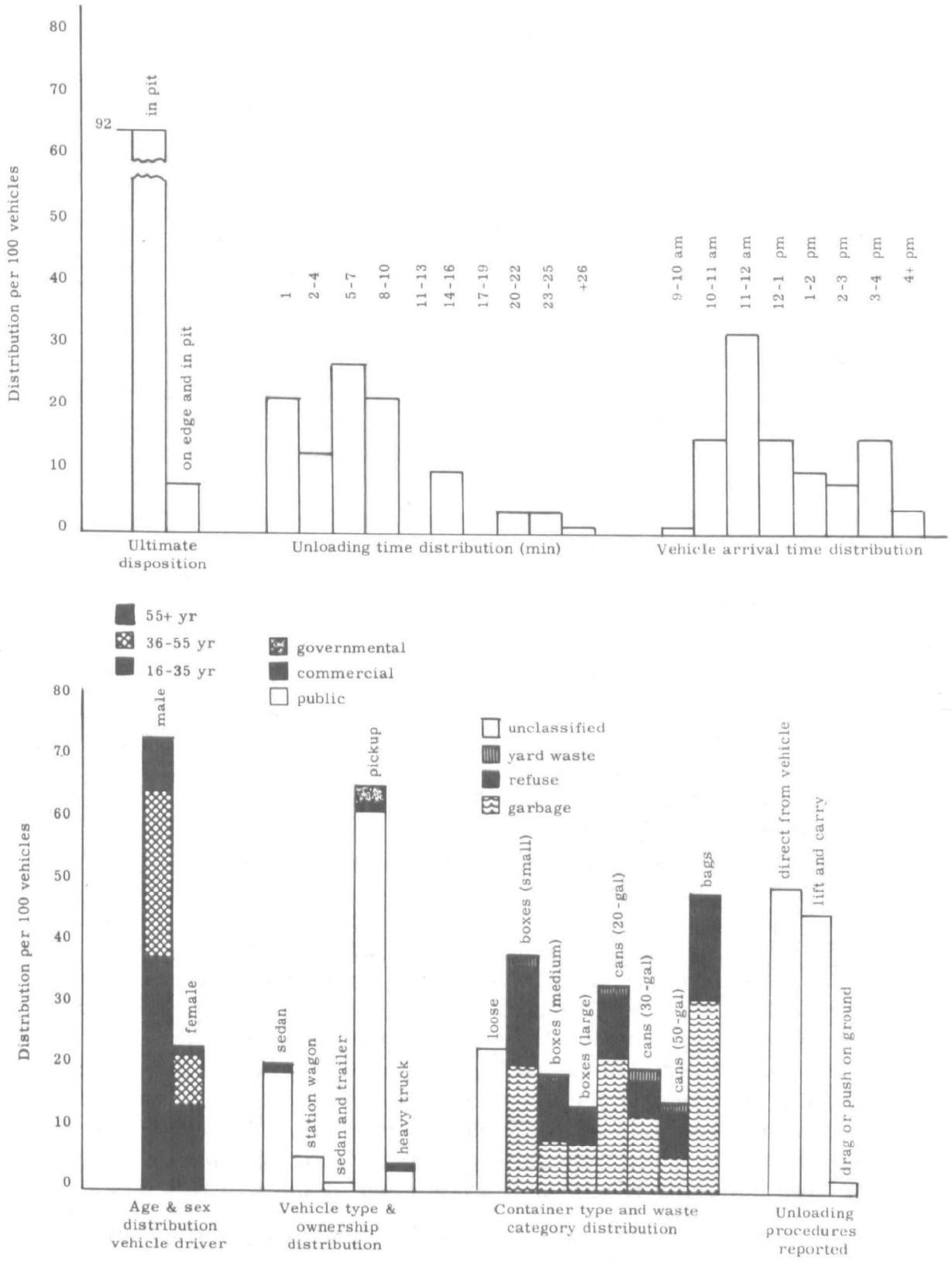


Figure 21. Dump survey indicates a number of variables related to the practices of dump users. (From Humboldt County, California, and Garretson-Elmendorf-Zinov-Reibin, Consultants. Rural storage and collection container systems. U.S. Environmental Protection Agency, interim report, 1972. p. 103-104.)

reason citizen support of the improved methods must be developed early in the planning phase of a solid waste system. The public education which occurs during that phase will undergo one of its must crucial tests when dumps are closed.

