Chapter 5. Major Problems

5.1 Introduction

The amount of waste collected by the BMA has increased remarkably since the present Governor took office in 1985. The current waste amount (about 4,100 ton/day) is 60 % higher than the amount collected in 1984.

Such a large increase in waste collection amounts is a result of the higher priority the BMA has given to solid waste management. The BMA not only made efforts in strengthening its waste collection capacity quantitatively, but also attempted at improvement on the collection capacity qualitatively through the introduction of various new collection systems such as 1) use of small vehicles for waste collection on the narrow streets, 2) use of boats for waste collection along canals, 3) collection with plastic bags, and 4) collection at night.

In spite of these praiseworthy efforts of the BMA, there still exist many problems as summarized in Fig. 5.2-1.

5.2 Structures of Problems

Fig. 5.2-1 shows the structure of the problems related to the solid waste management of Bangkok.

5.2.1 Major Problems

Major existing problems are:

1. Increases in waste amount
2. Increasing costs of waste collection, haulage and disposal
3. Low efficiency of waste collection and haulage
4. Poor sanitary conditions related to the waste collection, and resulting risks affecting workers' health and discomforting citizens' life
5. Open dumping practice and resulting risks affecting people's life and natural environment

6. Difficulty in acquisition of land for sanitary landfill
7. Inadequacies in planning

5.2.2 Socio-Economic Conditions Related to the Problems

These identified problems have been caused or worsened by the following socio-economic conditions over which the BMA has little control.

a. Increasing economic activities
b. Population increases
c. Salary increases
d. Expansion of the urban area
e. Increasing awareness and demand of the people for better sanitary conditions and environmental protection

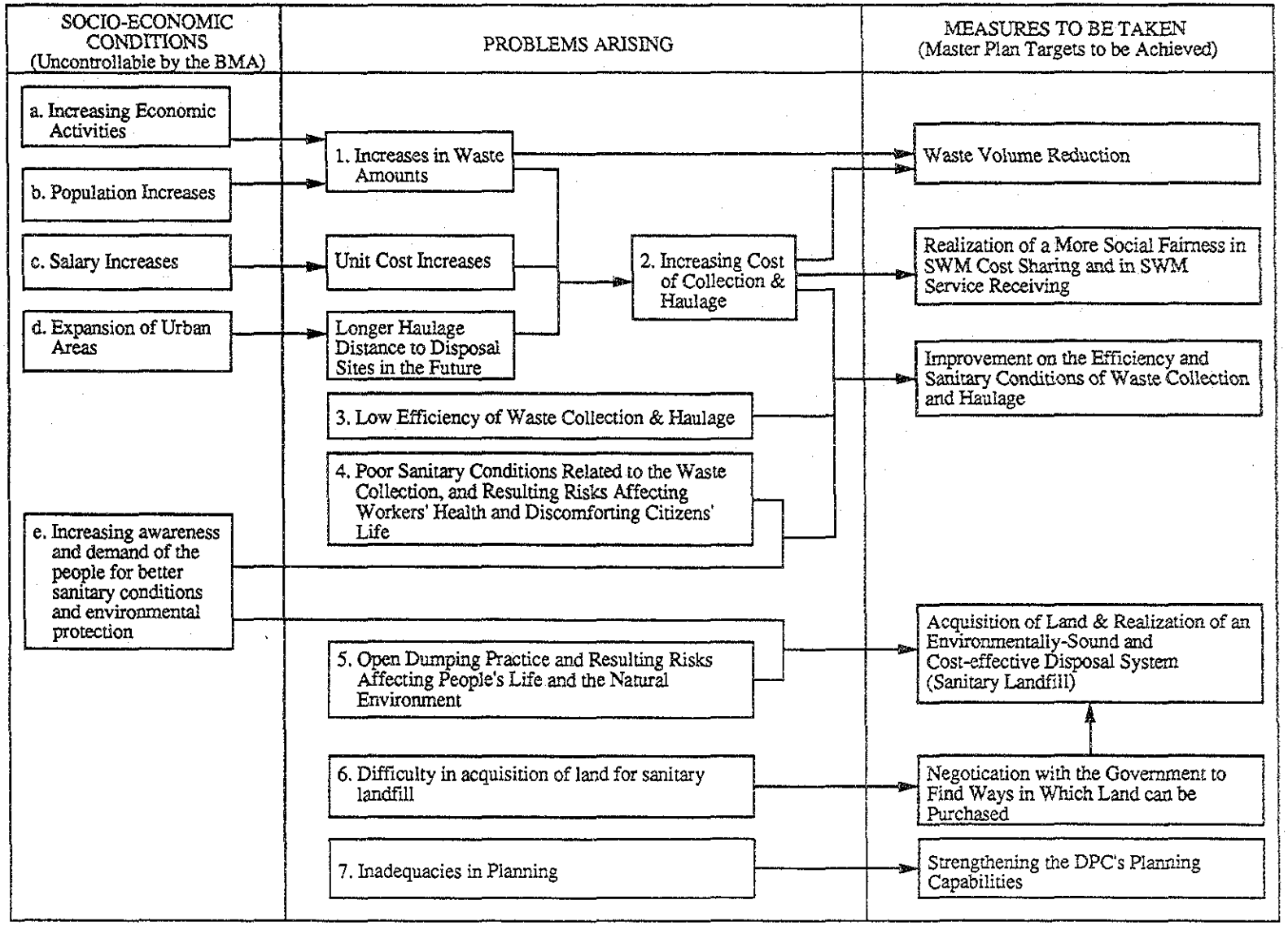


Fig. 5.2-1 Structure of Problems and Measures to be Taken

Chapter 6. Master Plan Goals and Actions Required

6.1 Master Plan Goals

The objective of solid waste management (SWM) is to efficiently remove waste from people's living and working places, and dispose of waste in a cost-effective, sanitary and safe manner while pursuing more social fairness in the SWM cost-sharing and SWM service receiving among members of society.

In view of these objectives of SWM and the problems described in Chapter 5, the following five Master Plan goals are proposed for BMA:

1. **Acquisition of land & Realization of environmentally-sound and cost-effective waste disposal systems**

2. **Improvement on the collection & haulage efficiency**

3. **Waste volume reduction**

4. **Realization of more social fairness in SWM costs-sharing and SWM service receiving**

5. **Strengthening of the DPC's Planning Capacity**

6.2 Major Means and Actions Required to Achieve the Goals

The following table shows the major means and actions required to achieve the Master Plan goals.

Table 6.2-1 Master Plan Goals and Major Means and Actions Required

MASTER PLAN GOALS	MAJOR MEANS TO ACHIEVE GOALS	ACTIONS REQUIRED TO ACHIEVE GOALS
1. Acquisition of Land & Realization of environment-ally-sound and cost-effective waste disposal systems	a. Negotiate with the central government about standard price regulations to find ways to purchase land.	1) Purchase two sites: one at Ram Intra, the other in the east part of Bangkok
	b. Introduction of sanitary landfill	2) Secure budget necessary for the purchase of land and construction of sanitary landfill facilities. 3) Purchase land and construct sanitary landfill facilities in a manner described in chapter 8. 4) Use reliable contractors for sanitary landfill disposal, and control them closely and effectively.
2. Improvement on the collection & haulage efficiency	c. Introduction of more cost-effective collection systems such as the waste station system or the bell system and use of plastic bags	5) Use appropriate collection systems by area types. 6) Collect waste regularly on fixed days of the week. 7) Encourage shop keepers to use plastic bins. 8) Buy collection vehicles of appropriate types and size
	d. Introduction of transfer stations in case the haulage distance gets longer	9) Plan for the transfer stations, and acquire the necessary land at appropriate places (ideally within 10 km from the waste generation center) so that the land may be used as sites for the future incinerators.
	e. Promotion of the use of collection contractors	10) Increase the contractors' share up to about 30 % in terms of the collection amount by the year 2000. 11) Encourage the Districts to develop better supervision systems.
	f. Introduction of a preventive maintenance system	12) Reorganize the Central Workshop or use actively private maintenance workshops. 13) Provide training for the maintenance personnel.
3. Waste volume reduction	g. Useful material recovery at sources	14) Strengthen public relations
	h. Introduction of intermediate treatment facility	15) Introduce an incineration plant
4. Realization of more social fairness in SWM costs-sharing and SWM service receiving	i. Increase waste collection fees	16) Enforce the waste collection fee rates as stipulated in 1985
	j. Shift of the responsibility for business waste collection from the BMA to business establishments (Dischargers)	17) Increase waste collection fees (This will be pre-requisite for the "shift")
	k. Increase waste collection coverage	18) Provide more collection service for slum areas
5. Strengthening the DPC's Planning Capability	l. To give more authority to the persons in charge of planning	19) Strengthening of the Technical Division of the DPC

Chapter 7. Collection and Haulage Plan

7.1 Increasing Costs--A Major Problem with Collection/Haulage

7.1.1 Future Cost Estimated

1) Future Condition Anticipated

It is anticipated that the BMA will face rapid increases of waste collection/haulage costs in the future due to the future conditions described below:

a. Bangkok's waste collection amount will increase rapidly, and will be doubled by the year 2000.
b. There is an increasing necessity for the expansion of the collection service coverage so that most Bangkok citizens should be provided with the service.
c. Haulage distance will be longer in the future as disposal sites would be located at remoter places than the existing ones.
d. Emolument (salary) for collection crew will rise.

2) The Future Collection/Haulage Costs

The future costs for waste collection/haulage will increase both in terms of unit per ton cost and total cost as shown below:

Table 7.1-1 The Present & the Future Costs for Collection and Haulage

	PRESENT COSTS IN 1990	ESTIMATED COSTS IN 2000 WITHOUT TRANSFER STATIONS& IMPROVEMENTS
Unit Per Ton Cost Total Collection/Haulage cost	290 Baht/ton 454Million Baht	About 450 Baht/ton About 1,428 Million Baht (About 3 times higher than the 1990 cost)

Note: 290 Baht/ton includes personnel costs incurred at the central workshop

The estimated cost 1,428 million Baht in 2000 will correspond to a 8.8% of the BMA's total revenue in 2000. The estimated share 8.8% seems to be too high. The corresponding percentages in recent years are around 5-6%.

3) The Future Efficiency of Waste Collection and Haulage

Assuming that:

1. Average haulage distance will be 45 km in the future.
   (25 km longer than the present average distance of 20 km)
2. Emolument for collection crew will increase 3 % every year.
3. Number of crew per vehicle will not change.

The efficiency of waste collection and haulage can be estimated as shown in Table 7.1-2.

Table 7.1-2 The Present and the Future Collection Efficiency (Estimated Averages of Both the Districts and DPC)

	1990	2000
Average round trip	1.44 times/vehicle/day	0.9 times/vehicle/day
Average collection amount	1.15 tons/worker/day	0.8 tons/worker/day
Emolument	41,000 Baht/worker/year	54,000 Baht/worker/year

7.2 Improvement Targets

1) Target Costs in 2000

The above estimated collection and haulage cost of 1,428 million Baht in 2000 (corresponding to approx. 8.8 % of the total BMA's revenue estimated for the same year) can be reduced by 306 million Baht (21 %), to the proposed target cost of 1,122 million Baht in 2000, 6.9 % of an estimated BMA's budget in 2000 if the BMA implement the collection and haulage plan as proposed in this Chapter. See Tables 7.2-1 (summary) and 7.2-2 (Detail).

Table 7.2-1 Target Collection & Haulage Cost and Waste Amount in 2000 (Summary)

(In 1990 Price)

	1	2	3
	Target in 2000 (Haulage Distance 45 km)with T/S, Improvement & Use of contractors	Estimated Costs and Waste in 2000 with the Existing Systems except increases of haulage distance to 45 km	Target Saving (Difference Between Items 2 & 1)
1. Total Collection & Haulage Cost	1,122 million Baht/year	1,428 million Baht/year	306 million Baht/year (21% Reduction)
2. Average Unit Per Ton Cost	350 Baht/ton	450 Baht/ton	100 Baht/ton (22% Reduction)

Note: It is assumed that emolument will increase 3% per year in real term while other cost per unit will remain to be at the same level in real term during the next 10 years.

Table 7.2-2 Target Collection & Haulage Costs and Waste Amount in 2000 (Detail)

(In 1990 Price)

	Estimated Costs and Waste in 2000 with the Existing Systems except increases of haulage distance to 45 km	Target in 2000 (Haulage Distance 45 km) with T/S, Improvements and Use of Contractors
1. Collection by BMA	(450 B/t) 1,428 M.B	(323 B/t) 718 M.B
2. Collection by Contractor	-	(315B/t) 300 M.B
3. T/S & Secondary Haulage	-	(90B/t) 104 M.B
4. Total	(450B/t) 1,428 M.B	(350B/t) 1,122 M.B
5. Waste to be collected per worker per day	0.8 t/d	1.23 t/d
6. Waste to be handled by BMA	8,700 t/d (100%)	6,090 t/d (70%)
7. Waste to be handled by Contractors	0	2,610 t/d (30%)
8. Waste amount to be transferred	0	3,170 t/d

B/t: Baht per ton, M.B: Million Baht, t/d: tons per day

2) Sources of Cost Saving

There are two major sources of the cost saving: 1) increases in waste collection efficiency and 2) increases in haulage efficiency. The proposed cost saving plans and their expected effects are summarized in Table 7.2-3.

Table 7.2-3 Cost Saving Plans and Their Effects

SOURCES OF COST SAVING	MEANS TO ACHIEVE COST SAVING	EXPECTED EFFECTS IN 2000
1. Increases in waste collection efficiency	a. Application of efficient collection systems such as a station collection system and bell systems, and use of tied plastic bags, and plastic bins at markets.	Item "a" will make possible an increase of collection amount per worker by about 10% or more.
	b. More use of compactor vehicles (instead of large side loaders) and other vehicles of appropriate types	Replacement of the BMA's all the existing side loaders (12 m3) to compactors (10 m3) will lead to a 10% increase in collection amount per vehicle per day.
	c. Introduction of transfer stations	Introduction of the transfer stations (T/S) contributes to the reduction of not only haulage costs but also collection costs because T/S will make possible an increase in number of trips to be made by collection vehicles.
	d. Use of contractors	Reduction of collection cost by 8 Baht/ton (with the implementation of the above improvement measures, the BMA's collection cost will be reduced to 323 Baht/ton in spite of increases in emolument in real term, while the contractors' price may be reduced to 315 Baht/ton due to a more thorough application of the proposed measures.)
2. Increases in waste haulage efficiency	Introduction of transfer stations (T/S) (Refer to Section 7.3)	Reduction of collection & haulage costs by 40 Baht/ton from 450Baht/ton (Direct haulage) to 410 Baht/ton (with T/S)

7.3 Collection Plan

In order to improve efficiency of waste collection and haulage, it is advised that the BMA should do the following.

