5.5 Collection and Disposal Amount

5.5.1 Future Waste Flow

Future waste flow will be established as the form of Fig. 5.5-1 based on following conditions.

a. All of domestic and commercial waste in the priority operational area shall be collected.

b. All of factory and other waste shall be hauled directly to disposed sites.

c. Collection systems is composed of a domestic waste collection, a bulky waste collection and large amount collection.

d. Waste generated outside of the priority operational area should be disposed of by residents themselves.

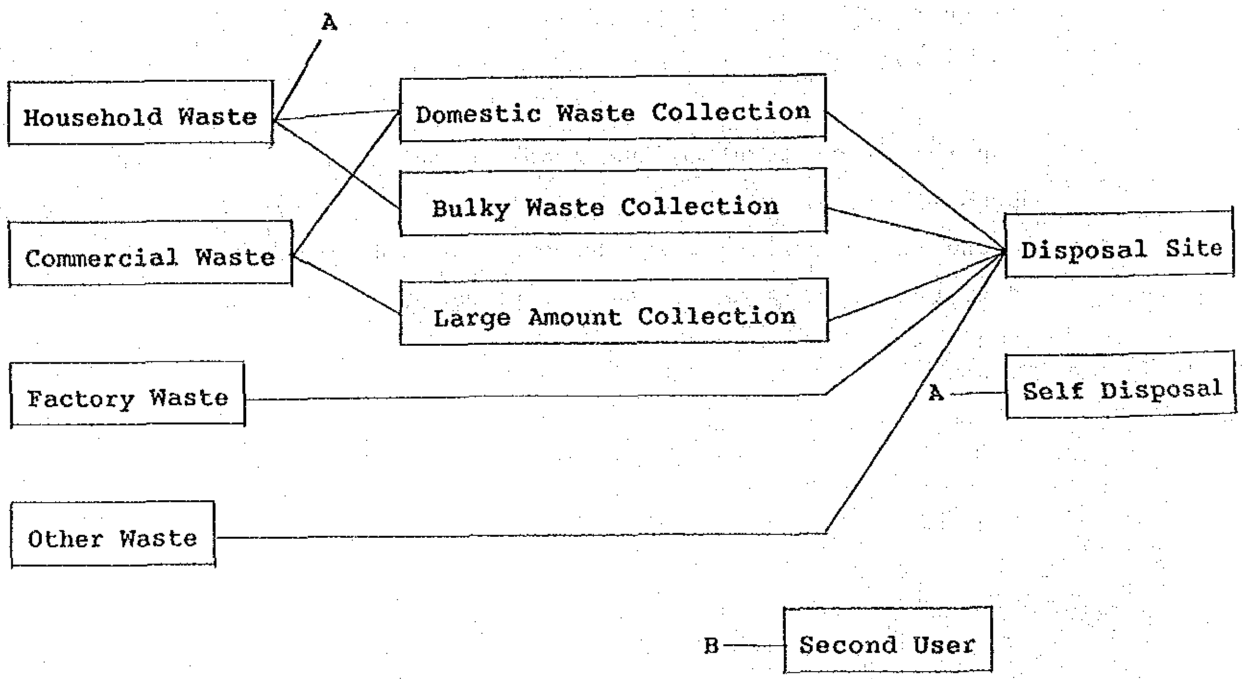


Fig. 5.5-1 Future Waste Flow

5.5.2 Waste Amount to be Collected

(1) MPPP

Commercial waste generated by large amount discharger will be collected through large amount collection system. Commercial waste from small shops will be collected together with domestic waste while domestic waste generated at flats will be collected through large amount collection. It assume that commercial waste amount collected through domestic waste collection is same as domestic waste amount collected through large amount collection will be about 40% of commercial waste amount. Bulky waste collection will be established in future therefore waste amount of bulky waste depends on the schedule of the introduction.

Table 5.5-1 Solid Waste Amount to be Collected in MPPP

	1987	1990	1995	2000	2005
Domestic Waste Collection					
George Town	153.6	162.1	189.8	220.1	247.6
Rural	118.0	130.8	164.9	204.9	260.3
Sub Total	271.6	292.9	354.7	425.0	507.9
Bulky Waste Collection*					
Georgetown	4.7	5.0	5.9	6.8	7.7
Rural	3.7	4.0	5.1	6.3	8.1
Sub Total	8.4	9.0	11.0	13.1	15.8
Large Amount Collection					
Georgetown	40.8	43.1	50.5	58.5	65.9
Rural	39.6	43.1	52.9	64.2	80.0
Sub Total	80.4	86.2	103.4	122.7	145.9
Total					
Georgetown	199.1	210.2	246.2	285.4	321.2
Rural	161.3	177.9	222.9	275.4	348.4
Total	360.4	388.1	469.1	560.8	669.7

* Bulky waste is estimated as 3% of domestic waste.

(2) MPSP

Large amount collection and bulky waste collection systems will be established in future, therefore waste amount of these waste depends on the schedule of the introduction.

Table 5.5-2 Solid Waste Amount to be Collected in MPSP

	1987	1990	1995	2000	2005
Domestic Waste Collection					
North	60.1	76.6	111.7	145.5	182.9
Central	58.5	74.2	108.6	135.7	166.5
South	10.2	17.2	32.8	44.6	59.1
Sub Total	128.8	168.0	253.1	325.8	408.5
Bulky Waste Collection					
North	1.9	2.4	3.5	4.5	5.7
Central	1.8	2.3	3.4	4.2	5.1
South	0.3	0.5	1.0	1.4	1.8
Sub Total	4.0	5.2	7.9	10.1	12.6
Large Amount Collection					
North	29.2	33.1	40.5	49.6	59.3
Central	23.4	26.3	32.2	39.3	47.3
South	5.8	6.5	7.9	9.6	11.8
Sub Total	58.4	65.9	80.6	98.5	118.4
Total					
North	91.2	112.1	155.7	199.6	247.9
Central	83.7	102.8	144.2	179.2	218.9
South	16.3	24.2	41.7	55.6	72.7
Total	191.2	239.1	341.6	434.4	539.5

5.5.3 Disposal Amount

(1) MPPP

	1987	1990	1995	2000	2005
Collected Waste					
Hauled Waste Directly	360.4	388.1	469.1	560.8	699.7
Georgetown	20.4	21.5	25.2	29.3	32.9
Rural	33.4	36.4	44.7	54.2	67.5
Sub Total					
Total					

(2) MPSP

	1987	1990	1995	2000	2005
Collected Waste					
Hauled Waste Directly	191.2	388.1	469.1	560.8	669.7
North	31.3	35.4	43.4	53.1	63.5
Central	29.1	32.6	40.0	48.7	58.6
South	8.7	9.8	12.0	14.0	17.8
Sub Total					
Total					

5.6 Financial Conditions

(1) Future Perspectives of Economic Growth

The technical report of the Structure Plan in MPSP has adopted the economic growth rate of 5.5% for the period 1985 - 1990 and 7.2% for 1990 - 2000.

Considering the actual estimated growth rate in recent years and the tendency of the world economy, it would be difficult to expect growth rate more than 5% per annum till 1990. It is also not ralistic to expect even a higher growth rate after 1990. It is natural to forecast a lower growth rate after a high economic growth of industrialization.

Therefore, in this study, the growth rate till 1990 will be set at the level of 5% as projected by the Fifth Malaysia Plan (FMP), and the rate after 1990 will be set at the level of 4.8%, which is, the lowest case set in the technical report for the structure Plan prepared by MPSP.

Table 5.6-1 Estimated Future GRDP in Penang State

	1985 -	1990 -	2000 -	2005
Growth rate (%)				
Forecasted by				
-FMP	5.0			
-Study of MPSP	5.0	7.2		
-JICA Study Team	5.0	4.8	4.8	
GRDP ($ million in 1978 price)				
Forecasted by				
-FMP	4,283	5,479		
-Study of MPSP	4,283	5,598	11,220	
-JICA Study Team	4,283	5,479	8,756	11,069

(2) Future Perspectives of Financial Scales

The technical report of the Structure Plan of MPPP projected the revenue of MPPP for the period 1987 to 2006, which shows $91.6 million in 1990 and $212.5 million in 2000.

In this projection, the assessement (property tax) is assumed to increase by 20% - 30% every five years due to the evaluation of properties. The actual evaluation in 1987 disappointed the expectation. The revenue in 2005 will probably be less than the projected one. There is no projection of MPSP's future revenue.

In this study, the future revenue of both MPPP and MPSP have been estimated as shown below by applying the same annual growth rates as those of GRDP in Penang State; 5%/yea for 1985 - 1989 and 4.8%/yea for 1990 - 2005.

Table 5.6-2 Estimated Future Revenue of MPPP and MPSP

($1,000 in 1985 price)

	1985	1990	2000	2005
MPPP	58,509	74,674	119,339	150,865
MPSP	32,148	41,030	65,571	82,893

6. Study on Sub-systems

6.1 Storage and Discharge of Solid Waste

At waste generation sources such as households, and industrial and commercial establishments, various types of containers can be used for storage and discharge of waste. An appropriate container to be used is the one which is 1) easy to handle, and suitable for waste collection, and 2) helpful to maintain cleanliness at discharge points, etc. From these view points, the comparison of respective containers (bins and bags) are made as follows.

6.1.1 Households

It is necessary to use plastic bags to discharge and to avoid the littering of solid waste.

(1) Detached House

Storage and discharge method at houses will differ according to type of collection; a door to door collection or a station collection. Generation amount per household is estimated at 3.6 kg/day based upon the following calculation.

0.62 Kg/capita x 5 persons/house x 1.1.5 = 3.6 Kg/day/house

Generation rate	0.62 Kg/capita/day
Number of family	5 person/house
Fluctuation factor	1.15

The following principles should be followed in the case of a door-to-door collection system is used.

a. Stands for household bins should be installed to avoid scattering to be caused by animals when household bins are placed outside the house at night.

b. Stands for household bins will not be necessary if household bins are kept inside the house and then placed in the frontage of the hose at collection time.

c. Gross weight of a household bin should be less than 20 Kg to avoid injuries to be caused to collection workers when they carry bins to collection vehicles.

d. Refuse should be put in a plastic bag when a household bin is fixed and cannot be moved.

As a summary, any one of 1) fixed household bin and plastic bags, or 2) plastic bin or 3) plastic bag is acceptable in the case a door-to-door collection is used. Capacity of bins or plastic bags should be as shown below.

a. Fixed household bin and plastic bag

Capacity of fixed Household bin	Daily collection:	30 liter
	Alternate day collection:	60 liter
	3 times a week collection:	90 liter

b. Capacity — Weight less than 20 Kg: (40-70 liter)

c. Plastic bag
Capacity — 40 liter

On the other hand, in the case of a station collection, residents should bring the waste to a specific place at specified day and time. A fixed household bin will be acceptable. Stationary container system can also be used for a station collection system. Any one of the following three systems is acceptable.

a. Communal bin at waste station
Daily collection: 40 households/station (1,000 ℓ x 0.2 x 07 ÷ 3.6)

b. Plastic bin : Weight should be less than 20 Kg

c. Plastic bag : Capacity will be 40 litter

Residents should put back their bins as soon as possible when plastic bins are emptied. It is very important to bring out the waste to the waste station at a specified day and time. Punctual collection is important especially in the case residents use plastic bags to avoid scattering by animals.

Communal-bins should be used in kampong area if the distance between houses and a waste station is far or if the houses are not accessible by vehicles. In an ordinary residential area, use of plastic bins and/or plastic bags are recommended since it is difficult to secure a suitable space to place communal-bins in residential area.

(2) Multi-storey Building

Two types of dust chute systems are used in multi-storey apartment buildings in MPPP at present. One has a container (Bulk bin) installed under each dust chute and collected by compactor vehicle. The other has only a dust chute and a small storage room without container.

Since dust chute cause problems to the living environment such as bad smell etc., it is desirable to close dust chutes and to employ a collection system with a waste station to which residents carry waste. Therefore, a new building should be designed based on this principle.

However, it is acceptable to continue to use the dust chute if the dust chute system satisfies the following conditions.

- One dust chute is provided for 25 households
  ($1,000 \ell \times 0.2 Kg/\ell \div 3.6$)
- A container is installed under each dust chute
- Dust chute is easily accessible by collection vehicles
- All residents accept to use the dust chute

If a dust chute is used, daily collection is required to avoid overflow of waste from containers.

Except the above case, all the other dust chutes should be closed and residents should bring out their waste to a waste station, using plastic bins or plastic bags in the same manner as in the station collection system in a residential area.

There are many buildings with a dust chute which is not easily accessible to a compactor truck. It takes a lot of time to bring out a container for loading and return to a storage room. Accessibility to the dust chute should be improved in this case.

Waste in dust chutes of old buildings where storage space is too small to install a container is collected through manual work which is unsanitary and causes of often blockage problems. In this case, to rebuild or close the dust chute is the only way to improve living environment and collection efficiency.

The dust chute of high rise buildings which have 23 stories in MPPP area is deficient. Ways to resolve this problem include:-

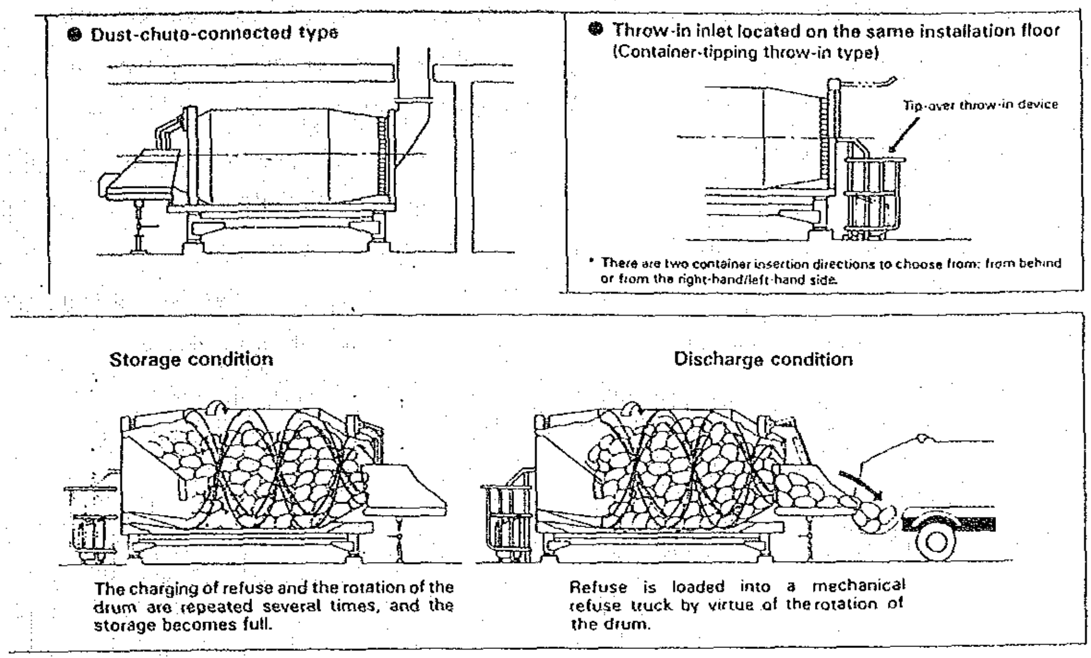
a. Closing of the dust chute and bringing down the waste by residents
b. Construction of an additional dust chute
c. Install a large container in a storage room
d. Install a drum type storage machine.

A hauling container with capacity of 6 to 10 m^3 can cover 150 to 250 households and 5 m^3 storage machine can cover 200 households. To install a large container or a drum type storage machine, rebuilding of the storage room and improvement of the access road will be required.

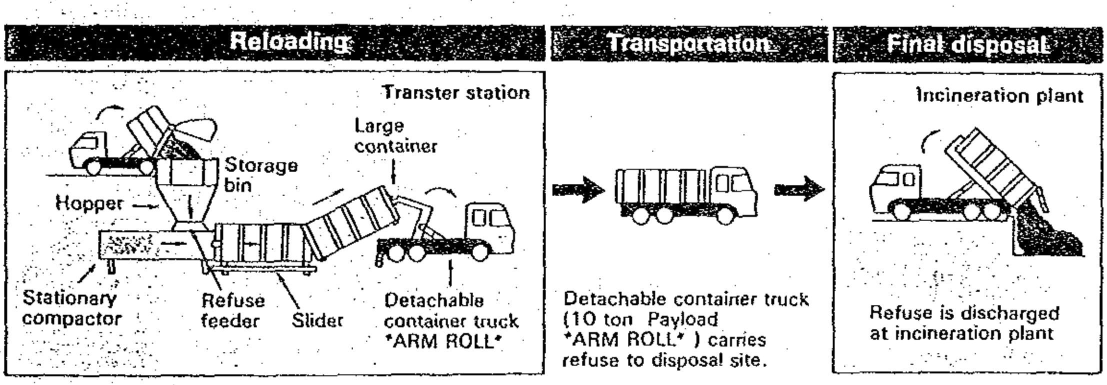
(3) Business Establishments, etc.

A container system is applied for the collection of solid waste from business establishments which discharge a large amount of waste. In particular, a roll-on container system is applied to marketplaces where a large quantity of waste is discharged. This system should be used for the future because it is economical. The container cannot be used at Komtar because a storage area in the Komtar is not accessible to large collection vehicles. It is necessary to examine the possibility of installation of drum type storage equipment.

Although the roll-on container system is economical relative to the other systems, the average waste amount put in a roll-on container is 1.5 ton at present, which is only a half of its capacity. A decrease in the collection frequency should be considered in view of increasing collection efficiency.



(a) Rotary-Drum System



(b) Compactor Container System

Fig. 6.1-1 Storage and Discharge in Large Building

Number of high-rise housing complex and commercial buildings which generate large amount of waste are likely to increase in the future. The handling process of building waste includes 1) discharge, collection, transfer and storage in the buildings, as well as 2) subsequent collection. An important point is to have a good coordination between the above two processes. Principally, a person responsible for building management shall be responsible for handling of waste within the buildings. The following figure shows one of the waste handling systems within a building.