Dump closings actually involve two elements. There is the physical closing which includes stopping all usage, extinguishing all fires, eliminating any vectors, and adequately compacting and covering the old site. The usual method for closing dumps is to cover them with soil using a loader, dozer, or other heavy equipment. At some sites cover material may have to hauled in while at others it may be more economical if the accumulated waste is collected and hauled to an adequate disposal site. There is also the psychological dump closing in which an improved alternative is accepted by the public, and the people are willing to end their previous dumping practices. Unless both elements are accomplished, a dump site cannot be permanently closed.

No simple guidelines exist for determining costs of dump closing. Chilton County, Alabama, closed 93 sites of varying sizes encompassing a total land area of 14.6 ha (36 acres). The total cost was $11,000 or approximately $756/ha ($306/acre). In another study in Lee County, Mississippi, small rural dump closing costs ranged from $15 for sites containing less than a tonne (ton) to $118 for sites containing up to two tonnes (tons) of waste. The highest cost was $920 for closing a site estimated to contain 100 tonnes (tons).

Sanitary Landfill. Terms such as dump, modified dump or landfill, and sanitary landfill are often used interchangeably—and incorrectly—to define disposal sites. The result is public confusion and distrust of any type of disposal operation including the only totally acceptable method currently practiced—sanitary landfilling: an engineered method of disposing of solid waste on land in a manner that protects the environment, by spreading the waste in thin layers, compacting it to the smallest practical volume, and covering it with soil by the end of the working day.

Numerous reports are available on operating a sanitary landfill; several are listed in the bibliography. Regardless of the size

of the site, the basic procedures for cell construction, adequate compaction and cover, and prevention of air and water pollution apply to all sanitary landfills.

One of the major purposes of regionalizing an area's solid waste system using organized collection and centralized sanitary landfill sites is to minimize the capital and operating costs of running an adequate operation. The estimates in Table 1 indicate that the larger the population served by a sanitary landfill, the lower the per capita costs will be. Table 2 shows a breakdown of the various cost items usually associated with a small sanitary landfill operation. It should be emphasized that while all operations will probably have a similar list of cost items, individual costs may vary greatly depending on specific site conditions.

As with a rural transfer station, a substantial number of the users of a rural sanitary landfill are also private individuals, and public access should be provided to the site during convenient, well advertised operating hours. Since the waste must be compacted and covered each operating day at a sanitary landfill, the number of days the site is kept open is often minimized to reduce costs. For example, a site could be kept open only on Monday, Thursday, and Saturday, and the users have access to the site only on those days. Containers (either large or small) are sometimes placed at the site entrance for the days the site is not open.

Equipment Used. Three types of heavy equipment—either crawler dozers, crawler loaders, or rubber-tire loaders—generally are used at rural disposal sites. The three types have the following characteristics:

Crawler Dozers

- Excellent for grading and economically dozing waste or earth distances up to 90 m (300 ft)
- Versatile all-weather machine
- Commonly applied on area landfill
- Usually equipped with a straight dozer blade or U-shaped landfill blade

TABLE 1

ANNUAL COST AND COST PER TONNE (TON)
OF SANITARY LANDFILLS
SERVING POPULATIONS TO 25,000*

Population	Annual cost+	Cost/tonne (ton)++
Minimum	$19,800	-
1,000	20,600	$34.30
2,000	21,300	17.20
3,000	22,000	11.80
4,000	22,700	9.16
5,000	23,400	7.49
6,000	23,900	6.42
7,000	24,400	5.62
8,000	24,900	5.02
9,000	25,400	4.55
10,000	25,800	4.03
15,000	33,900	3.67
20,000	35,600	2.86
25,000	37,100	2.36

*From Spindletop Research, Inc.

+Does not include haul cost and administrative cost.

++Varies according to the actual tonnage.

TABLE 2

TYPICAL SANITARY LANDFILL COSTS
POPULATION OF 5,000*

	Sanitary landfill cost	
	Capital	Annual
Engineering services	$ 1,500	$ 300
Land, legal fees	2,500	500
Personnel	-	10,000
Equipment and attachments	23,400	5,300
Equipment maintenance and operation	-	3,600
Access roads	3,800	760
Facilities (trailer and shed)	6,500	1,300
Utilities	1,000	740
Fences	2,500	500
Landscaping	500	100
Miscellaneous	1,000	300
Totals	$42,700	$23,400+

*From Spindletop Research, Inc.

+Does not include haul cost and administrative cost.

