Chapter B-1

Performance of transfer system in Mumbai

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B-1.1 INTRODUCTION

The centre or main business district of Mumbai is at the southern end of the peninsula, and traffic conditions are very congested during the daytime. From many parts of the city a refuse collection truck could make only one journey to the disposal site in one shift. It follows that, for the sake of economy, the vehicles that make this long and slow journey each day should be carrying the largest possible volume of waste. Large vehicles are not suitable for collecting waste in a congested city centre, so transfer is necessary, transferring waste from the smaller collection vehicles to the large bulk transport vehicles that take the waste to the disposal site. This chapter is concerned with the way this transfer and transport system was working in Mumbai in 1993.

Three different types of vehicles were employed for refuse collection in Central Mumbai:

- ◊ Compactor trucks, operated and owned by the MCGM, in conjunction with trolley containers. Some compactors were deployed for house-to-house collection.
- ◊ Dumper-placer trucks, operated and owned by the MCGM, for clearance of large capacity community containers.
- ◊ Open trucks, mostly operated by private contractors and rented to the MCGM for refuse collection.

All dumper-placers and some compactors delivered refuse to a transfer station at Mahalaxmi where the loads were transferred to large capacity trucks for bulk transport to Deonar dumping ground, some 21 kilometres north-east of Mahalaxmi.

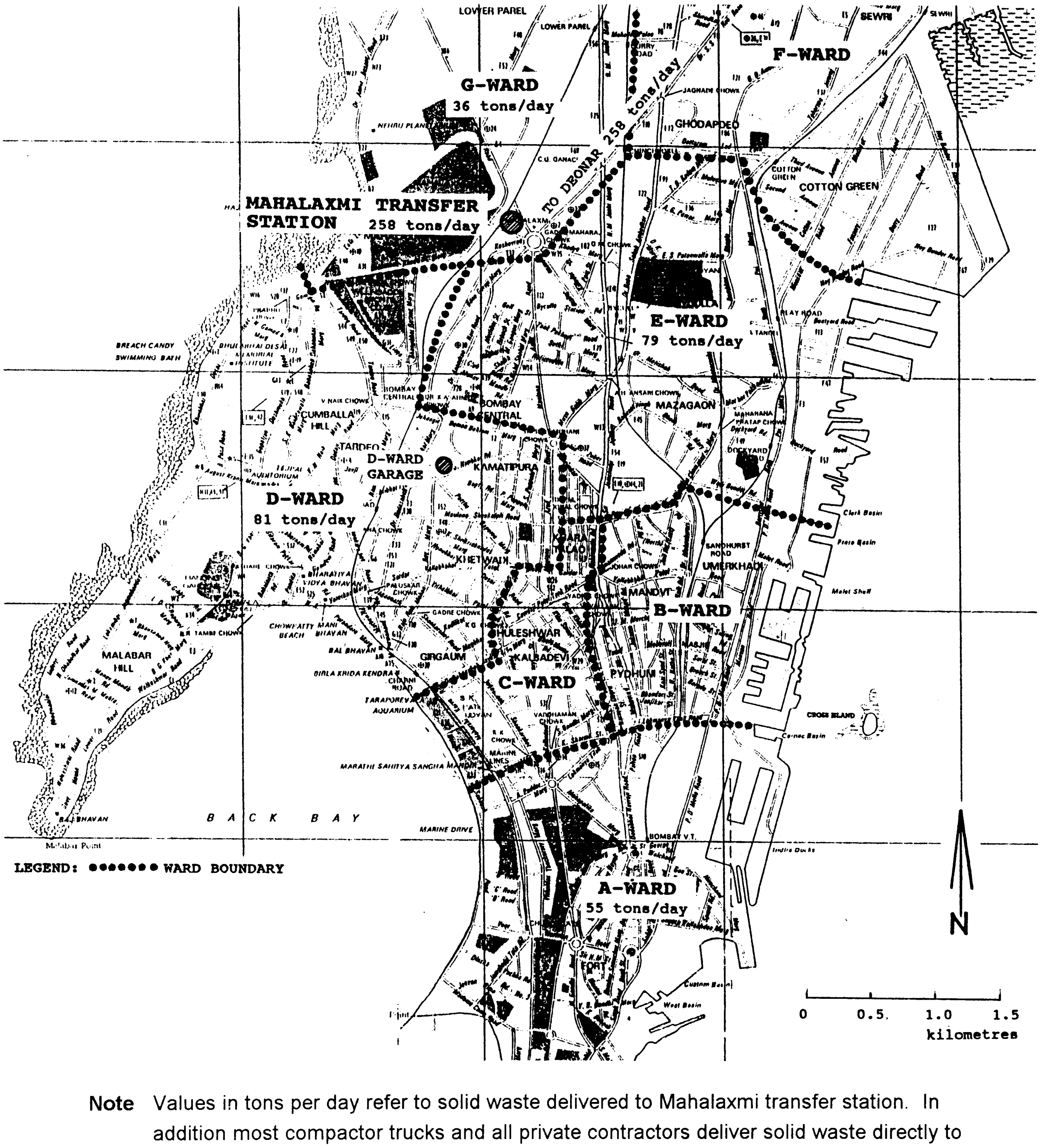
Trucks and drivers were under the Transport Department of the MCGM, and operated, maintained, and repaired through garages of this department. The vehicles were provided to the Conservancy Department on a rental basis and assigned to particular areas. Workers and mukadams of vehicles were under the Conservancy Department and supervision was through motor loader chowkies of this department. (See appendix 1 at the end of the report for explanations of Indian terms.)

Data on operations were obtained from records maintained at the transfer station and by observing operations. This information has been used to estimate costs for primary collection, bulk transport and transfer operations and to estimate total costs of the combined system. In addition, the information has been analysed to suggest possible improvements and to compare costs of alternative arrangements with the present system.

B-1.2 MAHALAXMI TRANSFER STATION

Solid waste transfer at Mahalaxmi has been practised for decades. Transfer is necessary because of the heavy traffic in Central Mumbai and the long distances to disposal sites. Until 1973, a rail transfer system was used to carry refuse from Mahalaxmi to Deonar. Operations were relatively complex because the refuse wagons had to change tracks three times - at Dadar, Kurla and at the junction to the Deonar landfill. With increasing passenger transport the railway became more and more congested and a road transport system had to be introduced in 1976. Mahalaxmi station was modified to allow for refuse transfer to large capacity trucks. The transfer station was extended to its present capacity between 1990 and 1992.

Figure B-1.1 shows the location of the transfer station in relation to other important features. It is clear that a very appropriate location was chosen to accommodate the transfer station - located north of the highly congested city centre, along the road to Deonar, and linked to the road network from the city and to the landfill. The station received waste from four different wards, namely A, D, E and G. Haul distances for primary collection vehicles were usually less than five kilometres, with a maximum of about ten kilometres from the A-South area. Refuse from Wards B and C was mainly collected by compactor trucks which carried their loads directly to Deonar.



Note Values in tons per day refer to solid waste delivered to Mahalaxmi transfer station. In addition most compactor trucks and all private contractors deliver solid waste directly to Deonar landfill site. All waste from Wards B, C, and F is hauled directly to Deonar.

Figure B-1.1: Location map

Based on records maintained at Mahalaxmi (see appendix BB-1.1) it is estimated that about 260 tons of refuse were passing through this station each day.

Table B-1.1 Refuse quantities at Mahalaxmi Transfer Station

Shift	Dumper-placers (a)	Open trucks (b)	Compactors (c)	Total
Morning	86.1 x 1.1 = 95 tons	7.3 x 2.4 = 18 tons	4.7 x 5.0 = 24 tons	137 tons (53%)
Afternoon	65.3 x 1.1 = 72 tons	7.4 x 2.4 = 18 tons	0	90 tons (35%)
Night	27.8 x 1.1 = 31 tons	0	0	31 tons (12%)
Total [tons/day]	179.2 x 1.1 = 198 (77%)	14.7 x 2.4 = 36 (14%)	4.7 x 5.0 = 24 (9%)	258

Notes: Data according to Appendix BB-1.1, one week considered.
(a) Number of trips per shift x estimated average load 1.1 tons per trip
(b) Estimated average load 2.4 tons per trip
(c) Estimated average load 5.0 tons per trip

It is shown that the largest proportion of the refuse was being delivered by dumper-placer vehicles (77%). Open trucks of the MCGM contributed about 14 % and compactor trucks some 9 %. These compactors were exclusively employed for house to house collection (in D-Central) whereas other compactors (those collecting refuse from trolley containers) as well as open trucks of contractors carried their loads directly to Deonar landfill. (The reason why the compactors collecting house-to house went to the transfer station was probably that this collection process took longer than other methods and so there was insufficient time to go to the disposal site.)

The transfer station consists of a very substantial structure, comprising a platform with a length of about 140 metres. Up to 14 bulk refuse carriers (BRC) may be parked at either side of the platform and the elevated part (width 18.5 metres) provides sufficient space for manoeuvring of primary collection vehicles during unloading to either side of the station. Slopes of the ramp are moderate (about 6.0 %) and easy to climb for full vehicles. Space is no problem and only one side of the platform was being utilised, while still leaving sufficient space between BRCs to allow individual vehicles to move in or out. In addition, parts of the platform were used to store old containers.

The organisation of transfer operations was closely linked to the primary and bulk transfer system. Primary collection by dumper-placer vehicles and refuse transfer by bulk refuse carriers are discussed in sections B-1.3 and B-1.4 respectively, before the transfer system at Mahalaxmi is analysed in section B-1.5.

B-1.3 PRIMARY COLLECTION BY DUMPER-PLACER VEHICLES

Dumper-placer trucks are designed to load, carry and unload a single container (capacity about 4 m^3). This type of vehicle has been employed in Central Mumbai since about 1987. At the time of the study, 18 dumper-placer vehicles were being used to deliver refuse to the transfer station.

a) Dumper-placer trucks

Most of the dumper-placer trucks were maintained at D-Ward Garage. Out of 17 vehicles, 14 were in service and 3 were kept as standby. This is equal to a standby factor of 1.21 (17 / 14), which seems adequate for this type of vehicle. Two different chassis were employed -TATA (6 trucks, purchased 1987) and Ashok Leyland (11 trucks, purchased 1991). [Maintenance records for this type of vehicle are shown in appendix DD-1.2.]