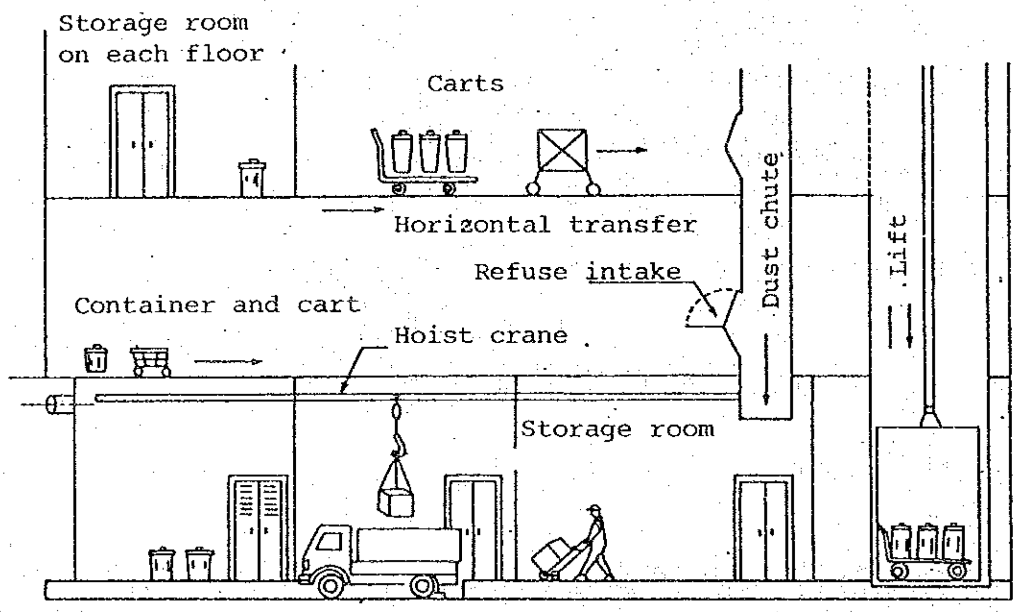


Fig. 6.1-2 Solid Waste Disposal System in Buildings

The method for storing and discharging building waste are classified as follows:

- Bin method
- Container method
- Container-compactor method
- Drum method
- Dust chute method

The dust chute method sometimes causes sanitary problems such as leachate, offensive odor, fly, fire, etc.

(4) Bulky Waste and Tree Waste

Presently, bulky waste and tree waste are left and illegally thrown away. Since bulky waste and tree waste cannot be loaded by using a small compactor vehicle, it is necessary to establish a collection system for such waste, which is independent of domestic waste collection system. In such a case, waste dischargers should observe the following points:

- Bulky waste and tree waste should be kept at the sources till designated collection date.

- Such waste should be brought out to designated place at designated time.

- Grass and leaves are discharged as general waste. Large trees and branches should be cut for easy handling. Twigs with the length of approx. 1 m or less and the weight of approx. 20 Kg should be put together and tied with strings to facilitate handling.

(5) Hospital Waste

Some waste discharged from hospitals and clinics are polluted by germs. Considering the possibility that scavengers and collection workers may contract some diseases through the handling of the waste, a special care should be taken in discharging such waste.

- In order to avoid the the mixture of general waste and hazardous waste, separate set-up of collection and storage system is necessary.
- Hospital waste should be separately discharge.
- Special containers are required for hazardous waste.

(6) Industrial Waste

There is a possibility that toxic waste is mixed in waste discharged from manufacturing industries. A special treatment and disposal are required so that toxic waste does not cause environmental pollution. Separate storage and collection system similar to that for hospital waste is also necessary. Industrial and commercial establishments which discharge toxic waste should be watched.

(7) Cost Bearing of Discharge

It is proper that the cost of waste storage container used by residents are borne by themselves. The possibility of the cost bearing by the council alone may be considered only in the following:

a. If containers have to be installed due to poor accessibility to kampong, etc.
b. Containers for a high-rise housing complex
c. Roll-on containers

In case of (a) it is necessary for residents to separately bear the cost of a household bin or a plastic bag. Distance to the communal container is so long, that the cost of communal containers should be borne by the council.

In case of (b) there are two systems; dust chute with containers system and the system where residents are required to bring out waste. Because the dust chute is used for convenience of residents, the cost of containers should be borne by residents. In the latter case it may be appropriate that the residents bear the cost of containers which may be used for a daily collection. It should be, however, noted that the cost bearing by the councils would contribute to enhance residents' practice of bringing out waste.

In case of (c) the cost of containers for public facilities should be borne by a facility owner to reduce the financial burden of the cleansing department.

In case of (d) roll-on containers are used for reduction of the collection cost. Facility owners are required to secure a space for a hauled container and to collect waste and put it in the containers. Therefore, the cost of the roll-on container should be borne by the body responsible for collection.

6.2 Collection

(1) Collection frequency

Fig. 6.2-1 shows the comparison of collection frequency based on following condition.

a. Waste stations are provided to each ten houses.
b. Population Density 150 person/ha

This shows

a. Cost of daily collection is about same as present cost

b. At the daily collection, use compactor truck is higher than use of side loader.
   However if 3 tim4s a week collection is employed, use of compactor will be cheaper.

c. Cost of 3 times a week collection together with station collection will be 60% of present cost.

Fig. 3.2-2 shows the cost at the time when laborer cost become twice. Present system will be higher than daily collection. The cost will be 1.7 times at present. The collection cost will be same as present cost if 3 times a week collection and station collection will be employed.

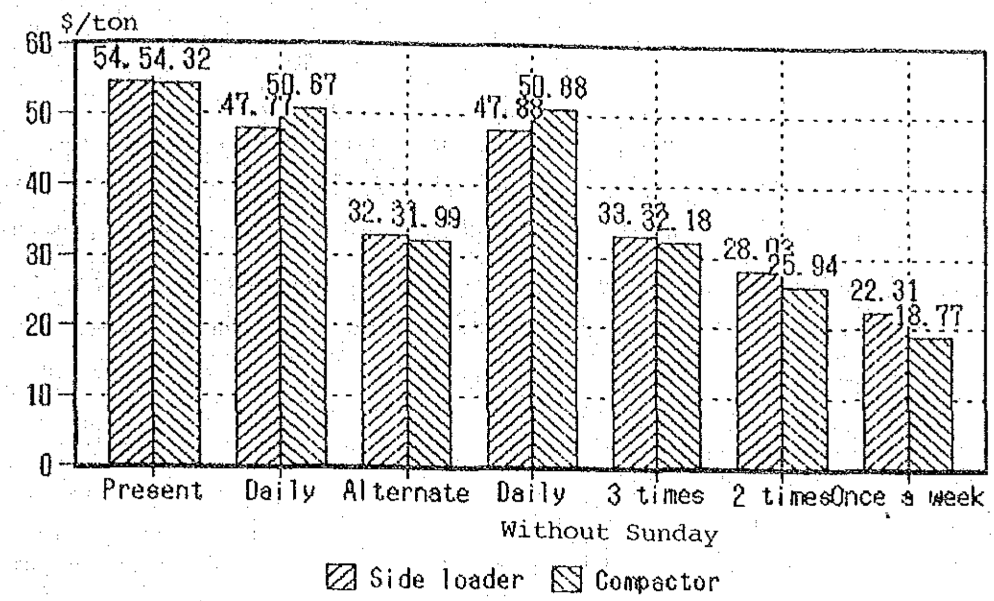


Fig. 6.2.-1 Collection Cost by Frequency

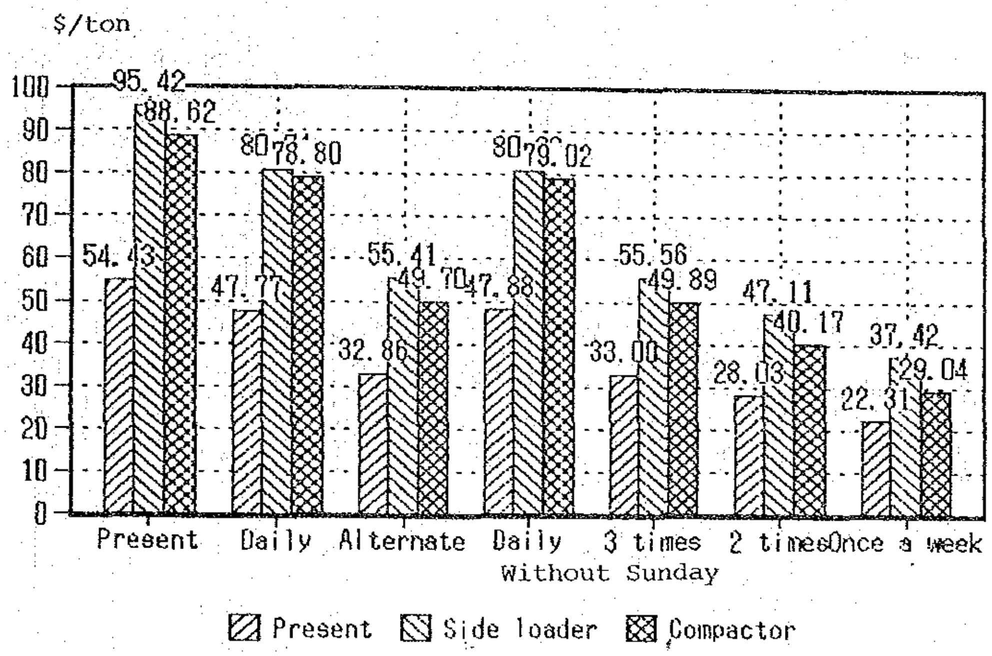


Fig. 6.2-2 Collection Cost by Frequency at Twice of Laborer Cost

(2) Station Distribution

Fig.6.2.-3 shows the comparison of station distribution in daily collection the left side and 3 times a week collection (the right side).

Cost of station collection (each ten houses) is about 60% of door to door collection (waste will be collect from 4 houses at a stop).

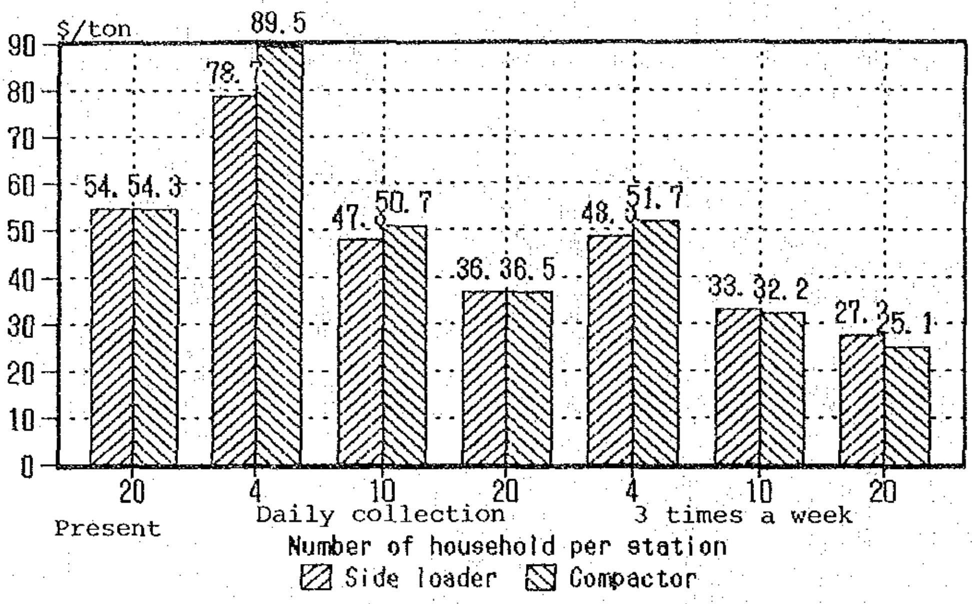
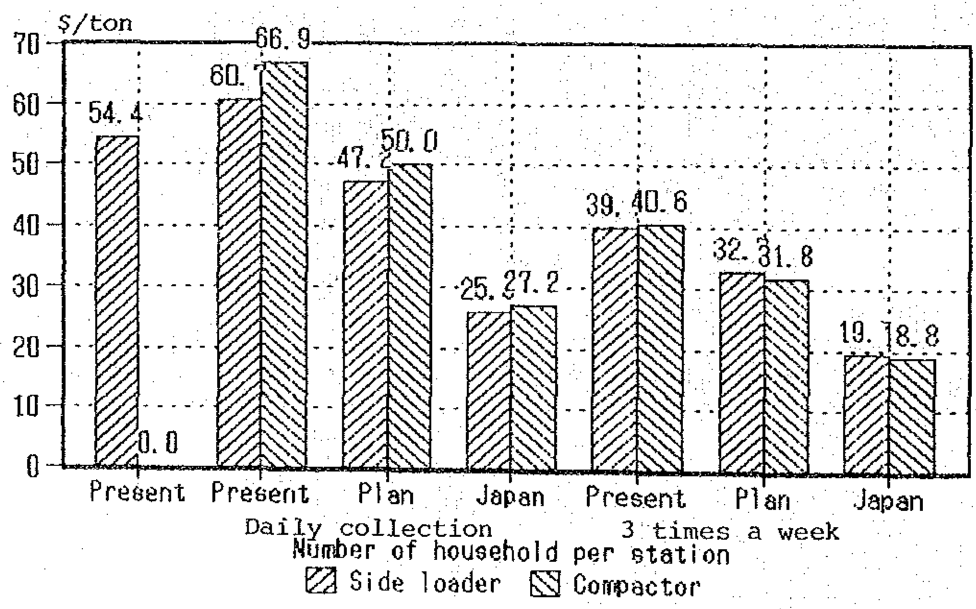


Fig. 6.2-3 Distribution of Stations and the Cost



Comparison of Loading Efficiency

(3) Vehicle Capacity

When distance to disposal site will be long, largervehicle have advantage in general. Fig. 6.2-4 shows the comparison of vehicles (Compactor vehicle) based on following condition.

a. Distance to disposal site;	30 km
b. Laborer cost;	present cost and 2 times
c. Collection frequency	Daily (the left side) and 3 times a week (the right side)

Difference of the cost of each capacity of vehicle is small except the case that laborer cost become twice and 3 times a week collection is employed. Therefore, it seems that area condition should be emphasised to select vehicle size.

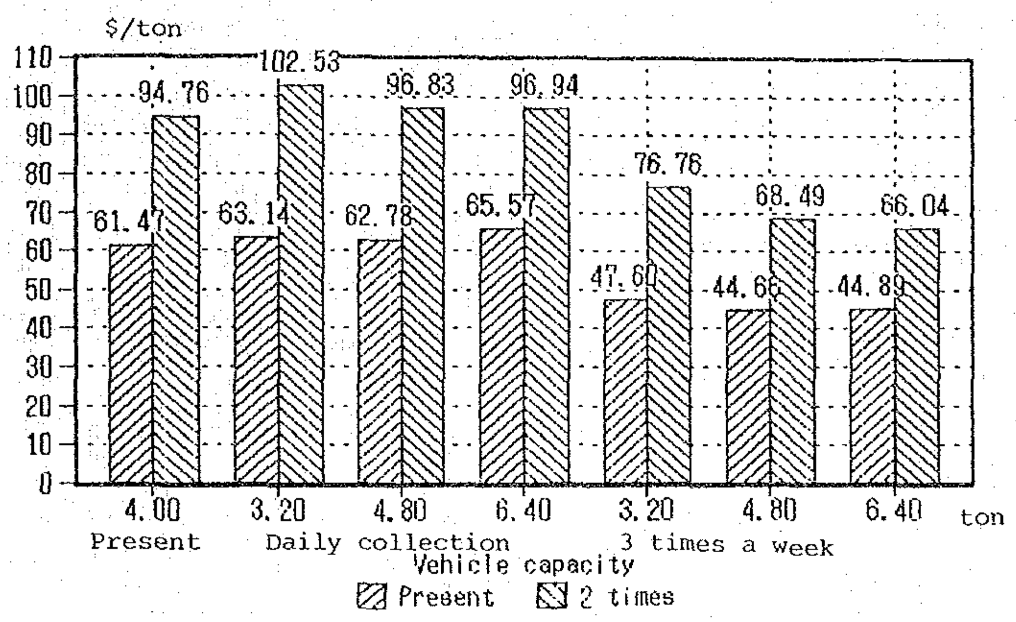


Fig. 6.2-4 Comparison of Vehicle Size (Compactor)

(4) Transfer haulage

Fig. 6.2-5 shows the comparison of transfer haulage and direct haulage. At the present level of laborer cost, transfer station is required in the case to reduce cost in the case that distance to disposal site is more than 25 km and side loader is employed.

Fig. 6.2-6 shows the situation when laborer cost will be twice. Equivalent distance become 15km for side loader and 35 km for compactor.