Crawler Loaders

- Excellent for excavating and carrying earth distances up to 90 m (300 ft)
- Versatile all-weather machine
- Commonly applied on trench landfill
- Usually equipped with a general-purpose or multi-purpose bucket

Rubber-tire Loaders (wheeled vehicle)

- Faster and more mobile than crawler vehicles (maximum forward or reverse speed of about 46.4 km/hr vs. 12.8 km/hr (29 mph vs. 8 mph) for crawlers)
- Can economically move earth distances of up to 180 m (600 ft)
- Limited mobility on wet or frozen ground
- Usually equipped with a general-purpose or multi-purpose bucket

Although moving equipment off the disposal site is not advisable in most situations, dual purpose machines can make small landfills more economically feasible. A wheeled vehicle can be used for road maintenance, at a feed lot, for snow removal, for closing dumps or at more than one disposal site. Crawler equipment also can be used, for example, for road maintenance but may have to be transferred over highways on a flat-bed trailer.

Even the rural disposal sites that have daily compaction and cover often have only one piece of permanent operating equipment. A scraper or other specialized equipment used to supplement the regular equipment for short periods of time is a common practice. Standby equipment should be readily available in case of breakdown or during needed maintenance through rental agreements with nearby equipment dealers, private operators, or public agencies.

FINANCING

One of the major deterrents to implementation of a desired solid waste system is inadequate financing. Financing is needed to meet both capital costs, which include the initial start-up expenses of land, facilities, equipment, and operating costs, which can include personnel, equipment, maintenance and other operating expenses.

Financing Methods

State and local legislation determine what financing methods are available for public agencies to consider. The most common methods used by governmental authorities to obtain revenues for capital expenditures are described below.

Pay-as-you-go assumes that the needed funds are either accumulated in advance of expenditures or are available at the time the financial obligations occur. This is a very common means of financing capital equipment and usually the least expensive because no interest is accrued.

Leasing or leasing with an option to buy is the rental rather than the purchase of land, facilities, and/or equipment. The primary advantage of leasing is that it requires no capital investment and is a highly flexible means for obtaining needed improvements. A major disadvantage is that generally leasing is the most expensive method of providing equipment and facilities for the life of the system, because the rate of return on private capital involved is much higher than any borrowing rate. Neither do the rental payments produce any equity in land, facilities, or equipment unless a lease with an option to buy is provided.

Still, the use of leasing arrangements may be justified where the leased land, facilities, or equipment is:

- Used for a limited period and is of no lasting use.
- Of limited investment value, use, and resale so that capital expenditure is not justified.
- Not purchasable.
- Leased from nonprofit organizations that share capital costs.

Leasing with an option to buy (or lease-purchase) gives communities a chance to purchase equipment at reduced costs or to include a portion of purchase payments in rental payments.[14]

Subsidies, grants, and loans are available to a very limited extent from some State and Federal agencies. This financial assistance often must be used for specific purposes, such as planning, land and equipment acquisition, or construction of facilities. Although grants can reduce initial costs, eventually the area will need to use another financing method to maintain their solid waste system.

Long-term borrowing is the most widely used method of financing capital outlays and can include bank loans, notes, and bonds.[15] In many instances commercial banks and other financial institutions can provide for the capital requirements of a system through loans. The solid waste system's equipment, land and facilities can serve as collateral against loans. Bonds as a method of long-term borrowing can include either general obligation bonds or revenue bonds. The first type is secured by the general credit and taxes of the issuing authority; the second type is secured solely by the fees and other funds of a specific revenue source.

If the private sector provides the solid waste services, this transfers the burden of financing capital costs from the local governments to private industry. Historically, solid waste management firms have financed their businesses with one or more of the three "traditional" corporate financing mechanisms; internally-generated funds, debt (loans from banks or other institutions), and equity (common stock and variations.)[16]

Operating costs are usually defrayed through some form of taxation or user charges.

TAXES (general property, sales, income, special taxes)

Advantages

1. The amount of revenue to be received can be accurately estimated.
2. Individual billing procedures are eliminated.

3. All citizens are required to support solid waste system.

4. Costs are distributed more nearly on an ability-to-pay basis.

Disadvantages

1. Solid waste tax revenues must compete with tax funds for other public services.

2. An inequitable relationship between cost and service often exists. The amount people pay in taxes can be totally unrelated to the amount of solid waste service they are provided.

3. Some properties are exempt from general taxation.

USER CHARGES (levied on the generators of solid waste)

Advantages

1. Fees can be directly related to the level and cost of services. Users would pay according to the amount and type of waste generated.

2. Taxation may be reduced or tax revenues may be used for other governmental activities.

3. Periodic review and updating of charges related to increased costs is generally easier than obtaining increased tax funds.