1) **Discouragement of the Use of Dust-chute and Promotion of Use of Containers**
2) **Introduction of more efficient collection systems such as the station collection, and the bell collection, and collection with containers**
3) **Use of collection vehicles of appropriate capacity and type**
4) **Regular Collection (on fixed days of the week)**
5) **Use of Contractors**
6) **Introduction of small transfer stations (capacity of 100 - 300 tons/day) in the inner districts** (Refer to Section 7.4.)
7) **Improvement on the Vehicle Maintenance (Refer to Section 7.5)**
   a. Daily check of vehicles by drivers by using Daily Check Sheet
   b. Monthly maintenance check by either using
      i) having own mechanics at district level or
      ii) using remote workshops or mobile workshop units which belong to the Central Workshop.
8) **Strengthening of the public relations**

1) Discouragement of the Use of Dust-chute and Promotion of Use of Containers

a. It is strongly advised that the BMA or the Government will ban the use of dust-chutes which are commonly used in commercial buildings and apartment buildings.
   Implementation of this advice will require legal arrangements (revision of construction laws or by-laws), through which installation of dust-chutes in new buildings should be banned as in the case of Malaysia. The BMA should discuss the matter with a relevant authority of the Thai Government.
b. The use of communal containers (about 1 m^3) should be encouraged instead.
c. In the market places, the use of either big hauled-in containers (8 m^3) or smaller containers (1 m^3) should be introduced.

2) Introduction of more efficient collection systems such as the station collection, and the bell collection, and collection with containers

Proposed collection systems by type of area are shown in Table 7.3-1.

Table 7.3-1 The Present and Proposed Collection Systems by Area Types

AREA	COLLECTION SYSTEMS PRESENTLY APPLLIED	PROPOSED COLLECTION SYSTEMS	REMARKS
1. Commercial areas	- Door-to-door collection	- Station collection - Use of plastic bags	A station collection method (a waste depot) has been already tried in Siam Square. Commercial establishments can afford for using plastic bags.
2. Office and commercial buildings, condominium and apartment buildings	- Door-to-door collection - Dust-chute	- Use of containers (use of dust-chutes should be banned.)	Dust-chutes are problematic also in view of safety and sanitation for collection crew.
3. Residential housing areas	- Door-to-door collection (Collection crew enter houses to collect waste.)	- Door-to-door collection (Residents should bring waste out of the house when collection vehicles visit houses.)	
4. Low income residential areas	- Collection with containers (Collection service is inadequate.)	- Collection with containers - Bell collection with use of music in areas where there are not much space to place containers	In slum areas, the larger the containers, the better. Under the bell collection system, residents are supposed to bring waste to collection vehicles upon hearing the music played.
5. Houses on the canal water	- Collection with barge on experimental basis	- Collection with barge	BMA plans to apply the barge collection to all areas wherever applicable by 1991.

3) Use of collection vehicles of appropriate capacity and type

It is advised that the BMA will replace large side loader trucks with large compactor vehicles in principle. Appropriate types of vehicles by area types are shown in Table 7.3-2.

Table 7.3-2 Proposed Type of Vehicle by Area

VEHICLE TYPE	APPLICABLE AREAS
1. Large compactor vehicles (10 m^3)	Main streets, commercial areas and large-scaled-facilities
2. Medium size compactor vehicles	Mainly in residential area with roads of medium width
3. Small side loader trucks	Soi (Narrow streets) where larger vehicle cannot pass
4. Hauled-in-containers (8 m^3)	Market places and other places where big containers can be placed

4) Regular Collection (on fixed days of the week)

Regularity of waste colection (collection on fixed days of the week) is very important for the improvement of the collection efficiency and of the colledction service quality.

5) Use of Contractors

It is planned that BMA will increase the use of contractors and that contractors will collect 30% of waste in 2000.

Reasons for Proposing a Target Rate of 30% Involvement of Contractors

It is advisable for the BMA to increase gradually the use of contractors. An annual increase rate of about 200 tons/day is considered reasonable as this amount is about the same as a typical waste amount generated by a district. (Collection of 200 tons/day of waste requires 30-40 collection vehicles)

With an annual increase of 200 tons/day, contractors' collection amount will be about 2,600 tons/day in 2000, which is 30% of the total collection amount expected in 2000.

6) Reguired Manpower and Vehicles

Table 7.3-3 shows estimated manpower and vehicles required for the years 1991-2000. It is estimated that a total of about 1,600 million Baht will be required to purchase all the vehicles (1,800 units) required.

Table 7.3-3 Vehicles and Manpower Required for 1991-2000

Year	Waste to be Collected By BMA (tons/day)	Vehicles to be Used	Vehicles to be Replaced By New Ones	Additional Purchase	Total Purchase	Drivers & Collectors Used	Net Increase In Man-power
	1	2	3	4	5=3+4	6	7
1991	4,488	1,075	0	48	48	3,929	180
1992	4,730	1,095	0	20	20	3,996	67
1993	4,872	1,113	342	18	360	4,062	66
1994	5,084	1,132	0	19	19	4,130	68
1995	5,280	1,146	342	14	356	4,182	52
1996	5,460	1,184	0	39	39	4,325	143
1997	5,624	1,255	342	70	412	4,582	257
1998	5,772	1,288	48	33	81	4,703	121
1999	5,976	1,333	20	46	66	4,869	166
2000	6,090	1,359	374	25	399	4,962	93
Total	---	---	1,468	332	1,800	---	1,213

Notes: The following assumptions were made:

1. A vehicle life is 7 years.
2. Additional vehicles will be purchased every 2 or 3 years.
3. there will be an average 3.65 crew (including a driver) per vehicle.
4. Daily number of operating vehicles will be 80 % of the total vehicles registered on average.

7.4 Introduction of Transfer Stations

1) Large Scale Transfer Stations

The BMA/DPC has a plan to use contractors which will be responsible for constructing transfer stations, and for hauling and disposing of waste at their own sites. Table 7.4-1 shows planned locations of transfer stations and estimated waste amount to be transferred.

Table 7.4-1 Planned Locations of Transfer Stations and Estimated Waste Amounts to be Transferred by Contractors

PLANNED LOCATIONS	TRANSFER AMOUNTS	
	MAXIMUM	IN 2000
1. On Nut	2,100 tons/day (1994 & 1995)	1,350 tons/day
2. Nong Khaem	3,100 tons/day (2000)	3,100 tons/day
3. Tha Rang	2,000 tons/day (1996)	1,330 tons/day

2) Small Scale Transfer Stations

It is strongly recommended that the BMA/DPC will construct a few small transfer stations in the inner districts in order to increase haulage efficiency of particularly small sized vehicles (1 ton - 3 m^3). At present, waste is transferred from small vehicles to larger vehicles on the streets. However, such transfer is not reliable as those vehicles cannot necessarily meet each other when transfer is required.

Although it would not be easy to obtain land for transfer stations in the inner districts, the BMA/DPC should provide at least one small transfer station as a pilot project.

7.5 Vehicle Maintenance Plan

It is recommended that the BMA should do the following:

1) To instruct all the Districts so that the daily check of the waste collection vehicles should be carried out by drivers, supervisors and section managers as shown below:

RESPONSIBLE PERSON	ACTIONS REQUIRED
Drivers	Check vehicles daily, and keep daily records in the "Daily Check Sheet" shown in Fig. 7.5-2 of Vol. 2 Master Plan.
Supervisors	Check the Daily Check Sheets recorded by the drivers, record problems in the vehicle history books or sheets, and report to the section manager.
Section Managers	Make necessary arrangements for repairs, and Prepare plans (schedule) for periodic maintenance of vehicles.

2) To strengthen the Districts' capacity in vehicle maintenance. Districts which have 25 or more waste collection vehicles should have mechanics of their own so that the Districts can carry out periodic (monthly) preventive maintenance by themselves.

3) To instruct all the Districts (with less than 25 waste collection vehicles) to actively utilize either the remote workshops or mobile workshops (trucks equipped with maintenance tools).

   Both the remote workshops and mobile workshops belong to the Central Workshop (the Mechanical and Maintenance Division--MMD of the Finance Department). The former (remote workshops) should be used by the Districts which do not have a parking area of their own, while the latter (mobile workshop) should be utilized by the Districts which have parking area.

4) The DPC should have its own mechanics in order to execute its own periodic (monthly) maintenance of the vehicles.

5) The Central Workshop should increase the number of mobile workshops to provide periodic maintenance and repair services for some districts.

6) To give a more authority to the Central Workshop to purchase necessary spare parts so that spare parts can be procured in a timely manner.

Note: At present, the maximum amount of an order the Central Workshop can place with its own discretion is 10,000 Baht per each order.

As the BMA is going to replace most of the existing vehicles with new vehicles with the revised 1990 budget, it is a matter of urgency to establish an adequate maintenance system so that the new vehicles can be utilized effectively.

Expected Effects of the Improved Vehicle Maintenance

If the preventive maintenance is adequately carried out as explained above, the following effects may be expected:

1) Reduction of repair time and costs by about 30%.
Note: Repair of vehicles will get more difficult and costly if they are continuously used without atttending to initial problems.

2) Reduction of unforeseeable troubles

3) Higher utilization of vehicles

4) To forecast the future needs for spare parts and repair by keeping registers and by analysis of each vehicles history.

7.6 Strengthening of the Public Relations

Considering the fact that the extent of success or failure of municipal solid waste management much depends on the availability of citizens' cooperation, it is advisable for the BMA/DPC to strengthen its public relations in order to increase their awareness of the necessity for the following:

1) Not littering
2) Proper manner of waste discharge with respect to discharge places, time and containers
3) Waste recycling
4) Paying fees for waste management services

For those purposes, the BMA should either establish a section responsible for public relations within DPC or strengthen the functions of the public relations of the BMA.

A responsible section should

1) Prepare annual program and schedule for public relations activities.
2) Discuss public education regarding cleanliness and environmental sanitation with the national government agencies so that some programs will be introduced as a part of school education.
3) Organize cleanliness competition among districts.
4) Inform citizens how much the BMA spend for maintaining the city clean.

Chapter 8. Treatment and Disposal Plan

8.1 Basic Plan

Basic treatment and disposal plan for the years 1991-2000:

A. Method of Disposal (Refer to Fig. 8.1-1 for the future disposal amounts by method.)	1) The BMA will apply Sanitary Landfill as a major disposal method from 1992 in view of the environmental soundness and cost-effectiveness. Refer to Section 8.2 for justification of the sanitary landfill. 2) Open dumping practiced on the existing sites at On Nut and Nong Khaem will be terminated by the end of 1991. 3) In view of its significance as a pioneering project and its contribution to the alleviation of problems that may arise from the difficulty in the land acquisition for sanitary landfill, it is advised that the BMA, with financial efforts, will construct an incinerator with the capacity of 600 tons/day (200 tons/day/unit x 3 units) during the planning period up to 2000 although sanitary landfill should be applied as a major disposal method. 4) The BMA will construct a new compost plant with the capacity of receiving 1,000 tons/day of waste according to the contract signed in August 1990. 5) The existing compost plants will be closed upon the commencement of the operation of the new compost plant because 1) they have had extremely poor performance, 2) the remaining life of the plants is a few years, and 3) they are not worth repairing judging from costs and benefits to be expected. As a matter of fact, earlier shut-down of the plants are advisable as the plants operation will incur costs much larger than benefits including both compost sales and waste volume reduction effects. The attached incinerator may be evaluated with consideration of the following, if it is possibly to be reused. (1) Most of components of attached incinerators have been so deteriorated in quality that they cannot be reused. (2) The remodeling will require additional and new components such as: - Induced draft fan - Air heater - Burners - Reception pit & cranes - Controllable feeding system to furnace bed - Anti-air pollution system (3) Use of existing building structures and foundations would also be risky and difficult from viewpoints of both design and construction.
B. Disposal of Hospital Waste	6) A hospital waste incinerator with capacity of 20 tons/day (10 tons/day/unit x 2 units - 24 hours-operation) will be constructed at On Nut with an estimated construction cost of 40 million Baht. (8 million Baht in 1991 and 32 million Baht in 1992)

C. Level (Standard) of Sanitary Landfill (S/L)	7) The S/L to be applied in Bangkok will have the following facilities: a. Embankment around sites b. Cover soil with either daily or periodic application c. Lining (either artificial lining or clay lining depending on the site conditions) d. Leachate treatment facilities e. Gas ventilation pipes
D. Responsible Body	8) The BMA/DPC is and will be responsible for treatment and disposal of all the municipal solid waste.
E. Use of Contractors	9) In view of contractor's ability to acquire land at competitive prices, the BMA/DPC will use reliable disposal contractors which will be responsible for waste transfer including construction of Transfer Stations (T/S), secondary haulage and sanitary landfill. (The ownership of T/Ss should be transferred to the BMA after the completion of the contract services.) 10) Location of T/Ss to be constructed, and waste amounts to be hauled and disposed of by contractors (to be employed in the future) will be as shown below: LOCATION OF COMMENCEMENT OF T/S OF OPERATION — INITIAL HAULING & DISPOSAL AMOUNT a. Tha Rang — 1,500 tons/day — 1992 b. On Nut (Existing Site) — 2,000 tons/day — 1992 c. Nong Khaem (Existing Site) — 1,500 tons/day — 1992 Note: The respective hauling and disposal amounts will increase about 10% annually through the contract period of 5 years. 11) Although the BMA will be obliged to depend heavily on disposal contractors upon the closing of the existing sites, it is strongly advised that the BMA should have at least one disposal site of its own in view of stable management of waste. 12) Schedule of using disposal contractors will be as shown in Table 8.1-2.
F. Removal of the Old Waste from the Existing Sites at On Nut and Nong Khaem	13) The BMA/DPC will remove all the waste from the existing sites by the end of 1996 by using contractors. The time schedule for removal will be as shown in Tables 8.1-3 and 8.1-4. 14) After the completion of the waste removal from the existing sites, those sites will not be used for waste disposal. Transfer stations to be constructed on the sites by contractors, will continue to perform their function after the completion of the waste removal.
G. Disposal Sites to be Constructed by the BMA G-1 Number, Location, Size and Capacity	15) The BMA will construct at least two sanitary landfill sites of its own as shown below: Refer to Fig. 8.1-2. LOCATION — LAND SIZE — CAPACITY 1. Ram Intra — 85 Rai — 1,825,000 tons 2. East part of Bangkok (First Phase) — 700 Rai — 3,650,000 tons Notes 1) The Ram Intra site will last about 5 years with an average daily waste receiving amount of 1,000 tons/day. 2) The second site (either in Min Buri or Nong Chock) should be one which will last about 5 years with an average daily receiving amount of about 2,000 tons/day during the first phase (1997-2001). It is also proposed that the BMA will acquire the adjacent land (500 rai) for the second phase (2002-2006), and another 500 rai for the third phase (2007-2011) totaling 1,700 rai for 15 years of landfill operation.

G-2 Time Schedule	16) Time schedule of the planned two sites will be as follows: CONSTRUCTION PERIOD / OPERATION PERIOD 1. Ram Intra Site: 2 years (1992-1993) / 6 years (1994-1999) 2. The Second Site (First Phase): 2 years (1995-1996) / 5 years (1997-2001)
G-3 The Future Use of the Sites	17) After the completion of the landfill operation, the sites will be used as public parks or for some other purposes.
G-4 Estimated Construction Costs	18) Construction costs are estimated as follows: Unit: Million Baht The First Site (Ram Intra Site) / The Second Site (East Part of Bangkok) (First Phase) - Construction: 356.5 / 478.0 - Land Purchase: 95.2 / 392.0 - Total: 451.7 / 870.0 Notes 1) The Land purchase cost of the Ram Intra Site is estimated at 1.12 million Baht/rai (1,600 m2) 2) The land purchase cost of the second site is estimated at 0.56 million Baht/rai.
H. Manpower Deployment	19) It is proposed that all the planned facilities (a new compost plant, sanitary landfill sites, and incinerator) will be operated by deploying the existing manpower (700 persons approximately) currently involved in waste disposal service.

