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MINISTRY OF PUBLIC WORKS
DIRECTORATE GENERAL OF HOUSING BUILDING
PLANNING AND URBAN DEVELOPMENT (CIPTA KARYA)

MEDAN URBAN DEVELOPMENT, HOUSING, WATER SUPPLY AND SANITATION PROJECT

TECHNICAL MEMORANDUM NO. 20

ALTERNATIVE SOLID WASTES MANAGEMENT SYSTEMS

This is a draft of Section 9 of the Master Plan Report
for Water Supply and Sanitation

OCTOBER 1979

ENGINEERING - SCIENCE, INC. • SINOTECH ENGINEERING CONSULTANTS, INC
A JOINT VENTURE
in association with
PADCO and P.T. DACREA

MEDAN URBAN DEVELOPMENT, HOUSING, WATER SUPPLY AND SANITATION PROJECT

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Our ref: 79/1183/MUDS/313 24 October 1979

Director General Cipta Karya
Ministry of Public Works
Jalan Pattimura 20
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Jakarta Selatan

Subject: Technical Memorandum No.20, Alternative Solid Wastes Management Systems

Dear Sir:

Attached are 20 copies of the subject Technical Memorandum for your information and review. The material contained in this memorandum constitutes submission of Section 9 of the Draft Master Plan for Water Supply and Sanitation report.

Yours faithfully,

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Report No.	Title	Date Submitted
1.	Preliminary Site Selection Criteria for Perumnas Medan III, SSCH/LCH Project	March, 1979
2.	Work Plan for Water Supply and Sanitation Master Plans and Feasibility Studies	April, 1979
3.	Policy Issues for Project Guidance	March, 1979
4.	Drainage - Principal Rivers and Rainfall Analysis	May, 1979
5.	Preliminary Evaluation of Sunggal Water Treatment Plant	May, 1979
6.	Public Health Considerations	July, 1979
7.	The Present Drainage System	August, 1979
8.	Recommended Drilling Program	August, 1979
9.	Medan Household Income/Expenditures	August, 1979
10.	Existing Land Use in Medan	August, 1979
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SECTION 9

ALTERNATIVE SOLID WASTES MANAGEMENT SYSTEMS

9.1 INTRODUCTION

The development of a feasible solid wastes management program for Medan requires the consideration of a broad range of alternatives. Financial and administrative constraints must be considered in developing the scope of the program relating to both the selection of the service area boundary and the levels of service to be provided to various sectors of the community. A set of alternatives can be selected involving variations in quality in terms of householder effort applied to the collection and disposal process, frequency of service, the location and size of system storage elements, and costs.

The objective of the program is to provide an acceptable standard of service to as many people as possible at an overall cost which is within the community's ability to pay.

9.2 ALTERNATIVE SERVICE LEVELS

9.2.1 Service Areas

The magnitude of the task of increasing the current level of service to provide for the collection of all wastes generated within the study area necessitates that a staged approach be considered. The critical need for improved service also requires that immediate action be taken to improve conditions in priority areas. The following priorities and tentative staging have been adopted for developing the master plan program alternatives.

By 1980 Immediate Action

Upgrade service to provide for the collection of all wastes generated in the primary area.

By 1985 First Stage

Extend service to include all of the primary and secondary areas, the corridors of regional roads and selected satellite residential areas within the tertiary area.

By 1990 Second Stage

Extend service to include the entire area of Kotamadya Medan excepting isolated low density rural areas, which can continue to effectively employ household disposal methods.

By 2000 Third Stage

Expand service to keep a pace with urban development.

Figure 9.1 shown the service areas of the city included within each of the foregoing stages. This staged program results in a partial collection of the total solid wastes generated. The following is a summary of the quantity of solid wastes which will require handling by DKKP under the foregoing program.

TABLE 9.1

PROJECTED SOLID WASTES COLLECTED

Source	Solid Wastes Collected, Tonnes per day			
	1980	1985	1990	2000
Domestic	234	468	795	1300
Commercial, Institutional and Industrial	161	242	274	354
Markets and Parks	91	103	131	196
Total	486	813	1200	1850

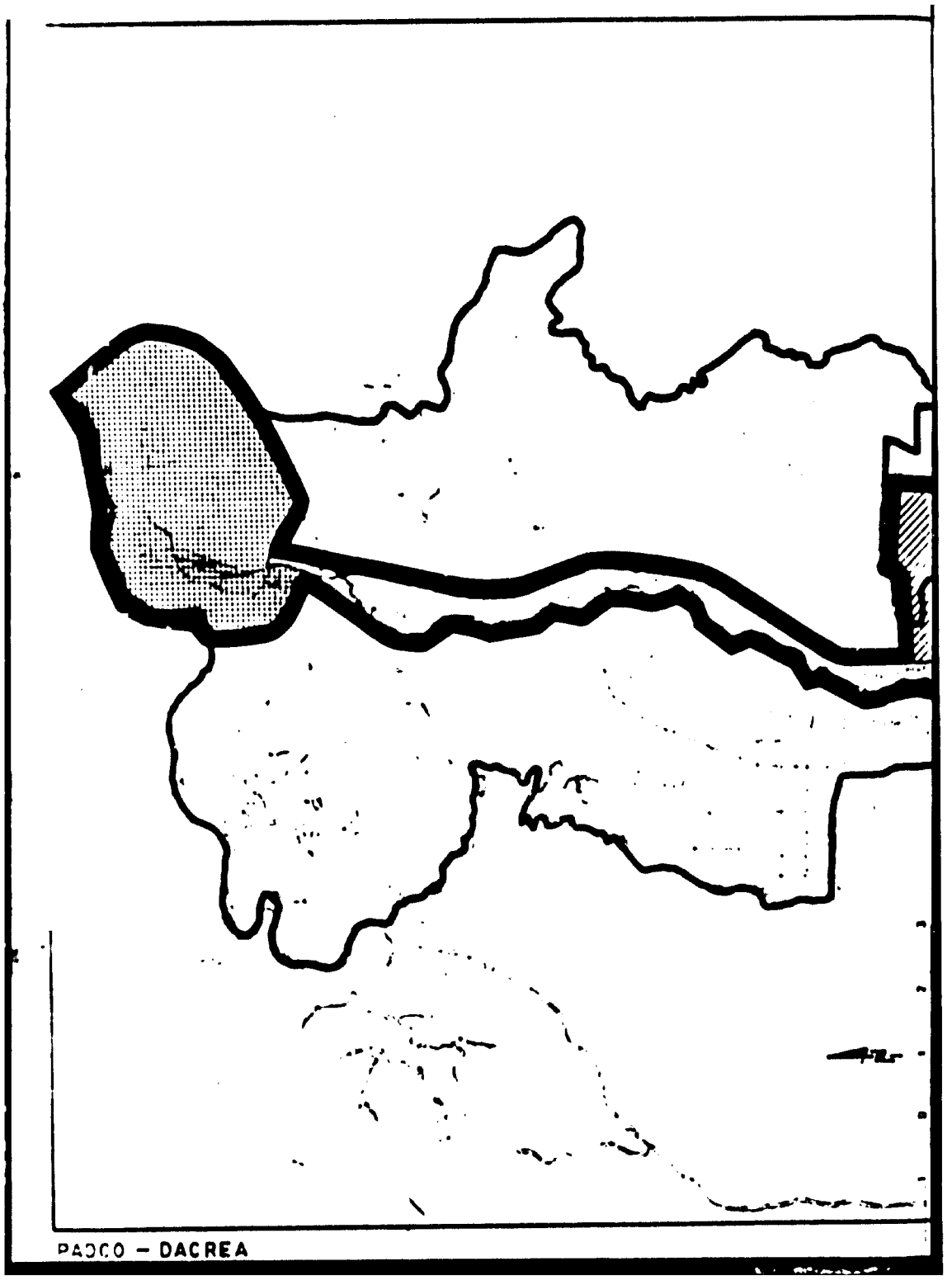
These estimates are summarized graphically in Figure 9.2.

9.2.2 Frequency of Collection

The frequency of collection is determined by two major factors:

1. Flies, which can make use of vegetable putrescible matter as a breeding medium, require about one week for a complete cycle from egg laying to emergence of the adult fly.

