COMMENT It should be noted that there is no single correct solution to this problem. It just works out that some solutions are better than others when they are implemented. It is only with experience that an intuitive sense can be developed about the layout of collection routes.

Schedules

A master schedule for each collection route should be prepared for use by the engineering department and the transportation dispatcher. A schedule for each route, on which can be found the location and order of each pickup point to be serviced, should be prepared for the driver. In addition, a route book should be maintained by each truck driver.

Transfer and Transport

The functional element of transfer and transport refers to the means, facilities, and appurtenances used to effect the transfer of wastes from relatively small collection vehicles to larger vehicles and to transport them over extended distances to either processing centers or disposal sites. Transfer and transport operations become a necessity when haul distances to available disposal sites or processing centers increase to the point that direct hauling is no longer economically feasible. See Example 11-4.

Example 11-4: Economic comparison of transport alternatives Determine the break-even time for a stationary-container system and a separate transfer and transport system for transporting wastes collected from a metropolitan area to a landfill disposal site. Assume the following cost and system data are applicable.

1. Transportation costs:
   a. Stationary-container system using an 18-m^3 compactor = \$20/h
   b. Tractor-trailer transport unit with a capacity of 120 m^3 = \$25/h
2. Other costs:
   a. Transfer station operating cost, including amortization = \$0.40/m^3
   b. Extra cost for unloading facilities for tractor-trailer transport unit = \$0.05/m^3
3. Other data:
   a. Density of wastes in compactor = 325 kg/m^3
   b. Density of wastes in transport units = 150 kg/m^3

SOLUTION

1. Convert cost data to units of dollars/tonne · min.
   a. Stationary-container system:

$$\text{Operating cost} = (\$20.00/\text{h})/(60\ \text{min/h}) = \$0.33/\text{min}$$

$$\text{Tonnes/load} = \frac{18\ \text{m}^3 \times 325\ \text{kg/m}^3}{1000\ \text{kg/tonne}} = 5.85$$

$$\text{Operating cost} = (\$0.33/\text{min})/5.85\ \text{tonne} = \$0.0564/\text{tonne} \cdot \text{min}$$

b. Transfer-transport system:

$$\text{Operating cost} = (\$25.00/\text{h})/(60\ \text{min/h}) = \$0.42/\text{min}$$

$$\text{Tonnes/load} = \frac{120 \times 150}{1000} = 18$$

$$\text{Operating cost} = (\$0.42/\text{min})/18\ \text{tonnes} = \$0.0233/\text{tonne} \cdot \text{min}$$

c. Transfer station cost:

$$\text{Operating cost} = (\$0.40/\text{m}^3)/(0.150/\text{tonne}) = \$2.47/\text{tonne}$$

d. Unloading cost:

$$\text{Operating cost} = (\$0.05/\text{m}^3)/(0.150/\text{tonne}) = \$0.33/\text{tonne}$$

2. Prepare a plot of cost versus haul time in minutes and determine break-even time.

a. Fixed cost for transfer and transport system:

$$\text{Cost/tonne} = \$2.67 + \$0.33 = \$3.00$$

b. Variable costs at 100 min:

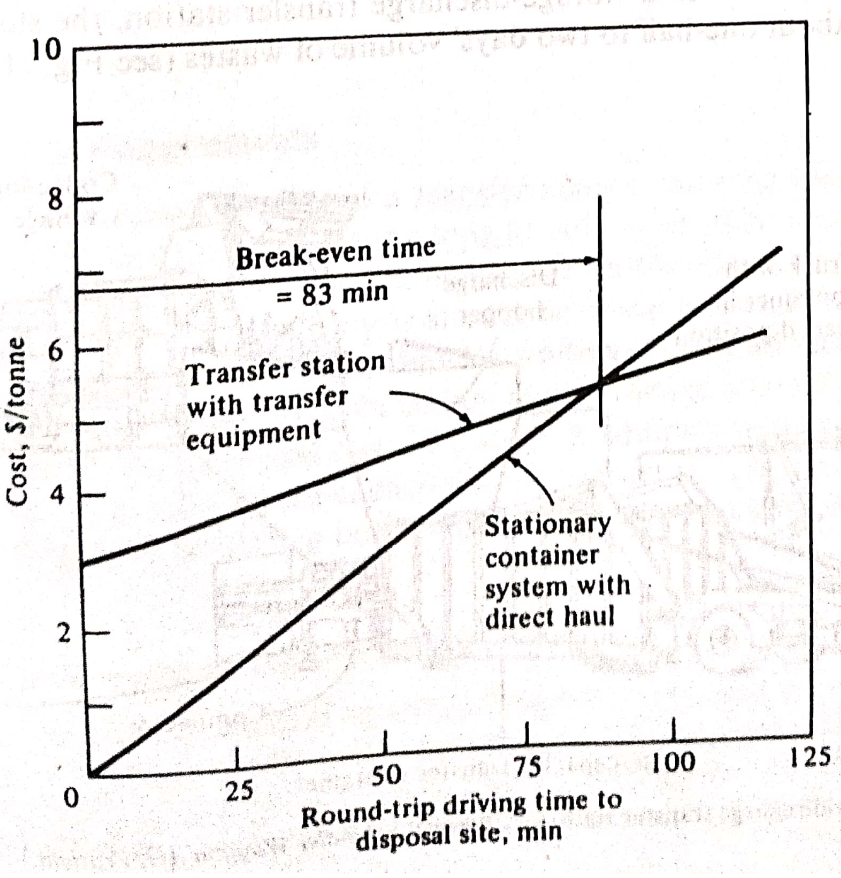
(1) Stationary-container system

$$\text{Cost/ton} = (\$0.0564/\text{tonne} \cdot \text{min})100\ \text{min} = \$5.64$$

(2) Transport system

$$\text{Cost/ton} = (\$0.0233/\text{tonne} \cdot \text{min})\ 100\ \text{min} = \$2.33$$

c. The above data are plotted in the accompanying figure. As shown, the break-even time is equal to 83 min.



11-12 TRANSFER STATIONS

Important factors that must be considered in the design of transfer stations include: (1) type of transfer operation to be used, (2) capacity requirements, (3) equipment and accessory requirements, and (4) environmental requirements. Depending on the method used to load the transport vehicles, transfer stations may be classified into three types: (1) direct discharge, (2) storage discharge, and (3) combined direct and storage discharge.

Direct Discharge

In a direct-discharge transfer station, wastes from the collection vehicles usually are emptied directly into the vehicle to be used to transport them to a place of final disposition. To accomplish this, these transfer stations usually are constructed in a two-level arrangement. The unloading dock or platform from which wastes from collection vehicles are discharged into the transport trailers is elevated, or the transport trailers are located in a depressed ramp. Direct-discharge transfer stations employing stationary compactors are also popular (see Fig. 11-11).

Storage Discharge

In the storage-discharge transfer station, wastes are emptied either into a storage pit or onto a platform from which they are loaded into transport vehicles by various types of auxiliary equipment. In a storage-discharge transfer station, the storage volume varies from about one-half to two days' volume of wastes (see Fig. 11-12).