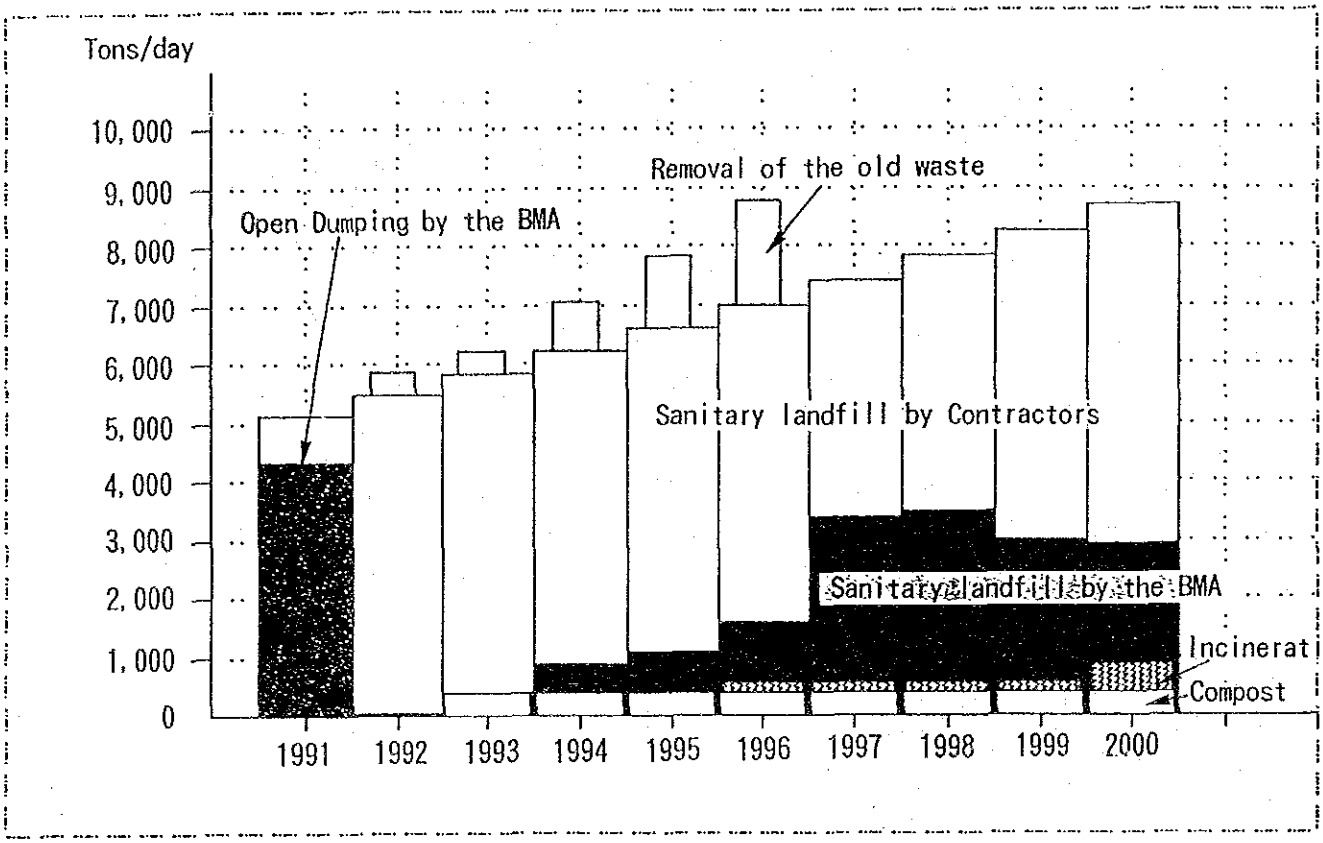
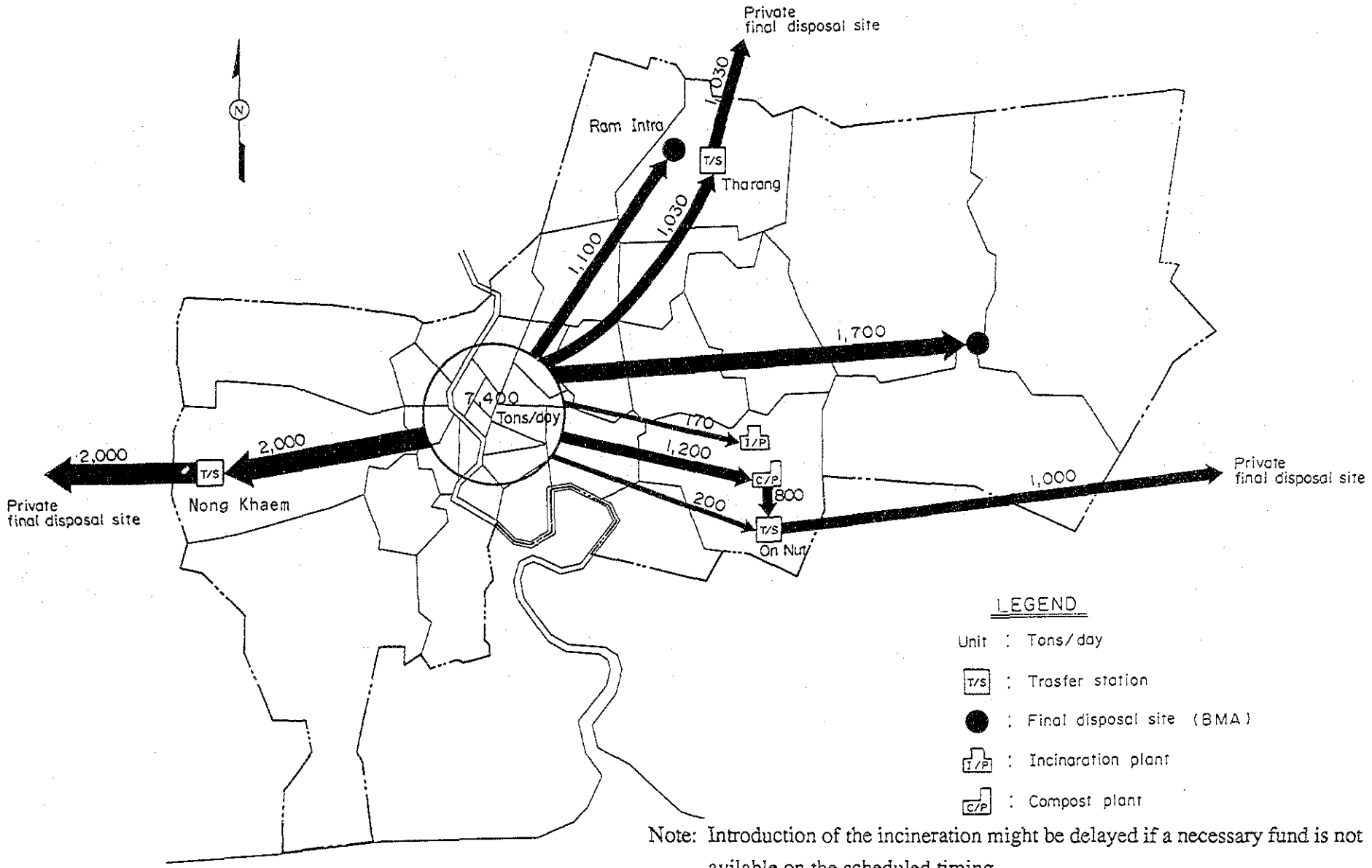


Fig. 8.1-1 The Future Disposal Plan (1991 - 2000)

Note: Introduction of the incineration might be delayed if a necessary fund is not available on the scheduled timing.



Note: Introduction of the incineration might be delayed if a necessary fund is not avilable on the scheduled timing.

Fig. 8.1-2 Disposal Plan in 1997

8.2 Selection of the Most Appropriate Disposal System

This section shows why the sanitary landfill has been chosen as the most appropriate major disposal system among various disposal system options.

8.2.1 Disposal System Options

The following options have been identified through the discussions made between the BMA and the Study Team.

Option 0. The existing SWM with dump sites at Nong Khaem, On Nut and Ram Intra

Option 1. A SWM system with open dumping (haulage distance 45 km) and transfer stations without any intermediate treatment facility

Option 2. A SWM system with sanitary landfill (haulage distance 45 km) and direct haulage without any intermediate treatment facility.

Option 3. Option 2 + Transfer Stations (20 km from the city center).

Option 4. A SWM system with the seashore sanitary landfill in Bang Khun Thian and transfer stations (20 km from the city center).

Option 5. A SWM system with compacting and binding plants (20 km from the city center) and reclamation of compacted waste (haulage distance 45 km).

Option 6. A SWM system with incinerators (20 km from the city center) and sanitary landfill for incineration ash (haulage distance 45 km).

8.2.2 Evaluation Criteria and Grading

The following two criteria and grading are used for the evaluation of the options:

Grade	CRITERIUM 1 Environmental Soundness and Technological Reliability	CRITERIUM 2 Cost
A	Good	Low cost
B	Need further assessment before making a decision	Reasonable
C	Risky	Costly
D	Bad (Not acceptable)	Very costly

8.2.3 Evaluation of Respective Options

1) The respective options are evaluated as follows:

OPTIONS	EVALUATION COMMENTS	CRITERIA 1	CRITERIA 2
OPTION 0 The existing solid waste management (SWM) system with open dumping sites in On Nut, Nong Khaem and Ram Intra	This option is neither advisable (because of environmental problems caused through the open dumping) nor sustainable (because the remaining capacity of the existing sites is small). This option is included just for comparison with other options.	D-	A+
OPTION 1 A SWM system with open dumping (haulage distance 45 km) and transfer stations without any intermediate treatment facilities	Although this option is the cheapest, the option is not advisable because the open dumping causes both environmental and aesthetic problems. This option cannot satisfy the minimum environment-sanitation standards required by the authorities concerned (the ONEB and the Ministry of Industry) in Thailand.	D	A
OPTION 2 A SWM system with sanitary landfill (haulage distance 45 km) and direct haulage without any intermediate treatment facility	Sanitary landfill is judged the most appropriate disposal method to Bangkok. As shown in Table 8.2-1, haulage system with transfer stations (as in Option 3) will be less costly than that without transfer stations.	A	B
OPTION 3 Option 2 + Transfer station (20 km from the city center)	This option is the most appropriate both in terms of Criteria 1 and 2.	A	B+
OPTION 4 A SWM system with the seashore sanitary landfill in Bang Khun Thian and transfer stations (20 km from the city center)	The seashore landfill may cause some marine environmental problems, i.e. it may affect Mangrove. This option is not a recommendable means of waste disposal though it may be feasible as means of construction of a public park provided that appropriate environmental measures are taken.	B	C
OPTION 5 A SWM system with compacting and binding plants (20 km from the city center) and reclamation of compacted waste (haulage distance 45 km)	The compaction and binding system is very costly and has technological defects. The Japanese experience shows that waste-packed-fill materials produced through this system cause serious problems such as shrinkage and breaking, further causing structural and environmental problems.	C	C-
OPTION 6 A SWM system with incinerator (25 km from the city center) and sanitary landfill for incineration ash (haulage distance 45 km)	This option is very costly. This option will be justified if the BMA cannot obtain land necessary for sanitary landfill. See Section 8.2.4 Item 5 for more discussion on this option.	A	D

Estimated costs are summarized in Table 8.2-1 and Fig. 8.2-1.

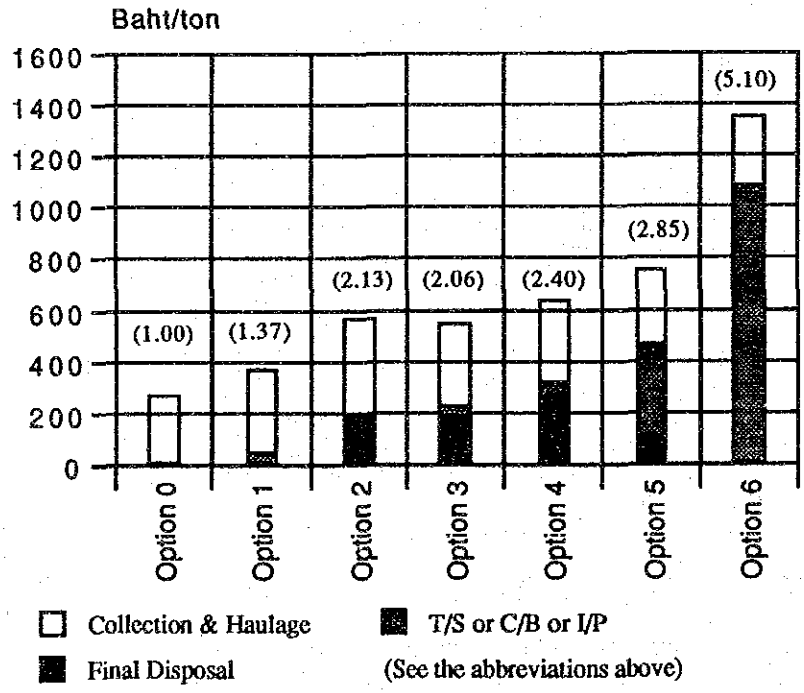
Table 8.2-1 Estimated Costs of Respective Options

Unit: Baht per ton of waste on collection basis

	Option 0	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6
Description	O/D at Existing Sites	O/D at Distant Places (45 km)	S/L at Distant Places (45 km)	Option 2 + T/S	Sea + S/L (45 km)	C/B + S/L (45 km)	I/P + S/L (45 km)
1. Collection & Haulage	255	315	375	315	315	285	265
2. T/S or C/B or I/P	0	(11) 50	0	(11) 50	(11) 50	(32) 394	(32) 1,107
3. Final Disposal	10	(68) 78	(87) 278	(87) 278	(65) 347	(52) 160	(5)15
Total	265	(79) 443	(87) 653	(98) 643	(76) 712	(84) 839	(37) 1,387
Total Excluding Land Cost	265	364	566	545	636	755	1,350
Cost Index Option 0 = 1.00	1.00	1.37	2.13	2.06	2.40	2.85	5.10
Cost Ranking	1	2	4	3	5	6	7

Abbreviations: O/D: Open Dumping, S/L: Sanitary Landfill, T/S: Transfer Station,
Sea: Seashore landfill, I/P: Incineration Plant,
C/B: Compaction & Binding,

Note: Figures indicated in parentheses are land purchase costs calculated for each one ton of waste.



Figures in Parentheses are cost indices (Option 0 = 1).

Fig. 8.2-1 Cost Comparison

2) Selection of the Most Appropriate Option

Option 3 (Sanitary landfill and Transfer stations) is judged as the most appropriate, and therefore the best option through the following evaluation process:

(1) Both Options 0 and 1 with open dumping were rejected because these options do not satisfy the minimum environment-sanitation standards required by authorities concerned (the ONEB and the Ministry of Industry) in Thailand.

(2) The comparison between the remaining Options 2-6 shows that Option 3 dominates the other options because Option 3 scores the highest grading for both Criteria 1 and 2.

8.2.4 Conclusions

1. The BMA should apply the sanitary landfill (Option 3) as the major means of waste disposal in terms of environmental soundness, technological reliability and cost-effectiveness.

2. The choice of Option 3 does not mean that all the Bangkok waste will have to go through transfer stations. The choice of Option 3 means that it is more economical to use transfer stations if the haulage distance is about 45 km or longer in general. Some waste collected near to disposal sites should be transported directly to the sites without going through transfer stations.