Maintenance and repair of the vehicles seemed to cause few problems. According to information obtained at D-Ward Garage, the hydraulic systems were very reliable and had not failed so far. Some problems with the power takeoff units of the Leyland vehicles had been experienced. It is clear from Appendix BB-1.1 that the number of trucks in service was very constant throughout the week and that only in one out of 286 trips (morning shift, A-South, 30.11.95) were operations short of a single vehicle.

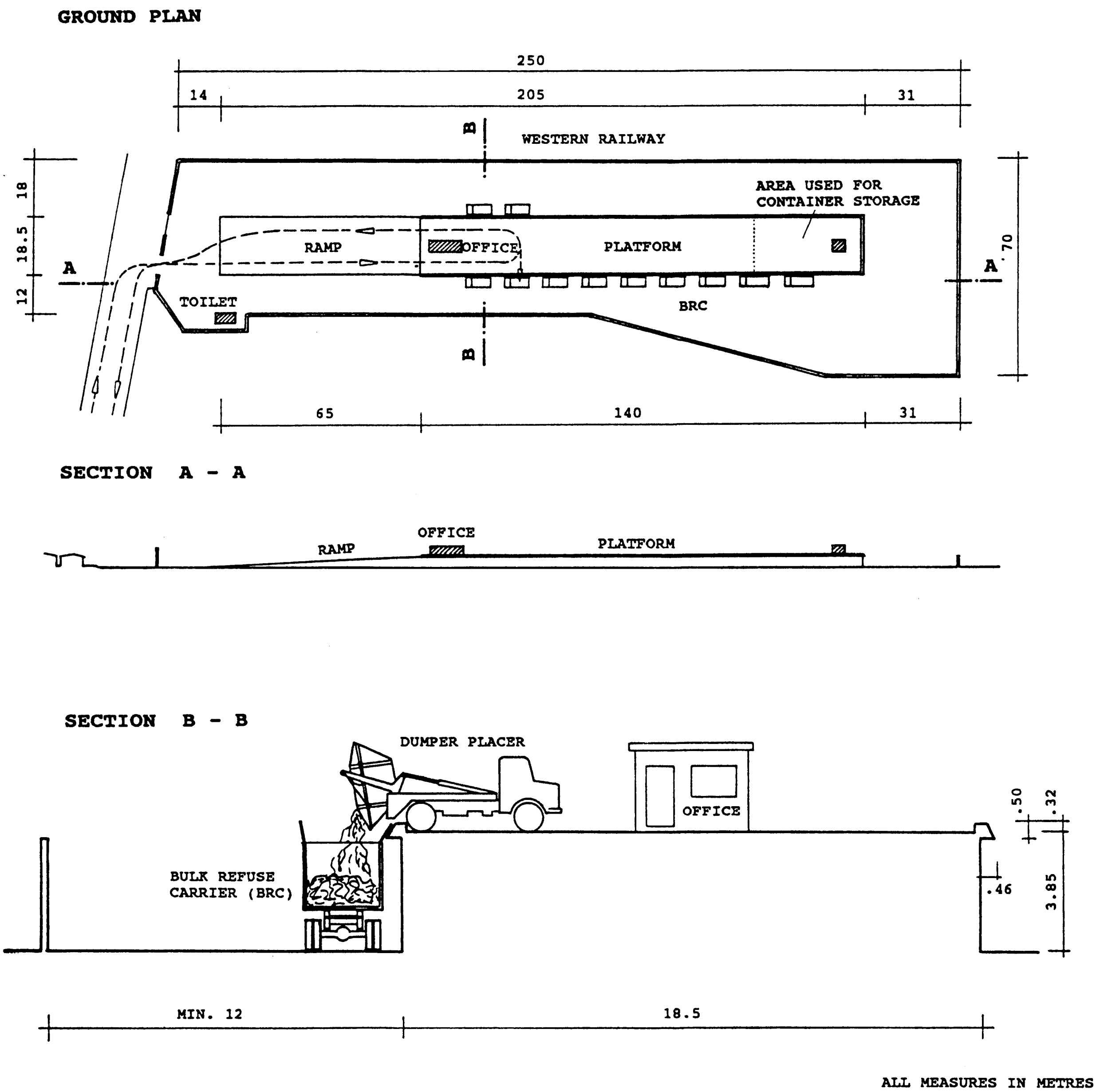


Figure B-1.2: Layout of Mahalaxmi Transfer Station

Dumper-placers were originally designed to collect containers from construction sites, handling heavy material like debris. Refuse is much lighter and therefore only a fraction of the permissible payload can be utilised if this type of vehicle is employed for solid waste collection.

Table B-1.2 indicates that even very heavy refuse with a density of 0.5 tons/m^3 (e.g. during monsoon) would only allow about 60 % of the vehicle's permissible payload to be utilised, and that common loads are well below 50 % of the payload capacity. This leads to relatively high vehicle costs because a large chassis and engine are used to collect small quantities of refuse. Therefore long range transport by dumper-placer vehicles is ruled out on grounds of economics and, in the case of Mumbai City, refuse transfer is a basic requirement.

Table B-1.2 Payload capacity of dumper-placer vehicles

				Notes
Permissible GVW	tons	12.0	(note 1)	1. TATA chassis 1210 (GVW 12 tons, 100 HP). GVW according to weights written on cab 15.7 tons. This seems too high and is not considered
Chassis and engine weight	tons	6.5	(note 2)	2. Empty weight written on cab of TATA chassis type 1210. It is assumed that the body weight is not included.
Body weight	tons	1.5	(note 3)	3. Estimated values
Container weight	tons	0.5	(note 3)	
Permissible payload	tons	3.5		
Container capacity	m^3	4.0		
Refuse density	tons/ m^3	0.3 - 0.5		
Actual payload	tons	1.2 - 2.0		

Suggestions: One option for improving the performance of dumper-placer vehicles would be to increase the container capacity by about 50% from about 4.0 m^3 to at least 6.0 m^3. However, major alterations of the body would be required and containers with higher sides are probably not desirable.
It may be more appropriate to use a smaller chassis to carry a similar body arrangement. For instance, the new (1993) TATA 0608 chassis (GVW 06 tons, 80 HP) could be employed for this purpose.
Alternatively. roll-off container trucks may be more suitable because this type of vehicle is capable of carrying larger containers (since the container can be as wide as the chassis, whereas the width of a dumper-placer container is limited by the space between the lifting arms). Market research is suggested to find out whether suitable vehicles are available in India.

b) Organisation and records

As with other vehicles of the MCGM, records of dumper-placer trucks were being maintained by the Garage (on behalf of the Transport Department) and drivers were obliged to keep log sheets requiring the following information

Name - licence plate - working area - containers attended - time out - time in - /mileage

Personnel at the D-Ward Garage were well aware of typical vehicle operational data such as average mileage, working hours and fuel consumption.

All trucks stopped at the motor loader chowki at the beginning and end of each shift and log books were stamped by the Junior Overseer (Conservancy Department). He was responsible for organising the clearance of containers. Locations to be attended were written on the back of the log sheets at the beginning of each shift and confirmed by the mukadam of the vehicle after clearance of individual containers. Log sheets were further used by the depot attendant at Mahalaxmi transfer station for keeping the tip register.

Suggestion: It is proposed to record additional information regarding the degree of filling of containers (e.g. 50%, 75%, 100%) on log sheets. This would help to adjust the clearance frequency of individual locations according to requirements. Provided that this suggestion is followed the log sheet system seems appropriate for controlling and monitoring operations. Further investigations are suggested regarding organisation, supervision and control of container clearance by the Conservancy Department.

c) Crew size

Crews of dumper-placer vehicles consisted of one driver, one attendant to assist the driver (e.g. fitting of lifting chains), and one mukadam to guide the vehicle and to supervise container clearance according to daily orders of the conservancy department.
In addition, six workers were assigned to each vehicle and responsible for cleaning the locations of the containers in the vehicle's area of operation. Depending on the haul distance, three to seven containers were cleared per shift, hence one to two workers were employed per container. There was not sufficient space in the vehicle's cabin to accommodate the workers and so they remained in the area and were supervised by the mukadam during container pick-up operations.
It has been mentioned that the crew size was based on the Union's policy that six motor loaders should be employed per truck, regardless of the type of vehicle. As a result, a simple and manually loaded truck was being operated by the same number of loaders as a dumper-placer vehicle equipped with a fully mechanised loading system.

Suggestions: It does not seem appropriate to assign workers for cleaning container locations to the vehicle. More than one person per container was employed full-time for cleaning. This is considered excessive and not justifiable. Street sweepers, who were also assigned to the localities, should be in charge of cleaning container locations (similar to the trolley container system) and mukadams based in the locality should be in charge of supervising labour. Further investigations are suggested to study whether existing sweepers are capable of taking over additional work or whether some additional sweepers are required to keep container locations tidy.

Another arrangement, which appears very promising, was observed in D-Ward - some container locations were handed over to rag pickers for cleaning. The rag-pickers were given an exclusive right to collect recyclable material from the containers and, in return, they were required to keep the locations in a clean condition. This proved successful and the locations were being kept very tidy at no cost. It is therefore suggested that this arrangement be extended to as many areas as possible. This would allow a very significant reduction in the costs of the dumper-placer system [see section B-1.3 (g) below].

In addition, there seems to be no need to assign one mukadam to each vehicle. The driver and his assistant would be sufficient to carry out the orders obtained from the J.O. at the motor loader chowki.

d) Working time of vehicle crews

Time records of a dumper-placer vehicle (morning shift, dumper-placer MH-X) are analysed in Appendix BB-1.2.1. The vehicle was employed in A-North Ward and carried four container loads to Mahalaxmi transfer station. Results are summarised in table B-1.3.

Table B-1-3 Time requirements of dumper-placer MH-X

Time, a.m.	Duration of trip, minutes				Time a.m.	Working time
Garage	1st trip	2nd trip	3rd trip	4th trip	Garage	(hours, min.)
7.06	38 (a)	43	50	89 (b)	10.58	3 h 51 m

Notes Time requirements are average values, based on records obtained at Mahalaxmi Transfer Station (tip register), one week considered (30.11.93 to 06.12.93).
(a) including time to report at A-Ward motor loader chowki.
(b) including time to report at A-Ward motor loader chowki and tea break.