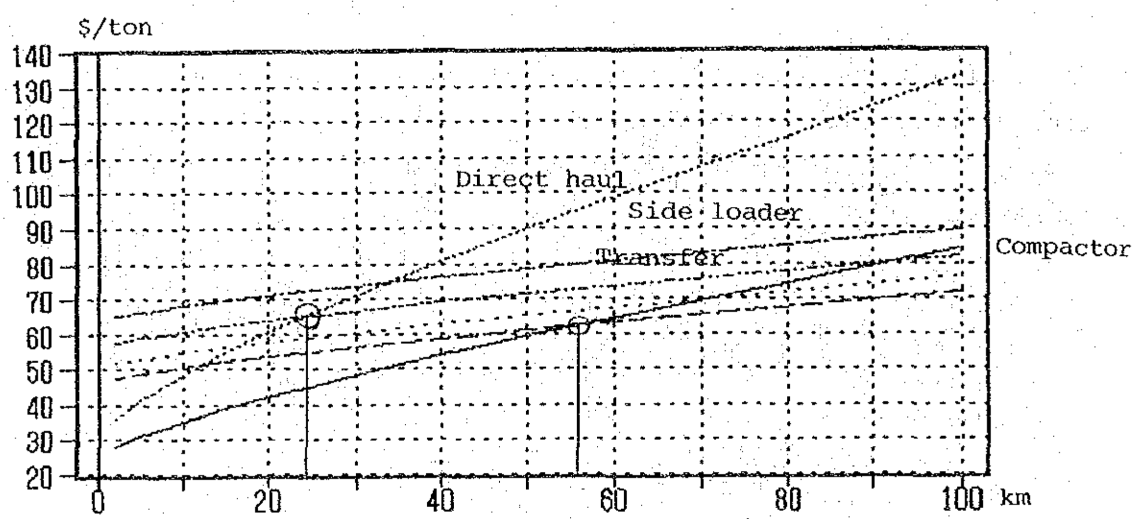


Fig. 6.2-5 Direct Haulage and Transfer Haulage

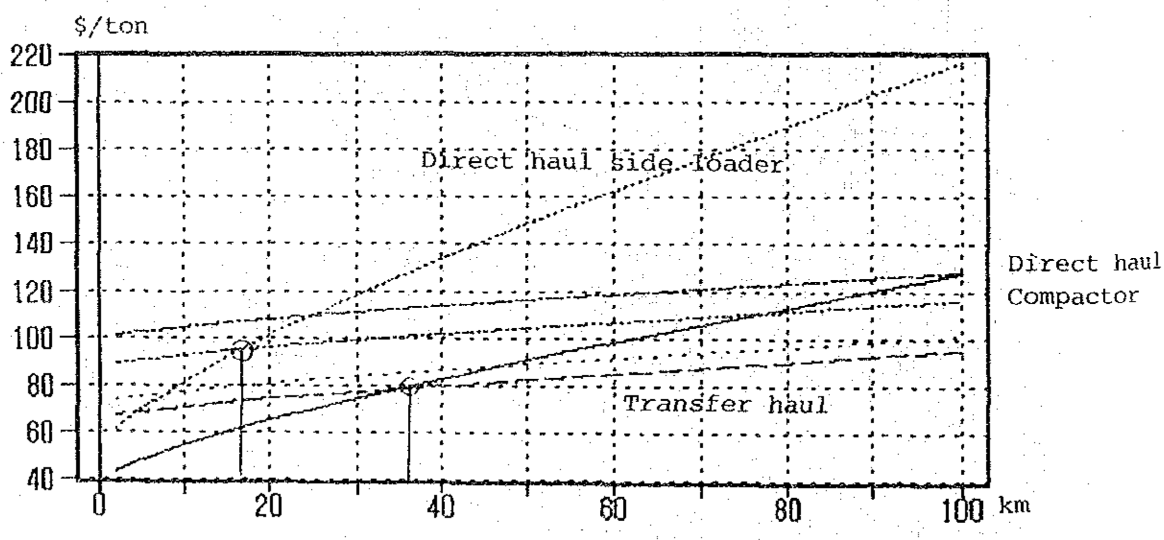


Fig. 6.2-6 Direct Haulage and Transfer Haulage at Twice of Laborer Cost

6.2 Collection and Cleansing Work

Fig. 6.2-7 shows the number of collection vehicles for each Alternatives.

Fig. 6.2-8, Fig 6.2.9 shows number of laborers and collection cost respectively.

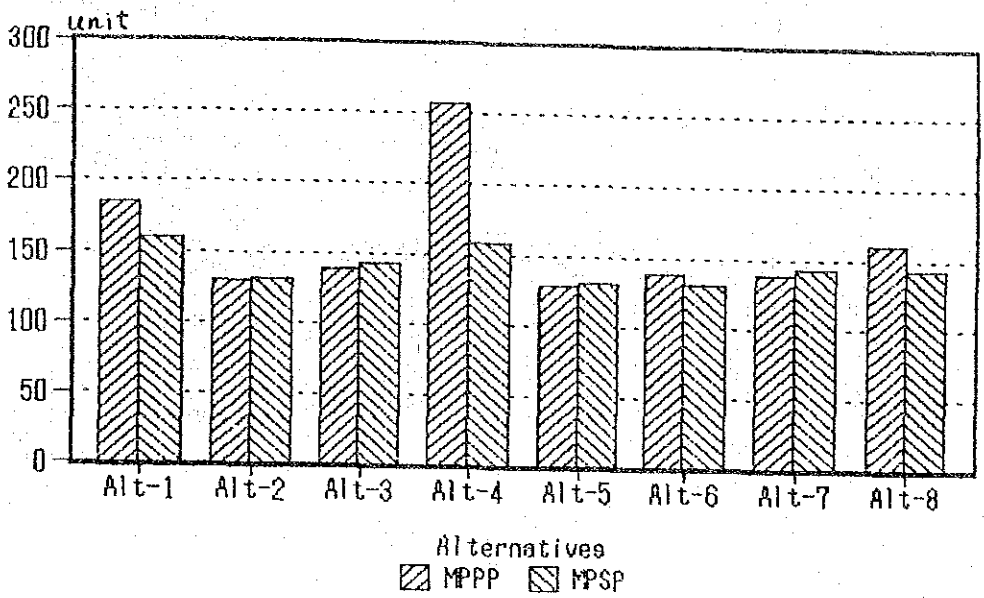


Fig. 6.2-7 number of Collection Vehicles

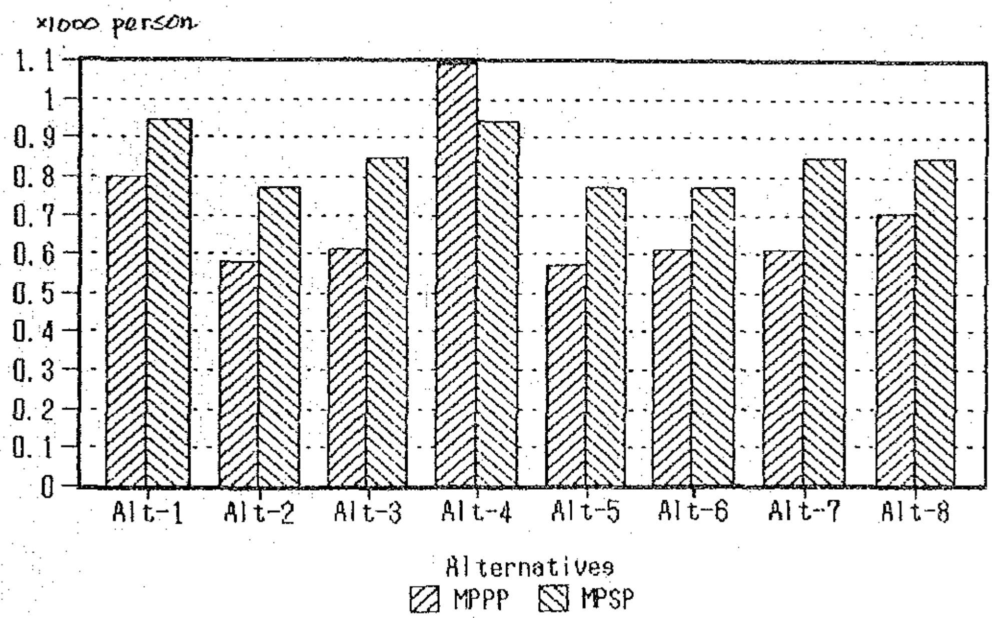


Fig. 6.2-8 Number of Collection Laborers

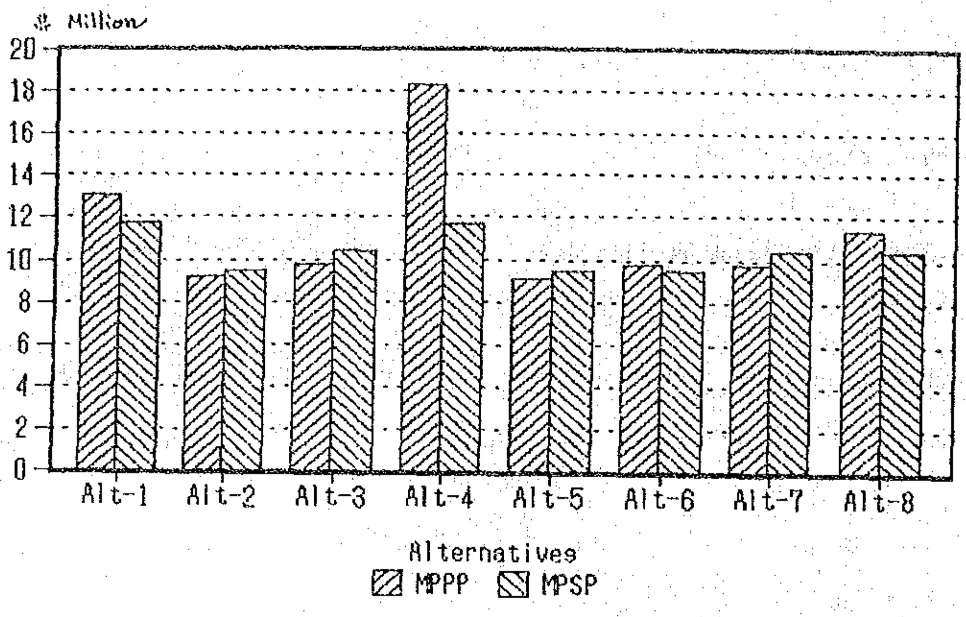
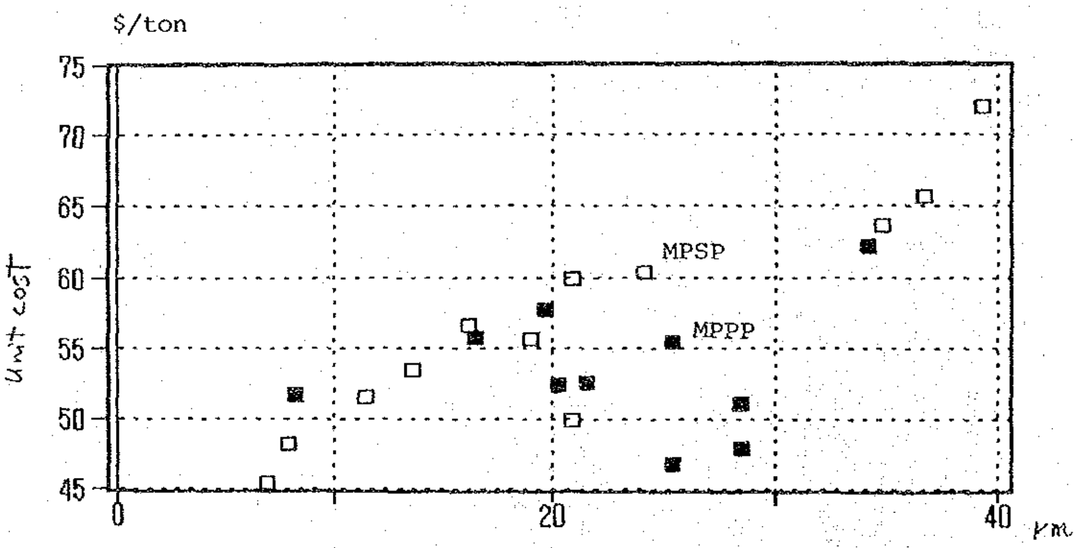


Fig. 6.2-9 Collection Cost



6.3 Cleansing Work (Drain Cleansing and Street Sweeping)

6.3.1 Manpower in MPPP

a.	Street sweeping	1.2 km/person
	Important place	138 person
	Main road	69 person
	Street in town	28 person
	Street in residential area	54 person
	Main road in rural area	46 person
	Sub-total	335 person
b.	Drain cleansing	1 km/person
	Drain town	83 person
	Drain in residential area	105 person
	Drain in rural area	42 person
	Sub-total	230 person
c.	Grass cutting	0.5 km/person
		90 person
d.	Beach	1 km/person
		36 person
e.	Stand-by	35 person
f.	Mandor	74 person
	Total	800 person
g.	Grass cutting Machine	76 unit

3.3.2 Manpower in MPSP

a.	Street sweeping	1.2 km/person
	Important place	138 person
	Main road	69 person
	Street in town	28 person
	Street in residential area	50 person
	Main road in rural area	46 person
	Sub-total	331 person
b.	Drain cleansing	1 km/person
	- Important place	-
	Drain town	83 person
	Drain in residential area	105 person
	Drain in rural area	42 person
	Sub-total	230 person
c.	Grass cutting	0.5 km/person
		90 person
d.	Beach	1 km/person
		12 person
e.	Stand-by	20 person
f.	Mandor	67 person
	Total	750 person
g.	Grass cutting Machine	76 unit

6.4 Transfer Station

6.4.1 Selection of Transfer Stations for Alternatives

(1) Transport Means and Methods

As for the principal means of the transportation of solid wastes, the followings are used at present ;

- Motor vehicles
- Railroads
- Ocean-going vessels
- Pneumatic and hydraulic systems

a. Motor vehicles transport

The motor vehicles transport is the most common means of transportation of solid wastes in all over the world as well as the Penang State. Almost every imaginable type of vehicle is being used at present.

b. Railroad transport

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

c. Water transport

Barges, scows, and special boats are being used to transport solid wastes to seaside and ocean disposal sites.

One of the major problems encountered when ocean vessels are used for the transport of solid wastes is that it is often impossible to move the barges and boats during storms or during times of heavy seas. In such cases, the wastes must be stored and the construction of costly storage facilities may be necessary.

d. Pneumatic and hydraulic systems of transport

Both low-pressure air and vacuum conduit transport systems have been used to transport solid wastes. The most common application is the transport of wastes from high-density apartments or commercial activities to a central location for processing or for loading into transport vehicles.

From a design and operational standpoint, pneumatic systems are more complex than hydraulic systems because of the complex control valves and ancillary mechanisms that are required. The necessity to use blowers or high-speed turbines further complicates the installation from a maintenance standpoint. Because installation costs for such systems are quite high, they are most cost-effective when used in new facilities.

The concept of using water to transport wastes is not new. Hydraulic transport is now commonly used for the transport of a portion of food wastes (where home grinders are used). One of the major problems with this method is that ultimately the water or waste used for transporting the wastes must be treated. As a result of solubilization, the organic strength of this waste water is considerably greater than that of other domestic waste water.

(2) Need for Transfer Stations

Transfer and transport operations become a neccessity when haul distances to available disposal sites or intermediate treatment plants increase to the point that direct hauling is no longer economically feasible. They also become a nesessity when disposal sites or intermediate treatment plants are in remote locations and cannot be reached directly by highway. Transfer operations and the introduction of transfer stations are necessary in the case that the followings are observed ;

a. The location of disposal sites is relatively far from collection routes (typically more than 15km).

b. The use of small-capacity collection trucks (generally under 15m³).

c. The widespread use of medium-sized containers for the collection of wastes from commercial sources.

d. The use of hydraulic or pneumatic collection systems.

Labor, operating, and fuel costs may rise in the future, thus making the introduction of transfer stations more feasible than it is today.

Transfer stations, as mentioned, are used to accomplish the removal and transfer of solid wastes from collection and other small vehicles to larger transport equipment. Transfer stations may be classified with respect to capacity as follows : small, less than 100 tons/day ; medium, between 100 and 500 tons/day ; and large, more than 500 tons/day.

(3) Selection of Transfer Station for Alternatives

As mentioned in the Chapter 3, all candidate sites for final disposal are in remote locations from the main solid waste production areas to be served. It is, therefore, necessary to study the introduction of transfer stations in SWM for the Penang State.

Since railroad lines is not available for this purpose and pneumatic and hydraulic systems for transport is economically not feasibility, the following two types of transfer stations are selected as the alternatives for the Master Plan.

- Transfer station for motor vehicles
- Transfer station for Ocean-going vessels

(4) Location of Transfer Station

Whenever possible, transfer stations should be located in the following places.

a. As near as possible to the weighted center of the individual solid waste production areas to be served.

b. Within easy access to major arterial highway routes as well as near secondary or supplemental means of transportation.

c. Where there will be a minimum of public and environmental objection to the transfer operations.

d. Where construction and operation will be most economical.

Paying careful considerations on the above-mentioned items a, b, c and d, the candidate sites are selected as follow ;

- Jelutong Mole in MPPP
- Free Trade Zone in MPPP
- Balik Pulau in MPPP
- Mak Mandin in MPSP

6.4.2 Preliminary Design of Transfer Station for Motor Vehicles

(1) Planning Procedure

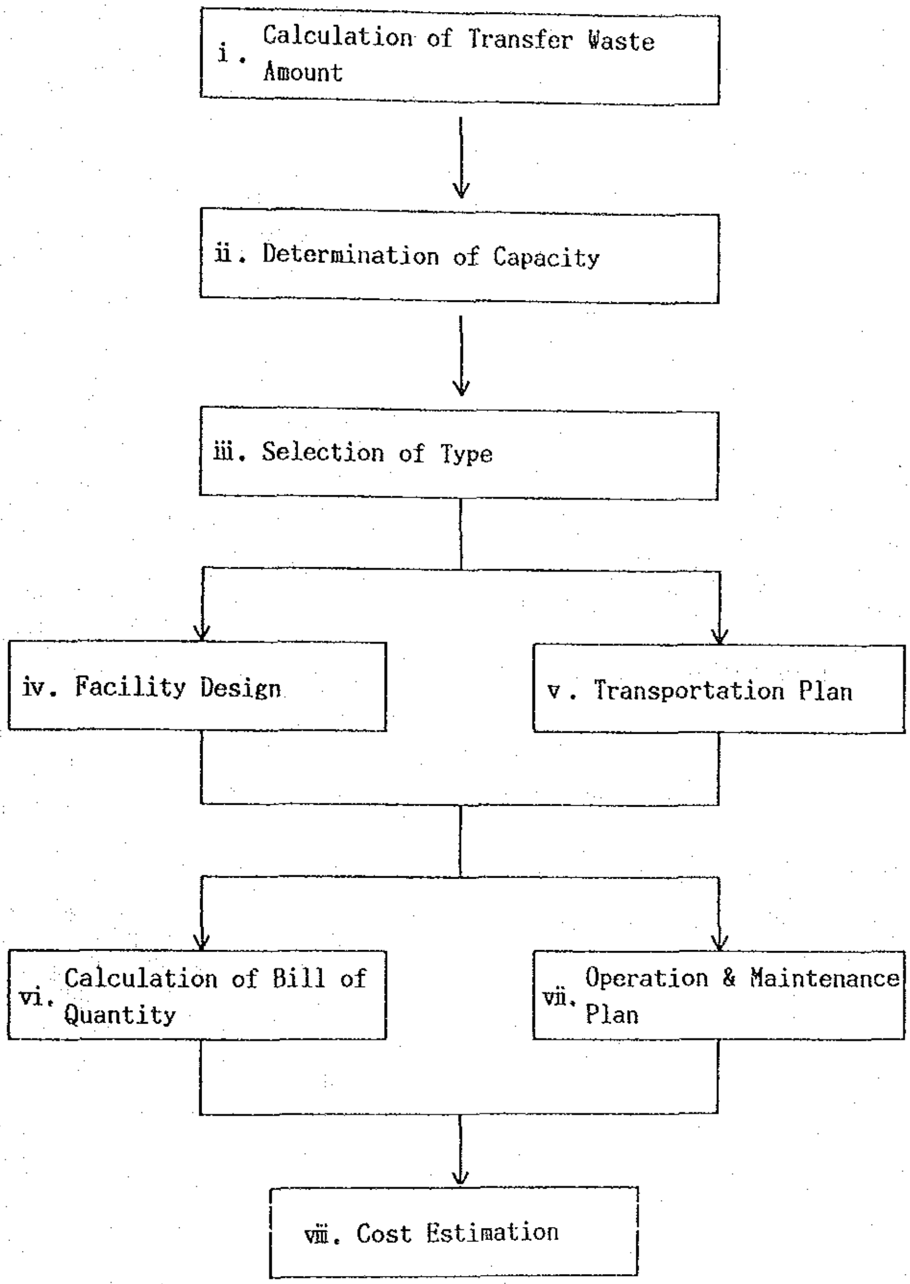
a. Planning flow

In order to plan a transfer station for motor vehicles at the Master Plan Stage, a planning flow is illustrated in Fig. 6.4-1.

b. Considerations for planning

In the application of above-mentioned planning flow, the following items are to be considered ;

Fig. 6.4-1 Planning Flow of Transfer Station for Motor Vehicles



i. Transfer waste amount

- Calculation of transfer waste amount
- Seasonal fluctuation of transfer waste amount

ii. Capacity requirements

- Number of working days (days/week)
- Peak month in terms of waste generation (i.e. transfer amount)

iii. Types of transfer stations

- Direct re-loading
- Indirect re-loading
  - With storage (pit & crane or reception yards)
  - Without storage (bailing or compaction)

iv. Facility design

- Incoming conditions
  - type and number of collection vehicles.
  - Working days and hours.
- Operational plan
- Equipment requirements
- Accessory requirements
- Sanitary requirements
- Civil works

v. Transportation plan

- Access condition
- Working hours
- Types of vehicles
- Number of vehicles

vi. Calculation of bill quantity

- Based upon design of transfer station and operation and maintenance plans.

vii. Operation and maintenance plan

- Personnel requirements

- Utilities

- Maintenance accessories

viii. Cost estimations

- Based on calculation of bill of quantity and construction price data collected.