3. Although the cost difference between Options 2 and 3 is small at present, the cost difference may be greater in the future in view of that:

   a. The long haulage with transfer stations would require less manpower than that without transfer stations would. The faster increase in emoluments (personnel costs) than equipment costs will make Option 3 (equipment-intensive system) more economical than Option 2 (more labor-intensive system) in the future.

   b. Sites of transfer stations can be converted to those for incinerators when needed. This is a very important point to be considered in view of the increasing costs and difficulty of land acquisition that is likely to happen in the future.

4. Therefore, it is advisable for the BMA to acquire as many transfer stations as possible within the areas reasonably near to the waste generation centers.

5. Introduction of Incinerators

   a. The most important factor to decide on the introduction of incinerators is the availability of land for sanitary landfill. If land is not available, incinerators will have to be introduced inevitably .

   b. In this sense, it is very important for the BMA to have an accurate forecast on the availability of the land and reliable contractors for waste disposal.

   c. Even if land prices increase sharply, the sanitary landfill will never be more costly than incinerators from the view point of Bangkok Citizens as a whole because the land value will never disappear after the completion of the sanitary landfill operation. As a matter of fact, it is very likely that the value of the land will substantially increase after the completion of the landfill if the BMA uses old borrow pits which exist in Bangkok.

      Note: Financial cost of the sanitary landfill will be equivalent to that of incinerators if the land price of sanitary landfill increase 10 - 25 times. Assuming that the land price would increase by 10 % every year, it would take 25 years to reach to a land price 10 times higher than the current price, and take 34 years to reach to a price 25 times higher than the current one.

   d. Although it is likely that the BMA would find land for sanitary landfill either by itself or through contractors during the current planning period till 2000, the introduction of an incineration plant as proposed in Section 8.4 might be advisable for the BMA in view of acquiring the plant-operation know-how and experience which may be needed in the future.

8.3 Plan for the Sanitary Landfill

8.3.1 Functions of a Sanitary Landfill and Major Facilities Required

Sanitary landfill is a solid waste disposal system which controls dumped waste, leachate (water generated as a result of the compaction and decomposition of dumped waste) and gas. Sanitary landfill systems have the following functions and facilities:

Table 8.3-1 Functions and Facilities Required for Sanitary Landfill

REQUIRED FUNCTIONS	REQUIRED FACILITIES
a. Dumped waste must be confined.	1. Embankment or borrow pits 2. Waste scattering prevention facilities
b. Dumped waste must be covered (to avoid the generation of bad odor and flies, and also to prevent waste scattering).	3. Cover soil with either daily or periodic application
c. Leachate must not escape outside the sites without treatment.	4. Lining (clay or rubber or plastic or concrete) 5. Leachate collection & drain facilities 6. Rain water collection & drain facilities Leachate pond
d. Leachate must be treated.*1	7. Leachate treatment facilities
e. Gas must be released.*2	8. Gas ventilation pipes
f. Site must be accessible.	9. Access roads and onsite roads
g. Operation must be controlled.	10. Control office 11. Weighbridge (Truck scale) 12. Fire fighting facilities

8.3.2 Major Points to be Considered for the Selection of Landfill Sites

Major Points to be considered for the selection of landfill sites include the following:

1) Geological conditions
2)Surrounding environment
3) Land price
4) Distance to collection area and haulage costs

Notes:

1. It is beneficial for the citizens of Bangkok to use old borrow pits as sanitary landfill sites because the value of the holes can be increased by filling it with waste. In the case of the Ram Intra pit, such increase in the land value is estimated at 211 million Baht according to the following calculation:

A - B = 306 million Baht - 95 million Baht

= 211 million Baht

where A is the value of the land after filling with waste. (3.6 million Baht/rai x 85 rai = 306 million Baht)

B is the current market value of the pit.

(1.12 million Baht x 85 rai = 95 million Baht)

(It is assumed the future land value after filling the pit with waste will be 3.6 million Baht/rai, 60 % of the current market price (6 million Baht/rai) of the flat land adjacent to the pit.)

2. Purchase of the planned site at Ram Intra can be justified when comparing the total cost of land and haulage for the Ram Intra site to that of a more distant site. The following table shows that the financial cost of disposal at the Ram Intra site is about 135 million Baht lower than that to be incurred at a place in an east part (e.g. Nong Chok) of Bangkok if other conditions are identical.

	PLANNED RAM INTRA SITE (1)	A PLACE IN NONG CHOCK (2)	DIFFERENCE (3) = (2) - (1)
(1) Land Purchase Cost (85 rai)	95.2	47.6	-47.6
(2) Additional Haulage Cost	0.0	182.5	182.5
(3) Total [(1) + (2)]	95.2	230.1	134.9

Remark:
It is assumed that financial costs of land purchase are 1.12 million Baht/rai in Ram Intra, 0.56 million Baht/rai in Nong Chock, 2) additional haulage cost is 100 Baht/ton, and 3) total disposal amount is 1,825,000 tons.

8.3.3 Two Types of Sanitary Landfill in Bangkok--Advantages and Disadvantages

There are the following two major methods of sanitary landfill in Bangkok considering geological and geographical conditions in Bangkok.

1. Sanitary landfill using flat land
2. Sanitary landfill using borrow pits made after soil removal.

Advantages and disadvantages of the two methods are summarized in Table 8.3-2.

Table 8.3-2 Advantages and Disadvantages of Sanitary Landfill using Flat land and Borrow Pit

	ADVANTAGES	DISADVANTAGES
Sanitary Landfill Using Flat Land	1. Less risk of damaging environment in the sense that the method will not affect underground water (Natural Bangkok clay will prevent leachate water from seeping into underground water.) 2. Economical in the sense that the method do not require: a. Purchase of artificial lining materials b. Purchase of cover material to cover waste Note: Under this method, about 3 m of top soil will be removed. Removed soil can be used as cover material.	1. Disposal capacity with this method may be smaller than that with the other method.
Sanitary Landfill Using Borrow Pits	1. Purchase cost of land (borrow pits) are lower than that of flat land if other conditions being equal. 2. This method will make possible to create a flat land which can be more useful and valuable than pits. Considering 1) the existence of many borrow pits in Bangkok and, 2) the expected increases in land values, this method would be very beneficial to Bangkok citizens. (See Fig. 8.3-1 for the location of the existing borrow pits in Bangkok.) It might happen that such benefit (increases in land value) might exceed the cost of waste disposal.	1. If pits are deeper than the depth of the existing clay, clay or artificial lining has to be purchased to lay it on the bottom of pits. (If no lining applied, this method may cause pollution of underground water.) 2. Cover soil has to be purchased if it is not available from pits.

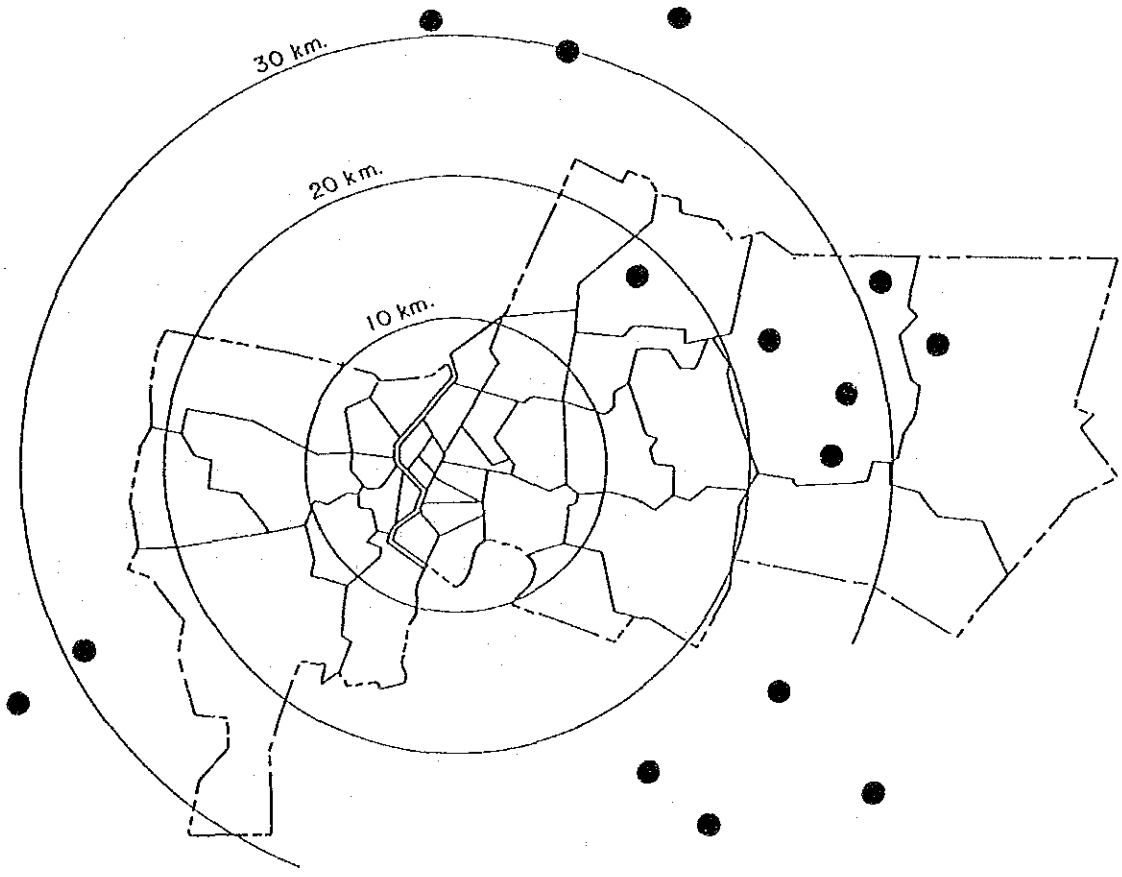


Fig. 8.3-1 Location Map of Big Borrow-pits in Bangkok

8.3.4 Plan for Sanitary Landfill

The BMA will construct and operate the following two sanitary landfill sites during the master plan period:

1. Sanitary landfill in Ram Intra using the existing borrow pit (85 rai)
2. Sanitary landfill in the east part (Its location has not been decided yet.) using a flat land (700 rai for the first phase)

Note: Refer to Volume 3 Feasibility Report Part 1 for the detail plan of the sanitary landfill in Ram Intra.

Ideally, the BMA should have disposal sites both in the east and west parts of Bangkok. In reality, however, the acquisition of a large land in the west part of Bangkok is extremely difficult. Therefore, it is planned that the BMA will purchase two sites both in the east part of Bangkok.

The reasons for choosing a borrow pit in Ram Intra as a disposal site are given below:

1. The land is readily available if the BMA wishes to purchase it.
2. The landfill in the chosen site will contribute to a large increase in the land value, through the conversion of the pit to flat land, that could be used as a public park or some other purpose, which can be beneficial to the citizens of Bangkok.
3. The successful implementation of sanitary landfill in the Ram Intra pit will imply that the BMA can possibly use many other borrow pits (similar to that in Ram Intra) in the future which exist in Bangkok.
4. The pit is not so far from the core districts. (about 20 Km)
5. The Ram Intra pit is an ideal location for "Incineration and Park Plan" in the future. (A public park can be constructed after the completion of sanitary landfill. It is then necessary for the BMA to purchase the land lying between the closed compost plant site and the pit for the realization of the Incineration and Park Plan.)

Outline of the planned two sites is summarized in Table 8.3-3.

Table 8.3-3 Outline of the Planned Two Sanitary Landfill

	SANITARY LANDFILL SITE 1 (RAM INTRA)	SANITARY LANDFILL SITE 2 (EAST PART OF BANGKOK)
1. Location	Ram Intra	A place (not decided yet) in the east part of Bangkok
2. Land condition	Borrow pit	Flat land
3. Site Area	85 rai	700 rai for the first phase (1,700 rai in total)
4. Effective Disposal area	80 rai	500 rai for the first phase (1,500 rai in total)
5.Capacity		For the first phase:
a. Total Waste Disposal Capacity	2,300,000 m^3	4,700,000 m^3
	(1,825,000 t)	(3,650,000 t)
b. Covering Material	700,000 m^3	1,4000,000 m^3
	(910,000 t)	(1,800,000 t)
c. Total (a + b)	3,000,000 m^3	6,100,000 m^3
	(2,735,000 t)	(5,450,000 t)
7. Layout Plan	Refer to Fig. 8.3-2 & Fig. 8.3-3	Refer to Fig. 8.3-4 & Fig. 8.3-5
8. Period of Operation	1994-1999	1997-2001
	Refer to Fig. 8.3-7	Refer to Fig. 8.3-7
9. Costs		(for the First Phase Only)
1) Land Purchase	95,200,000 Baht	392,000,000 Baht
2) Construction	356,500,000 Baht	478,000,000 Baht
3) Total (1+2)	451,700,000 Baht	870,000,000 Baht
4) Operation & Maintenance	210,370,000 Baht	277,400,000 Baht
5) Grand Total	662,070,000 Baht	1,147,400,000 Baht
	Refer to Table 8.3-6.	Refer to Table 8.3-6.