2. Decomposition of the putrescible component becomes apparent during the first two days.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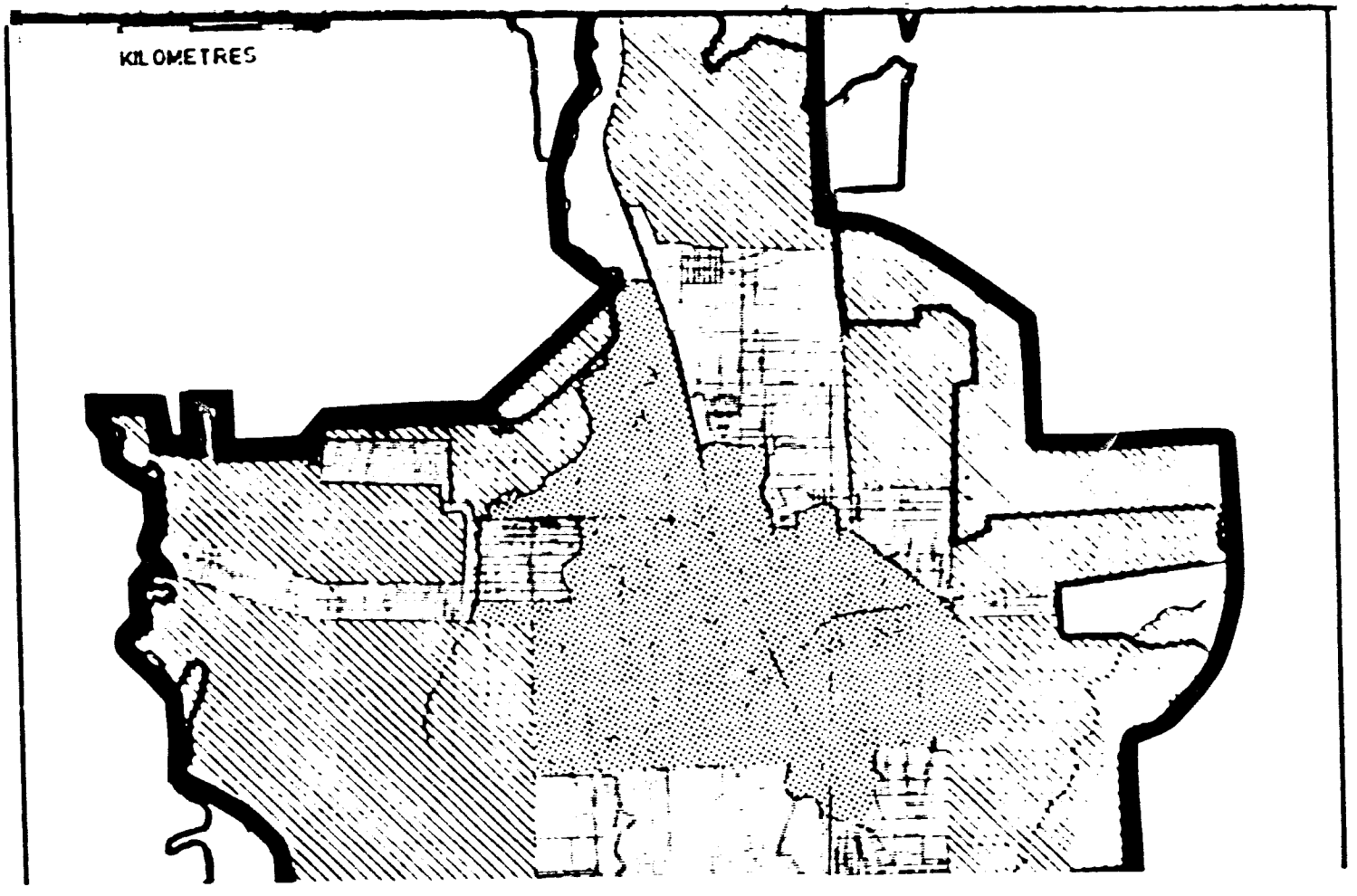
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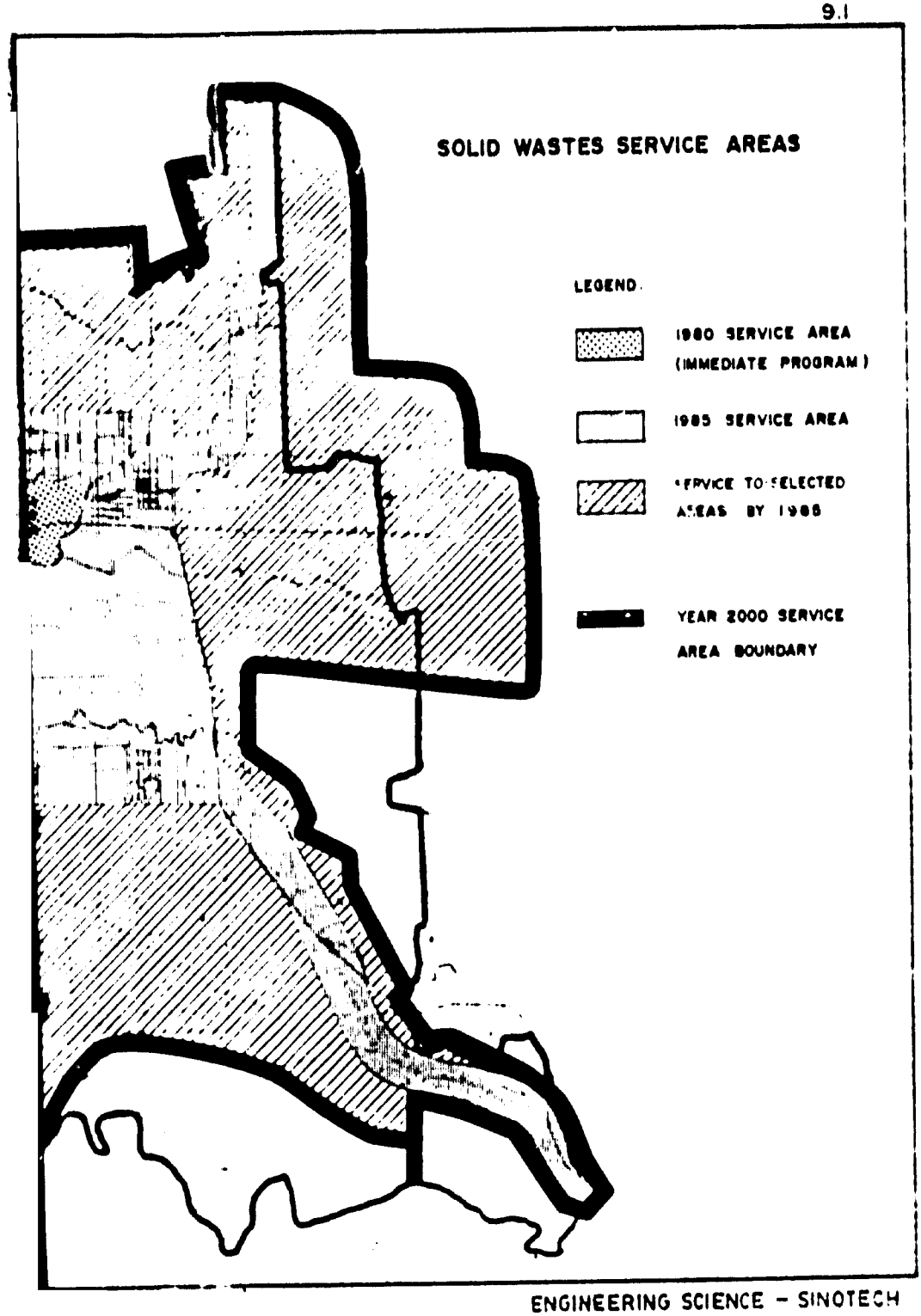

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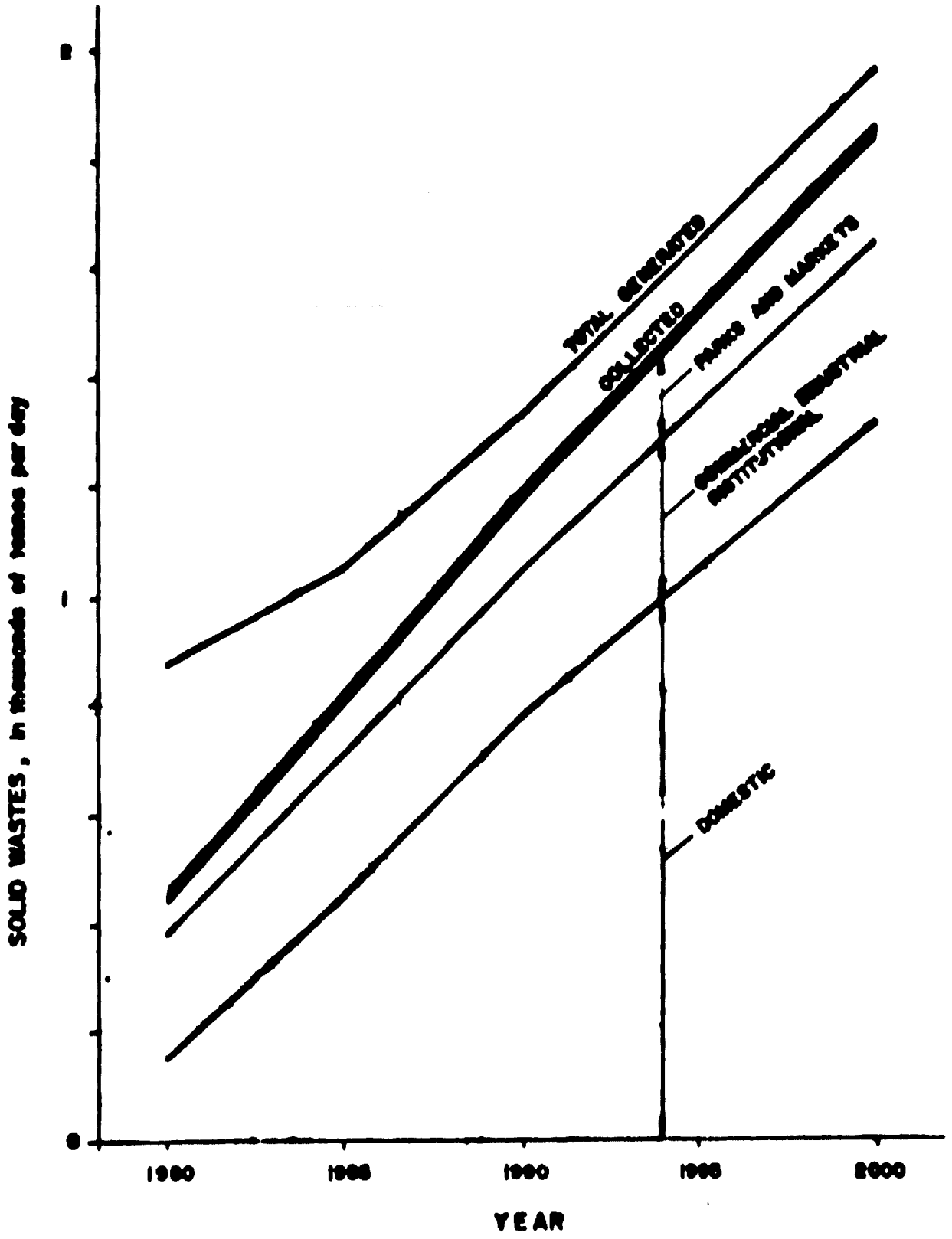