The data indicate that the time to complete one round trip is constantly increasing from 38 minutes (first trip) to ultimately 89 minutes (last trip). To some extent this may be due to increasing traffic in Central Mumbai. In addition, the last trip includes about 30 minutes for a tea break. The results also show that the average working time of the crew was slightly less than 4 hours. Considering that the morning shift was from 6.00 am to 2.00 pm (8 hours), the crew were spending less than 50 % of the shift on the job.

Appendix BB-1.2.1 also shows time values which are based on measurements made when following the vehicle on 8 December. Perhaps because they were being observed, the crew spent more than five hours to complete their usual daily programme (four round trips). One reason for the longer period was that the vehicle was being driven extremely slowly, whereas the vehicle's mileage did not vary significantly from a normal day. When arriving at the motor loader chowki at 11.46 am, the building was already locked and the vehicle had to leave without clearance from the J.O..

However, only one vehicle was studied like this in more detail, and results may be not representative of other cases. Therefore additional data from the tip register at Mahalaxmi Transfer Station were analysed in Appendix BB-1.2.2. Results are summarised below:

Morning shift:	82 out of 100 trips between 7.25 and 11.00 am (less than 4 hours, official shift until 2.00 pm)
Afternoon shift:	69 out of 75 trips between 2.25 pm and 6.00 pm (less than 4 hours, official shift until 10.00 pm)
Night shift:	26 out of 28 trips between 10.30 pm and 2.00 am (less than 4 hours, official shift until 6.00 am).

The data indicate the bulk of the work (87 %), whether in the morning, afternoon or night shift, is completed within the first four hours of the shift.

***Suggestions*:** Based on the data obtained the performance of vehicles could be increased by a factor of about two by extending the working time of crews to 8 hours (including tea breaks). However, this is probably not realistic. Working for six hours per shift may be acceptable if, in return, crews are permitted to leave the job earlier. Shifts could be adjusted to 6 hours as follows:

Morning shift	6.30 am to	12.30 pm.
Afternoon shift	12.30 pm to	6.30 pm.
Evening shift	6.30 pm to	0.30 am.

Drivers would have to be asked to attend 10 minutes earlier in order to leave the garage on time.

If this suggestion were followed, the performance of the system would increase by about 50 %. In addition, shorter shifts would lead to more balanced vehicle arrivals at Mahalaxmi as shown in Appendix BB-1.2.3. This is of particular importance when planning bulk transfer operations and will be further discussed in section B-1.4 (b).

e) Comparative performance of different shifts

Records presented in appendix BB-1.1 are employed in table B-1.4 to compare the performance of dumper-placer vehicles in the morning, afternoon and night shifts.

Table B-1.4 Comparative performance of different shifts

	morning shift		afternoon shift		night shift	
	vehicles	trips	vehicles	trips	vehicles	trips
total number	17.9	86.1	17.0	65.3	6.0	27.8
trips per vehicle	4.8		3.8		4.6	

The data indicate that the afternoon shift achieves about one trip less than the morning and night shift.

***Suggestions*:** Although time did not allow a study of the afternoon arrangements, it seems not acceptable that the performance is 20 % less than the morning and night shift. Further investigations are suggested to evaluate and adjust afternoon assignments. Either more containers should be assigned to each crew or, if the number of filled containers would not allow an increase in the total workload, the number of afternoon crews should be reduced.

Table B-1.5 provides an idea regarding what could be achieved if a 50% increase in workload were assigned to the crews and if all shifts were to perform an equal number of trips.

Table B-1.5 Alternative assignment of vehicles and crews

		morning shift	afternoon shift	night shift
Present	Trips per vehicle	4.8	3.8	4.6
	Total no. of trips	86.1	65.3	27.8
	Total no. of vehicles	**17.9**	**17.0**	**6.0**
Proposed	Trips per vehicle	7.2	7.2	7.2
	Total no. of trips	86.1	65.3	27.8
	Total no. of vehicles	**12.0**	**9.1**	**3.9**

Table B-1.5 indicates that the proposed system would allow:

- ◊ a reduction in the number of vehicles from 18 to 12.
- ◊ a reduction in the number of crews from 41 to 25.

f) Container design

The capacity of containers varied between 4 and 4.5 m^3, depending on who had manufactured the container. The containers were fabricated from welded mild steel sheet. Corrosion was severe and containers were phased out after about five years in service.

Most containers were covered by a metal sheet and lids as shown in figure B-1.3.

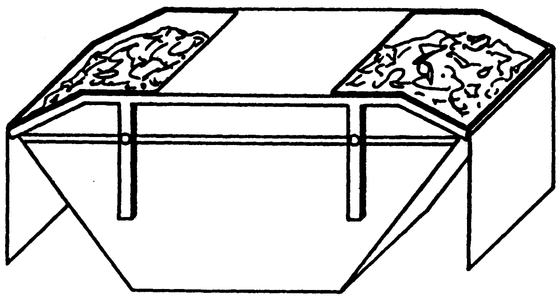


Figure B-1.3 Container with cover and lids

[Note Dumper-placer containers are also discussed in Chapter C-2]

It was observed that this arrangement causes significant problems during operations, in particular:

- ◊ Most lids had been removed because they were damaged during transfer operations. Only two containers were observed that were still equipped with lids, and in both cases the lids were left open during transport. When following different vehicles littering was significant and even large items - such as a cane basket - were blown off at normal speed.
- ◊ The covers caused severe problems during unloading. In nine out of twelve unloading operations that were observed, refuse became wedged in the containers during tipping. Different emptying techniques had been developed by the drivers. One was to drive eight times back and forth against the concrete upstand, with the container still lifted, until the container was finally empty. Other drivers lowered the container back onto the truck, drove forward, stopped suddenly to loosen the blockage, then drove back to the edge and repeated the tipping procedure. Up to three of these operations were required before containers were empty. Not only do these blockages cause delays, but they also lead to excessive wear of vehicles and containers.
- ◊ It was further observed that a void develops below the cover while the containers were being filled, so that the container capacity was not fully utilised. In addition, once the container was almost full, people placed refuse on top of the cover and it was necessary for an attendant to remove this material before the container could be taken away. A wooden stick was employed to fill the void and obtain sufficient space for the material from the cover. This procedure caused long waiting periods for the vehicles and should be avoided.

***Suggestions*:** It is generally considered doubtful whether suitable solutions for covering this type of container can be developed. In theory, close fitting lids would reduce fly breeding and bad smells. However, this only applies if lids are kept closed. Considering the size of dumper-placer containers it is hardly possible to design lids which are durable and yet light enough to be easy to open and close, so that the public, in particular women and children, would be able to open and close them conveniently.

Therefore the only reasonable purpose for covers is to prevent littering during container transport. In addition to the risk that covers remain open during transport (which seemed to be the practice during the observations) there are much simpler means of avoiding littering. It is proposed that all covers should be removed and that simple nets should be used to cover the waste during transport. Four hooks, one at each corner of a container, may be used together with rubber tubes to fix and remove the net quickly.

Regarding corrosion of containers, it is suggested that some containers should be manufactured, on a pilot basis, from galvanised or corrosion-resistant steel. In particular CorTen type steel, if available in India, may allow a doubling of the life span of containers. Special rods are required for welding such steels and the cost of using this steel would be about 30% more than if standard mild steel were used. (The subject of dumper-placer container design is discussed further in chapter C-2.)

g) Costs of the dumper-placers system

Data and information provided in this chapter are used to calculate unit costs of the present system and to compare costs with two modified systems (Proposals A and B). The proposals are based on the following assumptions:

- ◊ The crew size of vehicles will be reduced to one driver and one assistant. Both proposals operate without motor loaders and mukadam [see B-1.3.(c) above].
- ◊ Proposal A includes the provisions that two more street sweepers per vehicle crew will be assigned to the collection area to clean container locations, and that mukadams of districts become responsible for the supervision of these personnel.
- ◊ In Proposal B, containers are handed over to rag pickers who are given the exclusive right to collect recyclables and who, in return, are expected to keep the locations in a tidy condition.
- ◊ Additional work will be assigned to the crews to increase their performance by 50 %, and, in return, shifts are reduced to 6 hours (as mentioned in B-1.3(d) above).
- ◊ Vehicles of all shifts will achieve a similar performance [see B-3.(e) above].

Costs of the different systems are estimated in Appendix BB-1.2.4 and summarised in table B-1.6.

Table B-1.6 Costs for primary collection by dumper-placers

		Present system	[%]	Proposal A	[%]	Proposal B	[%]
Capital costs - vehicles	Rs/yr	1,58,000	[8.4]	1,58, 000	[13.1]	1,58,000	[17.9]
Capital costs - containers	Rs/yr	28,000	[1.5]	42,000	[3.5]	42,000	[4.8]
Operation and maintenance	Rs/yr	2,50,000	[13.3]	3,74,000	[30.9]	3,74,000	[42.3]
Labour costs per vehicle	Rs/yr	14,40,000	[76.8]	6,35,000	[52.5]	3,09,000	[35.0]
Costs per vehicle	Rs/yr	18,76,000	[100]	12,09,000	[100]	8,83,000	[100]
Performance per vehicle	t/yr	4,015		5,980		5,980	
Costs per ton	Rs/t	467		202		148	
Total daily costs (a)	**Rs/d**	**92,500**		**40,000**		**29,300**	

Note (a) Based on table B-1.1, about 198 tons per day collected by dumper-placers.

The results indicate that only 43 % of the present costs are required to operate Proposal A and that this could be further reduced to 32 % if container locations were cleaned by rag pickers. Potential cost savings for the MCGM are between Rs 52,500 per day (Proposal A) and Rs 63,000 per day (Proposal B).

It has been suggested that making an arrangement with rag-pickers could lead to large numbers of them claiming to be employees of the Municipality and therefore having the right to all the benefits of this position -pay, leave, pensions etc., thereby adding a huge expense to the wages bill of the MCGM which is already very high. There are a number of possible arrangements that could be made with rag-pickers, such as treating them as contractors or employing them for limited periods of time. It is obviously important to consult with experts in employment legislation and to keep the trade unions informed so that such consequences do not arise.