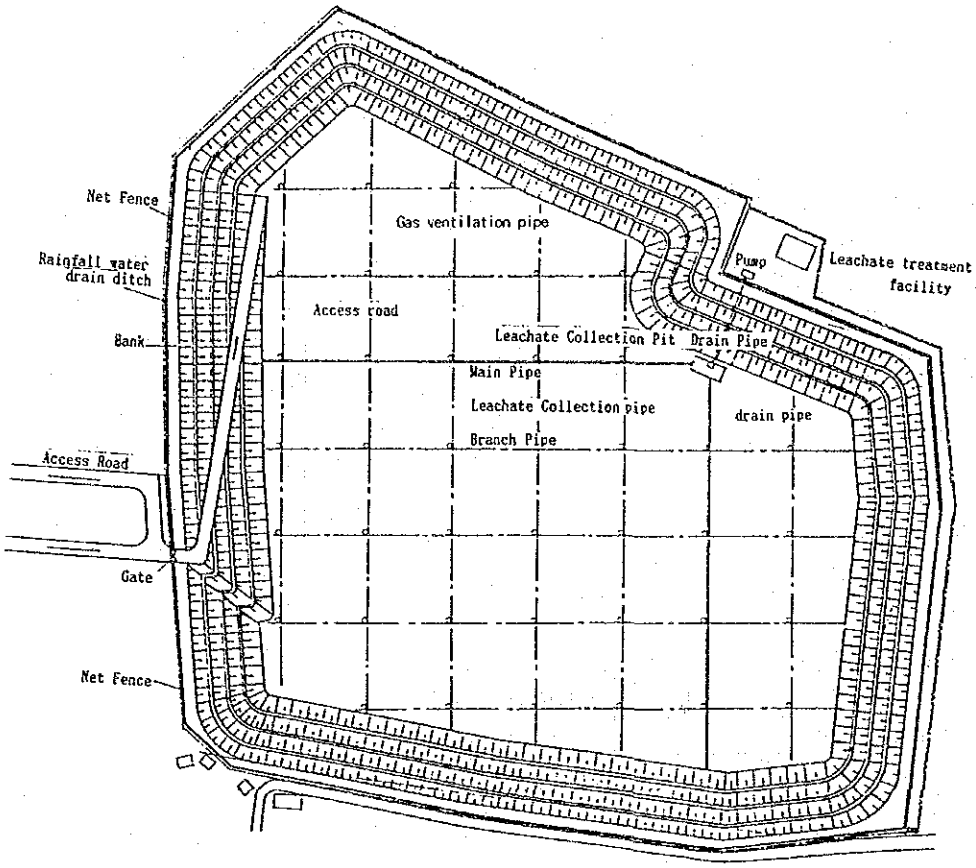


Fig. 8.3-2 Layout Plan for the Sanitary Landfill in Ram Intra

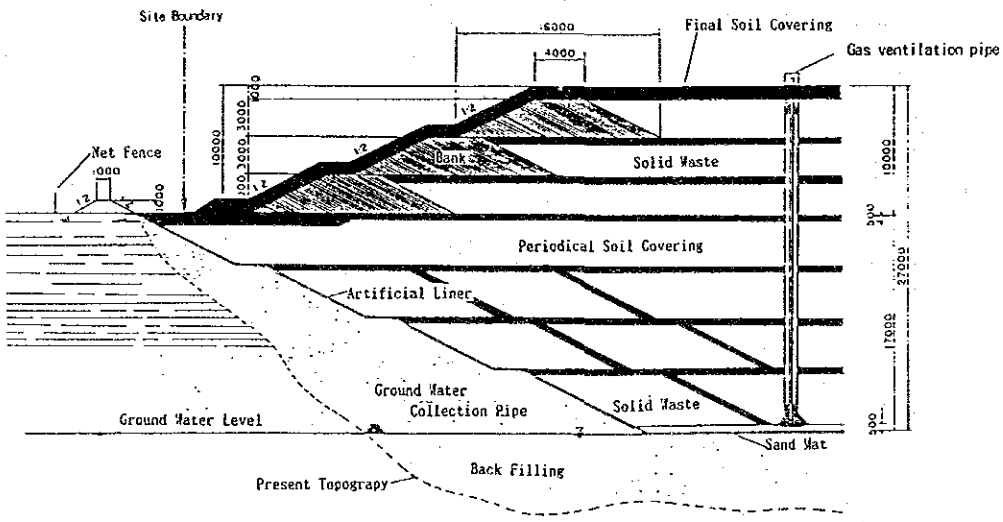


Fig. 8.3-3 Typical Cross Section of the Sanitary Landfill in Ram Intra

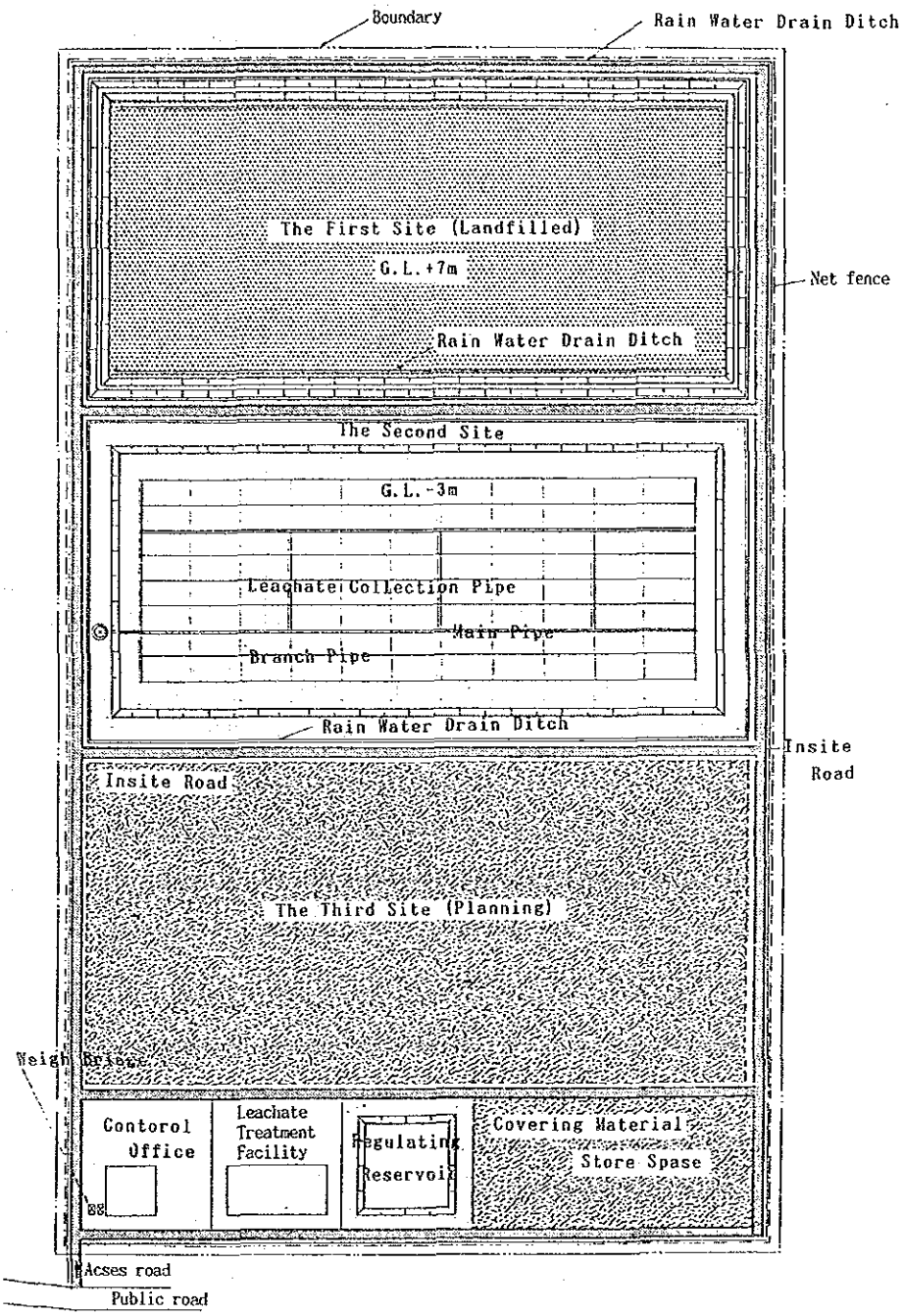


Fig. 8.3-4 Layout Plan for the Sanitary Landfill in the East Part of Bangkok

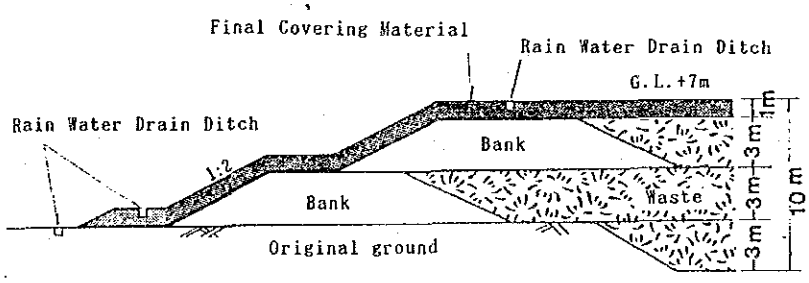


Fig. 8.3-5 Typical Cross Section of the Sanitary Landfill in the East Part of Bangkok

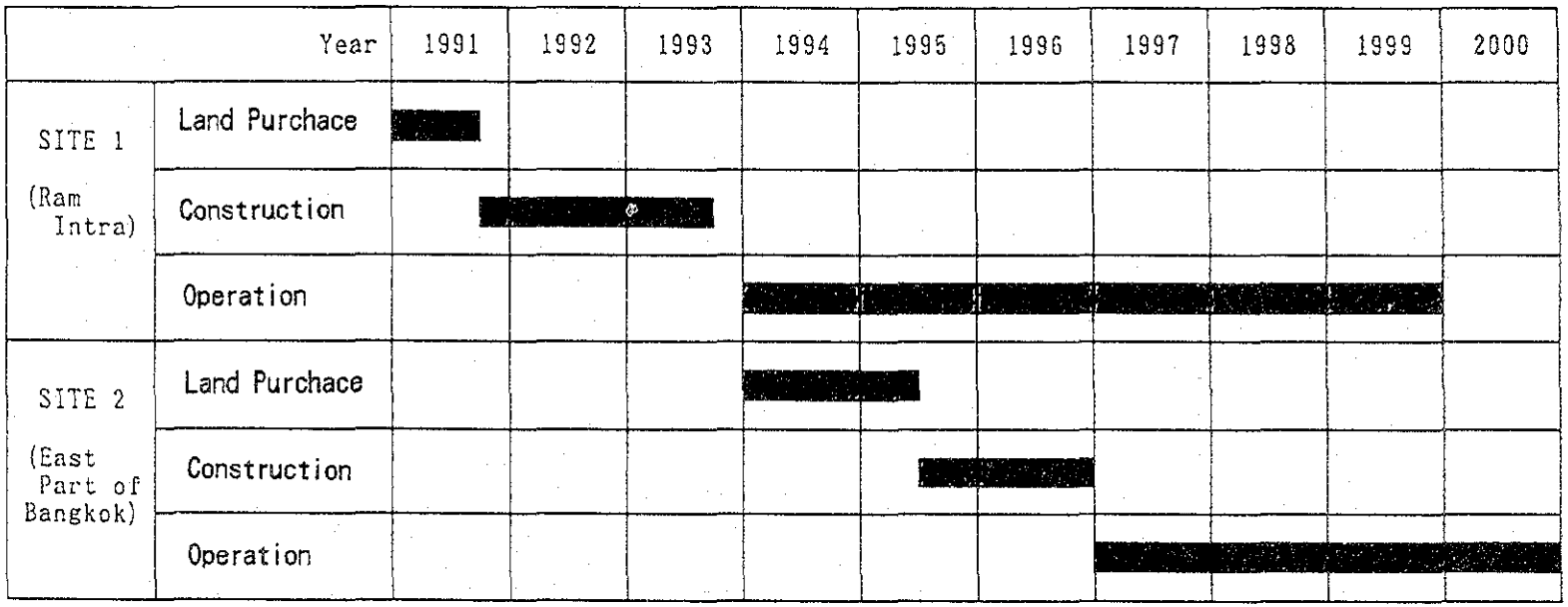


Fig. 8.3-6 Construction and Operation Schedule for the Two Sanitary Landfill Sites

Table 8.3-4 Estimated Costs of Construction and Operation/Maintenance of the Two Sanitary Landfill Sites

Items	Site 1 (Ram Intra)		Site 2 (East Part of Bangkok)		
	Total	Per Ton Cost	1st Phase Only	Total	Per Ton Cost
1. Land Purchase	95,200,000	52	392,000,000	952,000,000	87
2. Construction	356,500,000	195	478,000,000	1,178,000,000	107.7
a. Civil Work	(304,500,000)	(167)	(350,000,000)	(1,050,000,000)	(96)
b. Water Treatment Facility	(52,000,000)	(28)	(120,000,000)	(120,000,000)	(11)
c. Control Office	(0)	(0)	(6,000,000)	(6,000,000)	(0.5)
d. Weigh Bridge	(0)	(0)	(2,000,000)	(2,000,000)	(0.2)
3. Total (1+2)	451,700,000	247	870,000,000	2,130,000,000	194.7
4. Operation/ Maintenance	210,370,000	115	277,400,000	832,200,000	76
5. Grand Total (3+4)	662,070,000	362	1,147,400,000	2,962,200,000	270.7

8.4 Treatment Plan

Introduction

It is planned that the following treatment facilities will be constructed during the master plan period:

1. An incineration plant (600 tons/day)
2. An incineration plant (20 tons/day) for hospital waste (The budget for this incineration plant is included in the 1991 DPC's budget.)
3. A compost plant (1,000 tons/day of incoming waste) (The contract for the compost plant was concluded in August 1990.)

The Planned facilities are outlined in the table below:

FACILITY	CAPACITY	OPERATION PERIOD	COST OF CONSTRUCTION
Incineration Plant	200 tons/day/unit x 3 units = 600 tons/day (200 t/d during 1996 - 1999, and 600 t/d in 2000 and there after)	1996 - 2014 (Introduction of the incineration might be delayed if a necessary fund is not available in the scheduled timing.)	1,842 million Baht (1,209 million Baht for the first phase and 633 million Baht in the second phase)
Incineration Plant for Hospital Waste	20 tons/day	1993 - 2013	40 million Baht
Compost Plant	Incoming waste amount: 1,000 tons/day	1993 - 2008	370 million Baht

The remaining part of this chapter will concentrate on the plan of the incineration plant (600 tons/day) because 1) the BMA has already planned an incineration plant for hospital waste, and appropriated a 1991 budget (40 million Baht) for the construction of the plant, 2) the BMA, in August 1990, signed a contract with a contractor for the construction of the compost plant. Refer to Vol. 3 Part 2 for a more detailed study of the planned incineration plant (600 tons/day).

8.4.1 Reasons for the Introduction of an Incineration Plant

It has been agreed by both the BMA/DPC and the Japanese side that it is advisable for the BMA to construct an incineration plant during the planning period up to 2000 in view of the following:

1. Incineration would contribute to the stable disposal management of waste. (It will alleviate problems that will arise from the difficulty in land acquisition for disposal sites.).

2. Earlier introduction of an incinerator will be helpful for the BMA in the sense that it would enable the BMA to acquire the incineration know-how and experience, and to prepare for the future situation where substantial amounts of waste would have to be incinerated due to the difficulty in land purchase for sanitary landfill.

8.4.2 Design Policy for the Incineration Plant

An incineration with capacity of 600 tons/day has been planned based upon the following design policy:

Policy 1. WORKABLE INCINERATOR

A proposed incinerator should be the one which can incinerate the current waste of ordinary characteristics (in terms of calorific values and waste composition) without choosing a particular waste having higher calorific values.

Policy 2. USE OF RELIABLE TECHNOLOGY

A proposed incinerator should be the one which employs reliable technology that has been tested and proved in many places.

Policy 3. ECONOMICAL INCINERATOR

A proposed incinerator should be the most economical one under such conditions as waste quality and, environmental standards to be met.

Policy 4. PREVENTION OF THE SECONDARY POLLUTION

The prime objective of an incinerator is to dispose of waste in a sanitary manner by incinerating and reducing waste volume. It, however, may cause

a secondary pollution such as air pollution if adequate measures are not taken.

A proposed incinerator should be the one with facilities necessary for avoiding the secondary pollution. It should be the one which will meet the "Proposed Industrial Emission Standards by Industrial Environment Division, Ministry of Industry."

8.4.3 Outline of the Planned Incineration Plant

The proposed incinerator is outlined as follows:

1) Capacity of Incineration

- 600 tons/day: 200 tons/day/unit x 3 units
- Annual incineration amount: 600 tons/day x 315 days/year* = 189,000 tons/year
  (* 315 days/year is an average number of operation days per year calculated on the following conditions: Overhaul 20 days/year and monthly maintenance check 2-3 days/month.)

Reason for Proposing a Furnace of 200 ton/day/unit

Given the total capacity being 600 tons/day, and the calorific values of waste of Bangkok, 3 units of 200 tons/day/unit with a water injection system is judged most cost-effective and technically appropriate. A gas cooling system by water injection type does not function properly if the capacity of a furnace is over 200 tons/day/unit approximately. (A furnace of sizes bigger than about 200 ton/day are feasible in the case that a boiler system is applied as a gas cooling system.)