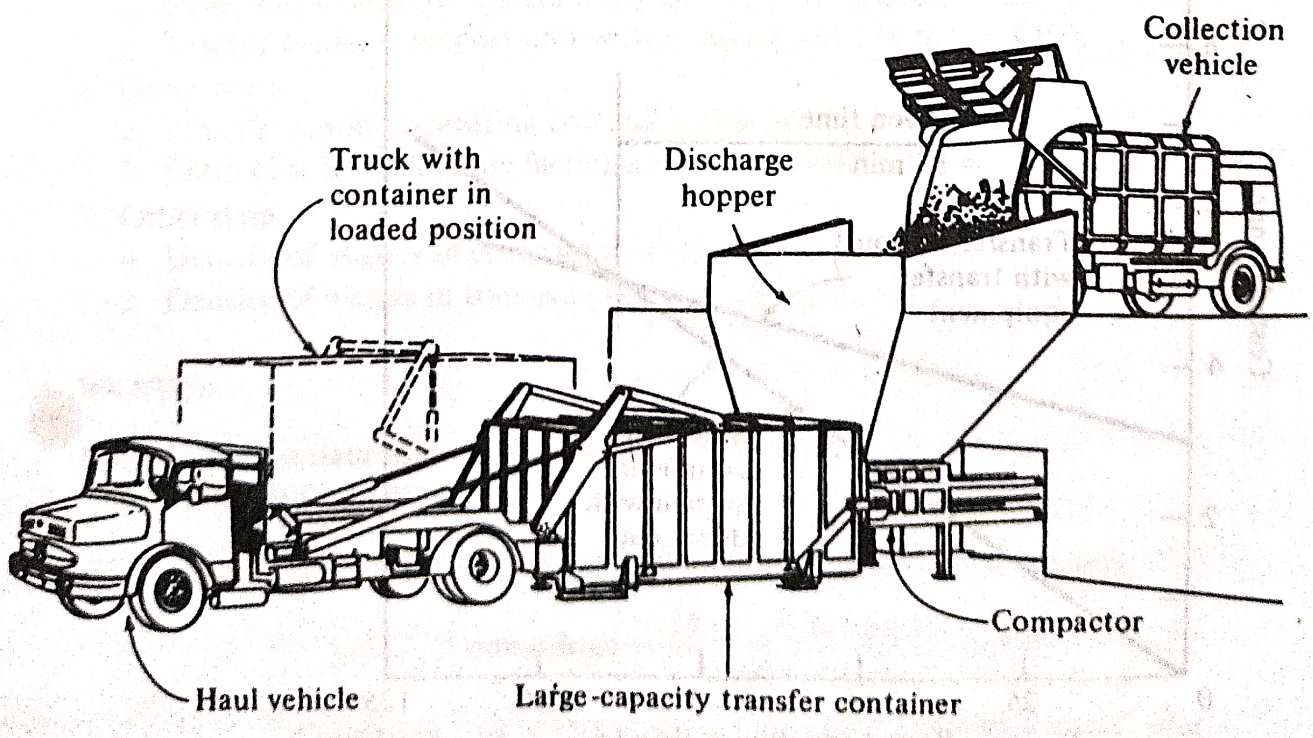


Figure 11-11 Typical direct-discharge transfer station. (*Courtesy Schindler Waggon AG, Prattein.*)