(2) Preliminary Design

As for the alternatives study for the Master Plan, the following transfer stations for motor vehicles are identified ;

- JMTS (Jelutong Mole Transfer Station) in MPPP
- BPTS (Balik Pulau Transfer Station) in MPPP
- MMTS (Mak Mandin Transfer Station) in MPSP

The alternatives for the Master Plan are shown in Fig. 6 .4-2 and 6.4-3. According to the planning procedure shown in Fig. 6.4-1, each transfer station is designed in the manner below.

a. Calculation of transfer waste amount

In order to start planning, the transfer waste amount of a transfer station shall be calculated. According to the alternatives, the transfer waste amount in the year 2005 of each transfer station is calculated and tabulated in Table. 6.4-1.

b. Determination of capacity requirements

The capacity requirement of each transfer station is calculated and tabulated in Table 6.4-1. The calculation is made by the following manner ;

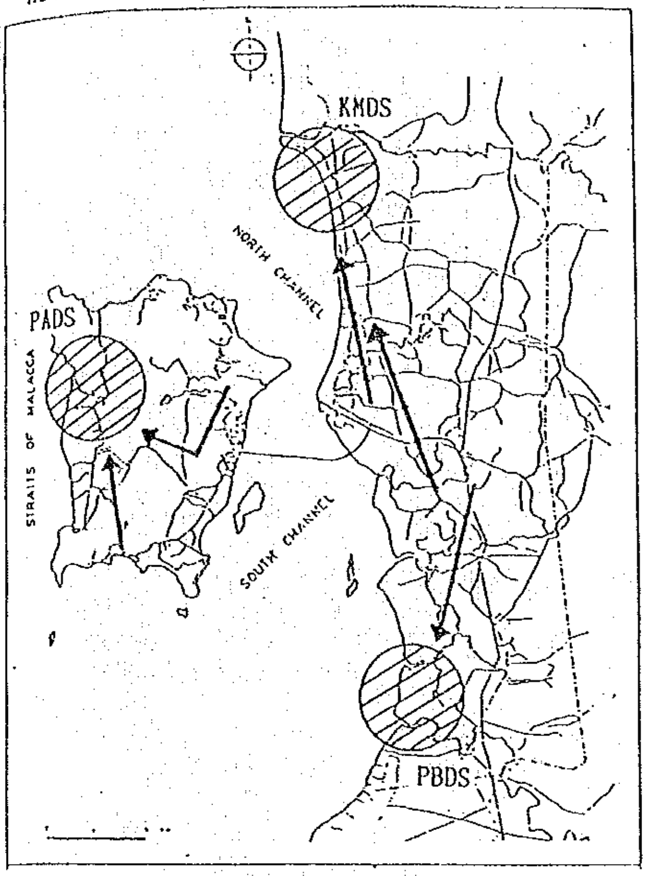
i . Average daily transfer waste amount of each transfer station in the year 2005 is calculated according to the collection plan for each alternative.

ii. Although a transfer station will work even on Sunday, transfer amount on Sunday is only 20% of the other days. In order to get capacity requirements of a transfer station, the working day of it is assumed as 6 days per week.

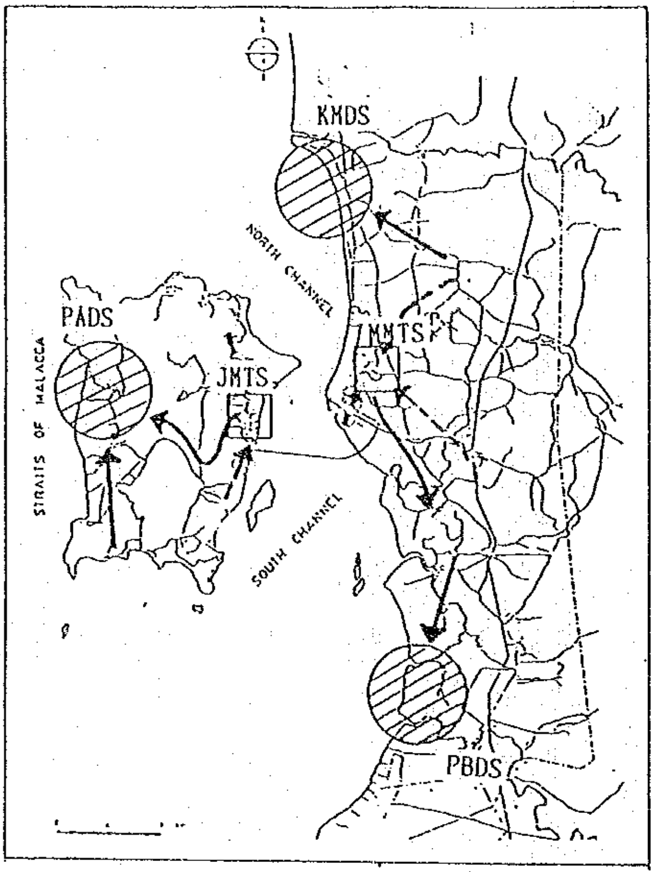
iii. According to the waste disposal amount done by this study, the ratio of maximum generation month to the average generation month is 1.14.

Fig. 6.4-2 Alternatives for Master Plan (1)

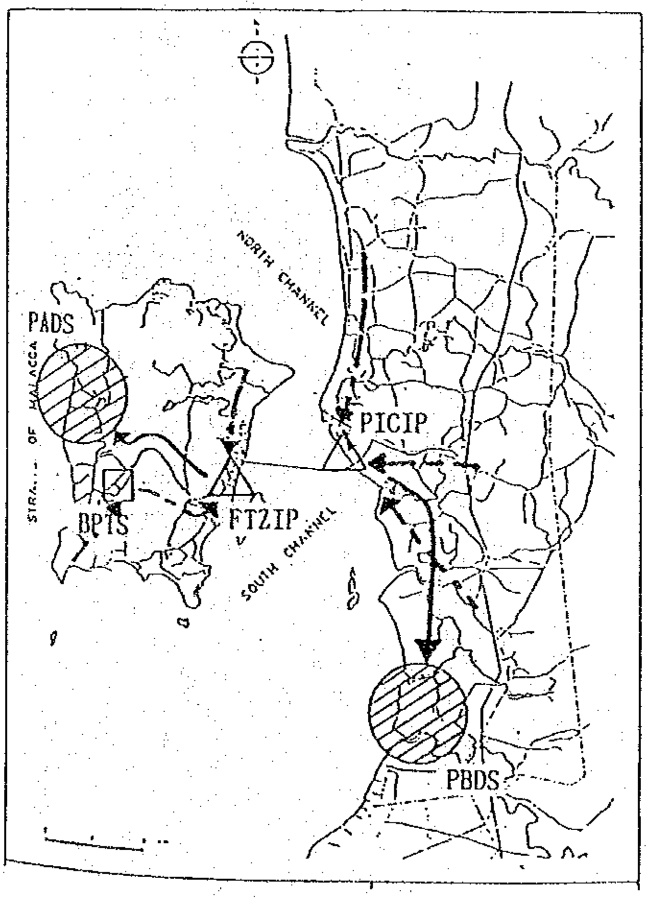
Alt.1 Independent Disposal-Direct Haulage



Alt.2 Independent Disposal-Introduction of Transfer Station



Alt.3 Independent Disposal-Introduction of Incineration Plant



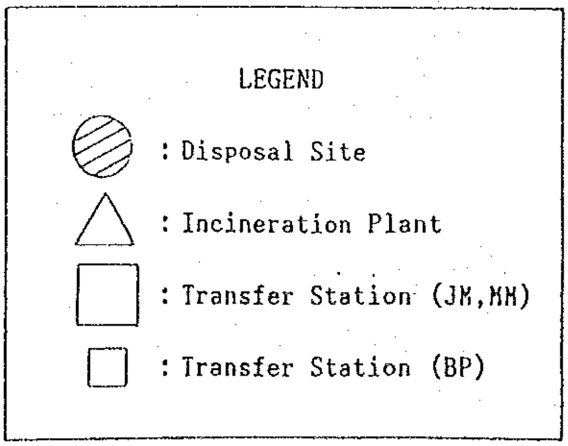
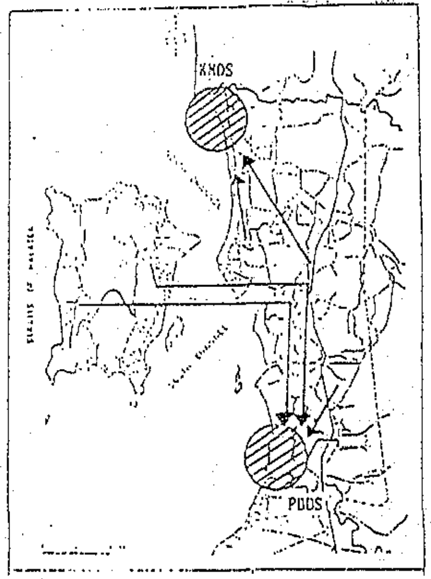
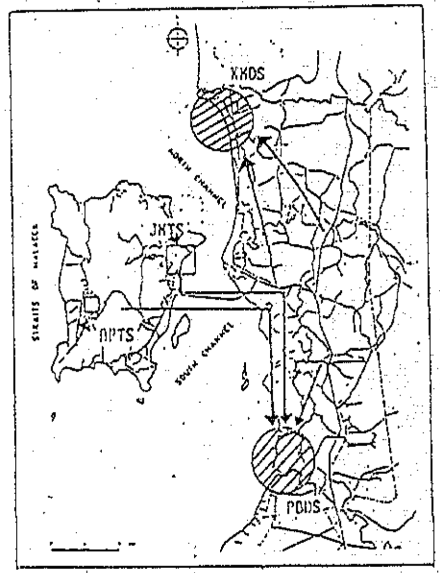


Fig. 6.4-3 Alternatives for Master Plan (2)

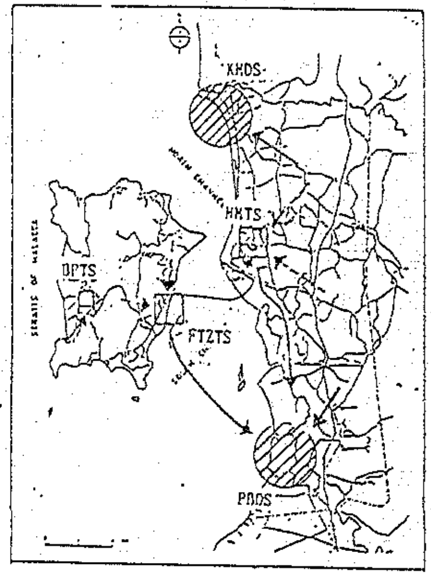
Alt.4 Intermunicipal Disposal-Direct Haulage



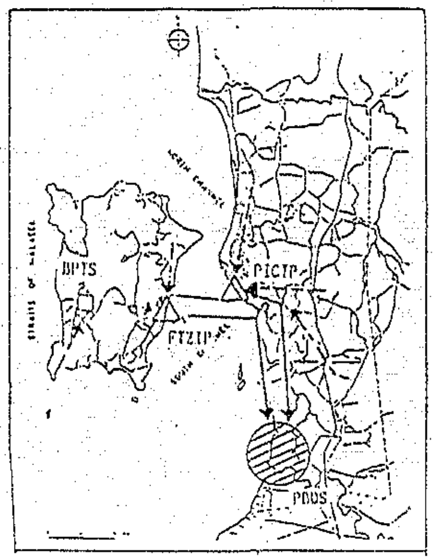
Alt.5 Intermunicipal Disposal-Introduction of Transfer Station for Motor Vehicles



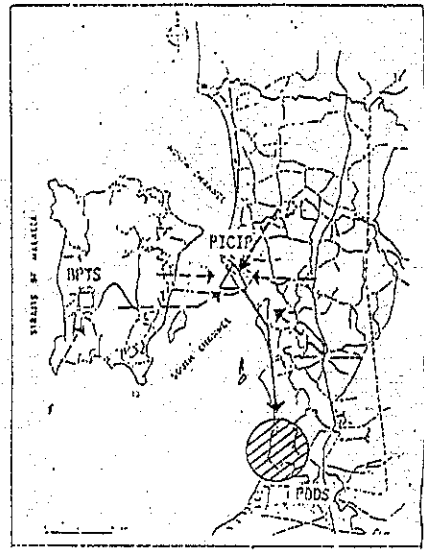
Alt.6 Intermunicipal Disposal-Introduction of Transfer Station for Ocean-going Vessels



Alt.7 Intermunicipal Disposal-Introduction of Incineration Plant



Alt.8 Intermunicipal Treatment and Disposal -Introduction of Incineration Plant



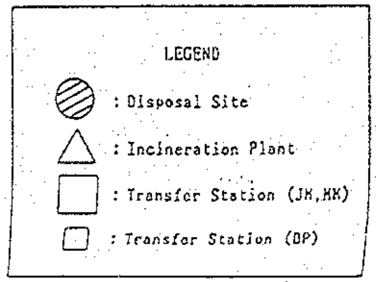


Table 6.4-1 Capacity Requirements of Transfer Stations for Motor Vehicles

Name of Transfer Station		① Average Daily Transfer Waste Amount in 2005(ton/day)	② ※ ①×7/6 (ton/day)	③ ※※ ②×1.14 (ton/day)	④ Capacity Requirement (ton/day)	Remarks
MPPP	B P T S	44.1	51.5	58.7	60	Alt. 3, 5, 6, 7 and 8
	J M T S	686.4	800.8	912.9	920	Alt. 2
	J M T S.	726.0	847.0	965.6	970	Alt. 5
MPSP	M M T S	462.2	539.2	614.7	620	Alt. 2 and 6

※ 7/6 is the ratio of No. of days per week to No. of working days.

※※ 1.14 is the ratio of the transfer amount of the maximum generation month to the average generation month.

c. Selection of type transfer stations

i. Type of transfer stations

Depending on the method used to load the transfer waste onto the transport vehicles, transfer stations may be classified into the following types ;

① Direct re-loading type

In this type of transfer station, wastes collected by each collection vehicle are directly re-loaded into the transportation vehicles or containers.

② Indirect re-loading

In the indirect re-loading type of transfer station, wastes collected are discharged from each collection vehicle at the transfer station.

- With storage type

As for indirect re-loading with storage type, wastes discharged are once stored at the transfer station then re-loaded into the transport vehicles.

These are the following types ;

· Pit and crane type with compactor

· Pit and crane type with baling

· Reception yards type with loading equipment

- Without storage type

Instead of storage facilities, this type has hopper for receiving wastes discharged from collection vehicles. Then, wastes discharged are processed by equipments. These types are classified into the followings according to the processing equipments ;

· Bailing type

· Compactor type

ii. Considerations for selection of types

In order to select the types of transfer stations, the following aspects are to be considered ;

- Economic feasibility according to the capacity requirements

· Construction cost

· Operation and maintenance cost

· Numbers of personnel required for operation

- Easiness and stability in operation

· Reliability of the system

· Storage capability

· Re-loading capability

· Simple operational manual

- Flexibility
  - Working hours
  - Flexibility to the fluctuation of transfer waste amount
  - Flexibility on the break down of the transfer station

- Safety

- Operation and maintenance
  - Easiness in maintenance and repair
  - Durability
  - Easiness in controling

- Space for the transfer stations
  - Required area

- Environmental acceptabilities
  - Environmental impacts on noise, dust and odor
  - Sanitation requirements

iii. Selection of type

Based on the above mentioned connsiderations, the following types are selected for the proposed transfer stations.

① BPTS

Direct re-loading type to the transportation vehicles.

② JMTS and MMTS

Indirect re-loading type with compactor and without storage facilities

iv. The reasons are as follows ;

① As for BPTS

- The capacity requirements of the station is only 60 ton/day.

- Construction is the cheapest and simplest.

- As for the fluctuation of transfer waste amount, it can be overcome by having spare vehicles.

- *Because this type does not require any mechanical facilities, any operational cost for facility is not incurred.*

② As for JMTS and MMTS

- The capacity requirements of the transfer stations are over 500 ton/day. The transfer stations are classified as large scaled transfer stations.

- Collection vehicles proposed in the study are compaction type and large (m³). Therefore, without compaction facility ; the proposed transportation vehicles become too big.

- This type of transfer station can transfer large amount of wastes efficiently.

- *From the environmental point of veiw, reception yards and bailing types are not recommended to wastes which contain large amounts of garbage.*

- Construction of storage facilities requires significant amount of funds.

- This type achieve high efficiency of transfer operation. This means less requirements of space per ton of transfer.