Reason for Proposing an Incinerator of 600 tons/day (200 tons/day/unit x 3 units)

An incinerator with the capacity of over 600 tons/day is not physically feasible in view of 1) size of the required waste pit and facilities and 2) size of the planned site in On Nut (Approx. 10.6 rai). An incinerator with the capacity of over 600 tons/day may put a very heavy financial burden on the BMA.

2) Gas Cooling System

- Water injection system

Reasons for Proposing a Water Injection System

The quality of waste (low heat values of waste) is the most important factor to decide on a type and capacity of an incinerator to be applied in Bangkok.

Waste of Bangkok has low calorific value as it contains a relatively high water content. It is judged that the low heat value (LHV) of waste in Bangkok will be 750 kcal/kg - 1,500 kcal/kg during the period of 1996 - 2010. Note: LHV is calory of waste calculated by subtracting water vaporation heat.

The above estimated calorific values, however, are not high enough to apply a high pressure steam boiler and generator system. The boiler and generator system is feasible if the waste constantly has low heat values of 1,400 kcal/kg or greater. Therefore, the Water Injection System should be applied as a gas cooling system.

3) Environmental Protection Measures

(1) Anti-Air Pollution

The planned incinerator will have all the facilities necessary to satisfy the "Proposed Standards by Industrial Environment Division, Ministry of Industry". The necessary facilities include the following.

a. Electric precipitator (to remove dusts and particles from ventilation gas)
b. HCl remover ($Ca(OH)_2$ dry spray) (to remove hydrogen cloride)
c. High stack (to disperse ventilation gas)

(2) Anti-water Pollution

The planned incinerator will have a closed system for discharged water, i.e. leachate generated in the waste reception pit will be put into the furnace for incineration; all other sewage water will be treated either only biologically or biologically/chemically. Treated water will be utilized to make ventilation gas cooler through the water injection system.

4) Site Location and Size

The plant site will be in the east side of the existing disposal site in On Nut. The site is 17,000 m_2 (10.625 rai). Refer to Fig. 8.4-1.

5) Layout Plan: Layout plan is shown in Fig. 8.4-2.

6) Major Specifications: Major specifications are shown in Table 8.4-1.

7) Estimated Costs

	TOTAL	PER TON
a. Construction		
- The First phase	1,209 million Baht	
- The second phase	633 million Baht	
- Total	1,842 million Baht	658 Baht
b. Operation/Maintenance for 19 years until 2014	1,965 million Baht	713 Baht
c. Total (a+b)	3,807 million Baht	1,371 Baht

(Refer to Table 8.4-2 for details of the costs.)

8) Construction Schedule

Construction will be divided into two phases in view of the required amount of investment for the incineration plant: In the first phase, the first unit (200 ton/day) and all facilities commonly used for all the three units will be constructed. In the second phase, the second and third units of furnaces will be constructed. The first furnace will start operation in 1996, the second and third furnace will start operation in 2000. Refer to Fig. 8.4-3 for the schedule.

9) Manpower Required

It is estimated that 85 persons approx. will be required for the operation of the planned incineration plant. Refer to Table 8.4-3.

10) Training of the Personnel

Training of the personnel for the plant operation should be included in a contract to be concluded between the BMA and a contractor. The training should be provided during a construction period. Refer to Volume 3 Part II Section 7.2 Training Plan.

Fig. 8.4-1 Site Location Map of the Incineration Plant

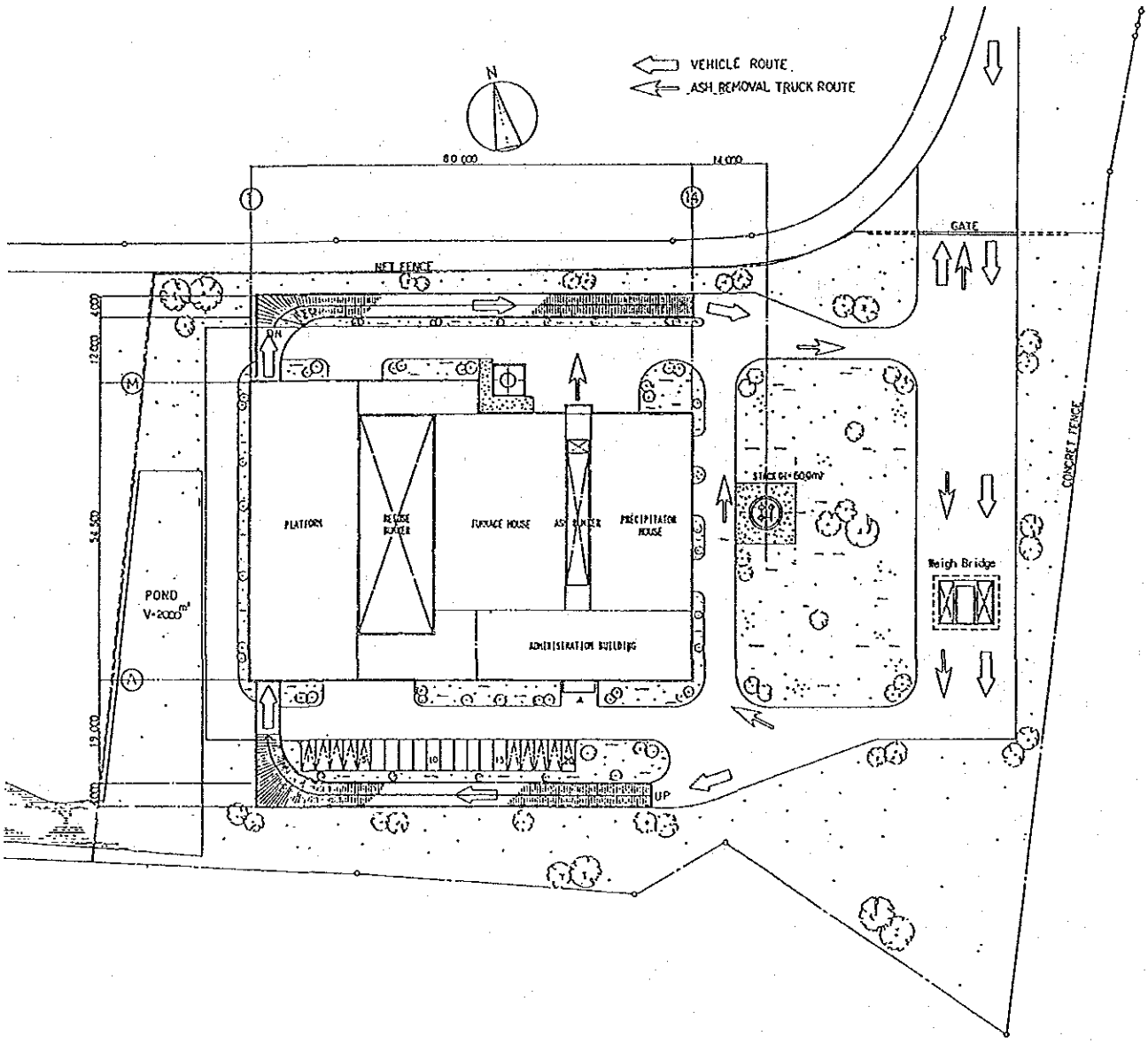
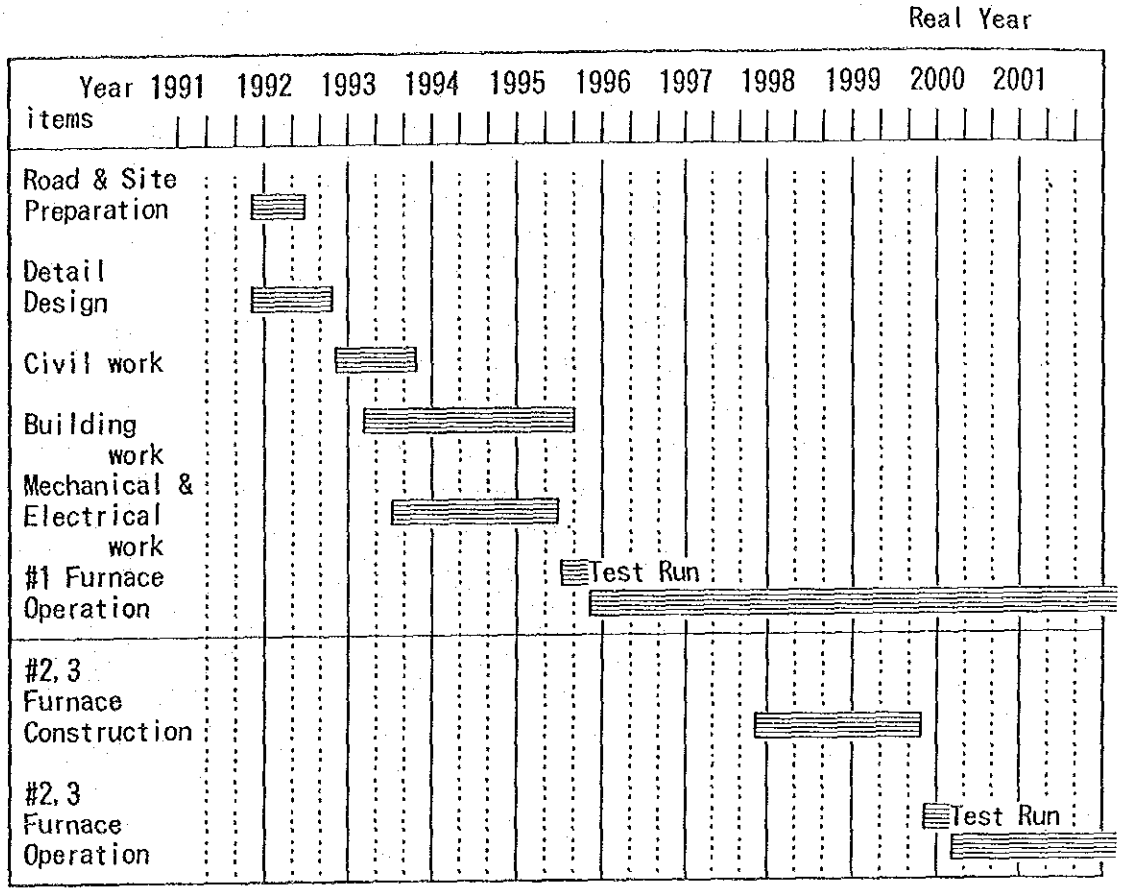


Fig. 8.4-2 Layout Plan of the Incineration Plant



Note: During the first phase construction, the first furnace together with common facilities such as waste pit, water treatment facilities for 2nd and 3rd furnaces will be constructed.

Fig. 8.4-3 Construction Schedule of the Incineration Plant

Table 8.4-1 Major Specifications of the Incineration Plant

ITEM OF INCINERATOR	SPECIFICATIONS
Furnace capacity	600 t/d (8.33 t/h x 3 units x 24 hours)
Number of furnaces	3 (200 t/d x 3 units)
Land required	17,000 m^2 in On-Nut
Low heat calorific values	750 - 1,500 kcal/kg, standard 1,150 kcal/kg
Weigh bridge	30 ton/unit x 2 units
Reception Pit	5,200 m^3 (3-days-capacity) w/v = 0.35
Number of pit gates	9, (platform, 42 m wide)
Cranes	2 units with bucket
Type of furnace	Step grate stoker
Burner	Diesel oil burner
Gas Cooling System	Water Injection System
Gas treatment for Anti-Pollution	HCl remover (dry $Ca(OH)_2$ spray) Electric precipitator
Heat utility	Hot water recovery
Draft	Induced draft fan (approx. 69,000 m^3 N/h x 3) Forced draft fan (approx. 34,000 m^3 N/h x 3)
Stack	60 m high 1 stack outside 3 inner stacks inside
Ash pit	840 m^3
Ash crane	1 unit
Water treatment	Closed system. Treated water is sprayed for gas cooling.
Guillotine shear	150 t x 1 unit

Table 8.4-2 Annual Costs of Construction and Operation/Maintenance for the Incineration Plan

(Unit: Million Baht)

Year / Items	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Construction	-	-	408	408	204	-	-	200	200	70	-
Maintenance											
Emolument	-	-	1.08	1.08	2.90	4.56	4.56	4.56	4.56	9.42	9.42
Utility	-	-	-	-	-	19.40	19.85	19.47	20.17	43.44	43.60
Parts*1	-	-	-	-	-	0.36	0.44	1.82	2.00	2.20	2.60
Repair*2	-	-	-	-	-	3.64	3.64	9.09	10.00	18.10	32.72
Subtotal	-	-	1.08	1.08	2.90	27.96	28.49	34.94	36.73	73.16	88.34
Total	-	-	409	409	207	28	28	235	237	143	88

*1: "Parts" include materials and equipment used for operation and maintenance.

*2: "Repair" means mainly overhaul which will be done by a contractor. Costs of minor repairs to be done the BMA is also included.

Table 8.4-3 Estimated Manpower Required for the Operation/Maintenance of the Planned Incineration Plant

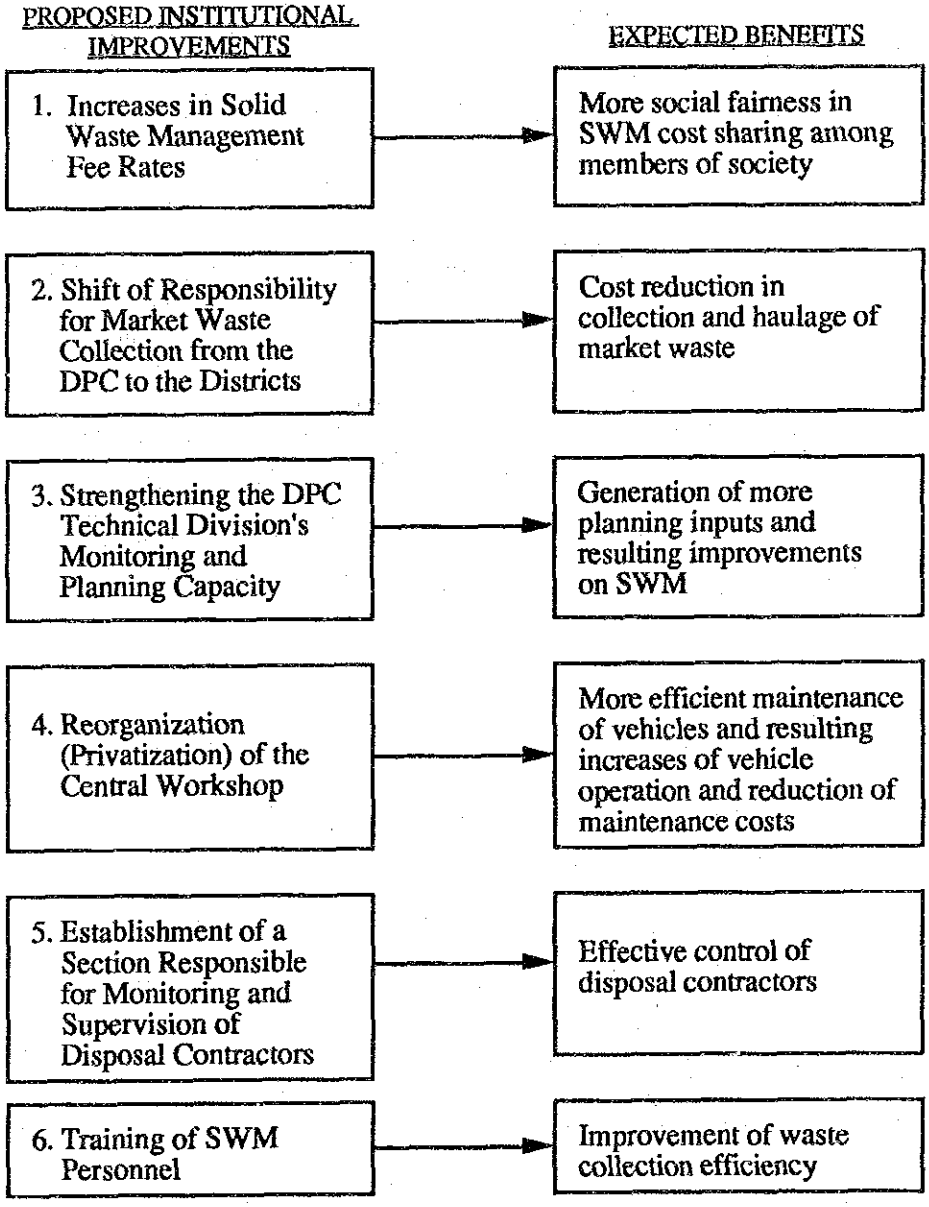
PERSONNEL	MANPOWER REQUIRED (PERSONS)
Plant Manager	1 (1)
Engineers	
- Mechanical	2 (1)
- Electrical	2 (1)
Equipment Controller	2 (1)
Operator	
- Crane	12 (8)
- Incinerator	12 (8)
- Weigh Bridge	8 (4)
Maintenance Crew	24 (8)
Cleansing Men	6 (4)
Guardmen	12 (8)
Clerk Chief	1 (1)
Assistant	3 (1)
Total	85 (46)

Note: Figures in parenthesis indicate number of persons required for the operation/maintenance of the incinerator with capacity of 200 tons/day during 1996 - 1999.