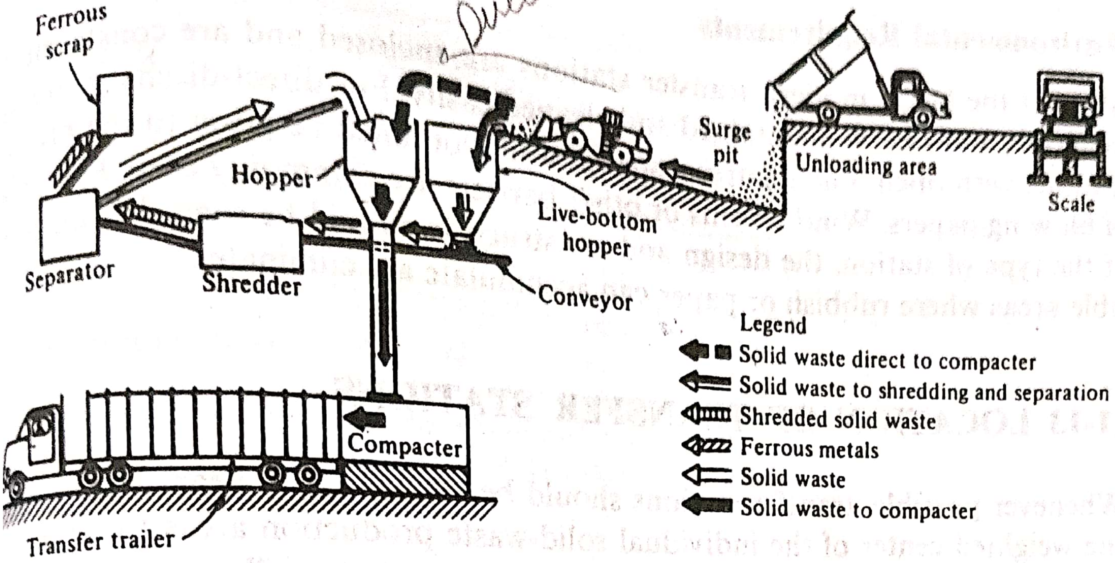


Figure 11-12 Typical storage-discharge transfer station. (*Courtesy of Municipality of Metropolitan Toronto, Department of Public Works.*)

Combined Direct and Storage Discharge

In some transfer stations, both direct-discharge and storage-discharge methods are used. Usually, these are multipurpose facilities designed to service a broader range of users than a single-purpose facility. In addition to serving a broader range of users, a multipurpose transfer station can also house a materials-salvage operation.

Capacity Requirements

The operational capacity of a transfer station must be such that the collection vehicles do not have to wait too long to unload. In most cases, it will not be cost-effective to design the station to handle the ultimate peak number of hourly loads. An economic trade-off analysis should be made between the annual cost for the time spent by the collection vehicles waiting to unload against the incremental annual cost of a larger transfer station and/or the use of more transport equipment. Because of the increased cost of transport equipment, a trade-off analysis must also be made between the capacity of the transfer station and the cost of the transport operation, including both equipment and labor components.

Equipment and Accessory Requirements

The types and amounts of equipment required vary with the capacity of the station and its function in the waste-management system. Specifically, scales should be provided at all medium and large transfer stations both to monitor the operation and to develop meaningful management and engineering data.

Environmental Requirements

Most of the large, modern transfer stations are enclosed and are constructed of materials that can be maintained and cleaned easily. For direct-discharge transfer stations with open loading areas, special attention must be given to the problem of blowing papers. Wind screens or other barriers are commonly used. Regardless of the type of station, the design and construction should be such that all accessible areas where rubbish or paper can accumulate are eliminated.

11-13 LOCATION OF TRANSFER STATIONS

Whenever possible, transfer stations should be located (1) as near as possible to the weighted center of the individual solid-waste production areas to be served, (2) within easy access of major arterial highway routes as well as near secondary or supplemental means of transportation, (3) where there will be a minimum of public and environmental objection to the transfer operations, and (4) where construction and operation will be most economical. Additionally, if the transfer-station site is to be used for processing operations involving materials recovery and/or energy production, the requirements for those operations must be considered.

11-14 TRANSFER MEANS AND METHODS

Motor vehicles, railroads, and ocean-going vessels are the principal means now used to transport solid wastes. Pneumatic and hydraulic systems have also been used. Still other systems have been suggested, but most have not been tested.

Motor Vehicle Transport

Motor vehicles used to transport solid wastes on highways should satisfy the following requirements: (1) the vehicles must transport wastes at minimum cost, (2) wastes must be covered during the haul operation, (3) vehicles must be designed for highway traffic, (4) vehicle capacity must be such that allowable weight limits are not exceeded, and (5) methods used for unloading must be simple and dependable. The maximum volume that can be hauled in highway transport vehicles depends on the regulations in force in the state in which they are operated.

In recent years, because of their simplicity and dependability, open-top trailers and semitrailers have found wide acceptance (see Table 11-9 and Fig. 11-13) for the transport of wastes. Some trailers are equipped with sumps to collect any liquids that accumulate from the solid wastes. The sumps are equipped with drains so that they can be emptied at the disposal site.