- It is rather easy to control environmental impacts such as littering, dust, odor and other in this type of transfer stations.

d. Facility Design of Each Transfer Station

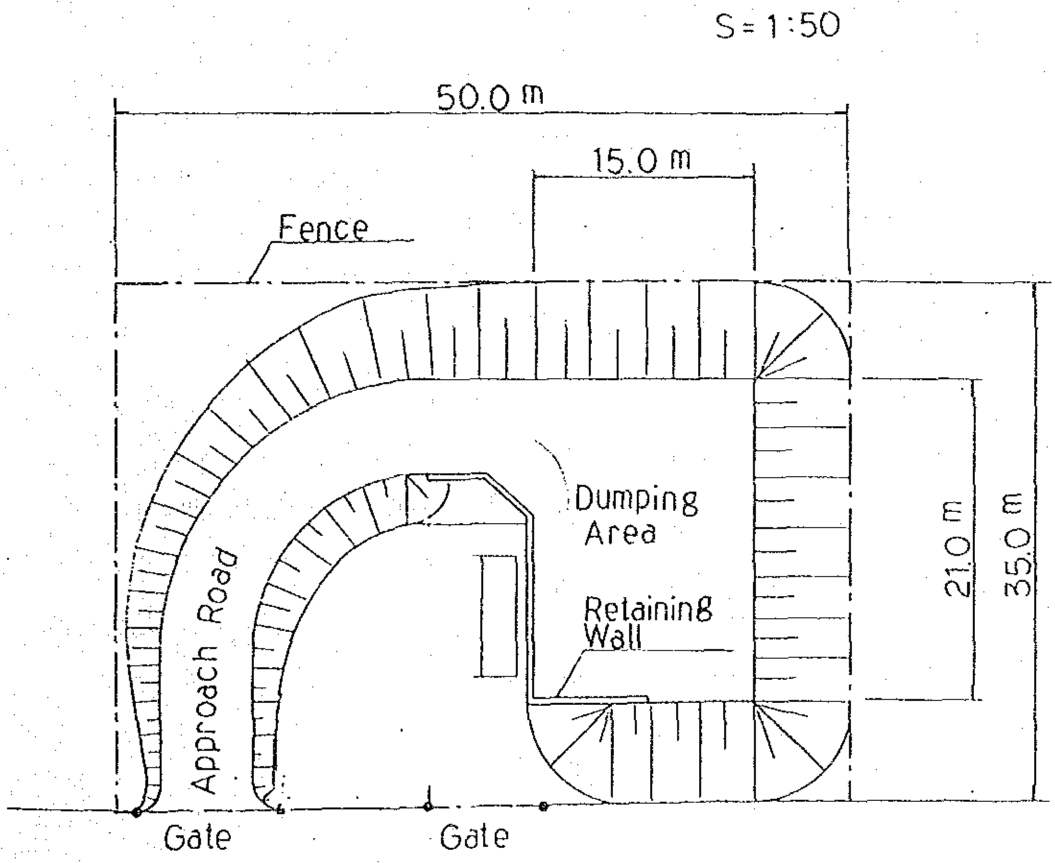
i . Direct re-loading

Transfer waste amount of Balik Pulau is estimated only 60 t/day. Therefore, the types of transfer station is selected to be simple and economical such as the direct re-loading type.

Topographic conditions of transfer station site is flat, therefore, the principal facilities of this consist of the followings and illustrated in Fig. 6.4.-4 below.

- Approach road (Width = 6 m Length ≒ 60m)
- Dumping area with the retaining well
- Temporary storage area for waste.

Fig. 6.4-4 Typical Features of Balik Pulau Transfer Station



ii. Indirect re-loading type transfer station with compactor

For large scale transfer station, the plans for indirect re-loading type with compaction equipment are studied in the 3 following cases:

- Jelutong Mole transfer station (2 plans with different capacity)
- Mak Mandin transfer station

Constituents of each plant are:

- Receiving and feeding facility
- Compaction equipment
- Accessory requirements
- Civil and building

① Receiving and feeding facility

The waste receiving and feeding facilities, weighbridge, platform, receiving hopper, feeder to compaction equipment etc., are provided.

The plan provides 2 weighbridges for JMTS and 1 for MMTS upon consideration of the number of incoming collection vehicles to the plant during the peak hours in a day. There 2 hours peak in the morning and 1 hour peak in the afternoon, and the number of vehicles in peak hour is estimated as 1.5 ~ 1.8 times to the hourly average in a day.

Receiving hopper provided on each compaction equipment is designed to have suffient width enabling 2 vehicles to reach each hopper at the same time, with storage capacity equivalent to waste expected at least 20 minutes during peak hours.

② Compaction equipment

- Number of compaction units.

  The number of compaction units for each plant must be sufficient to avoid the severe influence in capacity reduction during unexpected failure of equipment.

  In this case, considering the scale of plant capacity, the following number of compactors are required.

  - 4 compactor units for JMTS
  - 3 〃 〃 for MMTS

- Design capacity of each compaction unit

  The maximum capacity of each compaction unit is made upon consideration of the design conditions below.

  • Waste amount per day in peak month (t/d)
  • Waste amount in peak hour during peak month (t/k)
  • Type, size and loading capacity of secondary transport vehicle
  • Number of vehicles going to landfill site

    (Numbers / hr / Compactor units)
  • Required time for compaction per cycle
  • Idle time needed for connection/dis-connection of vehicle to compacter unit

- In each case, upon consideration of design factor that is related to the compression time and idle time, the real capacity of compaction equipment is decided as being capable of compacting 1.5 times the amount to be compacted during the peak hour.

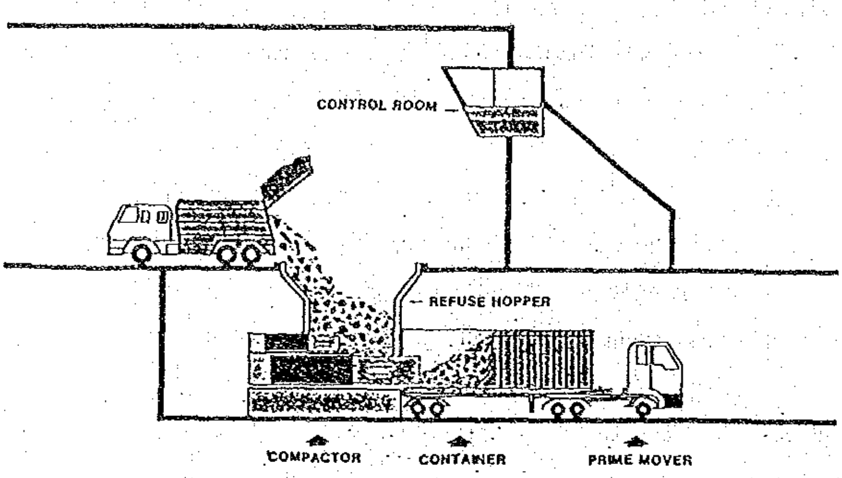
③ Major accessory requirements

For the operation of the whole plant and to execute the functions of a transfer station, accessory requirements are required and described as follows:

- Hydraulic oil pump units
- Remote operating devices and automatic controllers
- Electric power station
- Car washing device
- Waste water treatment facility
- Shovel loader (in-plant use)
- Prime mover (in-plant use), etc.

Fig. 6.4-5 shows a schematic diagram of transfer station with compaction equipment.

Fig. 6.4-5 Schematic Diagram of Refuse Transfer Operation



④ Civil and building works

2 storey main building constructed of reinforced concrete and steel structure is provided.

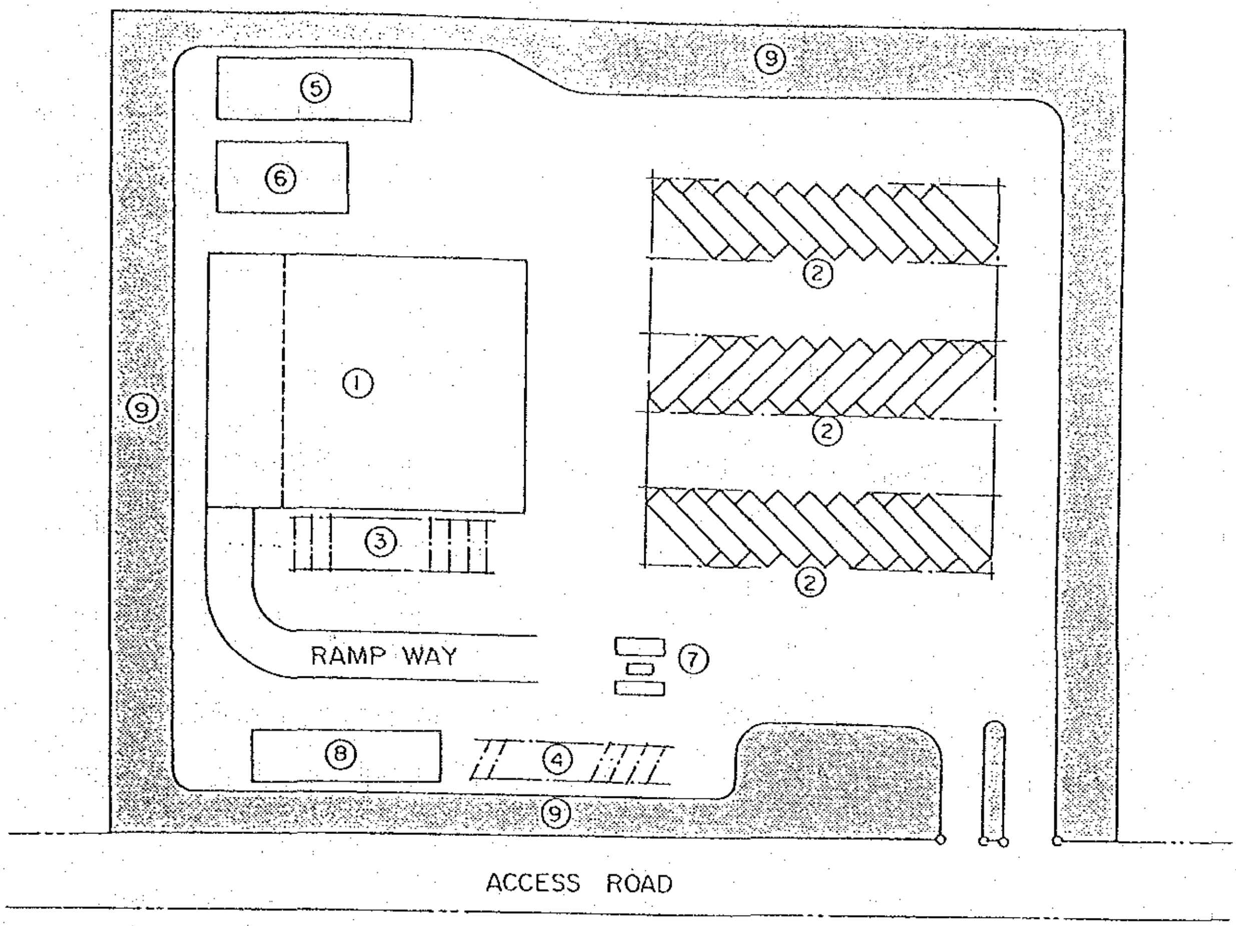
In the main building, the followings are contained.

Compaction equipment, feeder, hydraulic oil pump unit, electric power station, etc.

The office building with amenity facility for tractor drivers, and weighbridge house etc., are also housed here.

As for civil works, large parking area for transfer vehicles, ramp way for access to the platform, site road, car washing station, car repair bay etc., are necessary.

Fig. 6.4-6 Plan of Transfer Station
(with Compaction Equipment)



LEGEND

① Transfer Station Building
② Container Yard
③ Tractor Parking
④ Car Park
⑤ Car Washing Station
⑥ Repair Bay
⑦ Weighbridge
⑧ Office / Drivers Amenities
⑨ Green Belt

Details of Master Plant Alternative for Transfer Station

Alt.	Name of Plant	Plant Capacity (t/d)	Proposed Site Area
②	JMTS	920	135m×165m=2.2 ha
⑤	JMTS	970	135m×180m=2.4 ha
② & ⑥	MMTS	620	120m×150m=1.8 ha

e. Transportation from transfer station

Transportation from transfer station is studied on following six cases for the alternatives study. The aims of this study is to calculate 1). the proposed number of vehicles and 2). the cost of transportation from transfer station.

The six cases stated for the alternative study are as follows : -

① Alternative 2 : JMTS (Jelutong Mole Transfer Station) → PADS (Pantai Acheh Disposal Site)

② Alternative 5 : JMTS → PBDS (Pulau Burong Disposal Site)

③ Alternative 2 and 6 : MMTS (Mak Mandin Transfer Station) → PBDS

④ Alternative 3, 6 and 7 : BPTS (Balik Pulau Transfer Station) → FTZIP (Free Trade Zone Incineration Plant)

⑤ Alternative 5 : BPTS → PBDS

⑥ Alternative 8 : BPTS → PICIP (Perai Industrial Compax Incineration Plant)

Procedure in planning for transportation is shown in figure below.

Fig. 6.4-7 Procedure in Planning for Secondary Transportation

i . Planning Condition of Transfer Station

- ·Amount of refused collected at transfer station
- ·Type and load capacity of vehicles

↓

ii . Number of Transportation Vehicles Proposed

- ·Total number of trips
- ·Number of trips per vehicles per day
- ·Number of Spare vehicle on stand-by

↓

iii . Transportation Cost

- ·Cost of Fuel
- ·Toll fee at Penang Bridge

i . Basic data

The following basic data is established in order to calculated the proposed number of vehicles and the cost of transportation.

① Vehicles used for transportation

- Compacted container trailer (CCT) :

To be used for secondary transportation from large scale transfer station. (JMTS and MMTS)

Capacity : $40m^3$

Loading capacity : 20 ton (40×0.2×2.5)

Where 0.2 is the apparent specific gravity

2.5 is the compaction ratio

- Open Container Trailer (OCT) :

To be used for transportation from small scale transfer station (BPTS)

Capacity : $40m^3$

Loading capacity : 7.2 ton (40×0.2×0.9)

Where 0.2 is the apparent specific gravity

0.9 is the loading ratio

② Driving speed of vehicle for transportation

- Driving speed is established at 30km/hr in the case of trip through the mountains in Penang Island.
- Driving speed is established at 35 km/hr in other cases than those mentioned above.

③ Working time

- Total working time in a day is established as 7 hours per day.

- Loading time :

  Loading time is established as 0.2 hours at large transfer station.

  Loading time is established as 0.5 hours at small scale transfer station.

- Discharging time is established as 0.3 hours at disposal site.

④. Cost of fuel is established at M$ 0.468/liter (including cost of oil)

⑤. Distance covered per liter of fuel consumed : 2 km/liter

⑥. Toll fee of Penang Bridge : M$ 15/trip

Information on transportation , based on the above mentioned basic data is shown in Table 3.4-2.

ii. Number of transportation vehicles required.

Using the previous information, the following items are calculated.

①. Total number of trips per day.

Total number of trips per day = Average transfer amount per day/ Loading capacity of vehicle

②. Number of trips per vehicle per day

Number of trips per vehicle per day = 7 hours/Cycle time per vehicle

Basically , the number of trips for each vehicle in a day (7 hours/day) is determined by the above quotient. However , if the remainder time (hours) after division is over 70% against time of the cycle, one more cycle is considered with regards to the overtime.

③ Number of vehicles required per day

Number of vehicles required per day = (Total number of trips per day/
number of trips per vehicle per day) x 7/6

Number of vehicles required per day is based on the average transfer amount per day, calculated as the average of refuse collected every day. As the transfer station is planned to have a six days week, number of vehicles required per day should consider the ratio of number of days per week to number of working days i.e. 7/6.

④ Stand-by vehicles

Stand-by trailers are needed for maintenance and repairing period. Spare containers should also be prepared to effectively execute secondary transportation. For the maximum generation month, stand-by trailers and spare containers may be mobilized and overtime work may also be considered.

⑤ Number of vehicles proposed

Number of vehicles proposed is calculated as follows.

(Total No. of trips per day/No. of cycles per vehicle per day)×7/6 + (Stand-by vehicles)

Results are shown in Table 6.4-3.

iii. Transportation Cost

Transportation cost are calculated as follows.

Transportation Cost = (Cost of fuel) + (Toll fee at Penang Bridge)

where

(Cost of Fuel) = ((Total No. of trips per day × One round-trip distance)/
2 (km/liter)) × 0.468 (M$/liter)

Results are shown in Table 6.4-4.