4. Revenue bonds can be used.

5. System should pay for itself.

Disadvantages

1. Costs for administration and billing procedures can be high.

2. Some people will refuse to purchase or use the service.

The rate structure of user charges for collection is usually based on some combination of the following factors: (1) type of collection; (2) frequency of collection; (3) number and size of containers; and (4) type of waste. For disposal only, user charges are usually based on amount and type of waste disposed.

Additional information on financing methods can be obtained by contacting bankers, bond counsels, and financial consultants in one's area.

Sources of Financial or Technical Assistance

A number of different sources provide assistance to rural areas for solid waste management.

Limited financial or technical assistance is available from some Federal programs. Most of the aid is offered only to interstate, State, or local authorities or in some instances to public and private nonprofit organizations. The local, State, or regional offices of the different agencies should be contacted to learn what assistance is available for a particular area and what the eligibility requirements are. Federal programs which can be contacted include:

Environmental Protection Agency
- Office of Solid Waste Management Programs

Department of Agriculture
- Farmers Home Administration
- Soil Conservation Service
- Forest Service
- Extension Service

Appalachian Regional Commission

Department of Housing and Urban Development

Department of the Interior
- Bureau of Outdoor Recreation
- Geological Survey
- Bureau of Land Management

New England Regional Commission

Every State also has a designated agency responsible for solid waste management planning. Many of these agencies provide technical and financial assistance in addition to their planning function. This aid ranges from technical reviews of local plans to financial support for implementing solid waste systems. One of the first actions an area desiring to improve practices should take is to contact their State agency to ascertain the types of assistance available.

Cost Comparisons

In deciding upon a solid waste management system, the level of service to be provided must be weighed against the expected costs. If cost comparisons are the only consideration between alternatives, the result can be that an inadequate system is selected for an area.

Developing cost estimates involves determining the equipment, facilities, land, personnel, and supplies needed to operate a particular alternative. Equipment dealers and others using collection and disposal equipment can provide a valuable source for this information. Trade and public works magazines can also be an information source.

The sample budgets which follow indicate the type of costing which would occur for the different alternatives previously discussed. The actual costs for a specific area can vary considerably from these examples, and each area must generate their own cost estimates in more detail depending upon their own particular needs. The sample budgets are based on the following assumptions:

1. A rural population of 20,000 people (6,000 households) and 100 small businesses are distributed over a 2,600-km^2 (1,000-mi^2) service area.

2. The average weekly volume of waste collected is .2 m^3 (.25 yd^3) per household for transfer stations and .15 m^3 (20-yd^3) per household for other types of collection. An average of .76 m^3 (1.0 yd^3) per week is collected from each small business. For the house-to-house service and small container systems, the waste generators haul most bulky wastes directly to the landfill.

3. House-to-house collection occurs at the resident's mailbox or along the main roads traveled by the collection vehicle. Rear-loading vehicles with a two-man crew collect once a week.

4. The small containers are emptied on an average of twice weekly.

5. The transfer stations have no attendants at the site and each site requires two or three services a week. A pull-trailer is utilized on some of the routes to haul two containers at a time.

6. Any of the three collection systems would use the same centrally located sanitary landfill.

SAMPLE BUDGET FOR REGIONAL HOUSE-TO-HOUSE COLLECTION SYSTEM

Capital Costs

Equipment

7 15.3-m^3 (20-yd^3) rear-loading compaction units @ $8,000	$ 56,000
7 truck chassis @ 8,500	59,500
1 pickup truck	3,000
TOTAL	$118,500

Annual Costs

Labor (14 men @ $9,000)[1]	$126,000
Manager/supervisor ($\frac{1}{2}$ time)[2]	6,500
Secretary/bookkeeper ($\frac{1}{2}$ time)[2]	2,500
Billing expense (6,100 @ $2.00)[3]	12,200
7 Compaction units depreciation (5 yr @ 7%)	13,700
7 Truck chassis depreciation (5 yr @ 7%)	14,500
Pickup truck depreciation (5 yr @ 7%)	700
Fuel, oil, grease, etc.	7,000
Equipment maintenance	12,000
Insurance	6,000
Office supplies and miscellaneous	2,000
TOTAL	$203,100

[1]All labor costs given are total costs including fringe benefits.

[2]Also handles other responsibilities.

[3]Assumes billing cost of $2.00 per year per service.