PROJECTED SOLID WASTES QUANTITIES COLLECTED

When communal containers are used there is little control over the age of the wastes placed in the container which may be already infested with fly larvae. The larger quantities of wastes which are stored at communal sites have a greater potential to become a nuisance to nearby residents. It is preferable therefore to collect wastes from community pools daily. The collection frequency should not be less than three times weekly.

At individual households where there is space for outdoor storage of wastes in containers with well fitting lids, collection frequencies of once or twice weekly can be considered.

In commercial and industrial areas the quantities of wastes produced, the limited space for storage, the need to maintain higher aesthetic standards, and the quality of the wastes, all contribute to a general requirement for frequent collection service. In some parts of the central commercial area of the city, service is provided 24 hours per day. Daily service should be considered as standard for the commercial, institutional and industrial sectors with modified service available by special arrangement.

9.2.3 Collection Service Types

9.2.3.1 General

In addition to collection frequency the location and size of the storage and transport elements of the system are also major service level variables. Given the kinds of storage and transport methods available locally, the following alternative collection service types were identified for evaluation:

House to house-truck: the solid wastes worker enters the householder's compound to collect the wastes from a household container and carries the wastes to a truck.

House to house-handcart: as above but wastes are carried to a handcart which is taken to a site where the wastes are loaded into a truck or container.

Curbside-truck or handcart: householder carries solid wastes to the side of the road in a household container in which the wastes are

either retained or deposited in a roadside container and are left for subsequent collection by truck or handcart.

Block Collection: householder delivers the wastes to a collection vehicle at the time of collection.

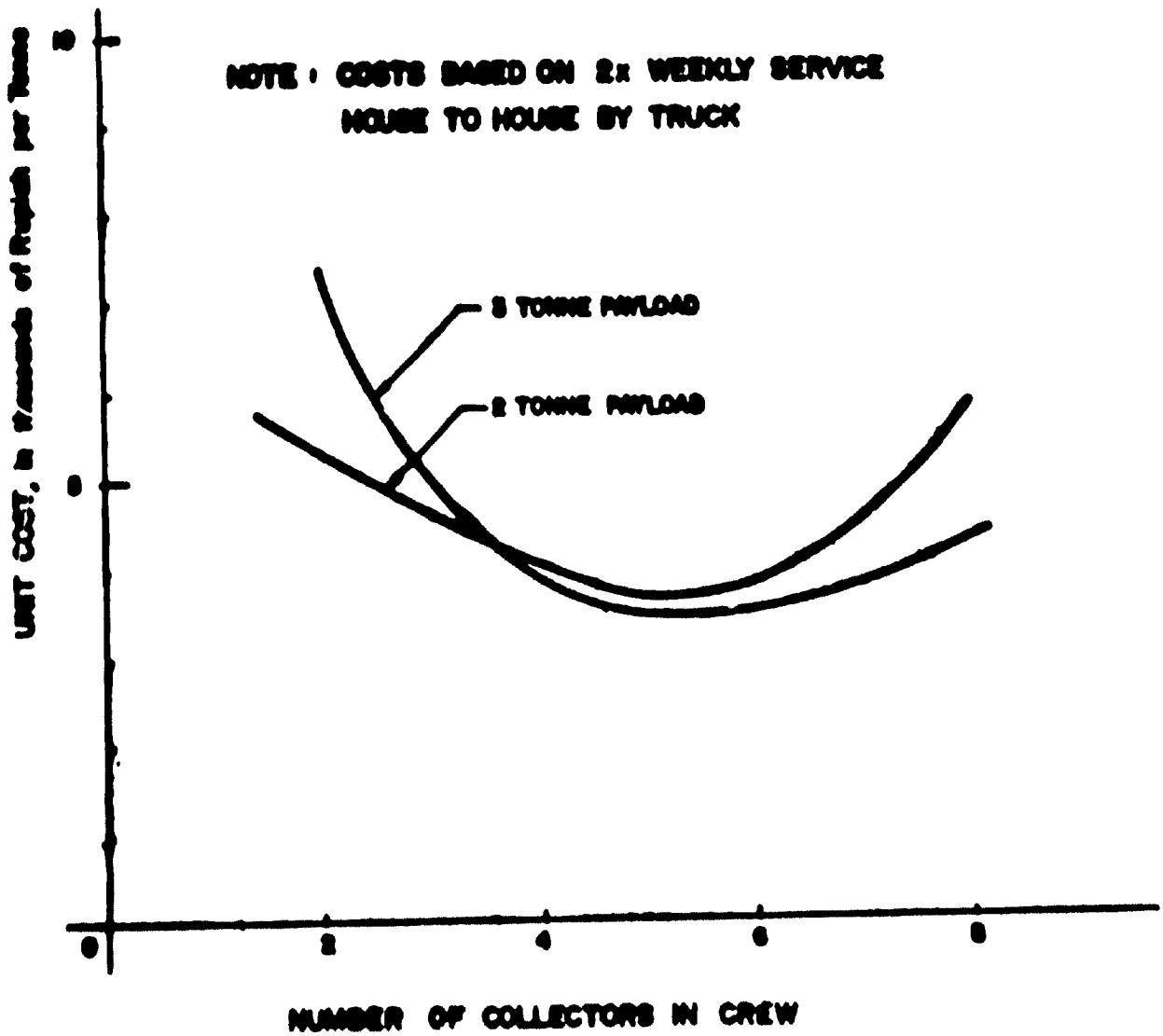
Communal Collection: householder delivers the wastes to a community storage facility from which the wastes are regularly collected.

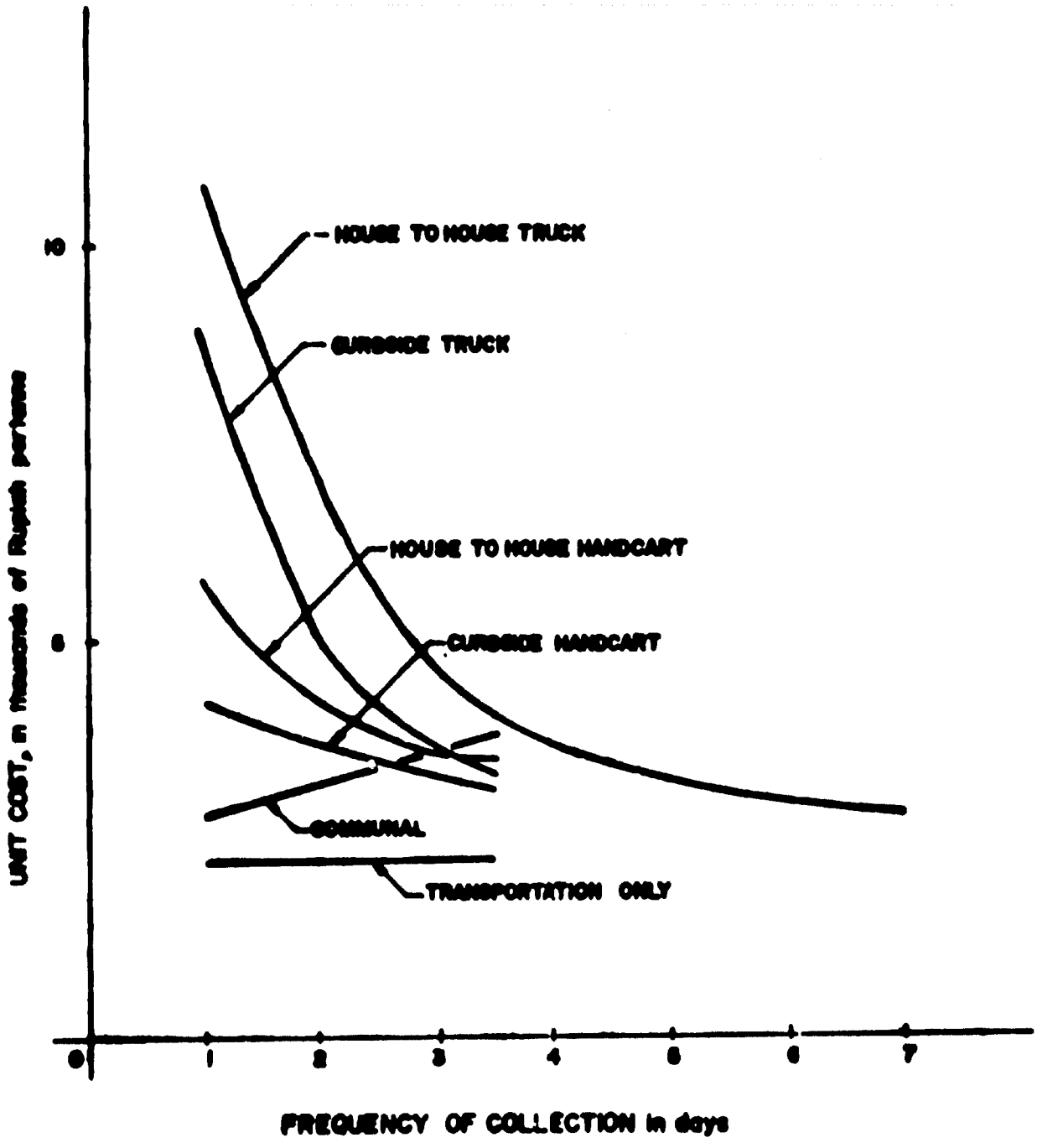
A large number of options are available for specific components of each of the foregoing collection service types. In the design of alternative collection systems, a number of important criteria which have become evident as a result of experience gained under the GOI/Netherlands program must be taken into consideration. These factors are listed below:

- Road conditions limit access to large vehicles in many areas and preclude all 4-wheeled vehicle access in many densely populated areas
- Delays in collecting containers result in overfilling and spillage creating additional environmental sanitation problems
- Container size selection in relation to access in various types of areas. (in Bandung small household containers were found impractical in kampung areas - large containers were found to be more practical)
- Container durability and the availability of replacement units and parts
- Maintenance of vehicles and availability of spare parts
- Vehicle operation at the disposal site
- Ease of container loading
- Availability of sites to locate large containers
- Public participation and education

Size in relation to accessibility is the single most important factor affecting collection vehicle selection. Current experience in Medan has resulted in maximum truck sizes of 2 tonne payload capacity for general collection service and 3 tonne payload capacity under special circumstances. The 14 m^3 containers used under the GOI/Netherlands program can be used on large major throughfares only.

CREW SIZE VERSUS COLLECTION COSTS





COMPARATIVE COST OF COLLECTION ALTERNATIVES

9.2.3.2 House to House Collection by Truck

The estimated number of households served per collection worker varies primarily with crew size. The more members in a crew the more houses a worker must pass to get to his next pickup. The following estimates, have been confirmed to apply to Medan and assume that dwellings are located on individual plots, with side yards and are set back from the street allowance. Both sides of the street are assumed to be collected simultaneously.

Crew size (collectors only)	Households per hour per crew	Households per hour per collection worker
2	60	30
4	100	25
6	132	22
8	152	19

Containers used at households will generally not have to be larger than 40 litres to provide for a family of 6 at a maximum collection interval of 4 days. Containers of 50 to 60 litre capacity can be used at shops and market stalls, multiple dwelling units, schools, hotels, and offices.

Comparative unit collection costs were estimated assuming trucks and crews of various sizes with the results show in Figure 9.3. The estimates indicate that:

1. Costs are relatively constant in relation to the size of the collection vehicles.

2. A crew consisting of 4 to 6 collection workers is optimum.

Figure 9.4 shows the relationship between cost and frequency of collection. Although a once weekly collection service is the least costly the increase in cost is particularly significant when collection is more frequent than twice weekly.

9.2.3.3 House to House Collection by Handcart

From the householder's standpoint, the quality of service differs from house-to-house truck service only by the presence of loading stations where the contents of handcarts are transfered to a truck. These stations would be located at intervals of approximately 1 km. Various designs

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can be considered for the loading stations which will be discussed in later sections.

Comparative costs for this collection alternative are illustrated in Figure 9.4 which shows that handcart collection costs are relatively insensitive the frequency of collection and are considerably lower than truck collection costs at collection frequencies of 1 and 2 days.

9.2.3.4 Curbside collection

Curbside collection results in more wastes being collected per hour per crew member because of the shorter distances the wastes must be carried to the collection vehicle. The disadvantage of this type of service is the unsightly presence of either fixed or portable containers at the edge of the road. Production rates are estimated to be as follows:

Crew size, (Collection workers only)	Households per hour per crew	Households per hour per collection worker
2	90	45
4	140	35
6	170	28

Comparative unit costs for curbside truck and handcart service have also been shown in Figure 9.4 illustrating that curbside collection service is about 70 percent of the cost of house to house collection service.

9.2.3.5 Block Collection

Discussions with local solid wastes management personnel indicate that with this type of service, it would be very difficult to synchronize truck location and householders'daily activities to ensure effective service. This difficulty is a common problem with this type of service, and for this reason this alternative was not given further consideration.

9.2.3.6 Communal collection

The size and spacing of loading sites used in connection with handcart of similar collection systems and communal facilities is a function of vehicle or container size, contributing population density and optimum travel distance. Distances over which individuals may be required to carry wastes to a communal facility should not exceed 100 to 150 metres.

Determination of the optimum spacing for loading sites requires more detailed analysis, however it is likely that maximum size of the loading facility is the critical factor. Suitable loading sites must be found where potential nuisances to nearby residents can be minimized. Sites with a storage capacity greater than 15 m^3 (4.2 tonnes approx.) should not be considered except under special circumstances. Figure 9.5 shows the maximum spacing for community storage and loading facilities in residential areas for various population densities. From this Figure it can be seen that the optimal range in size of community storage facilities, spaced with a maximum carrying distance of 125 metres, is from 0.5 to 2.0 m^3 in residential areas.

In residential areas where collection is by handcart and maximum storage capacity at a loading site is limited to 15 m^3, the spacing ranges from about 0.7 to 1.2 km for population densities ranging from 500 to 200 per ha.

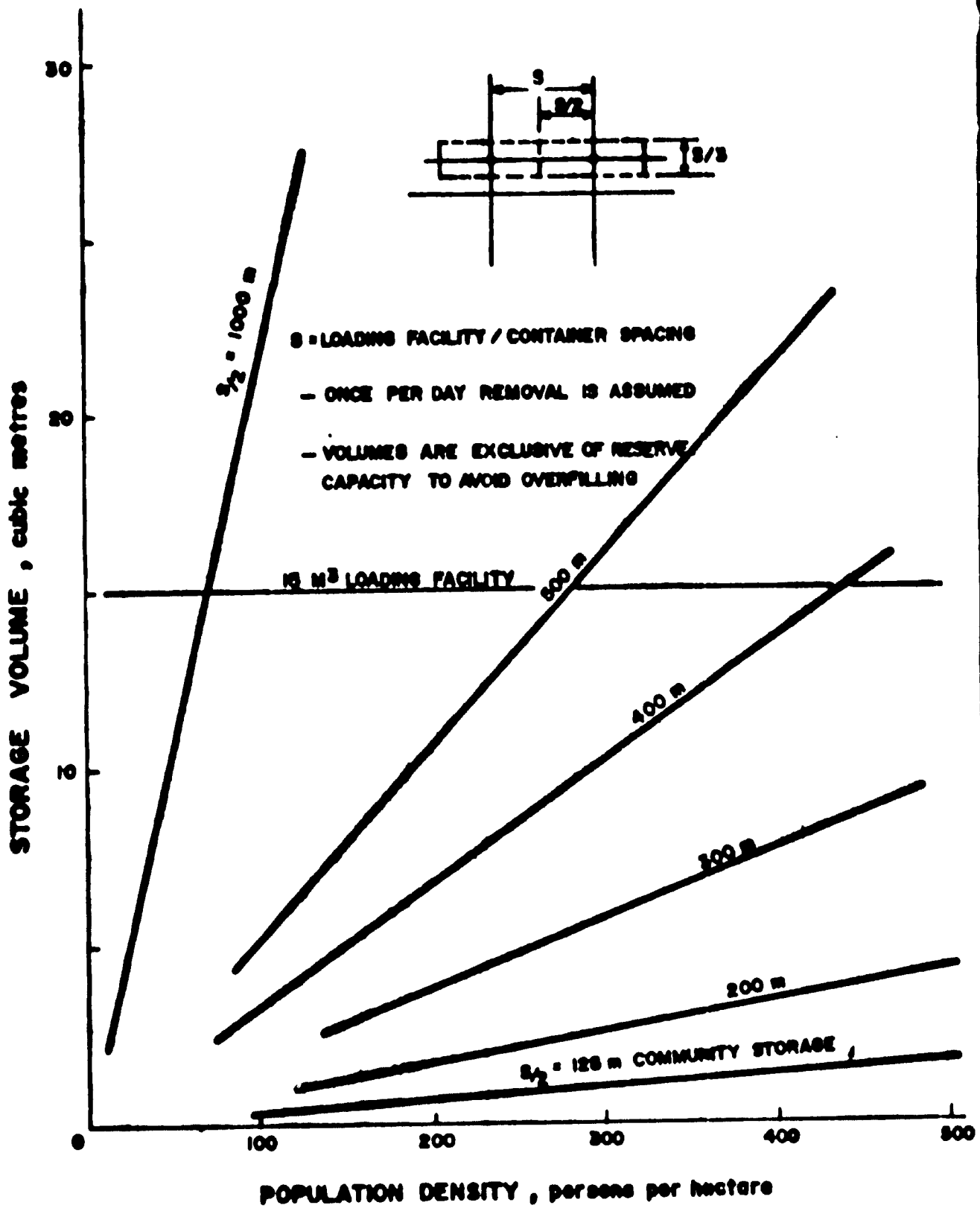
To minimize container overflow it is recommended that additional storage of from 50 to 100 percent be provided at community storage and loading facilities to allow for short-term variations in generation rates and some irregularity of collection service.