Table 6.4-2 Calculation of Transportation from transfer Station

Items		A-2		A-3	A-5		A-6		A-7	A-8
(1)Type of waste		Refuse	Refuse	Refuse	Refuse	Refuse	Refuse	Refuse	Refuse	Refuse
(2)Origin and destination		(JM-PA)	(MM-PB)	(BP-FTZ)	(BP-PB)	(JM-PB)	(BP-FTZ)	(MM-PB)	(BP-FTZ)	(BP-Prai)
(3)Average out-going amount of waste from transfer station (ton/day)		686.4	462.2	44.1	44.1	726.0	44.1	462.2	44.1	44.1
(4)Average incoming amount of waste at transfer station (ton/day)		686.4	462.2	44.1	44.1	726.0	44.1	462.2	44.1	44.1
(5)Type of vehicle		CCT	CCT	OCT	OCT	CCT	OCT	CCT	OCT	OCT
(6)Loading capacity (ton/vehicle)		20.0	20.0	7.2	7.2	20.0	7.2	20.0	7.2	7.2
(7)One-way distance (km)		33.3	38.3	13.0	63.5	50.8	13.0	38.3	13.0	34.1
(8)Round-trip distance(km)	(7)x2	66.6	76.6	26.0	127.0	101.6	26.0	76.6	26.0	68.2
(9)Speed(km/hr.)		30	35	30	30	35	30	35	30	30
(10)Round-trip time required (hr.)	(8)/(9)	2.22	2.19	0.87	4.23	2.90	0.87	2.19	0.87	2.27
(11)Loading time(hr.)		0.20	0.20	0.50	0.50	0.20	0.50	0.20	0.50	0.50
(12)Discharging time(hr.)		0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
(13)Cycle time(hr.)	(10)+(11)+(12)	2.72	2.69	1.67	5.03	3.40	1.67	2.69	1.67	3.07

*CCT:Compacted Container Trailer(40x0.5=20TON)
*OCT:Open Container Trailer(40x0.2x0.9=7.2TON)
*OT:Open Tipper Truck(10x0.7x0.9=6.3TON)

Table 6.4-3 Number of vehicles proposed at transfer station

Items		A－2		A－3	A－5		A－6		A－7	A－8
(1)Type of waste		Refuse	Refuse	Refuse	Refuse	Refuse	Refuse	Refuse	Refuse	Refuse
(2)Origin and destination		(JM-PA)	(MM-PB)	(BP-FTZ)	(BP-PB)	(JM-PB)	(BP-FTZ)	(MM-PB)	(BP-FTZ)	(BP-Prai)
(3)Average out-going amount of waste from transfer station (ton/day)		686.4	462.2	44.1	44.1	726.0	44.1	462.2	44.1	44.1
(4)Type of vehicle		CCT	CCT	OCT	OCT	CCT	OCT	CCT	OCT	OCT
(5)Loading capacity (ton/vehicle)		20.0	20.0	7.2	7.2	20.0	7.2	20.0	7.2	7.2
(6)Total number of trips	(3)/(5)	35	24	7	7	37	7	24	7	7
(7)Cycle time(hr.)		2.72	2.69	1.67	5.03	3.04	1.67	2.69	1.67	3.07
(8)Number of trips per vehicle per day	7hours /(7)	2	2	4	2	2	4	2	4	2
(9)	(6)/(8)	18	12	2	4	19	2	12	2	4
(10)Number of vehicles required per day	(9)x7/6	22	15	3	5	23	3	15	3	5
(11)Number of trailers proposed (spare)		25(3)	17(2)	4(1)	6(1)	26(3)	4(1)	17(2)	4(1)	6(1)
(12)Number of containers proposed (spare)		30(8)	23(8)	4(1)	6(1)	35(12)	4(1)	23(8)	4(1)	6(1)

*CCT:Compacted Container Trailer(40x0.5=20TON)
*OCT:Open Container Trailer(40x0.2x0.9=7.2TON)
*OT:Open Tipper Truck(10x0.7x0.9=6.3TON)

Table 6.4-4 Cost of transportation from transfer station

Items		A－2		A－3	A－5		A－6		A－7	A－8
(1)Type of waste		Refuse	Refuse	Refuse	Refuse	Refuse	Refuse	Refuse	Refuse	Refuse
(2)Origin and destination		(JM-PA)	(MM-PB)	(BP-FTZ)	(BP-PB)	(JM-PB)	(BP-FTZ)	(MM-PB)	(BP-FTZ)	(BP-Prai)
(3) Type of vehicle		CCT	CCT	OCT	OCT	CCT	OCT	CCT	OCT	OCT
(4)Average out-going amount of waste from transfer station (ton/day)		686.4	462.2	44.1	44.1	726.0	44.1	462.2	44.1	44.1
(5)Average incoming amount of waste at transfer station (ton/day)		686.4	462.2	44.1	44.1	726.0	44.1	462.2	44.1	44.1
(6)Total number of trips		35	24	7	7	37	7	24	7	7
(7)Round-trip distance(km)		66.6	76.6	26.0	127.0	101.6	26.0	76.6	26.0	68.2
(8)Cost of fuel(M$)	(6)x(7)/2 km /1x0.468 M$/1	545	430	43	208	880	43	430	43	112
(9)Toll fee of Penang Bridge(M$)		0	0	0	105	555	0	0	0	105
(10)Total cost for transportation (M$)	(8)+(9)	545	430	43	313	1435	43	430	43	217
(11)Transportation cost of waste per ton(M$/T)	(10)/(4)	0.79	0.93	0.98	7.10	1.98	0.98	0.93	0.98	4.92

*CCT:Compacted Container Trailer(40x0.5=20TON)
*OCT:Open Container Trailer(40x0.2x0.9=7.2TON)
*OT:Open Tipper Truck(10x0.7x0.9=6.3TON)

Table 6.4-5 Calculation Sheet for Transportation System from Transfer Station

Items		A－2		A－3	A－5		A－6		A－7	A－8
(1)Type of waste		Refuse	Refuse	Refuse	Refuse	Refuse	Refuse	Refuse	Refuse	Refuse
(2)Origin and destination		(JM-PA)	(MM-PB)	(BP-FTZ)	(BP-PB)	(JM-PB)	(BP-FTZ)	(MM-PB)	(BP-FTZ)	(BP-Prai)
(3)Average out-going amount of waste from transfer station(ton/day)		686.4	462.2	44.1	44.1	726.0	44.1	462.2	44.1	44.1
(4)Average incoming amount of waste at transfer station(ton/day)		686.4	462.2	44.1	44.1	726.0	44.1	462.2	44.1	44.1
(5)Type of vehicle		CCT	CCT	OCT	OCT	CCT	OCT	CCT	OCT	OCT
(6)Loading capacity (ton/vehicle)		20.0	20.0	7.2	7.2	20.0	7.2	20.0	7.2	7.2
(7)Total number of trips	(3)/(6)	35	24	7	7	37	7	24	7	7
(8)One-way distance (km)		33.3	38.3	13.0	63.5	50.8	13.0	38.3	13.0	34.1
(9)Round-trip distance(km)	(8)x2	66.6	76.6	26.0	127.0	101.6	26.0	76.6	26.0	68.2
(10)Speed(km/hr.)		30	35	30	30	35	30	35	30	30
(11)Round-trip time required (hr.)	(9)/(10)	2.22	2.19	0.87	4.23	2.90	0.87	2.19	0.87	2.27
(12)Loading time(hr.)		0.20	0.20	0.50	0.50	0.20	0.50	0.20	0.50	0.50
(13)Discharging time(hr.)		0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
(14)Cycle time(hr.)	(11)+(12)+(13)	2.72	2.69	1.67	5.03	3.40	1.67	2.69	1.67	3.07
(15)Number of trips per vehicle per day	7hours /(14)	2	2	4	2	2	4	2	4	2
(16)	(7)/(15)	18	12	2	4	19	2	12	2	4
(17)Number of vehicles required per day	(16)x7/6	22	15	3	5	23	3	15	3	5
(18)Cost of fuel(M$)	(7)x(9)/2 km /1x0.468 M$/1	545	430	43	208	880	43	430	43	112
(19)Toll fee of Penang Bridge(M$)	(7)x15	0	0	0	105	555	0	0	0	105
(20)Total cost for transportation (M$)	(18)+(19)	545	430	43	313	1435	43	430	43	217
(21)Transportation cost of waste per ton(M$/T)	(20)/(4)	0.79	0.93	0.98	7.10	1.98	0.98	0.93	0.98	4.92

*CCT:Compacted Container Trailer(40x0.5=20TON)
*OCT:Open Container Trailer(40x0.2x0.9=7.2TON)
*OT:Open Tipper Truck(10x0.7x0.9=6.3TON)

f. Caluculation of Quantity

According to facility design, outline of each transfer station is summerized and shown in Table 6.4-7.

g. Operation and Maintenance Plan

For the operation of each transfer station, manpower and utilities are required as shown in Table 6.4-6 the repair and maintenance plan will have to be prepared.

Table 6.4-6 Manpower and Utilities

Site Situated	in MPPP			in MPSP
No. of Alternatives	③,⑤,⑥ ⑦, ⑧	②	⑤	② & ⑥
Name of Plant	BPTS	JMTS	JMTS	MMTS
Capacity of Plant(ton/day)	60	920	970	620
Manpower for Plant				
Manager	—	2	2	2
Engineer	—	2	2	1
Junior Engineer	1	2	2	2
Operator	—	10	10	9
Worker	1	4	4	3
Sub-total	2	20	20	17
Manpower for Transport	Alt.③ ⑥ & ⑦ 4 Alt.⑤,⑧ 6	25	26	17
Utilities				
• Electricity (Mwh/year)	10	1250	1330	840
• Water (m^3/year)	Nil	6240	6630	4210

(3) Outline of each Transfer Station

The outline of each transfer station is as shown in Table 6.4-7 below.

Table 6.4-7 Outline of each Transfer Station

Site	in MPPP			in MPSP
No. of Alternatives	③,⑤,⑥ ⑦, ⑧	②	⑤	② & ⑥
Name of Plant	BPTS	JMTS	JMTS	MMTS
Capacity of Plant (ton/day)	60	920	970	620
Type of Transfer System	Direct Re-loading	Indirect Re-loading with Compaction Equipment		
1. Mechanical and Electrical Facility				
- Weighbridge	—	2	2	1
- Hopper & Feeder	—	4	4	3
- Compaction Equipment Hydraulically operated Compactor Unit with Automatic Controller	—	4	4	3
- Electric Power Supply Station	—	1	1	1
- Waste Water Treatment Equip't	—	1	1	1
- Shovel Loader (in-plant use)	—	1	1	1
- Prime Mover (in-plant use)	—	1	1	1
2. Civil & Building;				
- Site Area (ha)	0.2	2.2	2.4	1.8
- Scale of Main Building (m²)	20	1,700	1,750	1,300
- Retaining Wall (ht=6m) (m)	30	—	—	—
3. Transport Equipment				
Open Container Trailer (40m³)	Alt.③,⑥&⑦ 4 Alt.⑤&⑧ 6	—	—	—
Trailer	—	25	26	17
Container (40m³)	—	30	35	23

6.4.3 Preliminary Design of Transfer Station for Ocean-going Vessels

(1) Planning Procedure

a. Planning flow

In order to plan a transfer station for ocean-going vessels at the Master Plan Stage, a planning flow is illustrated in Fig. 6.4-7.

b. Considerations for planning

In the application of above-mentioned planning flow, the following items are to be considered;

i. Transfer waste amount

- Calculation of transfer waste amount
- Seasonal fluctuation of transfer waste amount

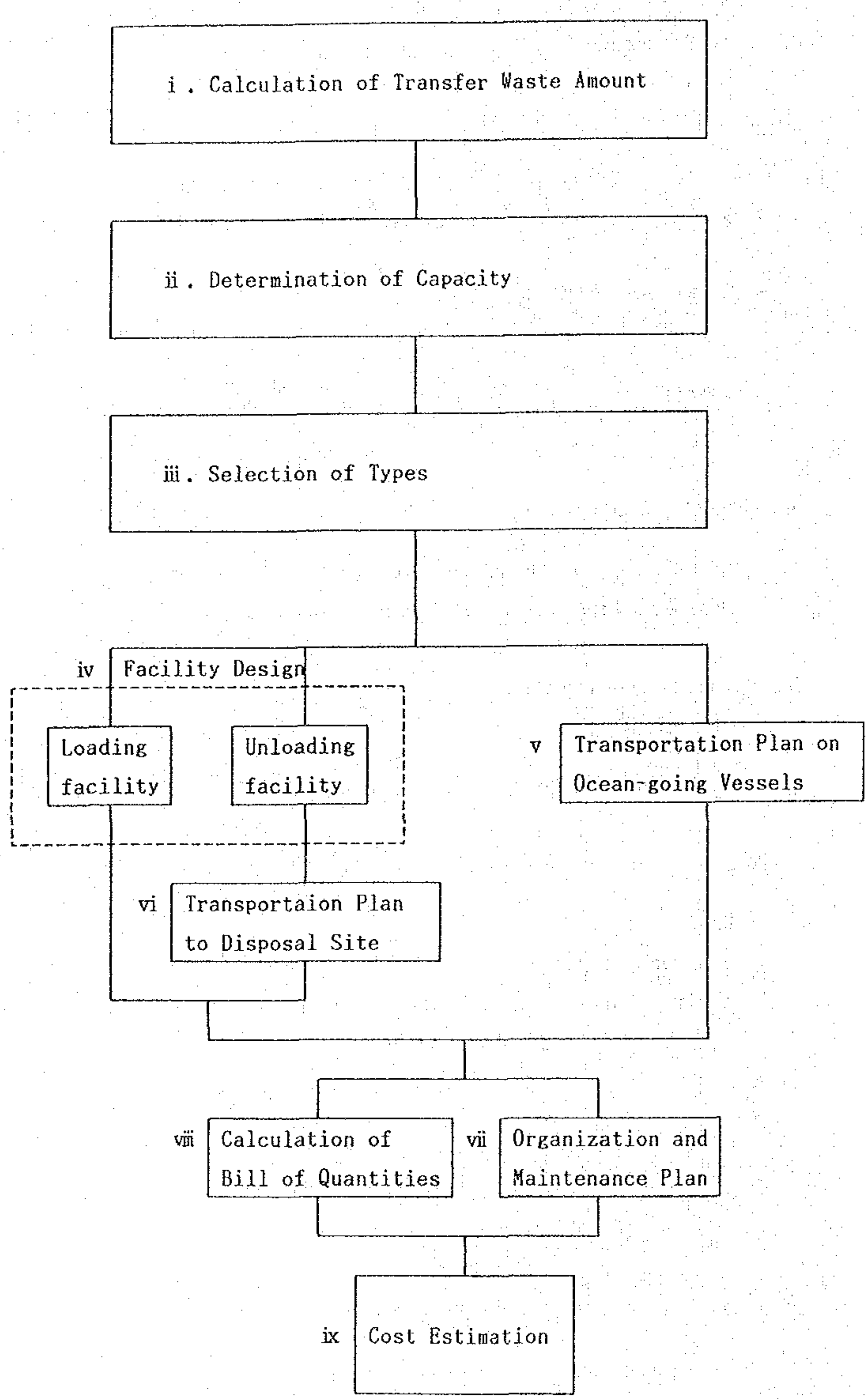
ii. Capacity requirements

- Number of working days (days/week)
- Peak month in terms of waste generation (i.e. transfer amount)

iii. Types of transfer stations

- Direct re-loading
- Indirect re-loading
  - With storage (pit & crane or reception yards)
  - Without storage (bailing or compaction)

Fig. 6.4-7 Planning Flow of Transfer Station for On-going Vessels



iv. Facility design

- Marine data
  - Sea level, depth of sea, tide, waves and sea current
- Incoming conditions
  - Type and numbers of collection vehicles
  - Working days and hours
- Operational plan
- Equipment requirements
- Accessory requirements
- Sanitary requirements
- Civil works

v. Transportation plan for ocean-going vessels

- Access condition
  - Distance, sea depth, sea route
- Working hours
- Types of vessels
- Number of vessels
- Loading and unloading time
- Unit weight of waste in the vessels
- Marine and weather data

vi. Transportation plan to disposal site

- Access condition
- Working hours
- Types of vehicles
- Number of vehicles

vii. Organization and maintenance plan

- Operation plan
- Personnel requirements
- Utility requiremens

viii. Calculation of quantities

- Based on design of transfer station, operation and maintenance plan

ix. Cost estimation

- Based on calculation of bill of quantity and construction price data collected.

(2) Preliminary Design

As for the alternatives study for the Master Plan FTZTS (Free Trade Zone Transfer Station) in MPPP for ocean-going vessels as loading station and PBTS (Pulau Burong Transfer Station) as unloading station are identified.

The alternatives for the Master Plan are shown in Fig. 6.4-2 and 6.4-3. According to the planning procedure shown in Fig. 6.4-7, FTZTS and PBTS including transportation facilities are designed below.

a. Calculation of transfer waste amount

In order to start planning, the transfer waste amount of a transfer station shall be calculated. According to the alternatives, the transfer waste amount in the year 2005 of the transfer station is calculated and tabulated in Table 6.4-8.

b. Determination of capacity requirements

The capacity requirement of the transfer station is calculated and tabulated in Table 6.4-8. The calculation is made by the following manner;

i. Average daily transfer waste amount of the transfer station in the year 2005 is calculated according to the collection plan for the alternative.

ii. Although a transfer station will work even on Sunday, transfer amount on Sunday is only 20% of the other days. In order to get capacity requirements of the transfer station, the working day of it is assumed as 6 days per week.

iii. According to the waste disposal amount done by this study, the ratio of maximum month in generation to the average generation month is 1.14.

Table 6.4-8 Capacity Requirements of Transfer Stations for Ocean-going Vessels

Name of Transfer Station	① Average Daily Transfer Waste Amount in 2005(ton/day)	② * ① x 7/6 (ton/day)	③ ** ② x 1.14 (ton/day)	④ Capacity Requirement (ton/day)	Remarks
MPPP FTZTS	770.0	898.3	1,024.1	1,050	Alt. 6
MPSP PBTS	770,0	898.3	1,024.1	1,050	Alt. 6

* 7/6 is the ratio of No. of days per week to No. of working days.

** 1.14 is the ratio of the transfer amount of the maximum generation month to the average generation month.

c. Selection of type of transfer stations

i . Type of transfer stations

Depending on the method used to load the ocean-going vessels, transfer stations may be classified into following types;

① Direct re-loading type

In this type of transfer station, wastes collected by each collection vehicle are directly re-loaded into the ocean-going vessels.

② Indirect re-loading

- With storage type

In the indirect re-loading type of transfer station, wastes collected are discharged from each collection vehicle at the transfer station and they into the ocean-going vessels.

As for with storage type, wastes discharged are once stored at the transfer station then re-loaded into the transportion vehicles. There are these following types;

- Pit and crane type with compactor
- Pit and crane type with baling
- Reception yards type with loading equipment

- Without storage type

Instead of storage facilities, this type has hopper for receiving wastes discharged from collection vehicles. Then, wastes discharged are processed by equipment. This types are classified into followings according to the processing equipments;

- Bailing type
- Compactor type

ii. Considerations for selection of types

In order to select the types of transfer stations, the following aspects are to be considered;

- Economic feasibility according to the capacity requirements
  - Construction cost
  - Operation and maintenance cost
  - Numbers of personnel required for operation

- Easiness and stability in operation
  - Reliability of the system
  - Storage capability
  - Re-loading capability
  - Simple operational manual

- Flexibility
  - Working hours
  - Flexibility to the flactuation of transfer waste amount
  - Flexibility on the break down of the transfer station

- Safety

- Operation and maintenance
  - Easiness in maintenance and repair
  - Durability
  - Easiness in controlling

- Space for the transfer stations
  - Required area

- Environmental acceptabilities
  - Environmental impacts on fishery, landscape, noise, dust and odor
  - Sanitation requiremens

iii. Selection of type

According to the considerations for selection of types, the following types are selected for the proposed transfer stations;

① FTZTS for loading
Direct re-loading type to the ocean-going vessels

② PBTS for unloading
Indirect re-loading type with crane and without storage facilities.

The reasons are described below;

① As for FTZTS
- This type of facility is the simplest.
- Construction cost is the cheapest.
- Operation and maintenance are rather easy.
- Because this type does not need any machanical facilities, any operational cost for facility is not required.