Chapter 9. Institutional Improvement Plan

9.1 Proposed Institutional Improvements and Their Benefits

The institutional improvements proposed in this chapter and their expected benefits are summarized as follows:



Fee Collected

The Districts and the DPC collected waste collection fees amounting about 32 million Baht in 1989. It is almost 4 % of the expenditure for the solid waste management (793 million Baht). And 0.46 % of the BMA's Revenue (6,900 million Baht). Table 9.1-1 shows that the fee rates are very low as compared to actual costs spent by the BMA.

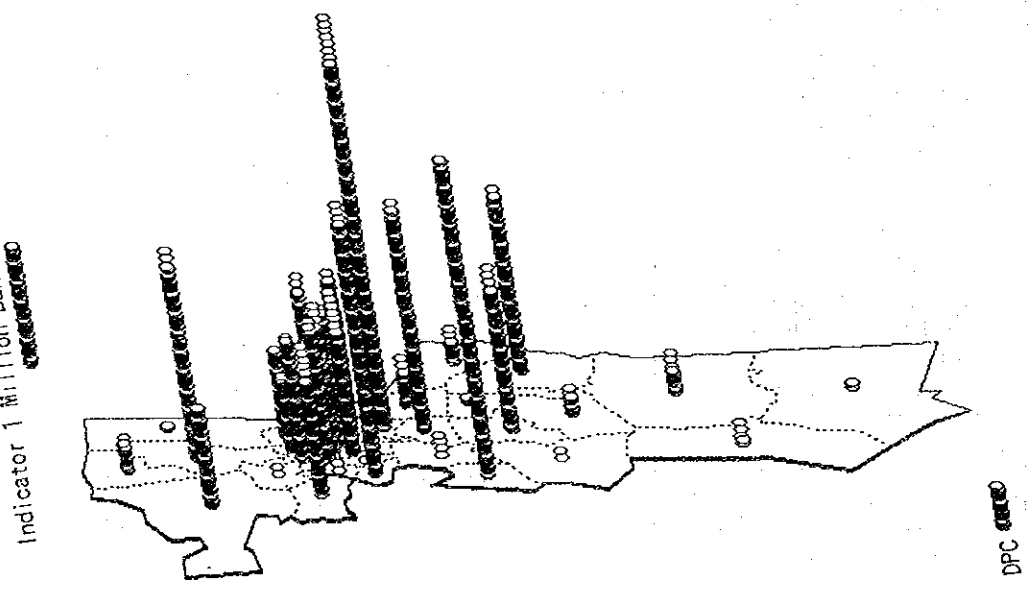
According to the results of questionnaire sent to each districts, there are about 70,000 business establishments paying over 40 Baht/month, of which 2,190 business establishments pay 500 Baht/month or more.

Table 9.1-1 The Fee Rates and the SWM Costs (Excluding Land Costs)

MONTHLY FEE RATE

	1 m3/day of Market, Factory & Other Waste	20 liter/day of House or Building Waste
1. Minimum Fee Rate Approved in 1962 (Currently Applied)	40 Baht/month (1.7 %)	4 Baht/month (8.3 %)
2. Maximum Fee Rate approved in 1985 (Not Yet Enforced)	2,000 Baht/month (83 %)	40 Baht/month (83 %)
3. The Current SWM Cost Estimated	2,400 Baht/month (100 %)	48 Baht/month (100 %)
4. SWM Cost with Option 3 (Longer Haulage 45 km & Sanitary Landfill)	4,446 Baht/month (185 %)	89 Baht/month (185 %)

Note: The figures in the parentheses indicate percentages of the fees to the current SWM costs shown in Item 3.



Top white part indicate collection fee collected from enterprises who discharge waste more than 1m³/d (500 Baht/y)October 1990 research by JICA Study team.

Fig. 9.1-1 Collected Collection Fee (1989)

Chapter 10. Financial Plan

Estimated Cash Expenditures and Costs for SWM

It is estimated that the future SWM (Solid Waste Management) will require 18,781 million Baht on a cash expenditure base during 1991 - 2000, corresponding to 14.7 % of the cumulative BMA budget estimated during the same period.

The above SWM amount can be recalculated at 15,629 million Baht on depreciation cost base, and the corresponding percentage drops to 12.3%. Refer to Fig. 10-1 and Table 10-1.

Notes: 1. The above percentages are calculated by using the estimated BMA's budget without government subsidies, which were excluded because the annual amounts of subsidies have fluctuated in recent years.

2. Land purchase expenses are not depreciated in the calculation of the above-shown SWM costs on a depreciation basis as it is correct to treat the land as an undepreciable asset.

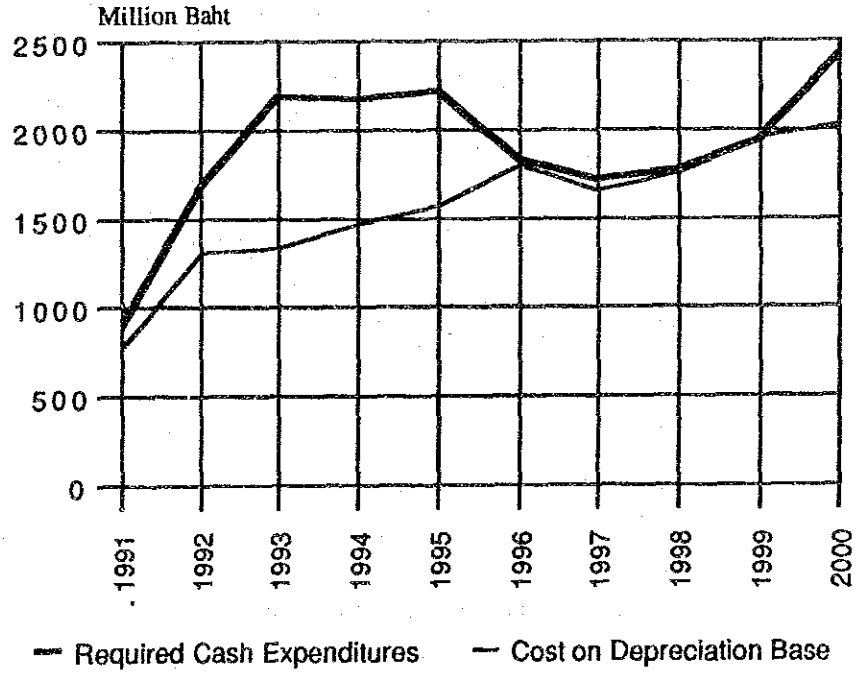


Fig. 10-1 Estimated Cash Expenditures and Costs for SWM (1991 - 2000)

Table 10-1 Estimated Cash Expenditures and Costs for SWM in Comparison to the BMA's Gross Budgets (1991 - 2000)

Unit: Million Baht in 1990 Price

	BMA'S REVENUE	SWM BUDGET (CASH EXPENDITURE)		SWM COST ON DEPRECIATION BASIS	
1991	9,140	891	9.8 %	771	8.4 %
1992	9,862	1,670	16.9 %	1,303	13.2 %
1993	10,641	2,183	20.5 %	1,338	12.9 %
1994	11,482	2,169	18.9 %	1,462	12.7 %
1995	12,389	2,214	17.9 %	1,571	12.7 %
1996	13,368	1,821	13.6 %	1,795	13.4 %
1997	14,036	1,716	12.2 %	1,657	11.8 %
1998	14,738	1,771	12.0 %	1,754	11.9 %
1999	15,475	1,938	12.5 %	1,955	12.6 %
2000	16,248	2,408	14.8 %	2,023	12.6 %
TOTAL	127,379	18,781	14.7 %	15,629	12.3 %

14.7%, an estimated percentage of the cumulative SWM cash expenditures borne to the cumulative revenue of BMA during 1991-2000, is 3.4% higher than 11.3 %, the corresponding percentage in the past years 1985-1990.

Table 10-2 The Past SWM Budgets in Comparison to the BMA's Gross Budget (1985 - 1990)

Unit: Million Baht in 1990 Price

	BMA'S REVENUE	SWM BUDGET (CASH EXPENDITURE)	
1985	4,763	700	14.7%
1986	5,482	518	9.4 %
1987	5,255	528	10.0 %
1988	5,517	763	13.8 %
1989	6,900	793	11.5 %
1990	8,600	840*	9.8 %
Total	36,517	4,142	11.3 %

* 1990 SWM budget is the original budget.

Major reasons explaining the future high SWM expenditures are:

1. Increases in waste amount
2. Introduction of sanitary landfill, which will be implemented by both the BMA itself and contractors to be employed by the BMA
3. Waste haulage costs will be higher as haulage distance to disposal sites will be longer in the future.
4. Removal of old waste (approx. 1.7 million tons in total) from the existing sites to some remote places by employing contractors
5. Introduction of an incinerator (600 tons/day)

Financial Impact of the Planned Incinerator

The construction and operation of the planned incineration plant will cost 2,061 million Baht (Construction 1,842 million Baht + Operation 219 million Baht) during the master plan period 1991 - 2000. The estimated SWM cost with the incineration plant is 12 % higher than that without the plant as shown in Table 10-3. Treatment and disposal cost alone will be 23% higher with the incineration than that without it.

13.1%, a percentage of cumulative expenditures without the incineration during 1991-2000 will increase to 14.7% with the incineration. (An increase of 1.6%)

If the BMA wishes, loans will be available for the construction of the incineration plant from an international lending authority at an interest rate much lower than the prevailing interest rates of commercial loans in Thailand. The use of such loan will help the BMA to reduce its SWM cash expenditures required during the master plan period.

Table 10-3 Future Cash Expenditures for SWM With and Without the Planned Incineration Plant (1991 - 2000)

	SWM COSTS WITHOUT THE INCINERATOR	SWM COST WITH THE INCINERATOR	DIFFERENCE = COST OF INCINERATOR
	A	B	C = B – A
1. Amounts	16,720 M.B.	18,781M.B.	2,061 M.B.
2. Cost Index	100 %	112 %	12 %
3. Share to BMA's Gross Budget	13.1 % (11.8 %)	14.7 % (12.3 %)	1.6 % (0.5 %)

M.B.: Million Baht

Figures in parentheses indicate percentages calculated on depreciation basis.

Table 10-4 Future Cash Expenditures for Treatment and Disposal With and Without the Planned Incineration Plant (1991 - 2000)

	TREATMENT & DISPOSAL COST WITHOUT THE INCINERATOR	TREATMENT & DISPOSAL COST WITH THE INCINERATOR	DIFFERENCE = COST OF INCINERATOR
	A	B	C = B – A
1. Amounts	8,771 M.B.	10,832 M.B.	2,061 M.B.
2. Cost Index	100 %	123 %	23 %

M.B.: Million Baht

SWM Cost Composition 1 - Treatment/Disposal Cost vs Collection/Haulage Cost

During the master plan period 1991 -2000, it is estimated that treatment and disposal will cost a cash expenditure of 10,832 million, 57.6 % of the total SWM cost, while collection and haulage will cost 7,778 million Baht, 41.4 % of the SWM cost. Obviously the treatment and disposal cost is higher than the collection and haulage cost. This makes a sharp contrast to the past situation where the latter was always much higher than the former. The introduction of sanitary landfill method is a major reason explaining such situation.

Annual expenditures for treatment/disposal and collection/haulage estimated during 1991 - 2000 are shown in Fig. 10-2 and Table 10-5.

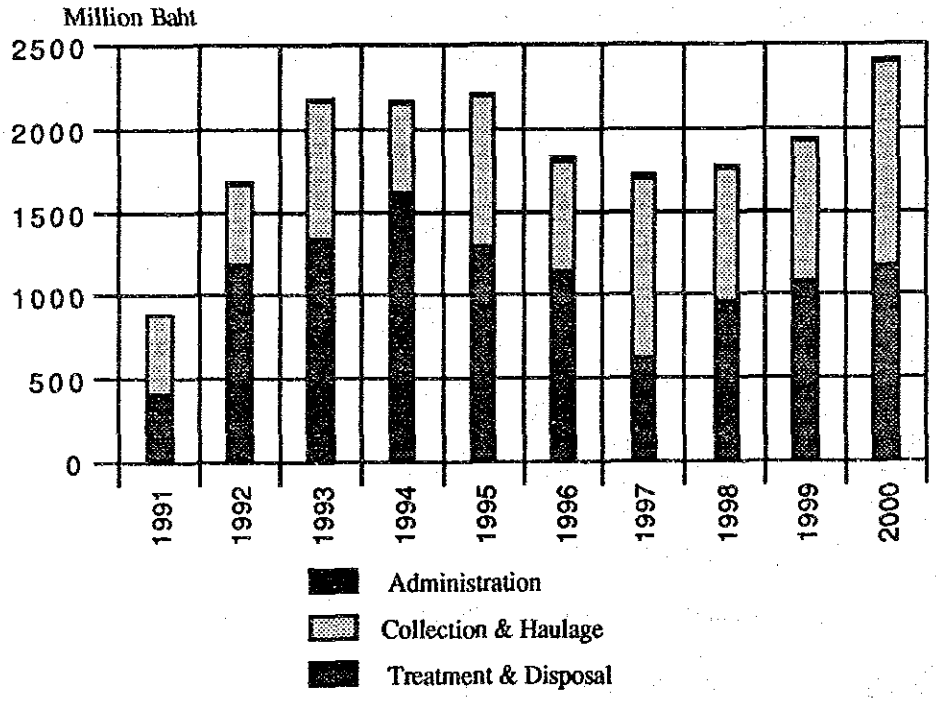


Fig. 10-2 Estimated Cash Expenditures for Solid Waste Management (1991 - 2000)

Table 10-5 Estimated Cash Expenditures Solid Waste Management (1991 - 2000)

Unit: Million Baht in 1990 Price

YEAR	TREATMENT & DISPOSAL	COLLECTION & HAULAGE	ADMINISTRATION	TOTAL
	A	B	C	D = (A+B+C)
1991	411	465	15	891
1992	1,182	473	15	1,670
1993	1,336	831	16	2,183
1994	1,611	542	16	2,169
1995	1,293	904	17	2,214
1996	1,149	655	17	1,821
1997	632	1066	18	1,716
1998	955	798	18	1,771
1999	1,089	830	19	1,938
2000	1,174	1,214	20	2,408
Total	10,832	7,778	171	18,781
Percent	57.6%	41.4 %	0.9 %	100 %

SWM Costs Composition 2 - Investment Cost vs Operation/Maintenance Cost

Total costs of investment, operation/maintenance, payments to contractors and administration required for 1991 - 2000 are estimated as follows:

	Million Baht	
1. Investment	5,631	(30.0 %)
2. Operation/Maintenance	6,193	(33.0 %)
3. Payments to contractors	6,786	(36.1 %)
4. Administration	171	(0.9 %)
5. Total	18,781	(100.0 %)

Cost details of the respective components are shown in Fig. 10-3.