Another issue that might need to be checked is whether there is already an informal "franchise" system in operation among rag-pickers to allocate rights for picking over specific accumulations of waste. If the right of access to a particular dumper-placer container has already been allocated by an informal system - a system set up by rag-pickers and not by the Municipal Corporation - it may be difficult for the Municipality to give the rights to that container as an incentive for someone else.

***Suggestions*:** Considering the present collection costs, the dumper-placer system is probably more expensive than using compactors in conjunction with trolley bins. This is primarily due to the excessive labour costs which could be reduced without negative impacts on the service. Negotiations with vehicle crews and labour unions are suggested to evaluate acceptable conditions to implement the proposals. If negotiations fail, privatisation of the dumper-placer system should be seriously considered. This privatisation could take many forms, such as hiring drivers, leasing vehicles or even selling the vehicle fleet to private contractors.

B-1.4 BULK TRANSFER OF SOLID WASTE

Bulk transfer vehicles are primarily employed to reduce refuse transport costs to a minimum and to increase the performance of primary collection vehicles. Large capacity trucks, operated without motor loaders, allow for low cost haulage of refuse over long distances.

a) Comments on bulk transfer vehicles

Two different types of vehicles - namely rigid body bulk carriers and semi-trailer type vehicles - are employed for bulk transfer of refuse from Mahalaxmi to Deonar disposal site. The haul distance is about 21 kilometres (one way) and vehicles operate three shifts per day.

Bulk refuse carriers (BRC) have a body capacity of 22.5 m^3 and are capable of carrying up to 15 tons per load (GVW about 26.0 tons, empty weight 11.1 tons). However, when one of these trucks was weighed, the load was found to be only 9.9 tons. Loads were probably higher when the loads contained high proportions of construction debris or wet organic waste, and perhaps when the bulk carriers were carrying waste that had previously be compressed in a compactor truck. They were equipped with an ejector plate and hydraulic cylinders to open the tail gate. The top of the body was open but could be partially closed during transport since they had two flaps, fitted to the side walls and operated by one hydraulic cylinder each.

Figures B-1.4 and B-1.5 show the two types of bulk carrier that were in use.

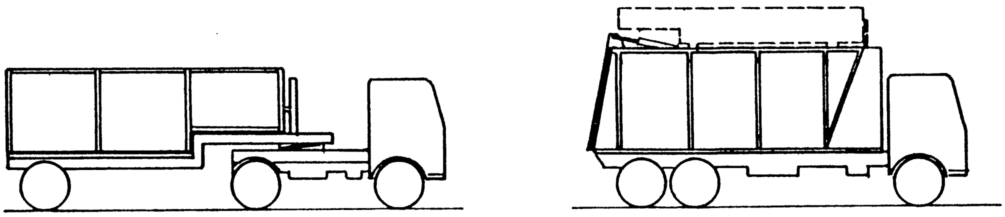


Figure B-1.4 Kirla semi-trailer ***Bulk refuse carrier***

Figure B-1.5 Bulk refuse carrier at Mahalaxmi

Fifteen of these vehicles were maintained at Worli Garage, some 3 kilometres north-west of the transfer station. Between eight and ten were available during the morning shift, up to eight in the afternoon and three during the night shift. Maintenance problems with the hydraulic systems were quoted as the main reason for poor availability.

In addition, two Kirla semi-trailer units, each consisting of two trailers and one engine, were employed for bulk transfer of refuse. The trailer capacity was about 18.5 m^3 and could carry up to 10 tons. Each trailer was equipped with a tipping device and the tailgate was opened manually. One unit was permanently parked at Mahalaxmi to act as a standby. According to information obtained at Mahalaxmi, the Kirla company had stopped producing this type of vehicle.

In addition to the vehicles already mentioned, open trucks with high side walls were also employed during the morning shift (see appendix BB-1.3.1).

***Suggestions*:** Further investigations are suggested to evaluate maintenance and repair problems with BRCs and to propose ways of improving the availability of these vehicles.
A larger body with a capacity of 28 to 30 m^3 would be desirable in order to utilise the permitted payload of the trucks more effectively. Although redesign of the rigid body trucks might be possible (i.e. longer chassis plus larger body), semi-trailer or roll-off type container systems would be more suitable and should be preferred in case this design is available in India. They avoid the need for the power unit and the driver to wait during loading so releasing more time for transport operations. In addition, these systems are more flexible because one engine unit is able to handle several body units. Market research is suggested to find out whether semi-trailer or roll-off type container systems are available in India (with a body capacity of about 30 m^3, and a GVW of about 26 tons). Another aspect that should not be forgotten is that, during the day time, the trucks spend most of their time in very congested traffic, and drivers may need special training before they feel confident to take such large vehicles onto busy and narrow streets.

b) Performance of the bulk transfer system

At the time of the study, transfer vehicles were performing only one trip per eight hour shift. Records from log books were used in appendix BB-1.3.1 to analyse time requirements for solid waste transfer. The results are summarised in table B-1.7.

Table B-1.7 Time requirements for bulk transfer of refuse

Elapsed time in minutes					
Waiting at transfer station	Driving to disposal site	Unloading at disposal site	Driving back to Worli garage	Time for one round trip	Working time
157	65	12	78	155	302

Note: These are average values for nine vehicles, taken from appendix BB-1.3.1

Results indicate that the waiting period at the transfer station was longer than the round trip transport time to the disposal site. Considering that only about 2½ hours were required for one round trip to Deonar it should be possible to carry out two round trips per vehicle in each shift. However, the waiting period at Mahalaxmi would have to be reduced to provide more time for transport operations. Two different options may be realistic:

1. Semi-trailer or roll-off type vehicles could be employed instead of rigid body BRCs. Containers or trailers would remain at the station for loading while the power units would carry a full load to the disposal site. On returning to the transfer station, a filled trailer or container is replaced by an empty one from the vehicle which leaves again for the disposal site. This would be the most elegant solution and will be discussed in more detail below (Scenario B).
2. Alternatively, existing BRC trucks may be employed in a similar way. Empty trucks remain parked at the transfer station for loading while full vehicles drive to the landfill. Coming back, drivers

change to full trucks, which have been loaded during their absence, and leave for a second trip to the landfill. As will be shown below (Scenario A) this option is not easy to organise and requires more vehicles than the semi-trailer or container option.

As has already been mentioned in section B-1.3.(d), bulk transfer operations are far easier to organise if primary collection vehicles deliver waste at a uniform rate to the transfer station. Appendix BB-1.2.3 shows that improvements to the primary collection system would allow vehicle arrivals at Mahalaxmi to be balanced to a large extent.

***Suggestions*:** Two alternative options for bulk transfer are set out in Appendix BB-1.3.2 (scenario A) and BB-1.3.3 (scenario B) respectively. Both options assume that the primary collection system will be improved as proposed in section B-1.3 and that the duration of shifts is reduced to 6 hours. Existing BRC trucks are deployed in scenario A, whereas scenario B is based on a roll-off or semi-trailer system. Vehicle and manpower requirements are compiled in table B-1.8.

Table B-1.8 Comparative manpower and vehicle requirements (bulk transfer)

	Duration of shifts	Required number of crews			Required number of trucks		
		service	standby	total	service	standby	total
Existing	8 hours	24	1	25	13	3	16
Scenario A	6 hours	12	2	14	9	3	12
Scenario B	6 hours	12	1	13	7	2	9

Table B-1.8 shows that both scenarios would allow a substantial reduction in the number of crews and trucks. The organisation of scenario A is more complex (see appendix BB-1.3.2) than scenario B and higher standby resources are recommended. Both options assume that vehicle crews will accept different working hours as shown in appendix BB-1.3.4, while the working time of drivers and attendants, although performing two trips per shift, would be only about 6 hours. To allow for some flexibility the operations are scheduled for teams of two crews in both cases (see Appendix BB-1.3.2 and BB-1.3.3).

It should be further mentioned that both suggestions require significantly less parking space at the transfer station. Whereas the existing system involved parking of up to twelve vehicles, this could be reduced to maximum of seven vehicles (scenario A) and to five containers or trailers in case of scenario B.

c) Costs of bulk transfer

Suggestions discussed in the previous section are employed to estimate and compare costs of bulk transfer. Calculations are presented in appendix BB-1.3.5 and summarised in table B-1.9 below.

Table B-1.9 Solid waste transfer costs

		Present system	[%]	**Scenario A**	[%]	**Scenario B**	[%]
Capital costs - vehicle	Rs/yr	209 000	[29.3]	230 000	[28.7]	262 000	[26.8]
Operation and maintenance	Rs/yr	229 000	[32.1]	341 000	[42.5]	439 000	[44.9]
Labour costs per vehicle	Rs/yr	275 000	[38.6]	231 000	[28.8]	276 000	[28.3]
Total costs per vehicle	Rs/yr	713 000	[100]	802 000	[100]	977 000	[100]
Performance per vehicle	t/yr	7 250		10 500		13 400	
Costs per ton	Rs/t	98		76		73	
Total daily costs (a)	**Rs/d**	**25 400**		**19 800**		**18 700**	

Note (a) According to table B-1.1, about 258 tons are delivered to Mahalaxmi transfer station each day

Results indicate that bulk transfer costs could be reduced by 22% (scenario A) and 26% (scenario B). Compared with primary collection the potential savings are less significant. It should be noted that real costs of the existing system were high for a number of reasons such as the very poor availability of BRC vehicles and the utilisation of small capacity open trucks. Unit costs of scenario B may vary slightly depending on the purchase price of the semi-trailer or roll-off container system. However, this system is likely to remain cheaper than scenario A and it would certainly be easier to manage and to operate.

***Suggestions*:** It is proposed to introduce a second round trip for BRC vehicles and to adjust the working hours of the primary collection system as discussed in section B-1.3.(d).

In addition, BRC vehicles should be gradually replaced by roll-off or semi-trailer type vehicles. Market research is proposed to find out whether such vehicles are available in India. It is further suggested to employ larger capacity vehicles with a capacity of about 30 m^3 (see section B-3.1).

Both systems - scenarios A and B - could operate in parallel for a period of time until the entire BRC fleet is replaced.