The relatively small size of communal storage facilities derived above suggests that a mobile container such as a gerobak or some alternative handcart design would be ideally suited for this application.

The collection task carried out by each worker would consist of pulling the handcart to a loading station site, transferring the contents to a truck, and then taking the emptied handcart to the next pickup location, leaving it there and taking the full handcart to the loading station site.

Experience in Medan has shown that about a 0.7 m^3 handcart can be conveniently handled by a 2-man crew. Handcarts would be positioned at suitable locations in the service community and spaced so that the container is filled to capacity during the time between collections. The maximum spacing would be about 150 metres.

With the above collection model the effect of providing less frequent service is to increase the required storage capacity in the system and to increase costs.



SPACING OF COMMUNITY STORAGE AND LOADING FACILITIES

Figure 9.4 also shows the comparative cost of this type collection service which at collection intervals of one or two days offers significant reductions in cost.

In the householder were to assume the task of carrying wastes to the loading facilities, a maximum distance of 0.5 km, costs could be further reduced as indicated in Figure 9.4. However, experience in other developing countries has shown that the effectiveness of this form of communal service is limited and will undoubtedly result in refuse being disposed of at more convenient locations such as drains or open areas.

It is also of interest to note that the longer the interval between collections, the less significant the cost difference among alternatives becomes.

9.2.3.7 Summary of collection service types

The comparative costs of the various collection alternatives are summarized in Table 9.2.

TABLE 9.2

SUMMARY OF UNIT COSTS FOR ALTERNATIVE SOLID WASTE SERVICE LEVELS

	Thousands of rupiah per tonne Frequency of collection		
Service Classification	1 day	2 day	2 x weekly
House to house truck	10.7	7.0	4.0
Curbside truck	8.7	5.0	3.3
House to house handcart	5.7	4.2	3.5
Curbside handcart	4.2	3.7	3.1
Communal	2.8	-	-
Transportation	2.3	-	-

In order to select appropriate systems for application in Medan it is necessary to rank the various service types according to local preferences. A ranking system is presented in Table 9.3.

TABLE 9.3

RANKING SYSTEM FOR ALTERNATIVE SOLID WASTE SERVICE LEVELS

Preference Ranking	System		Comparative Unit cost, thousand Rp. per tonne
1	Daily - house to house	- truck	10.7
2	Daily - house to house	- handcart	5.7
3	Daily - curbside	- truck	8.7 *
4	Daily - curbside	- handcart	4.2
5	2 day - curbside	- truck	5.0
6	2 day - curbside	- handcart	3.7
7	2 day - house to house	- truck	7.0 *
8	2 day - house to house	- handcart	4.2 *
9	2 x week - curbside	- truck	3.3
10	2 x week - curbside	- handcart	3.1
11	2 x week - house to house	- truck	4.0 *
12	2 x week - house to house	- handcart	3.8 *
13	Communal		2.8
14	Transportation only		2.3

* Denotes cost higher than a prefered alternative.

A strong local preference is evident for daily collection of any type rather than less frequent collection. For collection intervals exceeding 1 day, curbside pickup is prefered over house to house service as householders seem to prefer not to store wastes on their premises even for periods of 2 days. However, experience has indicated that with proper household containers and where adequate exterior household storage space exists, 2 day service can be acceptable.

Little preference was indicated between truck and gerobak service, possibly indicating that the householders primary concern is within the immediate environment of the home. However, current experience in Medan indicates that the acquisition of sites at which handcart loads can be transfered to transportation vehicles will be difficult to obtain because of fears that they will create a nuisance to nearby residents.

Based on the foregoing considerations, the alternative system shown in Table 9.4 have been identified as being suitable for application to the various categories of solid waste generators in Medan.

TABLE 9.4

APPROPRIATE SOLID WASTE SERVICE LEVELS FOR MEDAN

Service level	Description			Unit Cost Thousands of Rp/tonne
Domestic				
1	Daily	- House to house	- truck	10.7
2	2 Day	- House to house	- truck	7.0
3	Daily	- House to house	- handcart	5.7
4	2 Day	- House to house	- handcart	4.2
5	2 Day	- Curbside	- handcart	3.7
6	2 x weekly	- Curbside	-	3.3 *
7	Communal			2.8
Commercial, Industrial, Institutional				
1	Daily	- House to house	- truck	10.7
2	Daily	- Curbside	- truck	8.7
3	Daily	- Curbside	- handcart	4.2
Markets and Parks				
	Transportation only			2.3

* The difference in cost between the use of truck and handcart collection vehicles in this service level is insignificant.

9.2.4 Street Sweeping

Street wastes fall into the following categories:

Natural wastes - dust flown from unpaved areas
- decaying vegetation such as leaves, blossoms and seeds

Traffic wastes - oil, rubber and mud from motor vehicles
- animal excrement
- mud and debris from construction sites

- load spillage

Human generated - litter
- disposal of household and commercial solid wastes in the street
- human spittle and the excrement of household pets

Other - ditch, dredgings, grass and shrubbery clippings

Human generated wastes constitute the greatest proportion of the street wastes in most areas of the city.

Three types of surface are found in most of the street rights-of-way which are cleaned by the street sweepers:

- Paved road surface, consisting of the roadway crown and edges. The road edges may be provide with a curb and gutter with drainage outlets to allow street drainage to enter the roadside ditches or underground drainage contents
- walkways
- grassed areas with plantings.

The control of street wastes can be effected by the following methods in addition to the provision of an effective street cleaning operation.

Natural wastes - careful selection of the type of trees planted in the city

Traffic wastes - regulatory control, especially with regard to load spillage and wastes from construction sites

Human generated- effective municipal refuse collection
- provision of litter bins
- public education
- regulation

In Medan the low cost of labour and its flexibility is the major factor affecting the choice of cost effective methods for street cleaning. The operation of mechanized street sweepers would be confined to paved surfaces leaving walkways and grassed areas to be swept by hand. Congested streets also restrict the movement of street sweeping machines.

Projected future street sweeping requirementsin the city are presented in Table 9.5.

TABLE 9.5

PROJECTED STREET SWEEPING REQUIREMENTS

Frequency of sweeping	Length of street surface to be swept/km			
	Present	1985	1990	2000
1 x daily	101	118	135	168
2 x daily	104	121	139	173
3 x daily	16	19	21	27
4 x daily	3	3.5	4	5
Total	224	261.5	299	373