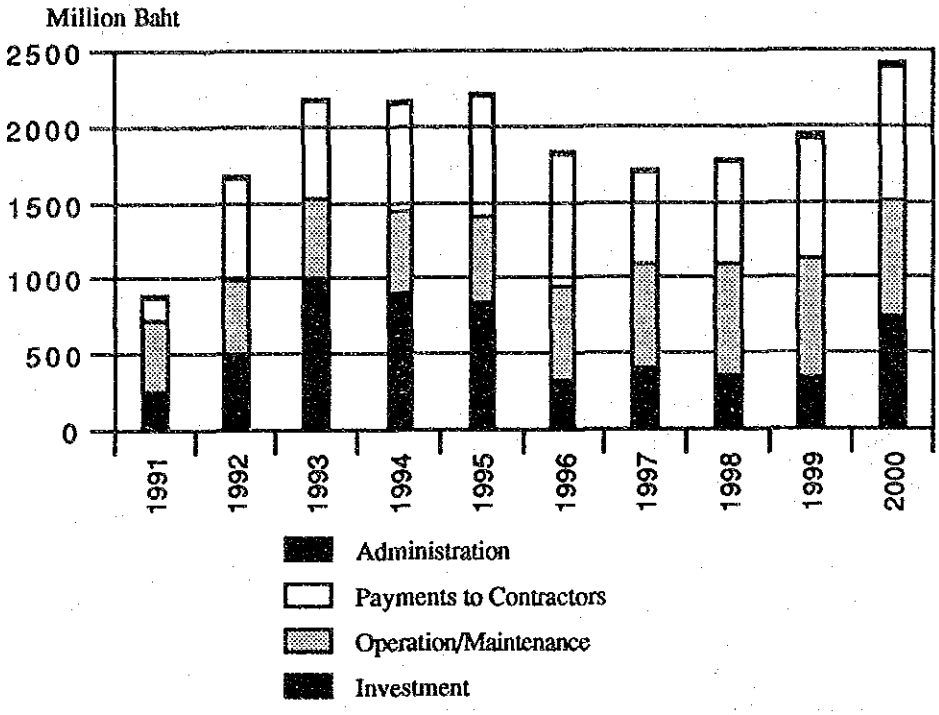


Fig. 10-3 Estimated Cash Expenditures Required for Solid Waste Management (1991 - 2000)

Conclusion

1. Unavoidable SWM Cost Increase and Necessity for Increases in Collection/Haulage Efficiency and Fee Revenues

Solid waste management during the next 10 years will require much higher cost than in the past both in terms of amounts and ratio to the BMA's revenues. An estimated cumulative SWM cost (cash expenditure) during the master plan period 1991-2000 without the incineration is 13.1% of a cumulative BMA's revenue during the same period, which is 1.8% higher than 11.3%, the corresponding percentage of the past years 1985-1990.

Like many other cities however, such a high increase in cash expenditures for waste disposal will be unabvoidable because of the situation where 1) waste amount will increase, 2) disposal sites will be farther, 3) sanitary landfill has to be implemented, and 4) all the old waste will have to be removed to distant places.

In view of these situations, increases in collection and haulage efficiency as well as increases in fee revenues for waste collection services will be important issues.

2. Implementation of Incineration Project

The implementation of the planned incineration project will require additional 2,061 million Baht for its construction and operation up to 2000, causing the said share to increase to 14.7% from 13.1%. An 1.6 % increase in the said share is not small, and required an extraordinary financial arrangements. However, it is advisable for the BMA to make such arrangement in view of the significance of the incineration project as explained earlier.

There are the following options and their combinations to finance the project.

1. Use of BMA's own budget by placing an higher priority to SWM than before.
2. Increase of the fee revenue for waste collection service by raising the fee rates and number of the fee payers.
3. Acquisition of subsidies from the government.
4. Acquisition of a soft loan from an international lending authority (Refer to a financial case study shown in Volume 3 Part II Section 10.3)

It is strongly advised that the BMA will actively examine all the above shown avenues for the realization of the project.

It would be more appropriate to consider the issue of incineration as a matter of timing instead of a matter of "IMPLEMENT" or "NOT IMPLEMENT", in view of an increasing necessity for the incineration system in the future.

3. Priority Ranking

It is advisable that BMA will implement all the projects proposed in the Master Plan. However, if BMA will not have funds enough to implement all the projects, BMA will have to delay the implementation of some projects. The proposed priority ranking of the projects are as follows:

1) Implementation of sanitary landfill in Ram Intra
2) Use of contractors for hauling both old and fresh waste, and disposing it by means of sanitary landfill.
3) Construction of the incineration plant (600 tons/day)

Chapter 11. Recommendations

This chapter lists the recommendations, most of which are contained in the Master Plan (Chapters 7, 8, 9 and 10).

1. Acquisition of the BMA's Own Disposal Sites

a. The acquisition of the BMA's own disposal sites is important and an urgent issue for BMA in view of the following:

1) The remaining capacity of the existing sites is small; one or two years at maximum.
2) It is not advisable for the BMA to depend entirely on disposal contractors.

b. A major constraint on the land acquisition is the existing Government regulation which, in principle, prevents local authorities from purchasing land at prices higher than the government-regulated-prices (standard prices). The BMA should continue to negotiate with the Government to find ways in which the BMA can purchase land for waste disposal.

c. Considering locational advantage, the BMA should obtain disposal sites both in the east and west parts of Bangkok though it may be difficult to obtain disposal land in the west part of Bangkok.

2. Construction of Transfer Stations in the Core and Urban Districts

It is strongly recommended that the BMA should construct a few transfer stations of small or medium sizes in core and urban districts in view of the following:

1) Transfer stations will contribute to the reduction of waste haulage costs that will increase as a result of the future situation where final disposal sites will be farther away from the core and urban districts.
2) Transfer station sites can possibly be used as sites for incinerators that may be needed in the future. It should be noted land acquisition will be more difficult in the future.

3. Systematic Use of Borrow Pits as Sanitary Landfill Sites

The use of the borrow pits will bring about two kinds of benefits:

1) Waste disposal benefit
2) Creation of useful flat land from less useful pits made as a result of soil-digging. (The created land can be used as a public park.)

In the case of the borrow pit in Ram Intra, it is expected that the land value will increase at least 3 times by properly filling the pit with waste. It is important, however, to take adequate measures to protect the surrounding environment; especially, provision of the lining (to be placed on the bottom of pits) and leachate treatment.

4. Use of Reliable Disposal Contractors and Close Monitoring and Supervision of the Contractors

The BMA intends to extensively use contractors for hauling both the old waste and fresh waste, and for disposing of waste at remote places. The BMA is advised to:

1) Select reliable contractors judging from their experience, qualification as well as financial and managerial capacity.
2) Prepare the adequate specifications of sanitary landfill, and include them in the contract conditions.
3) Make it a contractual requirement for contractors to make an environmental assessment of a proposed site, and to submit an assessment report to the BMA. Such report should include some arrangements that must be made for neighboring residents and local authority of the area where there is a proposed site if the site is located outside the BMA area
4) Monitor and supervise closely contractor's performance

5. Selection of a Reliable and Cost-Effective Incinerator

Because the incineration system is very costly, it is important for the BMA to choose a reliable and cost-effective one. An incinerator equipped with a power generation system is not advisable due to at present the low calorific value of waste in Bangkok.

6. Remodeling of the Incinerator attached to the Existing Compost Plant at On Nut

In the case the BMA is unable to construct the proposed incineration plant (600 tons/day) due to financial constraints, but can afford to construct a smaller incineration plant, it may be advisable for the BMA to construct a smaller model incinerator (with capacity of about 100 tons/day for example). Such incinerator will help BMA/DPC to acquire experience and know-how that would be required when operating incineration plants of much larger scale in the future.

In the case the BMA will construct a smaller incinerator as explained above, it will have to execute a feasibility study, and prepare new specifications and design for the incinerator. It should be noted that the specifications and design prepared for the incineration plant of 600 tons/day (200 tons/day x 3 units) by the JICA Study Team cannot be applied to a smaller incineration plant.

7. More Thorough Application of Beneficiary Pay Principle with Respect to Waste Collection Fees

1) BMA should collect more fees through raising the fee rates and increasing number of the fee payers based upon the BPP because the future SWM costs will further increase due to higher costs for waste collection, haulage, treatment and disposal.

2) BMA, firstly, should raise fee rates for the business waste collection service to the same level as those for household waste collection which is 5 times higher the fee rates for the business waste collection service. Then, the BMA should apply the maximum fee rates stipulated in the 1985 regulation.

3) It is advisable for the BMA to consider the possibility for the shift of the responsibility for the business waste collection service from the BMA to the waste dischargers themselves. It is also advisable that the BMA will apply such shift only to dischargers of large waste amounts in the initial stage, then increase the number of dischargers to which the shift is applied.

8. Improvement on the Maintenance of Collection Vehicles

It is recommended that the BMA will:

1) Strengthen monthly maintenance system by using
   a. Remote workshops,
   b. Mobile workshop Units, and
   c. Mechanics of the districts

2) Enforce all the drivers to do practice daily maintenance check.

3) Reorganize the Central Workshop or privatize it in order to increase its efficiency.

9. Cost Control of the New Compost Plant

The DPC has spent over 100 million Baht every year for the operation and maintenance of the existing compost plants which brought about much smaller benefits.

It is strongly recommended that the BMA should execute a through control over the costs for operation/maintenance of the new plant in comparison to benefits.

10. Solid Waste Management with Long Term Views and Planning

It is recommended that BMA/DPC will plan strategic facilities such as sanitary landfill sites, transfer stations and incinerators from long term viewpoints. Land acquisition and facility construction should be planned giving due consideration to the the future benefits arising from these facilities and socio-economic conditions of Bangkok.

11. Future Options Regarding Solid Waste Management

The current Master Plan covers the period until 2000. It is advisable that the BMA/DPC would examine the following options which may be applied after 2000.

1) Waste haulage to and disposal at remote places by using railway or other means

2) Waste recycling facilities
3) Separate collection of waste
4) Shift of responsibility for waste management from the BMA to generators of large waste amounts

In any case, however, a future solid waste management plan after 2000 will have to be prepared based upon the results of the implementation of the current Master Plan.

Appendix. The Study Organization and Members Involved

Appendix. The Study Organization and Members Involved

The Study organization is as shown below.

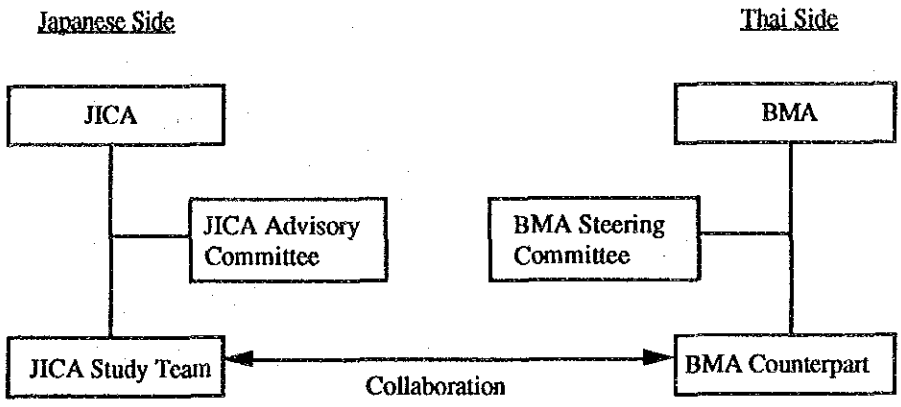


Fig. The Study Organization

Members involved in the Study are as follows:

1. Steering Committee Members

Ms. Pratuang Thaveesin	Director General of DPC, Chairman
Mr. Kanchai Nopakaew	Deputy Director General of DPC
Mr. Somchitt Trivichien	Director of Technical Division
Mr. Anati Sittipunt	Director of Garbage Disposal Division
Mr. Chalee Tiramanat	Director of Public Cleansing Service Division
Mr. Watana Luanratana	Chief of Nong Khaem Solid Waste Disposal Plant
Mr. Akedeck Haumsetthee	Chief of On Nut Solid Waste Disposal Plant
Mr. Phronarong Reablertron	Public Cleansing Service Division
Late Mr. Boonchern Suttapreyasri	Deputy Director of DPC

2. JICA Advisory Committee Members

Professor Dr. Sachiho Naito	President, Kanto Gakuin University Chairman of the Committee
Dr. Masaru Tanaka	Chief of Solid Waste Engineering Section Department of Sanitary Engineering The Institute of Public Health
Dr. Kunitoshi Sakurai	Senior Development Specialist Japan International Cooperation Agency (JICA)
Dr. Kazuo Fukui	Acting Chief Executive Officer (Technology Development) Bureau of Public Cleansing Tokyo Metropolitan Government
Mr. Minoru Sawachi	Assistant Manager Management Department, Facility Division Public Cleansing Bureau Osaka City Government

3. Counterparts

Mr. Thanoo Pholpunthin	Technical Division, DPC
Mr. Vitoonpan Vanachamrat	Technical Division, DPC
Mr. Manit Decrouthai	Garbage Disposal Division, DPC
Ms. Ratanaporn Kerdpakee	Technical Division, DPC
Ms. Vullaya Wattanasiritanawang	Technical Division, DPC
Mr. Paitool Sukpaibool	Technical Division, DPC
Mr. Suvit Suksin	Technical Division, DPC
Ms. Sompak Vudthithornnatirak	Technical Division, DPC

4. JICA Study Team Members

Mr. Kyoich Miyazaki	Team Leader
Mr. Kiichiro Sakaguchi	Economist
Mr. Masato Ohno	Waste Collection Planner
Mr. Toru Naito	Waste Collection Surveyor
Mr. Shinichi Suzuki	Waste Collection Surveyor

Mr. Shunsuke Aoyama	Intermediate Treatment Planner
Mr. Masao Takenaga	Equipment Maintenance Expert
Mr. Takashi Goto	Final Disposal Planner
Mr. Akinori Sato	Sanitation & Environment Expert
Mr. Atsushi Saito	Organization & Institution Analyst
Mr. Fuminori Tsurunaga	Facility Designer
Mr. Hideo Hattori	Incineration Expert