Involvement of the private sector should be considered if MCGM drivers were not willing to accept alternative arrangements. A variety of arrangements should be considered, including hiring drivers, leasing vehicles and selling the vehicle fleet to private contractors. It might be best if a single contractor were responsible for transporting all the waste from the transfer station; the contract period should be at least five years to allow him to replace the fleet by roll-off or semi-trailer vehicles.

B-1.5 TRANSFER OPERATIONS AT MAHALAXMI

Results and suggestions regarding the primary collection and bulk transfer system are combined in this section in order to analyse the operations at Mahalaxmi and to suggest which possible improvements should be examined further.

a) Utilisation of Mahalaxmi Transfer Station

Figure B-1.2 above shows that the design of the transfer station at Mahalaxmi provides sufficient space for parking and loading up to 28 BRC vehicles at one time. The greatest space requirements for bulk transfer operations are as follows:

- Existing system: 12 BRC vehicles at 6.30 am.
- Scenario A: 7 BRC vehicles (8.00 to 8.30 am).
- Scenario B: 5 trailers or containers (8.00 to 8.30 am).

Hence, less than half of the structure would be sufficient to operate the present system and only a small proportion would be needed if alternative operations were introduced. Reasons for the large size of the facility include that the transfer station was designed to handle all waste from the island city, including waste from compactor trucks. However, less waste than this was passing through the site and only four compactor trucks, which are employed for time-consuming house-to-house collection, deliver waste to Mahalaxmi, and the remaining compactors, which operate in conjunction with trolley bins, deliver refuse directly to the Deonar disposal site. It was mentioned "off the record" that compactor crews, supported by powerful unions, were generally not willing to load more than one truck per shift, even if loading in conjunction with trolley bins takes less than three hours.

***Suggestions*:** The transfer station is poorly utilised and capable of handling at least twice the present throughput. Efforts to increase its utilisation may include the following suggestions:

◊ Compactor trucks should be obliged to carry two loads per shift to the transfer station whenever possible. One BRC is able to carry at least two compactor loads. Hence, assuming two round trips of bulk transfer vehicles per shift, one additional truck would be sufficient to serve two compactor trucks. This would allow a 50% reduction in the number of compactor vehicles and crews with significant cost savings. Further negotiations with MCGM drivers and crews are suggested before operation of compactors by private contractors is considered.

◊ Transfer services should be offered to all private contractors operating in the island city. Charges should be set to provide some surplus and could be levied according to the amount of refuse delivered to Mahalaxmi.

b) Records

Three tip register books were maintained at Mahalaxmi, one for each shift. Records were neat, complete and kept in a very reliable manner. They were compiled by the depot attendant, who observed the vehicles from his office while they were unloading at the station. Records in the tip register comprise the following:

No. - Ward - Licence plate - Name of driver - Time in - Time out - Total trips

The number of total trips per vehicle was calculated towards the end of each shift and records were summarised daily as set out below:

Ward - Total - Vehicle loads - Number of D-P vehicles - Number of D-P loads

Filled register books were handed to the Cleansing Department (D Ward). However, the employees at Mahalaxmi were not informed whether any analysis of data was carried out and never received any feedback on their records.

***Suggestions*:** Although a good system of record keeping had been developed, the data seemed to disappear in the Cleansing Department without further analysis.
It is suggested that one officer in the Cleansing Department should be made responsible for analysing data, monitoring the system and co-ordinating operations with the Transport Department. Discussions with personnel at Mahalaxmi may help to improve the system and to motivate personnel to work more effectively. This will be of particular importance during implementation of improvement measures.

c) Staffing at the transfer station

Staffing at Mahalaxmi transfer station was as shown in table B-1.10.

Table B-1.10 Staffing at Mahalaxmi Transfer Station

	Morning shift 6.00 to 14.00	Afternoon shift 14.00 to 22.00	Night shift 22.00 to 6.00
Cleaner [levelling BRC loads, cleaning]	8	5	2
Mukadam [supervision of labour]	1	1	0
Junior overseer [responsible]	1	1	0
Depot attendant [record keeping]	1	1	1
Inspector of Transport Department	1 (from 10.00 to 17.00)		

The assignment of labour and supervisory staff was not studied in detail. Further investigations would be required to establish the number of employees required to operate the transfer station.

***Suggestions*:** Further investigations are suggested regarding the assignment of labour as detailed below:

◊ Cleaners: Only about two vehicles per hour were loaded at one time during peak periods. Hence, at least four cleaners were assigned to each truck for levelling the load and cleaning. Further investigations are proposed to evaluate whether the number of cleaners could be reduced.

◊ Supervision: It seems to be doubtful whether one mukadam and one junior overseer are both required at the station. One person, probably a J.O., may be sufficient to supervise transfer operations.

◊ Inspector: The tasks of the inspector were unclear and should be evaluated. As already outlined in B-1.5.(b) above, one officer of the Cleansing Department should be responsible for analysing records, monitoring the system and to co-ordinating operations with the Transport Department.

It is further proposed to adjust the working hours at the transfer station to co-ordinate with the primary collection system, from eight hours at present to six hours. This could be used as an incentive if the number of cleaners were reduced.

d) Operation costs of the transfer station

Operation costs at Mahalaxmi primarily consist of labour costs as shown in table B-1.11.

Table B-1.11 Operation costs of the transfer station

	Labourers	Mukadams	J. Overseer	Attendant	Inspector	TOTAL
Number	15	2	2	3	1	23
Costs / capita Rs/d	170	190	210	170	210	
Total Rs/d	2 550	380	420	510	210	4 070

Note: Labour costs are estimated in appendix AA-2.1

Considering that about 258 tons of solid waste are handled at Mahalaxmi each day the unit costs for transfer operations are about:

Rs 4,070 per day / 258 tons per day = Rs 15.8 per ton.

This includes neither investment costs for the facility nor the very high value of land in Central Mumbai (about 3.5 acres are occupied by the station). Hence, total costs for solid waste transfer are likely to be considerably higher.

Suggestions**:** There are basically two options to reduce costs for transfer operations:

◊ Better utilisation by increasing the amount of waste handled at the transfer station [see B-1.5(a) above]

◊ Reduction of labour employed to operate the transfer station [see B-1.5(c) above].

Both options should be investigated and may be combined if appropriate.

B-1.6 SUMMARY AND CONCLUSIONS

Suggestions outlined in this chapter are summarised and combined in this section.

a) Combined unit costs for refuse collection

Estimated costs of the system components - primary collection, bulk transfer and transfer station - are combined in table B-1.12. Costs of the present system are compared with alternative arrangements according to suggestions outlined in this chapter.

Table B-1.12 Combined unit costs for refuse collection

	Primary collection	Bulk transfer	Transfer station	TOTAL [Rs/ton]
Existing system	467	98	16	581
Proposal A & scenario A	202	76	16	294
Proposal B & scenario B	148	73	16	237

Note:: Proposals A and B refer to the primary collection system.
Scenarios A and B refer to the bulk transfer system.

These estimates suggest that it should be possible to operate the system at less than half of the present costs. The main potential saving lies with the primary collection system where costs could be reduced by more than 2/3.

It should be mentioned that additional measures are considered possible to reduce costs still further, in particular:

◊ A smaller chassis size for primary collection vehicles would allow more effective utilisation of the vehicles and reduce capital and operation costs.

◊ Larger capacity bodies for bulk transfer would allow a further reduction in transfer costs.

◊ Better utilisation of the transfer station would reduce costs for transfer operations.

In addition, the involvement of the private sector would be likely to reduce costs considerably.

b) Primary collection

- **Records**: Log sheets of dumper-placer vehicles should include filling rates of containers to monitor and adjust the clearance frequency according to requirements.
- **Crew size**: The assignment of motor loaders to dumper-placer vehicles for cleaning container locations is considered not appropriate. Street sweepers, who are already assigned to the localities, should be made responsible for cleaning container locations (proposal A). A less costly approach consists of handing over responsibility for cleaning around containers to rag-pickers in return for an exclusive right to collect recyclable material from the containers (proposal B).
- In addition, there seems to be no need to assign one **mukadam** to each vehicle. A driver and his assistant should be sufficient to operate vehicles according the orders of the Conservancy Department.
- **Performance**: The performance of vehicles should be increased by 50% by extending the working time of crews from 4 hours at present to 6 hours. It is further suggested that the duration of each shift should be reduced to six hours (morning 6.30 to 12.30, afternoon 12.30 to 18.30, night 18.30 to 0.30). In addition, afternoon crews should be obliged to work as much as their colleagues on the morning shift.

  If these suggestions are followed the number of vehicles could be reduced from the existing 18 to 12, and the number of crews from the current 41 to 25.
- Container design: It is proposed to remove all covers of containers and to employ simple nets to avoid littering during transport. Corrosion resistant steel may be considered on a pilot scale to increase the life span of the containers.

c) Bulk transfer

Waiting periods of BRC vehicles at the station should be reduced to allow the introduction of two round trips to the disposal site per shift.

1- In scenario A, the existing BRC trucks are deployed and empty trucks remain parked at the station for loading while full vehicles drive to the landfill. Coming back, drivers change to full trucks, which have been loaded during their absence, and leave for a second trip to the landfill.

   This would allow a reduction in the number of vehicles in service from the existing 13 to 9, and the number of crews from 24 to 12.

2- Semi-trailer or roll-off type vehicles are employed in scenario B to improve the performance of vehicles. Containers or trailers remain at the station for loading while trucks carry a full load to the landfill. When coming back, a filled trailer or container is replaced by the empty one from the vehicle, which then leaves again to the disposal site.

   This would allow to reduce the number of vehicles in service from the existing 13 to 7 and the number of crews from 24 to 12.

It is recommended that the arrangements described as scenario A should be introduced as soon as possible and that the BRC vehicles should subsequently be gradually replaced by roll-off or semi-trailer type vehicles (if such vehicles are available in India).

d) Transfer operations

- ◊ **Utilisation**: The transfer station is poorly utilised and capable of handling at least twice the present load. Compactor trucks should be obliged to carry two loads per shift to the transfer station and transfer services should be offered to private contractors on a payment basis.
- ◊ **Records**: One officer in the Cleansing Department should be in charge of analysing data, to monitor the system and to co-ordinate operations with the Transport Department.
- ◊ **Staffing**: Further investigations are suggested to evaluate whether the number of labourers at the transfer station could be reduced.