② As for PBTS
- Construction cost is cheap.
- Operation and maintenance are easy.
- It is possible to respond to the fluctuation of transfer waste amount by having spare vehicles.
- Construction of storage facilities require some amount of money.

d. Facility design

i . Loading facility

① Dock

- In order to secure minimum 5m depth of water for shipping of vessels a dock is to be constructed at 200m out from seashore.
- For the loading efficiency, two docks are planned.
- Based on the following considerations, each dock has 6 hoppers.
  - Number of incoming barges
  - Loading time into barges
  - Number of vehicles at peak hour
  - Discharge time of each collection vehicle
- Waiting yards is considered at platform

② Jetty

- A jetty is planned for the access from seashore to the dock
- Width of jetty is 6m for of collection vehicles

③ Others

- Three weighbridges are considered at the seashore.
- For the operation of loading facility and inspection of incoming vehicles, a site office is considered.

An illustration of the loading facility is shown in Fig. 6.4-8.

ii . Unloading facility

① Sea route

- In order to secure the sea route for barges, which require 5m of water depth, 4,700m of sea bottom dredging is necessary.
- The width of sea route is more than 100m to secure safe sailing.

② Dock

- The location of dock is the sea shore of Pulau Burong.
- For the loading efficiency, two docks are planned.
- For the construction, iron sheet piling is necessary.

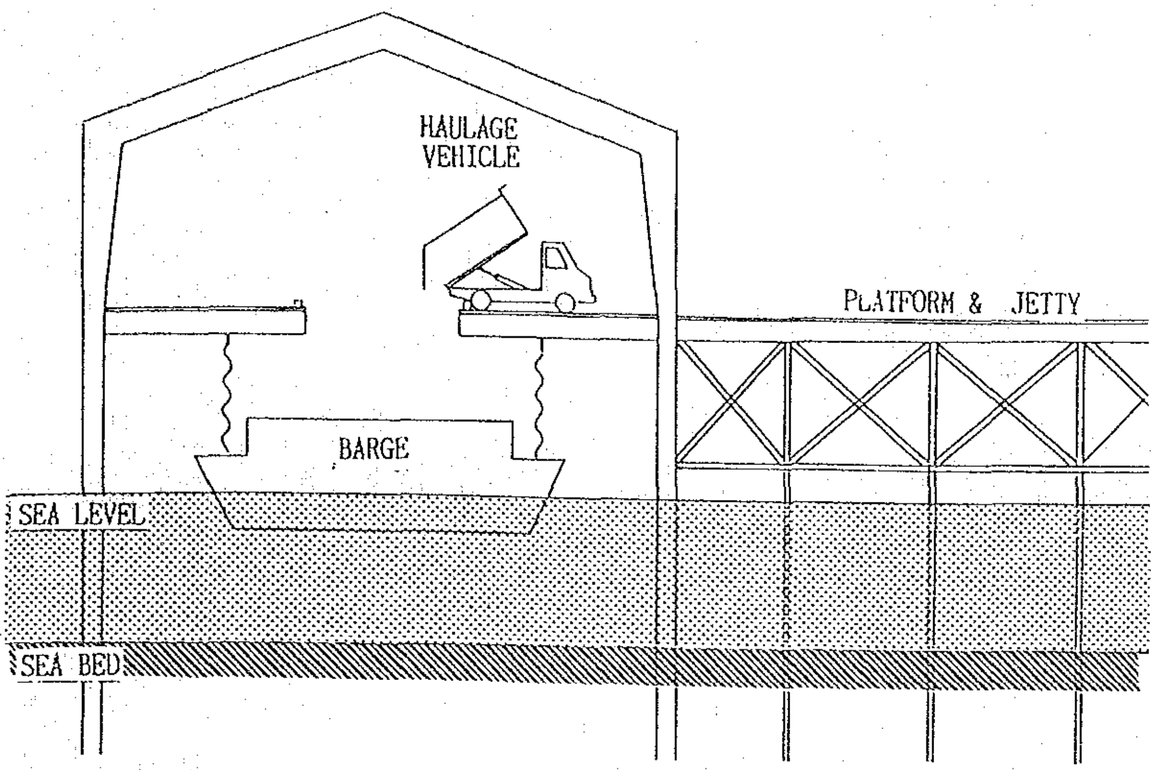


Fig. 6.4-8 Loading Facility

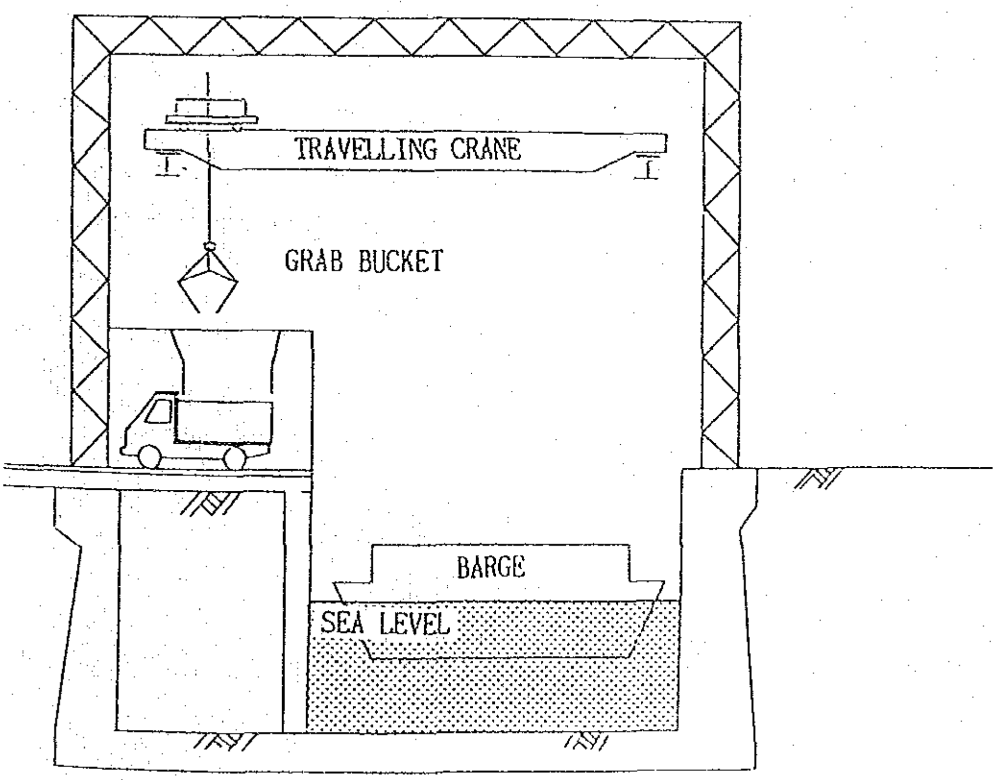


Fig. 6.4-9 Unloading Facility

③ Crane structure frame and travelling crane

Three travelling cranes for each dock (6 in total) are considered.

- Based on following aspects, 6m³ grab buckets are attached to each travelling crane.

- Unloading time
- Wastes amount
- Capacity of grab bukket

- Crane structure frame is planned as steel truss

④ Others

- Hopper is installed for loading wastes into transportation vehicles.

An illustration of the unloading facility is shown in Fig. 6.4-9.

e. Transportation plan

i. Type of ocean-going vessels

- Barge with pusher boat is planned considering aspects mentioned as follows;
  - Less water depths required for sailing
  - Easy operation of vessels
  - Less investment and operation cost

- There as three means to the sailing of barge; i.e. using pusher and tug boats and self-sailing. Because of the above-mentioned reasons, pusher boats type is planned.

ii. Operation plan

The operation plan of barge with pusher boats is prepared based on the considerations described as follows ;

- Transportation amount
- Working hours
- Number of shipping times

The operation plan is shown is Fig. 6.4-10. The sea route for barges is shown in Fig. 6.4-11.

Fig. 6.4-10 Operation Plan of Barge

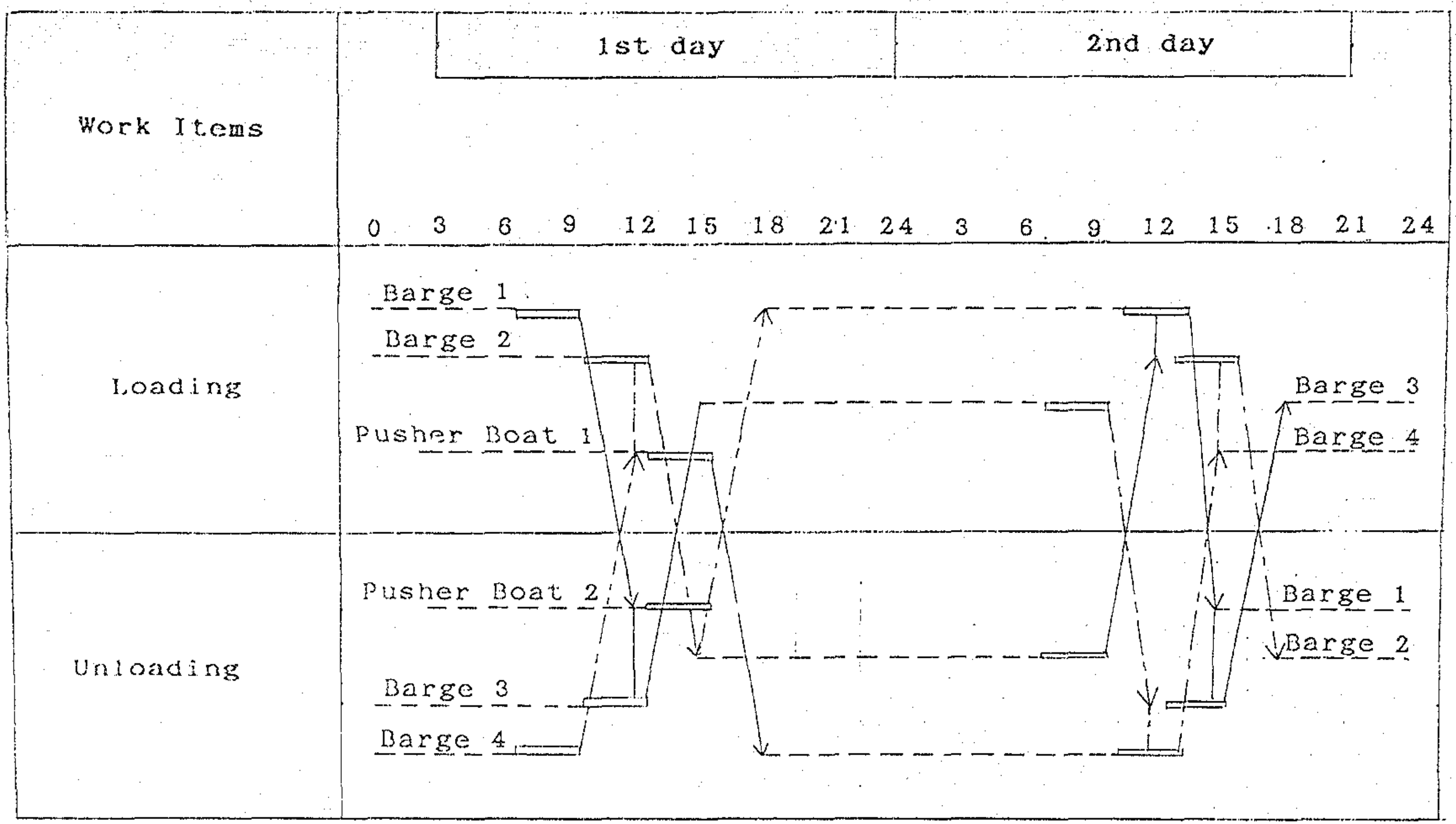
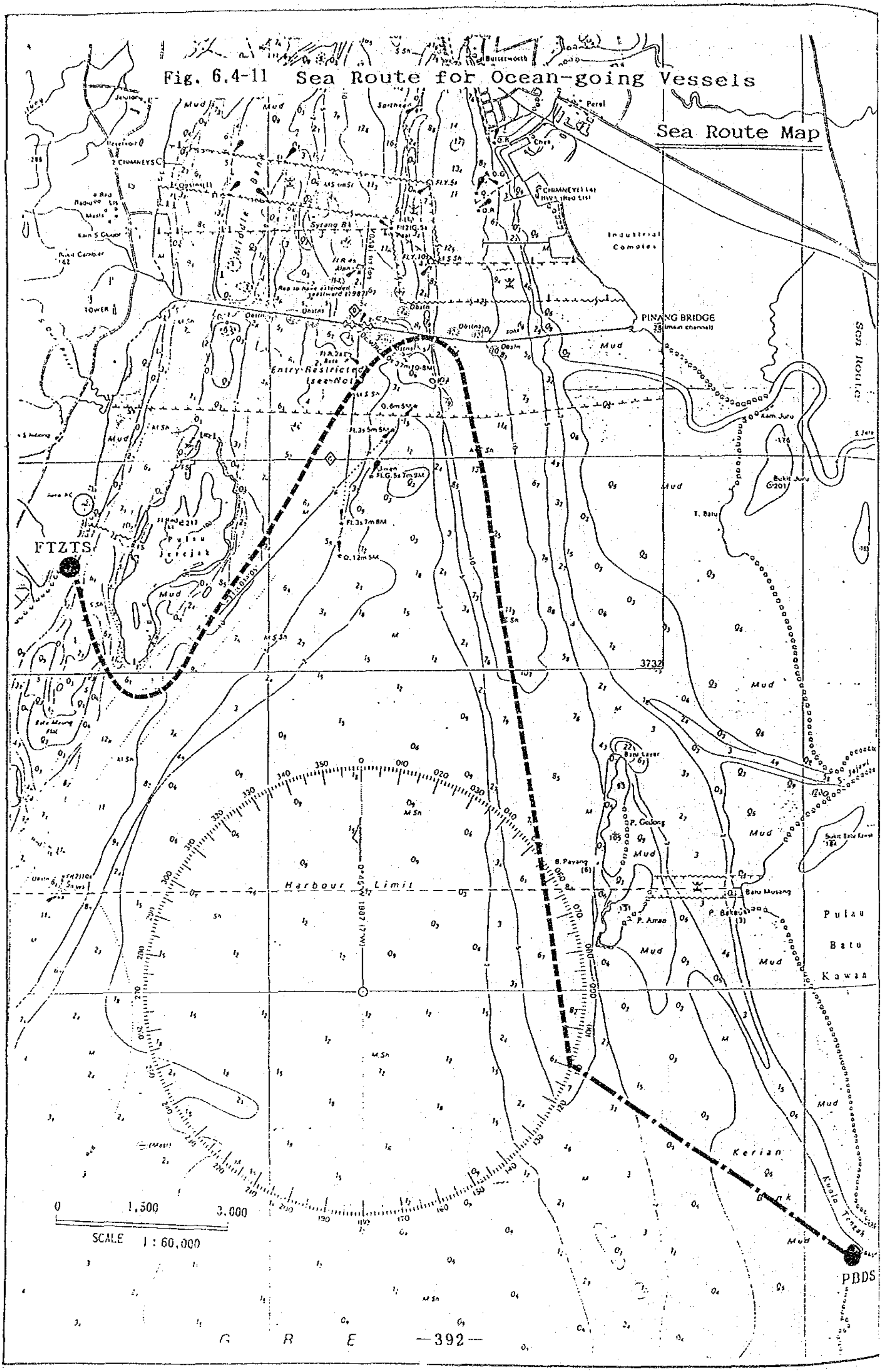


Fig. 6.4-11 Sea Route for Ocean-going Vessels



iii. Required numbers of barges and pusher boats

According to the operation plan shown in Fig. 6.4-10, the required numbers of barges and pusher boats including spare boats is as follows;

- Pusher boats   3 units (including spare boats)
- Barges   5 units (including spare barge)

iv. Collection boats for floating wastes

One collection boat for collection of floating wastes is considered for the protection of the surrounding sea from littering of blown wastes.

f. Transportation plan to disposal site

- At the unloading facility, wastes hauled by barges are transfered into open tipper trucks.
- Numbers of open tippers required are calculated based on the following items.
  - Unloading time
  - Wastes amount
  - Capacity of open tipper
  - Cycle time of round trip from unloading facility to disposal site
- Numbers of open tippers are 22 units including spares.

g. Operation and maintenance plan

The consideration for the operation and maintenance plan at this stage is described below.

① Operation plan
Basically, usual practice is 6 days/week and 7 hours/day. However, even on Sunday 20% of wastes amount of usual days is coming to the FTZTS and the FTZTS has no storage facilities. Therefore, 7 days/week and 7 hours/day is to be practiced.

② Personnel requirements
Personnel required for the operation of each facilities is considered.

③ Utility
Utility consumption for the operation of each facilities is considered.

h. Calculation of bill of quantity

Based on the design of landfill, operation and maintenace plan, bill of quantity of each site for each alternative is calculated.

i. Cost estimation

After the calculation of bill of quantity, cost estimation is done based on construction price data collected.

(3) Outline of Transfer Station for Ocean-going Vessels

Based on the preliminary design, the outline of each facilities is summarized and tabulated in Table 6.4-9.