SAMPLE BUDGET FOR A REGIONAL SMALL CONTAINER SYSTEM

Capital Costs

Site preparation costs: (assume 65 sites @ $100)	$ 6,500
Equipment	
2 22.9-m^3 (30-yd^3) front-loading compaction units @ 13,000	26,000
2 Truck chassis @ $19,000	38,000
1 Pickup truck	3,000
130 4.6-m^3 (6-yd^3) containers @ $325	42,250
TOTAL	$115,750

Annual Costs

Labor (2 drivers @ $9,000)[1]	$ 18,000
Manager/supervisor ($\frac{1}{4}$ time)[2]	3,300
Secretary/bookkeeper ($\frac{1}{4}$ time)[2]	1,300
Site depreciation (8 yr @ 7%)	1,100
2 Compaction units depreciation (5 yr @ 7%)	6,300
2 Truck chassis depreciation (5 yr @ 7%)	9,300
1 Pickup truck depreciation (5 yr @ 7%)	700
130 4.6-m^3 (6-yd^3) containers depreciation (8 yr @ 7%)	7,100
Fuel, oil, grease, etc.	4,000
Equipment maintenance	6,000
Insurance	2,700
Office supplies and miscellaneous	2,000
TOTAL	$ 61,800

[1]All labor costs given are total costs including fringe benefits.

[2]Also handles other responsibilities.

SAMPLE BUDGET FOR A REGIONAL TRANSFER STATION SYSTEM

Capital Costs		
Land Acquisition (11 sites @ $750)[1]		$ 8,250
Site Construction		
Clearing, drainage, access road, etc.	$ 5,000	
Concrete retaining walls and pad for containers	5,000	
	10,000	
11 sites @ $10,000		110,000
Equipment		
14 38.2-m^3 (50-yd^3) containers @ $3,000		42,000
2 Truck chassis @ 23,000		46,000
2 Understructures @ 7,500		15,000
2 Pull-trailers @ 16,000		32,000
TOTAL		$253,000
Annual Costs		
Labor[2] (1 driver/mechanic @ $9,000) (2 drivers @ 9,000)		27,000
Manager/supervisor ($\frac{1}{4}$ time)[3]		3,300
Secretary/bookkeeper ($\frac{1}{4}$ time)[3]		1,300
Site depreciation (15 yr @ 7%)		12,100
2 Pull-trailers (5 yr @ 7%)		7,800
2 Truck chassis depreciation (5 yr @ 7%)		11,200
14 38.2-m^3 (50-yd^3) container depreciation (8 yr @ 7%)		7,000
Fuel, oil, grease, etc.		4,000
Equipment maintenance		9,000
Insurance		2,300
Office supplies and miscellaneous		2,000
TOTAL		$ 87,000

[1]There are actually 12 sites available for the region since waste is taken to the sanitary landfill by people in the nearby area.

[2]All labor costs given are total costs including fringe benefits.

[3]Also handles other responsibilities.

SAMPLE BUDGET FOR A REGIONAL SANITARY LANDFILL

Capital Costs	
Site	
Land acquisition (20 ha @ $1,000, or 50 acres @ $400)	$20,000
Site preparation, surveys, and land clearing	9,000
Access road	10,000
Site fencing across road	1,500
Scalehouse	5,000
Scales	8,500
Equipment	
1 Crawler tractor	45,000
TOTAL	$99,000
Annual Costs	
Labor (1 operator @ $10,000; 1 assistant @ $9,000)[1]	$19,000
Manager/supervisor ($\frac{1}{4}$ time)[2]	3,300
Secretary/bookkeeper ($\frac{1}{2}$ time)[2]	2,500
Site preparation, construction and scale depreciation (10 yr @ 7%)[3]	4,800
Equipment depreciation (8 yr @ 7%)	7,500
Equipment maintenance	5,000
Fuel, oil, grease, etc.	600
Utilities	800
Insurance	200
Office supplies and miscellaneous	2,000
TOTAL	$45,700

[1]All labor costs given are total costs including fringe benefits.
[2]Also handles other responsibilities.
[3]The land is not depreciated.

CITIZEN SUPPORT

Throughout this report, different attitudes and needs of people have been continually referred to: i.e., the affinity some residents have for "their dump;" the unenforceability of laws without citizen support; the citizens' inherent distrust of any project related to solid waste disposal; the equating of transfer stations, sanitary landfills, and dumps as identical; the difficulty in obtaining public acceptance for container or disposal site locations; and the general reluctance people have to changing past habits. Citizen support then is possibly the most essential element of any solid waste management system.