APPENDIX BB-1.1 SOLID WASTE TRANSFER OPERATIONS AT MAHALAXMI

Records are based on the tip register at Mahalaxmi transfer station

MORNING	30.11.93		01.12.93		02.12.93		03.12.93		04.12.93		05.12.93		06.12.93		AVERAGE
SHIFT	D-P	Other	D-P	Other	D-P	Other	D-P	Other	D-P	Other	D-P	Other	D-P	Other	D-P only
A-South	2/08 *		3/10		3/09		3/12		3/12		3/11		3/10		2.9/10.3
A-North	3/12		3/12		3/12		3/12		3/10		3/12		3/11		3.0/11.6
D-East	2/11	1/1 o	2/10	1/2 o	2/09	1/2 o	2/10	1/1 o	2/11	1/2 o	2/10	1/2 o	2/09	1/1 o	2.0/10.0
D-Central	1/07	1/1 o	1/07	1/1 o	1/07	1/1 o	1/04		1/05	1/1 o	1/06	1/1 o	1/06		1.0/6.9
D-West	1/04	4/4 c	1/05	4/4 c	1/02	4/4 c	1/04	4/4 c	1/05	3/3 c	1/05	4/4 c	1/05	4/4 c	1.0/4.3
E-East	2/11		2/09		2/12		2/11		2/11		2/12		2/10		2.0/9.1
E-Central	3/15	2/4 o	3/16	2/4 o	3/17	2/4 o	3/12	2/3 o	3/15	2/3 o	3/17	2/4 o	3/15	2/4 o	3.0/15.3
G-South	3/19		3/19		3/19		3/19		3/19		3/16		3/14		3.0/17.9
LGP		1/1 o						1/1 o		1/1 o					
Offal		1/1 o		1/1 o		1/1 o		1/1 o		1/1 o		1/1 o		1/1 o	
BV		2/2 c		1/1 c		1/1 c		1/1 c		1/1 c					
D-P	17/87		18/88		18/87		18/84		18/88		18/89		18/80		17.9/86.1
Trucks		6/8		5/8		5/8		5/6		6/8		5/8		4/6	5.1/7.3
Compactors		6/6		5/5		5/5		5/5		4/4		4/4		4/4	4.7/4.7
TOTAL	29/101		28/101		28/100		28/95		28/100		27/101		26/90		

Notes

* 2/08 means 2 trucks, making a total of 8 trips per shift.
D-P = Dumper-placer truck Other trucks: o = open truck; c compactor truck
LGP = Waste from Lowground pumping station; Offal = fish and chicken waste from markets; BV = breakdown vehicle

SOLID WASTE TRANSFER OPERATIONS AT MAHALAXMI (continued)

AFTERNOON	30.11.93		01.12.93		02.12.93		03.12.93		04.12.93		05.12.93		07.12.93		AVERAGE
SHIFT	D-P	Other	D-P	Other	D-P	Other	D-P	Other	D-P	Other	D-P	Other	D-P	Other	D-P only
A-South	3/06		3/06		3/06		3/06		3/06		3/06		3/07		3.0/6.1
A-North	3/09		3/09		3/09		3/09		3/08		3/08		3/09		3.0/8.7
D-East	1/04	2/2 o	1/05	2/2 o	1/04		1/04	2/2 o	1/04	2/2 o	1/04	2/2 o	1/04	2/2 o	1.0/4.1
D-Central	1/06		1/06		1/04		1/06		1/04		1/04		1/04		1.0/4.9
D-West	1/04	1/1 o	1/05		1/04	1/1 o	1/02	1/1 o	1/03	2/3 o	1/03	2/2 o	1/07	1/1 o	1.0/4.0
E-East	2/10		2/09		2/09		2/10		2/09		2/08		2/09		2.0/9.1
E-Central	13/12	2/2 o	3/14	2/4 o	3/14	2/2 o	3/14	2/2 o	3/14	3/3 o	3/13	2/4 o	3/15	2/4 o	3.0/13.7
G-South	3/15		3/15		3/14		3/15		3/15		3/13		3/15		3.0/14.6
LGP										2/2 o					
Offal		1/1 o		1/1 o		1/1 o		1/1 o		1/1 o		1/1 o		1/1 0	
BV															
D-P	17/66		17/69		17/64		17/66		17/63		17/59				17.0/65.2
Trucks		6/06		5/07		4/04		6/06		10/11		7/09		7/09	6.4/7.4
TOTAL	23/72		22/76		21/68		23/72		27/74		24/68		24/79		

Note: 06.12.93 was a bank holiday so there was no afternoon shift; data from 07.12.93 are considered instead

NIGHT SHIFT - only dumper-placer trucks in use

	30.11.93	01.12.93	02.12.93	03.12.93	04.12.93	05.12.93	06.12.93	AVERAGE
A-South	2/09	2/08	2/09	2/08	2/08	2/09	1/04	2.0 / 8.5
A-North	1/05	1/05	1/05	1/05	1/04	1/03	1/03	1.0 / 4.5
D-West	2/10	2/10	2/10	2/10	2/09	2/10	2/05	2.0 / 9.8
E-Central	1/05	1/05	1/05	1/05	1/05	1/05	1/04	1.0 / 5.0
TOTAL	6/29	6/28	6/29	6/28	6/26	6/27	6/16	6.0 / 27.8

Note: 06.12.93 was a bank holiday, so it was not considered in the average values

APPENDIX BB-1.2 PRIMARY COLLECTION BY DUMPER-PLACER VEHICLES

BB-1.2.1 Time requirements of dumper placer MH-X

Times days	30.11.93	01.12.93	02.12.93	03.12.93	04.12.93	05.12.93	06.12.93	Average	08.12.93 **
Leaving D Ward garage	7.00	6.55	7.05	7.15	7.15	7.05	7.25	7.06 *	7.23
Interval, minutes	15	15	15	15	15	15	15		14
Reporting to chowki	7.15	7.10	7.20	7.30	7.30	7.20	7.40		7.39
Interval, minutes	30	20	15	15	15	25	40	23	36
First transfer	7.45	7.30	7.35	7.45	7.45	7.45	8.30		8.15
Duration of trip, minutes (1)	40	40	40	50	55	35	40	43	66
Second transfer	8.25	8.10	8.15	8.35	8.40	8.20	9.10		9.19
Duration of trip, minutes	60	50	55	40	45	50	85	50 *	76
Third transfer	9.25	9.00	9.10	9.15	9.25	9.10	10.35		10.35
Duration of trip, minutes	80	100	95	115	75	70		89 *	115
Fourth transfer	10.45	10.40	10.45	11.10	10.40	10.20			12.30
Interval, minutes	15	15	15	15	15	15	15		15
Arrival at D Ward garage	11.00	10.55	11.00	11.25	10.55	10.35	10.50	10.58 *	12.45
WORKING HOURS	4.00'	4.00'	3.55'	4.10'	3.40'	3.30	3.25	3.51' *	5.22'
DISTANCE PER SHIFT km	42	67	47	55	55	63	39	55 *	61

Notes (1) Estimated time. * 06.12.93 being a bank holiday, was not included in average values

: Data for morning shift, based on records obtained at Mahalaxmi Transfer Station (tip register), dumper-placer MH-X, Ward A-North.

** Data at 08.12.93 are based on measurements when following the truck (same vehicle, same shift).

BB-1.2.2 Present vehicle arrivals at Mahalaxmi

(01.12.1993)

MORNING SHIFT (6.00 to 14.00)		AFTERNOON SHIFT (14.00 to 22.00)		NIGHT SHIFT (22.00 to 6.00)	
Period	Vehicles	Period	Vehicles	Period	Vehicles
7.25 to 8.00	11	14.25 to 15.00	10	22.30 to 23.00	5
8.00 to 8.30	17	15.00 to 15.30	15	23.00 to 23.30	4
8.30 to 9.00	9	15.30 to 16.00	9	23.30 to 24.00	4
9.00 to 9.30	15	16.00 to 16.30	12	0.00 to 0.30	3
9.30 to 10.00	11	16.30 to 17.00	12	0.30 to 1.00	5
10.00 to 10.30	9	17.00 to 17.30	6	1.00 to 1.30	2
10.30 to 11.00	10	17.30 to 18.00	5	1.30 to 2.00	3
11.00 to 11.30	6	18.00 to 18.30	4	2.00 to 2.30	1
11.30 to 12.00	3	18.30 to 18.55	2	2.30 to 3.00	1
12.00 to 12.30	4				
12.30 to 13.00	3				
13.00 to 13.30	2				
Total morning 100		Total afternoon 75		Total night 28	

NOTE: Data based on the tip register, Mahalaxmi Transfer Station.

BB-1.2.3 Scenario of vehicle arrivals at Mahalaxmi

ASSUMPTIONS: Shifts will be reduced from 8 hours at present to 6 hours.
The performance of crews will increase by about 50 %.
All shifts achieve an equal number of trips per vehicle.

NOTE: Vehicle arrivals at the transfer station are approximate. Monitoring of actual operations would be required to determine more accurate values.

MORNING SHIFT (6.30 to 12.30) 12 crews instead of 18		AFTERNOON SHIFT (12.30 to 18.30) 9 crews instead of 17		NIGHT SHIFT (18.30 to 00.30) 4 crews instead of 6	
Period	Vehicles	Period	Vehicles	Period	Vehicles
6.55 to 7.30	8	12.55 to 13.30	6	19.00 to 19.30	2
7.30 to 8.00	11	13.30 to 14.00	8	19.30 to 20.00	3
8.00 to 8.30	11	14.00 to 14.30	8	20.00 to 20.30	4
8.30 to 9.00	11	14.30 to 15.00	8	20.30 to 21.00	4
9.00 to 9.30	10	15.00 to 15.30	8	21.00 to 21.30	4
9.30 to 10.00	8	15.30 to 16.00	8	21.30 to 22.00	3
10.00 to 10.30	8	16.00 to 16.30	8	22.00 to 22.30	3
10.30 to 11.00	10	16.30 to 17.00	7	22.30 to 23.00	2
11.00 to 11.30	10	17.00 to 17.30	6	23.00 to 23.30	2
11.30 to 12.00	8	17.30 to 18.00	5	23.30 to 24.00	1
12.00 to 12.30	5	18.00 to 18.30	3	24.00 to 00.30	0
Total morning	100	Total afternoon	75	Total night	28

BB-1.2.4 Costs for primary collection by dumper-placer vehicles

PRESENT SYSTEM:

Crew: 1 driver, 1 attendant, 1 mukadam, 6 motor loaders.
Working time of crew about four hours per shift.
Three shifts, based on table B-1.5 about 2.27 shifts per vehicle daily (18 morning + 17 afternoon + 6 night / 18 vehicles).
Average performance of vehicles according to table B-1.5 about 10.0 round trips per day (86.1 morning + 65.3 afternoon + 27.8 night / 18 vehicles).