Methods used to unload the transport trailers may be classified according to whether they are self-emptying or require the aid of auxiliary equipment. Self-emptying transport trailers are equipped with mechanisms such as hydraulic

Table 11-9 Typical data on haul vehicles used at transfer stations

Type	Capacity per trailer, m^3	Capacity per trailer, Tonnes	Length of tractor and trailer units, m*
Tractor-trailer-trailer	54	11.4	
	54	10.0	19.8
Tractor-trailer	74	17.3	18.3
Tractor-compactor trailer	58	18	14.0

* Overall length will vary with the type of tractor (e.g., conventional or cab-over) and the turning radius of the trailers.

dump beds, powered diaphragms or moving floors that are part of the vehicle (see Fig. 11-14). Moving-floor trailers are an adaptation of equipment used in the construction industry. An advantage of the moving-floor trailer is the rapid turnaround time (typically 6 to 10 min) achieved at the disposal site without the need for auxiliary equipment. Unloading systems that require auxiliary equipment are usually of the "pull-off" type, in which the wastes are pulled out of the truck by either a movable bulkhead or wire-cable slings placed forward of the load. The disadvantage of requiring auxiliary equipment and work force to unload at the disposal site is relatively minor in view of the simplicity and reliability of these methods.

Another auxiliary unloading system that has proved very effective and efficient involves the use of movable, hydraulically operated tipping ramps located at the

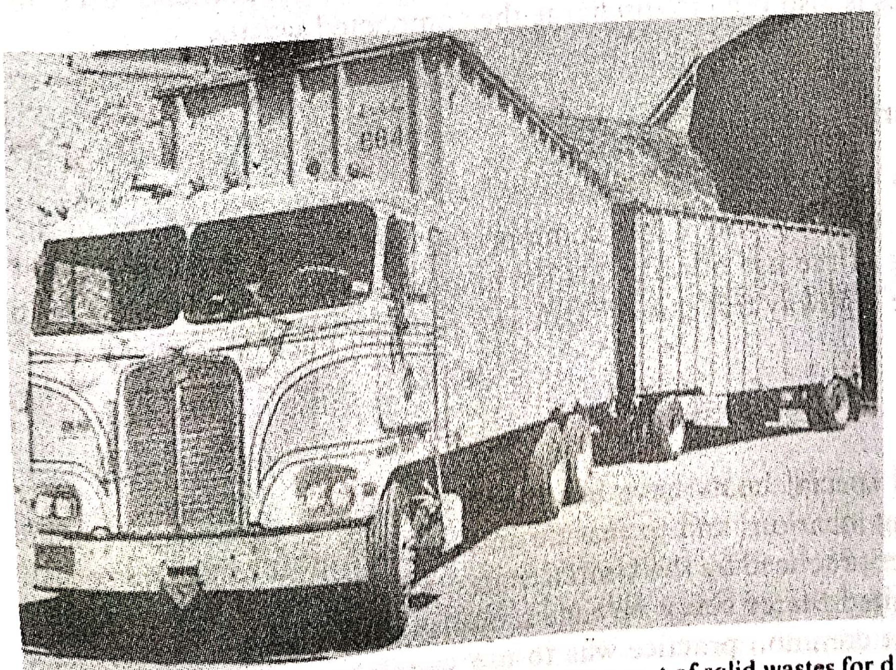


Figure 11-13 Typical large vehicles used for the transport of solid wastes for disposal.