Rural solid waste systems are generally more dependent upon citizen cooperation than are urban systems. Urban residents' efforts are usually limited to carrying household wastes to their garbage cans or at most to carrying the cans or bags to the curb. The rural resident, in comparison, is often expected to provide his own collection and transportation service and in many instances must accept responsibility for the disposal of his waste as well. Even most of the improved solid waste methods that have been described in this report require that the rural resident assume a more active role in the waste system than his urban counterpart.

The purposes in encouraging citizen involvement are twofold. One major focus of all public education programs should be to show the need for improved solid waste management practices. In other words the emphasis here is on communicating the concept of good practices rather than on a specific method. The second advantage of citizen involvement is to identify the needs and desires of the residents. Even residents who want to

improve solid waste management in their communities are often concerned about whether the new "container system" will degenerate into a "neighborhood dump." Affirmative--but accurate--terms such as "convenience centers" or "green boxes" or "transfer stations," rather than "mini-dumps" or "dumping stations," should be used just to assuage this distrust of a new system.

Encouraging citizen involvement should begin during the earliest part of developing improved practices--the planning and organization stage. The best way to assure the public's cooperation in a project is to encourage the public to assist in developing the project. Citizen participants may include representatives of the area's housewives, businessmen, farmers, students, community leaders, and anyone else who will use the solid waste system. Of course, anyone who will work in actually implementing or operating the system, such as public works and health department personnel, private solid waste companies, and government officials, also should be involved.

Involvement can take various forms. Some communities develop large voluntary planning or advisory committees of 50 or more interested persons representing the diverse backgrounds of their community's residents. Subcommittees of these citizens investigate such factors as organizational mechanisms, legislative requirements, technical processes, financing techniques, and public information or citizen support activities which would result in the best possible solid waste system for their areas. Or involvement may take the form of surveys of the area residents' attitudes to learn what the potential users of a new system perceive their needs to be. These

surveys can be mail, telephone, or personal house-to-house samplings of people's attitudes. Perhaps one of the best methods is to conduct a survey at the different active dumps. This method assures that those surveyed are the actual users of the solid waste system. It also provides an excellent opportunity to inventory the user's waste generation rates. As a Humboldt County, California, study attested, however, it is not unusual for many residents to feel no need for a change and be totally satisfied using a dump, especially when increased dollar costs are involved. A third method of eliciting citizen involvement is to encourage community leaders to discuss solid waste problems and issues at various organizational and community meetings. Groups such as garden clubs, Chambers of Commerce, Granges, Scouting or 4-H organizations, conservation groups, and social clubs all can serve as excellent meeting forums. Schools may also be visited and students informed about what is being done.

The news media should be contacted so it can inform the public through press releases, tabloids, and radio and television spots. News media personnel can be especially helpful as members of the original planning group. Actually the public support techniques which can be used are limited only by the ingenuity of the planning group. Successful approaches have included:

- Using a slide presentation at a county fair to present a new solid waste system
- Developing a visual display on a project for community shopping centers and post offices
- Dividing an area into districts where interested and respected community leaders were responsible for selling the new methods to their area

- Giving school children certificates for students and parents to sign stating that they will be environmentally-minded
- Preparing booklets on improved practices for distribution throughout a community
- Touring solid waste systems in other communities that have made improvements
- Conducting general clean-up and beautification campaigns in conjunction with the start-up of a new solid waste system

The residents not only need to be sold on the new practices; they need to know what is expected of them--where and when they should take their wastes, and how different types of wastes should be stored and disposed of. The users should also be informed of how the system is paid for.

Unless the community supports the system, even with substantial legal enforcement, the chance of success of improved practices is remote. In some cases, where changes have been made as a result of State legislative requirements and without local citizen acceptance, overt resistance has ensued. Enforcement of solid waste ordinances should be necessary only to encourage the few dissenters of a community into proper action and not to bludgeon a community into acquiescence.

Community education and acceptance continue to be important even after the new methods are in operation. Adequate handling of citizen complaints is essential, and mechanisms for efficiently receiving complaints or recommendations are advantageous . One area keeps suggestion boxes and forms at each of the unattended transfer stations; another area has a toll-free phone system to a county office for suggestions or complaints..

Whatever solid waste practices are ultimately decided upon, a massive program to inform the public is a necessity. Whether it involves a program to solicit voluntary subscribers for a "mailbox" system or to encourage proper usage of a container site or transfer station, user acceptance is mandatory. No matter how adequate the proposed methods and financing, strong citizen support is crucial to the success of any rural solid waste management system .

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