PROPOSAL A:

Reduced crew: 1 driver, 1 attendant, no motor loaders, 2 additional sweepers per shift to clean container locations.
Working time of crew 6 hours per shift.
Three shifts, based on table B-1.5 about 2.08 shifts per vehicle daily (12 morning + 9 afternoon + 4 night / 12 vehicles).
Average performance of vehicles according to table B-1.5 about 14.9 trips per day (86.1 morning + 65.3 afternoon + 27.8 night / 12 vehicles).

PROPOSAL B:

Reduced crew: 1 driver, 1 attendant, cleaning of container locations by rag pickers.
Working time of crew 6 hours per shift, 2.08 shifts per vehicle daily, performance as proposal A.

	Present	Proposal A	Proposal B
VEHICLE CAPITAL COSTS			
Unit price of vehicle [Rs]	6,00,000.-	6,00,000.-	6,00,000.-
Unit price including standby (factor of 1.2) [Rs]	7,20,000.-	7,20,000.-	7,20,000.-
Depreciation (life span 10 years) [Rs/yr]	72,000.-	72,000.-	72,000.-
Interest on capital (12 % per annum) [Rs/yr]	86,400.-	86,400.-	86,400.-
TOTAL CAPITAL COSTS PER VEHICLE [Rs/yr]	1,58,000.-	1,58,000.-	1,58,000.-
CONTAINER CAPITAL COSTS			
Unit price of container [Rs]	17,500.-	17,500.-	17,500.-
Round trips per vehicle, day (average, 3 shifts)	10.0	14.9	14.9
Containers per vehicle (average clearance twice daily)	5.0	7.5	7.5
Container capital costs per vehicle [Rs]	87,500.-	1,31,000.-	1,31,000.-
Depreciation (life span 5 years) [Rs/yr]	17,500.-	26,300.-	26,300.-
Interest on capital (12 % per annum) [Rs/yr]	10,500.-	15,800.-	15,800.-
TOTAL CAPITAL COSTS CONTAINERS [Rs/yr]	28,000.-	42,000.-	42,000.-
OPERATION AND MAINTENANCE COSTS			
Mileage per round trip [km]	15	15	15
Round trips per vehicle, day	10.0	14.9	14.9
Mileage per day [km/d]	150	224	224
Fuel cost per year (0.3 l/km, 6.65 Rs/l, 365 d) [Rs/yr]	1,09,000.-	1,63,000.-	1,63,000.-
Maintenance and repair (estimated 2.5 Rs/km) [Rs/yr]	1,37,000.-	2,04,000.-	2,04,000.-
Container maintenance (5 % of capital costs, year) [Rs/yr]	4,400.-	6,600.-	6,600.-
TOTAL OPERATION AND MAINTENANCE COSTS [Rs/yr]	2,50,000.-	3,74,000.-	3,74,000.-
LABOUR COSTS (1)			
Driver [Rs/shift]	1 x 200 = 200.-	1 x 200 = 200.-	1 x 200 = 200.-
Attendant [Rs/shift]	1 x 170 = 170.-	1 x 170 = 170.-	1 x 170 = 170.-
Loaders [Rs/shift]	6 x 170 = 1,020.-	2 x 170 = 340.-	0
Mukadam [Rs/shift]	1 x 190 = 190.-	1/4 x 190 = 50.-	0
Total labour costs [Rs/shift]	1,580.-	760.-	370.-
Shifts per vehicle, day	2.27	2.08	2.08
Labour costs per year [Rs/yr]	13,10,000.-	5,77,000.-	2,81,000.-
Management & Admin (10 % of labour costs) [Rs/yr]	131,000.-	58,000.-	28,000.-
TOTAL LABOUR COSTS [Rs/yr]	14,40,000.-	6,35,000.-	3,09,000.-
COSTS PER VEHICLE [Rs/yr]	18,76,000.-	12,09,000.-	8,83,000.-
PERFORMANCE (trips/d x 1.1 tons/trip x 365 d) [tons/yr]	4,015	5,980	5,980
COSTS PER TON [Rs/ton]	467.-	202.-	148.-

(1) Labour costs according to Appendix AA-2.1.

APPENDIX BB-1.3 BULK TRANSFER OPERATIONS

BB-1.3.1 Time requirements for bulk transfer of refuse

Table shows clock time
and interval in minutes between each clock time - intervals are shown in [ ]
MTS in Mahalaxmi transfer station

Departure W. Garage		Report at M.T.S.		Departure from M.T.S.		Arrival at Deonar		Departure from Deonar		Arrival W.Garage
6.30	[10]	6.40	[100]	8.20	60'	9.20	[10]	9.30	[70]	10.40
6.30	[10]	6.40	[120]	8.40	[70]	9.50	[10]	10.00	[110]	11.50
6.35	[10]	6.45	[110]	8.35	[65]	9.40	[10]	9.50	[75]	11.05
6.35	[10]	6.45	[135]	9.00	[70]	10.10	[20]	10.30	[90]	12.00
6.40	[10]	6.50	[145]	9.15	[75]	10.30	[15]	10.45	[70]	11.55
6.40	[10]	6.50	[180]	9.50	[70]	11.00	[10]	11.10	[80]	12.30
6.45	[10]	6.55	[200]	10.15	[65]	11.20	[10]	11.30	ignored	18.00
6.45	[10]	6.55	[225]	10.40	[50]	11.30	[10]	11.40	[65]	12.45
7.05	[10]	7.15	[195]	10.30	[60]	11.30	[10]	11.40	[65]	12.45

Average period 2h 37' waiting at transfer station.

Average time per round trip 1h 05' + 12' + 1h 18' = 2h 35'
Distance and speed 21 km 19 km/h 24 km 18 km/h

Own observations (08.12.93) 1h 30' 10' 1h 50' = 3h 30'

NOTE: Data based on the log sheets of drivers, Worli Garage.

Observations at Mahalaxmi transfer station (08.12.1993)

- 8.10 am: 8 BRC at station, loading.
- 9.15 am: 4 BRC at station, one empty; two open trucks, empty; one Kirla trailer, empty.
- 10.35 am: 1 BRC at station, full; 3 open trucks, empty.
- 12.25 am: one open truck, full.

BB-1.3.2 Scenario A for bulk transport of refuse

ASSUMPTIONS: BRC vehicles perform two trips per shift.
Drivers are allowed to change vehicles at the transfer station.
"Primary" column indicates number of loaded vehicles arriving in that period

PERIOD	PRIMARY	BULK TRANSPORT TO LANDFILL (BRC number 1 to 9)
06.55-07.30	8	(1 and 2 parked, loading / 7 and 8 parked / 9 standby)
07.30-08.00	11	3 arrives 7.45, leaves with 1 at 8.00, back MTS 10.30. 4 arrives 7.45, leaves with 2 at 8.00, back MTS 10.30.
08.00-08.30	11	(3 and 4 parked, loading / 7 and 8 parked)
08.30-09.00	11	5 arrives 8.30, leaves with 3 at 8.45, back MTS 11.15. 6 arrives 8.30, leaves with 4 at 8.45, back MTS 11.15.
09.00-09.30	10	(5 and 6 parked, loading / 7 and 8 parked)
09.30-10.00	8	crew arrives 9.30, leaves with 5 at 9.45, back MTS 12.15. crew arrives 9.30, leaves with 6 at 9.45, back MTS 12.15. (7 and 8 parked, loading)
10.00-10.30	8	(7 and 8 parked, loading)
10.30-11.00	10	1 back 10.30, leaves with 7 at 10.45, back Garage 13.25. 2 back 10.30, leaves with 8 at 10.45, back Garage 13.25.
11.00-11.30	10+	(1 and 2 parked, loading)
11.30-12.00	8+	3 back 11.15, leaves with 1 at 11.30, back Garage 14.10. 4 back 11.15, leaves with 2 at 11.30, back Garage 14.10.
12.00-12.30	5	(3 and 4 parked, loading) 5 back 12.15, leaves with 3* at 12.30, back Garage 15.10.
----------------		6 back 12.15, leaves with 4* at 12.30, back Garage 15.10.
12.55-13.30	6	(5 and 6 parked, loading)
13.30-14.00	8	(5 and 6 parked, loading)
14.00-14.30	8	7 arrives 14.00, leaves with 5 at 14.15, back MTS 16.45. 8 arrives 14.00, leaves with 6 at 14.15, back MTS 16.45.
14.30-15.00	8	(7 and 8 parked, loading)
15.00-15.30	8	1 arrives 15.15, leaves with 7 at 15.30, back MTS 18.00. 2 arrives 15.15, leaves with 8 at 15.30, back MTS 18.00.
15.30-16.00	8	(1 and 2 parked, loading)
16.00-16.30	8	(1 and 2 parked, loading)
16.30-17.00	7	5 back 16.45, leaves with 1 at 17.00, back Garage 19.40. 6 back 16.45, leaves with 2 at 17.00, back Garage 19.40.
17.00-17.30	6	(5 and 6 parked, loading)
17.30-18.00	5	(5 and 6 parked, loading)
18.00-18.30	3	7 back 18.00, leaves with 5* at 18.15, back Garage 20.55.
----------------		8 back 18.00, leaves with 6* at 18.15, back Garage 20.55.
19.00-19.30	2	(7 and 8 parked, loading)
19.30-20.00	3	(7 and 8 parked, loading)
20.00-20.30	4	(7 and 8 parked, loading)
20.30-21.00	4	(7 and 8 parked, loading)
21.00-21.30	4	1 arrives 21.00, leaves with 7 at 21.15, back MTS 23.45. 2 arrives 21.00, leaves with 8 at 21.15, back MTS 23.45.
21.30-22.00	3	(1 and 2 parked, loading)
22.00-22.30	3	(1 and 2 parked, loading)
22.30-23.00	2	(1 and 2 parked, loading)
23.00-23.30	2	(1 and 2 parked, loading)
23.30-24.00	1	7 back 23.45, leaves with 1* at 24.00, back MTS 02.30. 8 back 23.45, leaves with 2* at 24.00, back MTS 02.30.
24.00-00.30	0	(7 and 8 parked) (1 back at MTS 2.30, parked) (2 back at MTS 2.30, parked)

+ Primary collection vehicles include 4 compactor trucks.
* In case one of the vehicles is not full, standby BRC 9 could be emptied.