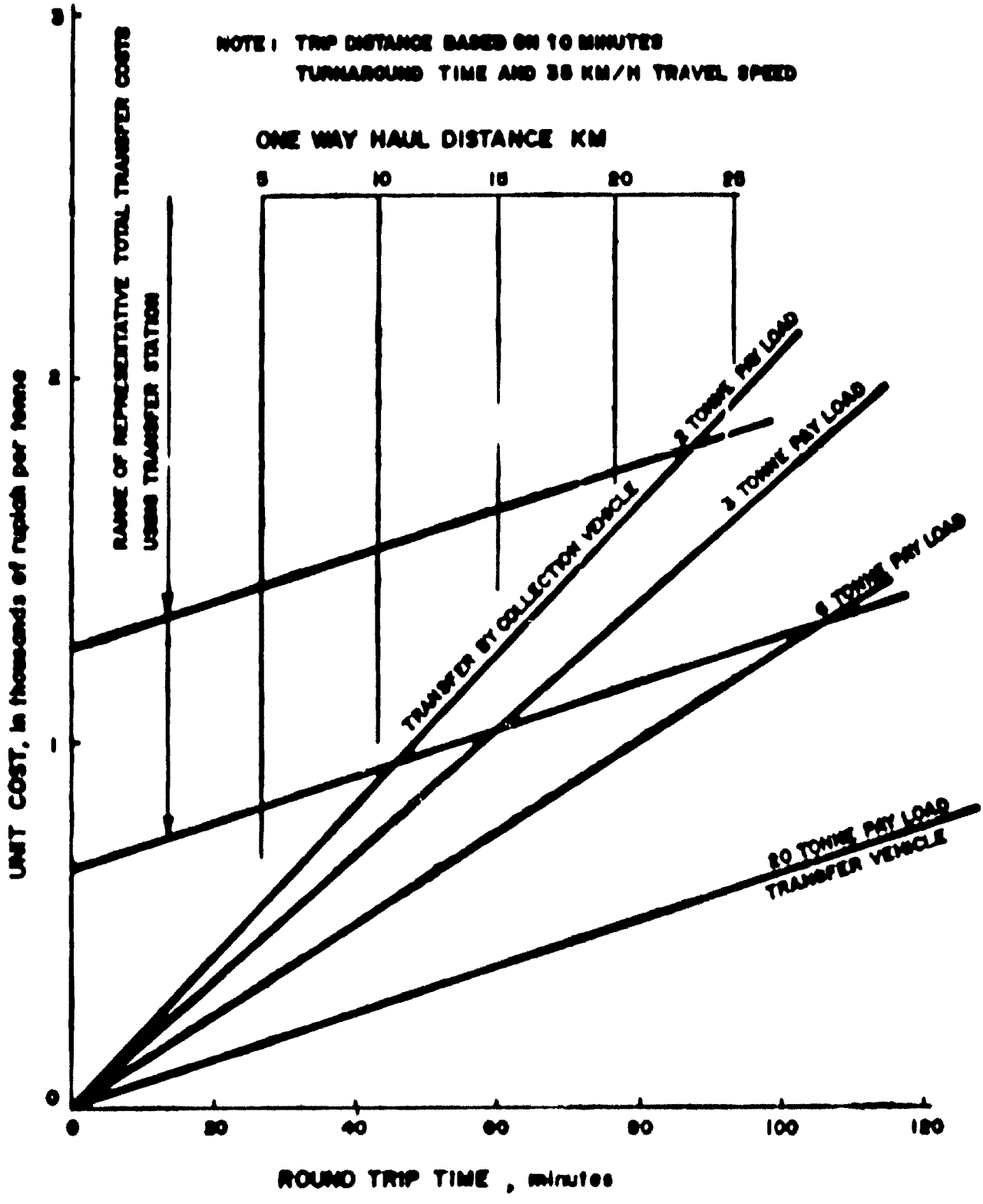
9.3 TRANSFER AND DISPOSAL ALTERNATIVES

9.3.1 Transfer

Conventional solid wastes transfer facilities are employed at central locations in or near the service area to transfer solid wastes from collection vehicles to larger truck/trailer combinations, for transportation to distant disposal sites. Typically such facilities may be more cost effective than direct haul in the collection vehicles when one way haul distances exceed approximately 10 km. Typical relationships are shown in Figure 9.6.

In Medan the maximum probable mean one way haul distance (to a potential disposal site near Belawan) is approximately 20 km. A number of other potential disposal sites are located within 10 km.

On the basis of the foregoing it is apparent that transfer facilities should only be considered for mean haul distances in excess of 10 - 20 km, and then only after making a careful analysis and evaluation of costs and operational factors for any specific site. It is unlikely that transfer stations will prove to be a cost effective system element of the solid waste management system in Medan.



COMPARATIVE COSTS OF TRANSFER ALTERNATIVES

9.3.2 Disposal

9.3.2.1 General Considerations

Sanitary landfill, composting and incineration are commonly considered for application for the disposal of solid wastes. Representative comparative costs for these systems are as follows:

Alternative			Unit Cost Rp./Tonne
Sanitary landfill			2,000
Composting	: Windrow system		
	Cost per tonne compost	7,500 Rp.	(3,750)
	Revenue per tonne compost	4,500 Rp.	
	Netcost per tonne compost	3,000 Rp.	1,500
Incineration	: No heat recovery and no special emission controls		7,000

Composting also has two interesting variants which are currently applied in Medan:

1. Compost derived from old landfill sites, and
2. The use of old landfill sites for agricultural purposes such as banana cultivation.

Both of these options represent future benefits derivable from proposed landfill operations.

Experience with composting operations elsewhere in the world has clearly indicated that composting as a commercial venture should be approached cautiously and should be undertaken only when markets and prices can be assured by contract, as is the case with the existing composting operations in Medan.

The expanded application of composting on a larger scale than at present as part of the master plan solid wastes disposal program should be a subject of ongoing investigation based in part upon experience gained by the existing commercial operations. Should it be determined that increased production of compost is commercially viable the payment of a disposal fee to the composting operation could reasonably be considered.

In the meantime, it is recommended that future system planning be based upon the use of sanitary landfills for solid waste disposal.

Alternative sanitary landfill systems which can be considered are discussed in the following section.

9.3.3 Sanitary Landfill Alternatives

The topography of the study area provides three general types of sites that are available for landfill operations.

Ravines:

Erosion of the volcanic soils has created many ravine or gully type configurations. The adjacent topography associated with some of these, as related to drainage through the ravine, make some ravines suitable for consideration as potential landfill sites using ravine fill methods. These are located primarily to the south of Medan.

Plains:

To the north, east and west of Medan there are tracts of flat land, most of which is currently under agricultural production, which are suitable for the development of landfill sites using an area fill type of operation.

Coastal lowlands:

These areas are subject to frequent flooding. At other such locations in Indonesia, land reclamation using solid wastes as a fill material has been practiced. Future uses of such fill areas must take into account potential problems associated with:

1. The escape of leachate from the fill to adjacent natural waters.
2. Long-term settlement of the solid wastes, making such sites unsuitable for the application of many building foundation systems.
3. Production of methane which can create hazardous conditions.

Areas of this type which can be considered are located in the vicinity of Belawan.

Typical sites which can be considered are shown in Figure 9.7. In view the relatively small capacity of collection transfer vehicles the simultaneous use of more than one landfill site must be considered in the interest of overall system economy and such disposal systems are evaluated in the following section. Total landfill volume requirements to year 2,000 are shown in Figure 9.8.

9.3.4 Salvage and Recycling

At the present time materials recovery from domestic wastes is practiced in Medan by:

1. Householder recovery - bottles, rags, old clothing and paper are collected commercially directly from the householder, and
2. Recovery at pool and disposal sites.

In the future it is recommended that householder recovery be encouraged and that salvage operations at other points within the collection system be discouraged. It is recommended that such salvage activities be limited to the disposal area. Some control should be exercised to ensure minimum interference with disposal operations. Control could be accomplished by restricting access to the site and by issuing permits to salvage operators.

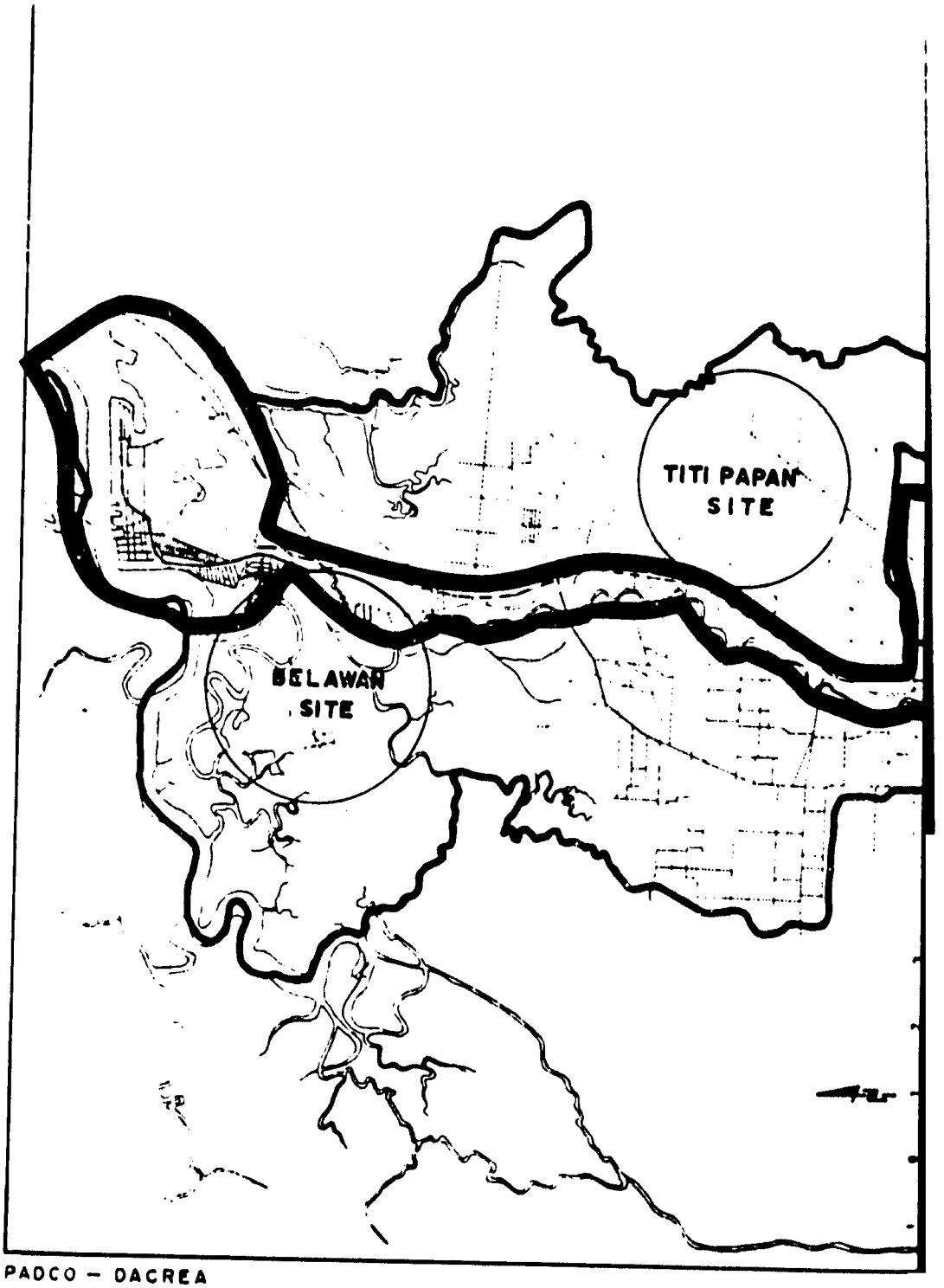
9.4 COLLECTION AND DISPOSAL OUTSIDE MUNICIPAL SERVICE AREAS

In many less densely populated areas existing household disposal practices such as burial or household composting can be continued with little difficulty. Under the staged program described in Section 9.2, many areas will continue to be without municipal solid wastes collection service provided by DKKP until 1990. It is proposed that in these areas DKKP offer an advisory service at the Kecamatan and Kampung levels to assist local officials with critical solid wastes management problems.