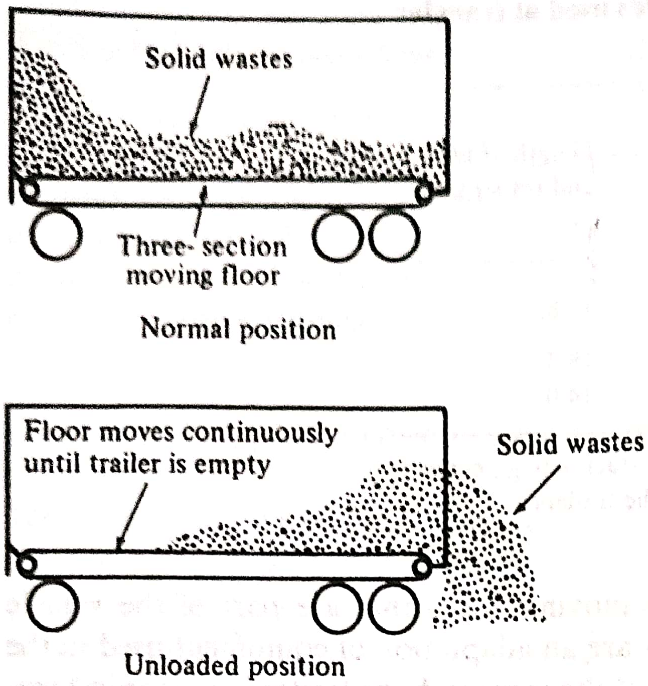


Figure 11-14 Typical self-emptying transport trailer.

disposal site (see Fig. 11-15). Operationally, the semitrailer of a tractor-trailer-trailer combination is backed up onto one of the tipping ramps; the tractor-trailer combination is backed up onto a second tipping ramp. The backs of the trailers are opened, and the units are then tilted upward until the wastes fall out by gravity. The time required for the entire unloading operation typically is about 5 min/trip.

Large-capacity containers and container trailers are used in conjunction with stationary compactors at transfer stations. In some cases, the compaction mechanism is an integral part of the container. When containers are equipped with a self-contained compaction mechanism, the movable bulkhead used to compress the wastes is also used to discharge the compacted wastes.

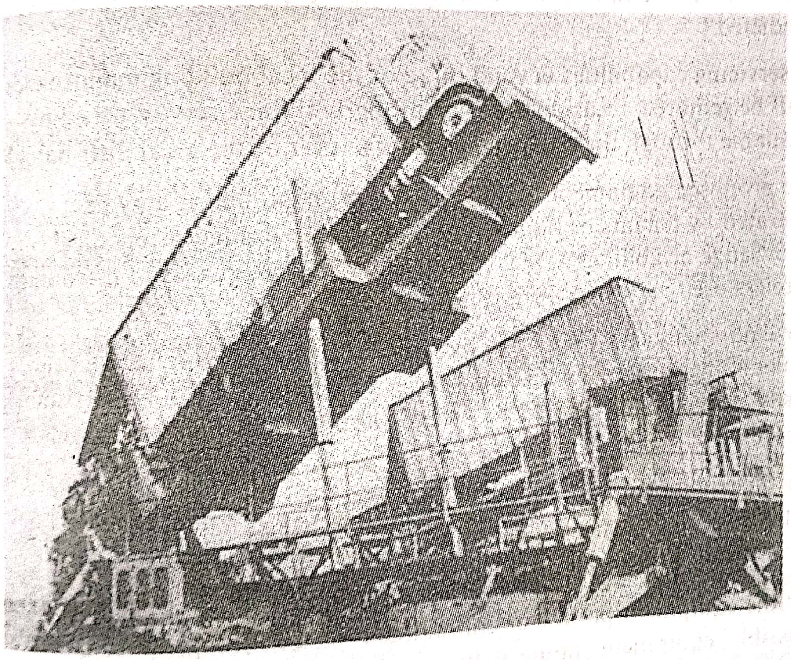
Railroad Transport

Although railroads were commonly used for the transport of solid wastes in the past, they are now used by only a few communities. However, renewed interest is again developing in the use of railroads for hauling solid wastes, especially to remote areas where highway travel is difficult and railroad lines now exist.

Water Transport

Barges, scows, and special boats have been used in the past to transport solid wastes to processing locations and to seaside and ocean disposal sites, but ocean disposal is no longer practiced by the United States. Although some self-propelled vessels (such as United States Navy garbage scows and other special boats) were once used, the most common practice was to use vessels towed by tugs or other special boats.

(a)



(b)

Figure 11-15 Hydraulically operated tipping platforms for unloading transport vehicles.

Pneumatic Transport

Both low-pressure air and vacuum conduit transport systems have been used to transport solid wastes. The most common application is the transport of wastes from high-density apartments or commercial activities to a central location for processing or for loading into transport vehicles. The largest pneumatic system now in use in the United States is at the Walt Disney World amusement park in Orlando, Florida.