BB-1.3.3 Scenario B for bulk transport of refuse

ASSUMPTIONS: A new semitrailer or roll-off container system will be employed for bulk transfer.
Vehicles perform two trips per shift.
"Primary" column indicates number of loaded vehicles arriving in that period

PERIOD	PRIMARY	BULK TRANSPORT TO LANDFILL (vehicles number 1 to 7)
06.55-07.30	8	(two empty trailers at station, vehicle 7 standby)
07.30-08.00	11	1 arrives 7.45, leaves at 8.00, back at MTS 10.30.
		2 arrives 7.45, leaves at 8.00, back at MTS 10.30.
08.00-08.30	11	(two empty trailers at station, one standby)
08.30-09.00	11	3 arrives 8.30, leaves at 8.45, back at MTS 11.15.
		4 arrives 8.30, leaves at 8.45, back at MTS 11.15.
09.00-09.30	10	(two empty trailers at station, one standby)
09.30-10.00	8	5 arrives 9.30, leaves at 9.45, back at MTS 12.15.
		6 arrives 9.30, leaves at 9.45, back at MTS 12.15.
10.00-10.30	8	(two empty trailers at station, one standby)
10.30-11.00	10	1 back at 10.30, leaves at 10.45, back at Garage 13.25.
		2 back at 10.30, leaves at 10.45, back at Garage 13.25.
11.00-11.30	10+	(two empty trailers at station, one standby)
11.30-12.00	8+	3 back at 11.15, leaves at 11.30, back at Garage 14.10.
		4 back at 11.15, leaves at 11.30, back at Garage 14.10.
12.00-12.30	5	(two empty trailers at station, one standby)
		5 back at 12.15, leaves at 12.30*, back at Garage 15.10.
-----------------		6 back at 12.15, leaves at 12.30*, back at Garage 15.10.
12.55-13.30	6	(two empty trailers at station, one standby)
13.30-14.00	8	(two empty trailers at station, one standby)
14.00-14.30	8	1 arrives 14.00, leaves at 14.15, back at MTS 16.45.
		2 arrives 14.00, leaves at 14.15, back at MTS 16.45.
14.30-15.00	8	(two empty trailers at station, one standby)
15.00-15.30	8	3 arrives 15.15, leaves at 15.30, back at MTS 18.00.
		4 arrives 15.15, leaves at 15.30, back at MTS 18.00.
15.30-16.00	8	(two empty trailers at station, one standby)
16.00-16.30	8	(two empty trailers at station, one standby)
16.30-17.00	7	1 back at 16.45, leaves at 17.00, back at Garage 19.40.
		2 back at 16.45, leaves at 17.00, back at Garage 19.40.
17.00-17.30	6	(two empty trailers at station, one standby)
17.30-18.00	5	(two empty trailers at station, one standby)
18.00-18.30	3	3 back at 18.00, leaves at 18.15*, back at Garage 20.55.
-----------------		4 back at 18.00, leaves at 18.15*, back at Garage 20.55.
19.00-19.30	2	(two empty trailers at station, one standby)
19.30-20.00	3	(two empty trailers at station, one standby)
20.00-20.30	4	(two empty trailers at station, one standby)
20.30-21.00	4	(two empty trailers at station, one standby)
21.00-21.30	4	5 arrives 21.00, leaves at 21.15, back at MTS 23.45.
		6 arrives 21.00, leaves at 21.15, back at MTS 23.45.
21.30-22.00	3	(two empty trailers at station, one standby)
22.00-22.30	3	(two empty trailers at station, one standby)
22.30-23.00	2	(two empty trailers at station, one standby)
23.00-23.30	2	(two empty trailers at station, one standby)
23.30-24.00	1	5 back at 23.45, leaves at 24.00*, back at Garage 02.40.
		6 back at 23.45, leaves at 24.00*, back at Garage 02.40.
24.00-00.30	0	(two empty trailers at station, one standby)

+ Primary collection vehicles include 4 compactor trucks.
* In case one of the trailers is not full, the standby trailer could be emptied.

BB-1.3.4 **Working hours of crews** (Scenario A)

CREW NUMBER			WORKING HOURS clock time	duration	TRIPS/SHIFT
Standby morning		M-1:	7.30 to 13.30	6 h 00'	up to 1
Morning	M-2 &	M-3:	7.30 to 13.25	5 h 55'	2 x 2 = 4
Morning	M-4 &	M-5:	8.15 to 14.10	5 h 55'	2 x 2 = 4
Morning	M-6 &	M-7:	9.15 to 15.10	5 h 55'	2 x 2 = 4
Standby afternoon		A-1:	13.45 to 19.45	6 h 00'	up to 1
Afternoon	A-2 &	A-3:	13.45 to 19.40	5 h 55'	2 x 2 = 4
Afternoon	A-4 &	A-5:	15.00 to 20.55	5 h 55'	2 x 2 = 4
Night	N-1 &	N-2:	20.45 to 02.30	5 h 45'	2 x 2 = 4
TOTAL	14 crews				up to 26

Notes: Arrangements for Scenario B are similar but without a standby crew in the afternoon (total 13 crews, up to 25 trips per day).
M, A and N refer to morning, afternoon and night shifts respectively

BB-1.3.5 Cost comparison for bulk transport of refuse

PRESENT SYSTEM: Calculations assume that bulk transfer is exclusively by BRC type vehicles. One crew, consisting of 1 driver and 1 attendant, performs one trip per shift as follows:
Morning 13 trips / 13 crews; afternoon 8 trips / 8 crews; night 3 trips / 3 crews.
The number of required vehicles in service is 13. 16 vehicles are considered (standby factor 1.23). This assumes that the present availability of vehicles will be improved.

SCENARIO A: It is assumed that three equal shifts of 6 hours will be introduced and that drivers perform two trips per shift (see Appendix BB-1.3.2) as follows:
Morning 13 trips / 7 crews; afternoon 9 trips / 5 crews; night 4 trips / 2 crews.
The number of required vehicles in service is 9; a total of 12 vehicles are considered (standby factor 1.33). This includes one standby vehicle directly at the station, as well as two standby crews, who perform two extra trips per day (on average).

SCENARIO B: Arrangements as for scenario A, but utilizing semi-trailer or roll-off container systems with a capacity similar to the present BRC vehicles (see Appendix BB-1.3.3):
Morning 13 trips with 7 crews; afternoon 8 trips with 4 crews; night 4 trips with 2 crews.
The number of required vehicles in service is 7; in addition 2 trailers or containers are required, so in total 9 vehicles are considered (standby factor 1.29). This includes one standby vehicle, which is permanently parked at the station, as well as one standby crew, who perform one extra trip per day (on average). It is assumed that capital costs for the trailer or container system are 20 % higher than the capital costs of the present BRC vehicles.

	Present	Scenario A	Scenario B
VEHICLE CAPITAL COSTS			
Unit price of vehicle [Rs]	7,70,000.-	7,70,000.-	9,24,000.-
Standby factor (vehicle number / vehicles in service)	1.23	1.33	1.29
Unit price including standby (factor 1.25) [Rs]	9,47,000.-	10,24,000.-	11,92,000.-
Depreciation (life span 10 years) [Rs/yr]	94,700.-	1,02,400.-	119,000.-
Interest on capital (12 % per annum) [Rs/yr]	1,14,000.-	1,22,900.-	1,43,000.-
TOTAL CAPITAL COSTS PER VEHICLE [Rs/yr]	2,09,000.-	2,30,000.-	2,62,000.-
OPERATION AND MAINTENANCE COSTS			
Mileage per round trip [km]	50	50	50
Total number of trips per day / number of vehicles	24 / 13	26 / 9	25 / 7
Round trips per vehicle, day	1.85	2.89	3.57
Mileage per vehicle, day [km/d]	93	145	179
Fuel per vehicle (0.45 l/km, 6.65 Rs/l, 365 d) [Rs/yr]	1,02,000.-	1,58,000.-	1,95,000.-
Maintenance per vehicle (estimated 3.75 Rs/km) [Rs/yr]	127,000.-	1,83,000.-	2,44,000.-
TOTAL O & M COSTS PER VEHICLE [Rs/yr]	2,29,000.-	3,41,000.-	4,39,000.-
LABOUR COSTS (1)			
Driver [Rs/shift]	1 x 200 = 200.-	1 x 200 = 200.-	1 x 200 = 200.-
Attendant [Rs/shift]	1 x 170 = 170.-	1 x 170 = 170.-	1 x 170 = 170.-
Total labour costs [Rs/shift]	370.-	370.-	370.-
Total crews per day / vehicles in service per day	24 / 13	14 / 9	13 / 7
Crews per vehicle per day	1.85	1.56	1.86
Labour costs per vehicle in service [Rs/yr]	2,49,000.-	2,10,000.-	2,51,000.-
Management & Admin (10 % of labour costs) [Rs/yr]	25,000.-	21,000.-	25,000.-
TOTAL LABOUR COSTS PER VEHICLE [Rs/yr]	2,75,000.-	2,31,000.-	2,76,000.-
COSTS PER VEHICLE [Rs/yr]	7,13,000.-	8,02,000.-	9,77,000.-
PERFORMANCE PER VEHICLE			
Average load (258 tons per day / trips per day) [tons/trip]	10.8	9.92	10.3
Performance (trips/d x tons/trip x 365 d) [tons/yr]	7,300	10,500	13,400
COSTS PER TON [Rs/ton]	98.-	76.-	73.-

(1) Labour costs according to Appendix AA-2.1.