9.5 EVALUATION OF ALTERNATIVES

9.5.1 Service Area and Staging

The service area and staging alternative previously described would result in the provision of solid wastes service to the various service groups as summarized in Table 9.6.



PADCO — DACREA

SITE
C
SITE
B
KILOMETRES
0
1
2
3

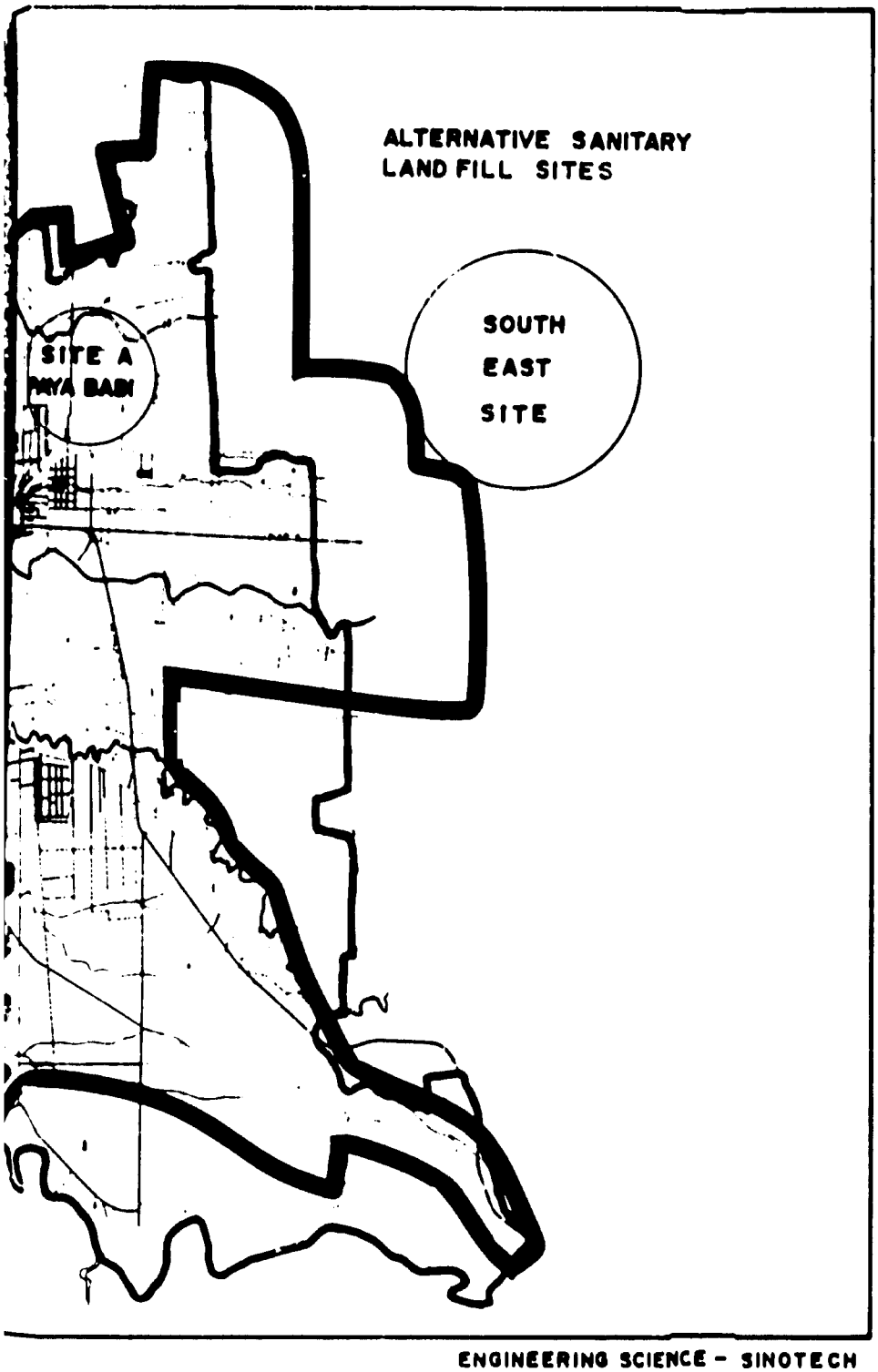


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FIGURE 9.8

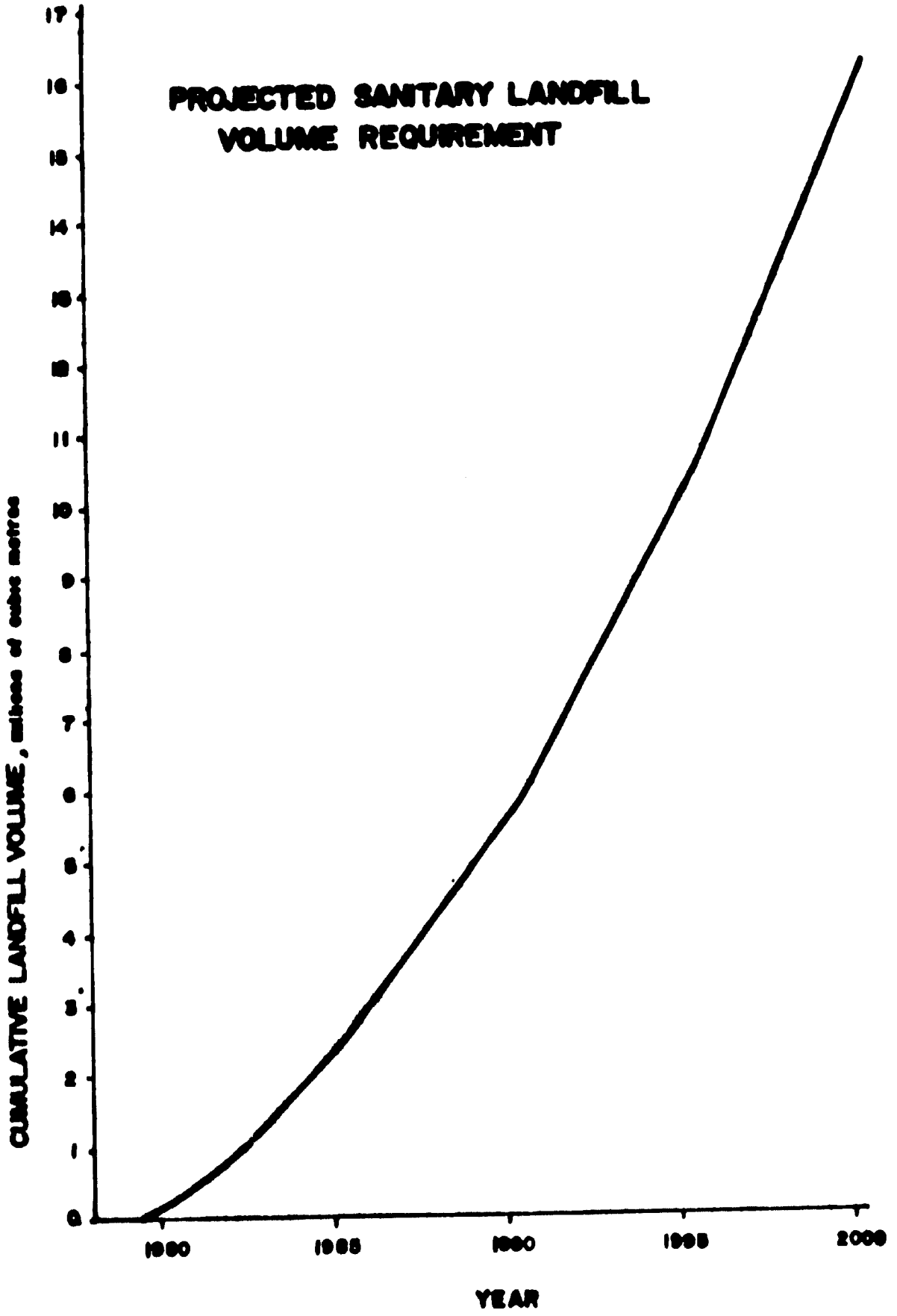

PROJECTED SANITARY LANDFILL
VOLUME REQUIREMENT
CUMULATIVE LANDFILL VOLUME, millions of cubic metres
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
1980
1985
1990
1995
2000
YEAR

TABLE 9.6

ESTIMATED PERCENTAGE OF SOLID WASTES COLLECTED UNDER STAGED PROGRAM

Service group	Percent of solid wastes collected 1980	1985	1990	2000
Domestic				
Low Income				
High Density	49	78	84	89
Medium Density	34	62	84	89
Low Density	15	80	84	89
Sub total	35	67	84	89
Medium Income	76	82	84	89
High Income	60	71	84	89
Total Domestic	42	69	84	89
Commercial, Industrial Institutional	81	100	100	100
Markets & Parks	100	100	100	100
Total	57	73	88	90

Under the staged program, by the end of 1980, service would be provided to most of the commercial areas, markets and parks and also to about 35 percent of the low income group including 49 percent of the low income high density population.

The first stage program will then focus on the central city high density kampungs so that by 1935, 67 percent of the low income group including 78 percent of the high density low income population will be provided with service.

One of the distinct benefits of the staged program is that the proportion of wastes collected from the commercial, institutional and industrial sectors is large in relation to the domestic component including the income groups who must be provided with subsidized service. This enchances the overall financial feasibility of the program and the opportunity for cross subsidy in developing a rate structure for solid wastes service.

9.5.2 Alternative Collection Systems

The major factors in the evaluation and application of alternative types of collection service are cost and affordability. For the purposes of this evaluation it was assumed that the average household will be able to devote about one percent of its monthly household expenditures for solid wastes service. The cost per household for each alternative collection system was calculated as summarized in Table 9.7.

TABLE 9.7

ESTIMATED UNIT COSTS OF ALTERNATIVE SOLID WASTE SERVICE LEVELS

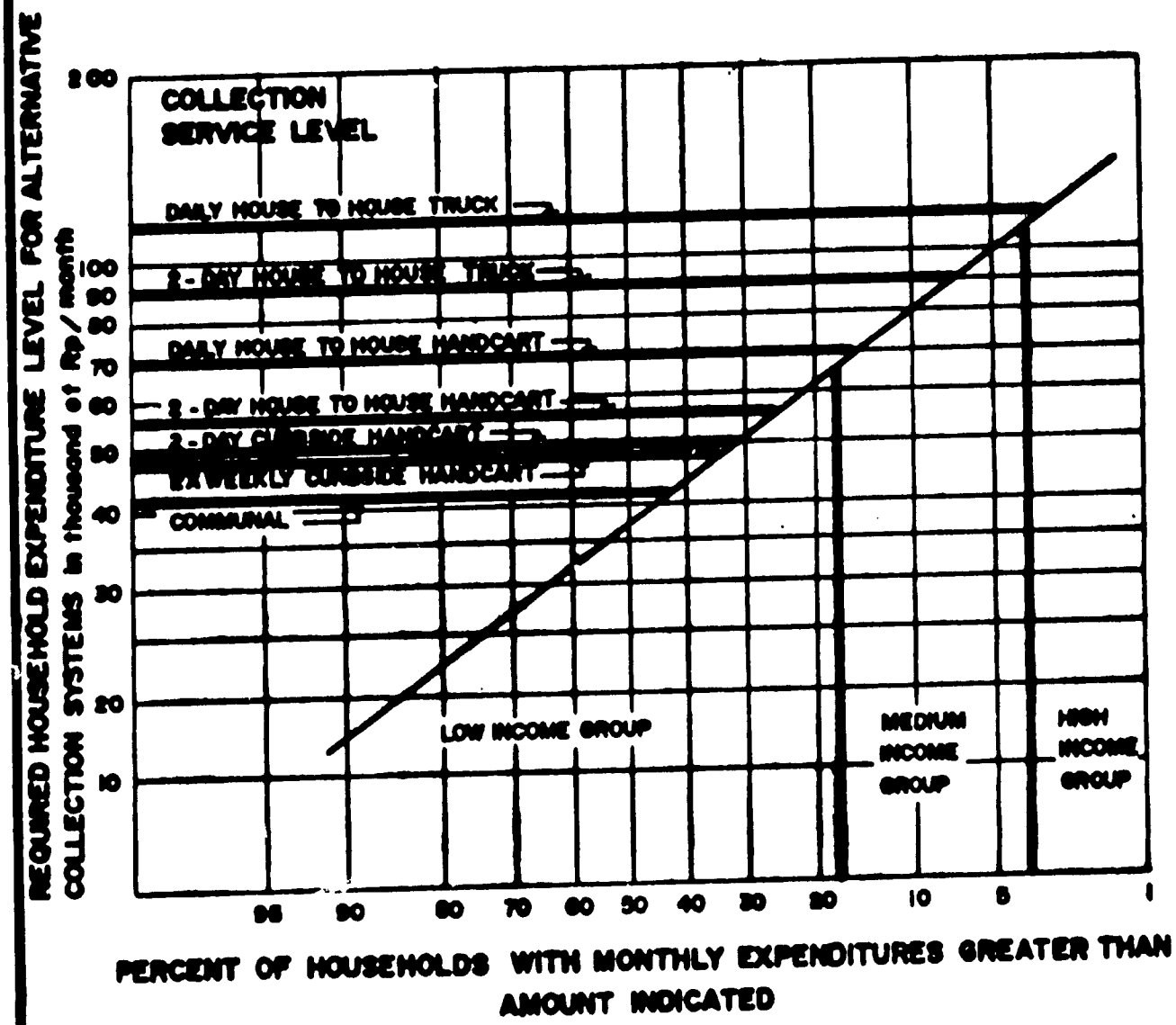
Alternative Collection Service Level		Cost, Rp./month/ household
Daily	- house to house, truck	760
2-day	- house to house, truck	420
Daily	- house to house, handcart	310
2-day	- house to house, handcart	170
2-day	- curbside handcart	130
2 x weekly	- curbside	90
Communal		50

Transportation and disposal costs were then added and the required household expenditure level was calculated.

The proportion of the population which can afford the various levels of service based on the foregoing criteria are shown in Figure 9.9.

This analysis indicates that only the high income group consisting of about 4 percent of Medan's households can afford the highest level of collection service, daily house to house collection by truck. For the middle income group, comprising 15 percent of households, intermediate levels of service can be provided. The recommended service types are therefore 2-day house to house truck and daily house to house handcart.

To the majority of households in the low income group, which make up about 82 percent of the population, not even the least costly form



AFFORDABILITY OF SOLID WASTES COLLECTION ALTERNATIVES

of collection service is affordable. Almost 60 percent of all households will require some level of subsidy if a minimum acceptable level of communal service is to be applied throughout the city.

For the remainder of the low income group (about 21 percent of all households a somewhat more prefered service can be considered including the 2-day house to house handcart, and 2-day or 2 x weekly curbside handcart service levels.

9.5.3 Costs

9.5.3.1 Transfer and Disposal Alternatives

The cost of alternative transfer/disposal systems is a critical factor affecting selection. A comparative cost analysis has been carried out considering transportation, site acquisition and operating costs with the reaults shown in Table 9.8.

TABLE 9.8

SUMMARY OF ESTIMATED CAPITAL COSTS OF TRANSFER AND DISPOSAL ALTERNATIVES

Alternative Description	Unit Cost (4) Thousand of Rp./Tonne		
	Transfer	disposal	Total
1. Single site Belawan (1)			
a. Direct	1,000	900	1,900
b. Transfer station	1500-2100	900	2400-3000
2. Single site - Titipapan (2) - South East (2)	800	1,600	2,400
3. Single site A Medan Barat (3) B Paya Babi Area (3)	400	2,000	2,400
4. Multiple sites (3)			
Medan: a. Site A & B	350	2,000	2,350
b. Sites A, B, & C	300	2,000	2,300

Notes: (1) Land costs based on 200 Rp./m2

(2) Land costs based on 500 Rp./m2

(3) Land costs based on 700 Rp./m2

(4) Land costs exclude compensation for improvements and crops. Disposal costs assume cover material is available on site and that sites are readily accessible.

From the foregoing it is evident that the cost differential is not large among the transfer/disposal alternatives. The use of multiple sites does not result in significant cost reductions within the range of alternatives examined. The greater haul distances associated with the Belawan, Titi Papan and South East sites are offset by lower land costs. The use of transfer stations for the Belawan site is significantly more costly.

The acquisition of landfill sites is at best a difficult process from the standpoint of public acceptance. Without significant benefits the selection of multiple sites is difficult to justify. Initially in Medan a single landfill site should be considered.

The selection of the optimum site will depend upon a number of factors including land cost, compensation for land improvements and crop losses, accessibility, and site development costs including the availability of cover material, all of which are dependent upon site-specific investigations.

At this stage of the investigation sites in Belawan; Titi Papan and to the South East of the city are all promising. Site development costs and the availability of cover material and the short term congestion along the road Belawan tend to make the cost and convenience of a Belawan site somewhat uncertain. With construction of the proposed Toll Road this latter situation will be improved considerably. Other disadvantages must be weighed against the advantage of the isolation of the site from areas suitable for urban development. If similarly priced sites are available closer to Medan, they would result in significant reduction in overall haul and disposal costs. Accordingly, system requirements for the Master Plan investigation have been based upon the use of the Belawan site. If all of the solid wastes generated under the staged program to the year 2000 are disposed of at Belawan to a finished depth of 2 metres the site area requirements would be approximately 800 hectares. Landfill sites are frequently developed to elevations much higher than the surrounding terrain with corresponding reductions in the total site area required. Such practices can be considered in Medan, although it must be recognized that future potential beneficial uses of the completed site would be restricted.