Table 6.4-9 Outline of Transfer Station for Ocean-going Vessels (1/2)

ITEMS	Unit	Quantity	REMARKS
1. Facilities			
1.1. Loading Facilities			
Dock	No.	2	1650m2
Platform	m2	1000	
Jetty	m	200	6 m Wide
Site Office	LS	1	200m2
Others	LS	1	Weighbridge,Car Wash, and Electrical Facilities,etc.
1.2. Unloading Facilities			
Dredging of Sea Route	m	4700	
Temporary Works	LS	1	Sheet Pile
Dock (Foundation)	No.	1	Reinforced Concrete with Pile
Crane Stand	No.	1	Steel Works
Travelling Crane	No.	6	
Others	LS	1	Hopper & Erectrical Facilities,etc.
2. Transport Equipment			
2.1 Boats			
Pusher Boat	No.	3	2000PS
Barge	No.	5	2000m3
Waste Collection Boat	No.	2	
2.2 Tertiary Transport Equipment	No.	22	Open Tipper Truck (15m3)

Outline of Transfer Station for Ocean-going Vessels (2/2)

Classifications	Unit	Loading Facility	Unloading Facility	Transportation Ocean-going Vesseles	Transportation to Disposal Site	REMARKS
B. Operation & Maintenance						
1. Personnel						
Manager (High Class Sailor)	No.	1	1	6		
Technician	No.	3	4			
Overseer (Sailor)	No.	6	7	12		
Driver (Operator)	No.	12	8		24	
Laborer	No.	21	20	22		
		43	40	40	24	
2. Utility						
Water	1000m3	Nil	Nil	Nil	Nil	
Electlicity	MWH	67	790			
Fuel	1000 l	Nil		3714	535	
3. Maintenance						
Others	LS	1				Weighbridge, Car Wash, and Erectrical Facilities, etc.
Travelling Crane	No.		6			
Others	LS		1			Hopper & Erectrical Facilities, etc.
Pusher Boat	No.			3		2000 PS
Barge	No.			5		2000 m3
Waste Collection Boat	No.			2		
Open Tipper Truck	No.				22	15 m3

6.5 Intermediate Treatment

6.5.1 Characteristics of Intermediate Treatment Systems

(1) Composting

Combined with recycling facility, composting system has been considered as one of the cost-effetive alternative for the refuse disposal. The followings are description of various methods of composting, and also gives advantages and disadvantages.

a. Classification and description of typical compost plants

Composting plants have been divided into four general types: a. high-rate continuous flow, b. batch area or bin type, c. batch windrow type, and d. modified landfill employing in-place composting.

i. High-rate continuous flow

High rate composting system consists of various equipment, devices, etc.(with a unit operation) in order to perform the function of composting treatment, regardless of its method or size. This system has functions of feeding principally sorted and collected solid wastes, shredding, sorting and adjusting wastes in the equipment, fermentation, curing post-treatment then taking out refined compost and residue continuously and smoothly according to fed wastes.
Composting operation must be kept at a constant condition so that oxygen amount, temperature, moisture, and C/N ratio, etc. can be easily controlled and secondary pollution especially offensive odor can be prevented securely. Composting system consists of the following equipment:

Waste receiving/feeding equipment is composed of the measuring equipment to measure the weigtht of fed solid waste, carrying in/out passage through which waste collecting vehicle goes in and out platform and preparation stand, platform on which waste collecting vehicle feeds wastes into waste pit or receiving hopper, feeding stand, waste pit which stores wastes temporarily, receiving hopper, and waste crane which transfers wastes from pit to hopper.

Wastes fed into this equipment most have been sorted and collected as a principle. Pre-treatment equipment for composting consists of bag breaking machine, shredding machine, screen, sorting machine, adjusting machine, etc. Thus treated wastes enter fermentation equipment in which fermentation control is done properly, and they are sent to curing equipment for complete fermentation. Then they go through sorting equipment for fine sorting and another sorting equipment for removing impurities, and if necessary, they are dried granulated, compressed, packed and carried out.
Offensive odor generated from these treating facilities is deodored by an appropriate method which has been environmentally assessed. Water supply and drainage equipment supplies water from water supply source to each equipment, supplies water to buildings, and discharges water contained in wastes into drainage equipment. Waste water treatment equipment treats effluent discharged from treatment facilities, and is generally composed of various treatment devices according to individual planning condition.

ii. Batch area or bin type

A batch process has the inefficiency lag periods wherein large populations of the light bacteria must be developed. Although stirring is employed, there is no intermixing of today's material placed in the digester with that from the day before or the day before that. Each employs some type of aeration and each uses sorted and preshredded material.

iii. Batch windrow process

Numerous plants were constructed throughout the world during this century, in which several types of turners have been designed to turn windrows or compost stacked over a wide area. Probably the best known is the modified Athey gravel loader. This has been successfully used for several years and is capable of cutting through a pile of refuse. Another well tested machine is Gobey Rotor-Shredder which shreds material as it turns it. It consists of 5 meter long, one diameter, rotating steel drum with teeth on it. It is mounted on flotation type tires. This has a high capacity and moves well along the length of a windrow but cannot cut through a pile of material. It is capable of handling most raw refuse and gradually shreds it up.

iv. Modified landfill employing in-place composting

This process has been recommended as the lowest cost composting method yet available today. Essentially the process calls for preshredding of refuse and placing it in a sanitary landfill without cover. Composting may be conducted by the use of forced air blown through pre-laid, low-cost, four inch corrugated polyethylene pipes. Preshredding can be accomplished either centrally or with a rotor shredder on site. The cost of the stabilized refuse is approximately the same as or slightly more than a sanitary landfill, but there are the advantages of; (1) no cover, (2) neglegible water pollution, and (3) approximately one-third of the fill area required due to digestion and greater compaction. The end product can be dug out and sold if a market exists thus making room for more material. The filled area can be reused, making the pile deeper with a second and a third layer possible.

In each system, basically most important are;

- forced air and its control
- temperature control
- turning
- moisture control
- seeding and reseeding

b. Value of organic matter, utilization and marketing

Organic composts used as low-grade fertilizer or soil conditioner have a real benefit to most soils but particularly heavy clays or loose sand where its usage can increase crops by several fold, whether chemical fertilizers are available or not.

Early problems, such as, spread of pathogens, seeds, poor economics, failure of the processing plants and the lack of flexibility should be a thing of the past.

The need for organic matter in the soil can be summarized as follows:

i. Improves physical character:

Organic matter markedly improve the physical character of the soil, making it easier to till. Organic matter supports earth worms which in turn keep the soil porous, thus greatly increasing aeration. During heavy rains these worm holes and porous soil texture increase percolation which reduces surface runoff and erosion.

ii. Increases moisture holding capacity:

The organic matter is very absorptive of moisture and holds it like a sponge. Thus, in periods of drought, a crop planted in fields containing large amounts of organic matter will remain green and grow, whereas crops in soil without organics may wither and die.

iii. Reduces leaching of chemical fertilizer especially nitrogen and phosphorous:

The presence of adequate organic matter reduces the amount of chemical fertilizer required by as much as 40%. This is largely due to the prevention of leaching. With the organic matter present, the water does not wash the chemical fertilizer out of the soil as it does in barren soils. Nitrogen added as a fertilizer is in a soluble state and can be readily leached away from a barren soil, however, in the presence of organic matter and biological activity, large portion of this soluble nitrogen is converted into organic nitrogen as micro-organism bodies. As these micro-organisms die, the nitrogen again becomes available to the plant roots. In the interim period, it is neither lost by leaching nor by loss to the atmosphere, in the form of ammonia. The same phenomenon occurs with phosphorous. About 95% of the soluble phosphorous can, as shown by actual test, be converted into organic bodies and living protoplasm, and released slowly to the plant rather than being lost by leaching.

iv. Healthy biological activity stimulates root growth:

Experiments by soil scientists indicate that the presence of organic matter is a prerequisite to a healthy biological activity of the soil, and the presence of a healthy biological activity in the soil is very stimulating to root growth. Roots have been shown to grew several times as fast where organic matter is, high as compared with ordinary barren soil.

c. Advantages and Disadvantages

Composting system has several advantages and disadvantages.

-Advantages are as follows:

i. As aforementioned, compost product by waste are used as organic fertilizer and soil conditioner.

ii. A certain quantity of usable material can be recovered at the pre-treatment stage.

iii. A certain quantity of reduced waste volume at landfill is expected.

-Disadvantages are as follows:

i. The recovery rate of compost product will be 35% maximum of total waste weight. Rejected materials have to haul to the landfill site again.

ii. Reduction of waste volume can be expected considerably compared with incineration or pirolysis system.

iii. Quality of waste suitable for composting is very limited. Therefore in order to collect the above material for compost, modifications of existing systems for collecting and hauling way be required.

iv. Efficency of compost system is not enough, therefore :

- it takes long times for fermentation.

- wide stock yard for fermentation and storaging the compost product will be required.

v. Bulk density of compost product is very limited, therefore compared with chemical fertilizer, this compost have the following inconveniencss:

- high cost for transportation.

- difficult for spredding to plantation.

vi. Generation of offensive odor have to be avoided.

(2) Refuse Derived Fuel (RDF) System.

a. Present Situation on RDF System

The production of refuse derived fuel can be done in several ways. In some of the earlier systems raw refuse was first shredded to a nominal particle size of about 4 inches. More recent systems employ a rotary trommel before shredding. This trommel allows for prior separation of heavy, larger materials. After shredding ferrous metals are separated magnetically for recycling. The remainder is then separated into a lighter, mostly combustible fraction and a heavier, mostly non-combustible fraction using an air classifier. The lighter fraction is then further processed to produce the RDF through secondary shredding and screening. The RDF that is produced can be burned as a coal or can be burned as a primary fuel in a specially designed boiler.
Today, RDF systems are mainly adopted in the United States and Canada. But the extensive use of this technology elsewhere in the world are not recommendable.

The Paper presented at the 5th Japan-United States Governmental Conference on S.W.M.(1982), describes as follows :

Many RDF systems are new and in the shakedown stage. There are only 4 fully operational RDF systems in the U.S.A and Canada.
Three more are in shakedown operation and 10 addtional are under development. Of significance are 5 facilities that were expected to come on line in the past two years but have been closed due to technical or financial difficulties. This demonstrates the developmental nature of this technology.
While many of these systems will attempt to also recover glass, non-ferrous metals and other products from the non-combustible fraction, the technology for doing this economically is still unproven.

b. Advantages and Disadvantages

-Advantages are:

i. Combustibles in municipal waste can be converted to substitute fuel which is able to store and easy to handle.

-Disadvantages are:

i. Waste which can be converted to RDF is very limited, and their availability can be founded only in waste with much paper content.

ii. The market of RDF product will be limited by the reason of necessity of special burner which is able to burn hard solid fuel such as coal.

iii. Technical difficulties are still remained, such as causing explosions in crusher, cloggings in storaging silo, etc., have to be solved.

(3) Pyrolysis

a. Situation of Pyrolysis System

Recently, considerable attention has been given to pyrolysis in providing means of recycling municipal solid wastes. Pyrolysis is a process for breaking down organic substances by applying heat, in the range of 700 - 1,200 C, in the absence of oxygen or at oxygen levels insufficient for total combustion. Under these temperature and pressure conditions, organic materials break down to shorter chain organic compounds and in some cases are reduced to charcoal, a carbon residue. Various modifications of the basic process are under development by different companies. A variety of potentially useful products may be produced, depending on refuse composition and operating conditions. Master products are charcoal, tar and pitch, light oil, organic acids, ammonium sulfate and combustable gases. Theoretically, pyrolytic operations lend themselves well to a total recycling approach. Prior to the actual pyrolysis step, waste materials must go through a number of preparatory operations. Generally solid wastes are first shredded, glass and metals are separated and these materials are soled where an available market exists. Unusable residue, reduced to a small percentage of the original total, is left for ultimate disposal at a sanitary landfill.

b. Advantages and Disadvantages

Inherent in any pyrolytic processing operations are certain advantages and disadvantages. Among the advantages are:

i. Reduced land requirements.

ii. Reduction of solid wastes to a minimum volume.

iii. Little air or water pollution-
Since little or no oxygen is involved combustion products are not a factor.

iv. Recycling of solid wastes into potentially useful products-

Considering the effective energy saving, production of such items as fuel oils, gas and steam are desirable and needed.

-Basic disadvantages are:

i. Large capital investment and high operation cost.

ii. The nature of oil or gas obtained from the facility is still in the level of insufficient for commercial use, therefore the market is limited to in-plant use only. For purifying the oil or gas, high cost have to be consumed, therefore it is not effective their cost.

Notes;

1)

In Japan, first commercial pyrolysis gasification plant which has 450tons/day throughput had commenced in operation in 1983.
However due to several accidents caused during its operation, many revisions or improvement work were made to this plant.
The plant is still in operation, however, it is said that large scale basical improvement plan is now under way by the unfavorable reasons, such as the lack of energy recovery benefit, complexity, high waste treatment cost, etc.

2)

The present situation on the pyrolysis technology in the Unitrd States is shown in the Paper presented at the Japan-USA Govermental SWM Conference (1982).

It is said:

"Pyrolysis of municipal waste to produce a marketable oil or gas product has not proven feasible. The pilot plants that were beeing developed for that purpose have been closed."

(4) Slagging Pyrolysis

a. General

The slagging pyrolysis is a new refuse conversion process characterized as high temperature slagging pyrolysis. Pyrolysis, commonly referred to as destructive distillation, is an irreversible chemical change brought about by the action of heat in an oxygen-deficient atmosphere. Pyrolysis of the organic materials in refuse causes the volatile fraction to distill, forming combustible liquids and vapors. The vapors are composed primarily of methane, hydrogen, carbon monoxide, carbon dioxide, water and the more complex hydrocarbons and such as ethane, propane, oils and tars. The exact components and percent composition of the gases formed by pyrolysis of municipal refuse cannot be predicted, in that in a real system, the complex, multi-component fraction would be converted to more stable gases such as ethylene, etc., through a continuing pyrolysis action, and are a result of complex time/temperature kinetic reactions. The material remaining after pyrolysis is char, a charcoal-like substance consisting primarily of fixed carbon residue.
In these System, the char is combusted in the gasifier using preheated air, thereby generating the temperatures required for pyrolysis and for melting of the inert materials contained in refuse.

b. Pyrolysis and Combustion Processes

The principal components of the system are the gasifier, secondary combustion chamber, primary air preheating regenerative towers, energy recovery/conversion systems, and the gas cleaning system. The pyrolysis and combustion parts of the system are shown in Figure 9.4-1. The refuse is charged as received from the refuse pit, without prior preparation other than shearing bulky items to approximately one meter dimensions, into the gasifier. The gasifier is a vertical shaft furnace designed so that the descending refuse burden and the ascending high temperature gases become an effective counter-current heat exchanger. The uppermost portion of the descending refuse serves as a refuse plug to minimize the infiltration of ambient air. As the refuse descends, three distinct process changes occur. The first is the drying where the moisture is driven off; the second is the pyrolyzing due to the heat transfer from the ascending, hot gases to the refuse; and the third is combustion in the hearth where the carbonaceous char is oxidized to carbon monoxide and carbon dioxide, and melting of the inert fraction of the refuse.

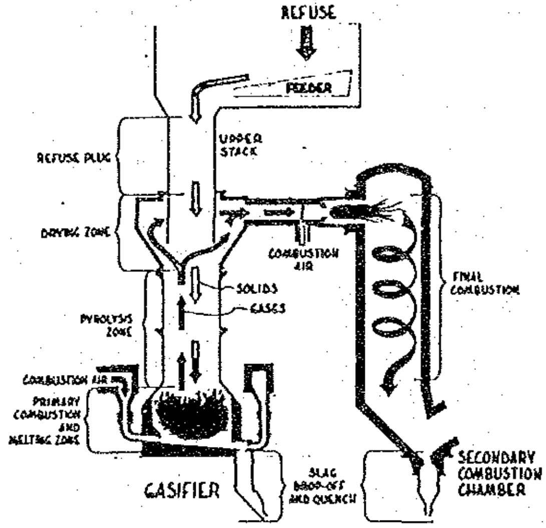


Fig. 6.5-1
Gasifier and Secondary Combustion Chamber
(Andco-Torrax system)

The heat for pyrolyzing and drying the refuse and for melting the inert fraction is produced by the combustion of the carbon char with 1000 C preheated air supplied to the hearth zone of the gasifier. The heat thus generated melts the inerts to form a molten slag, which is drained continuously through a sealed slag tap into a water quench tank to produce a black, sterile, granulated residue. The quench tank is periodically purged into the system slag pit from where the granulated material is transported to suitable storage.

The volatile products of pyrolysis and products of primary combustion exit from the gasifier via an offtake plenum, called a lantern, and are drawn into the secondary combustion chamber by the system's induced draft fan. At the entrance to the secondary combustion chamber, these gases are mixed with a near-stoichiometric quantity of ambient air in a high energy burner.

The secondary combustion chamber is a vertical, refractory-lined vessel in which temperatures to 1400 C are realized, and where sufficient residence time to assure complete burning is maintained. The majority of the particulate matter entrained in the offgas from the gasifier is burned, or slagged-out into another slag quench tank. The resulting slag residue is sluiced into the system slag pit. The now completely combusted and partially cleaned gaseous mixture exits from the secondary combustion chamber at 1150 - 1250 C.

c. Air Preheating, Energy Recovery and Gas Cleaning

There are a number of possible methods for the preheating of primary combustion air and for the recovery and utilization of energy from the hot combustion products which issue from the secondary combustion chamber. An example of equipment system is shown as Figure 9.4-2.

Referring to Figure 9.4-2, approximately 15% of the hot waste gas from the secondary combustion chamber is directed through the regenerative towers where its sensible heat is recovered and used for preheating the process air supplied to the gasifier hearth.
These regenerative towers, successfully used for many years in the steel industry, are two refractory lined vessels containing a high heat capacity refractory checkerwork material. Hot products of combustion from the secondary combustion chamber and ambient process air are passed through the towers on a cyclical basis for preheating the hot blast.

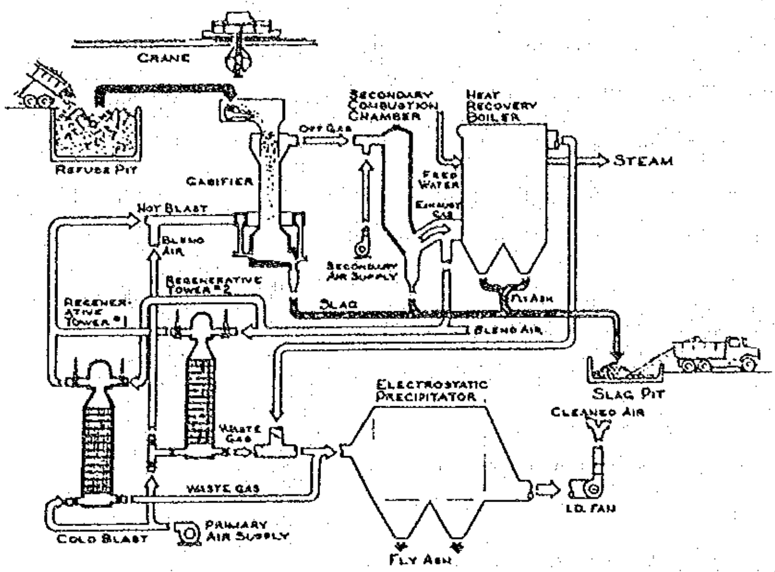


Fig. 6.5-2
Refuse Conversion System Diagram

The larger, approximately 85%, portion of the secondary combustion chamber exiting flow is supplied to the energy recovery system, a waste heat boiler. Typically, the waste heat boiler is of the combination radiation /convection type. These characteristics are high temperature inlet gases, from 1150 C to 1250 C, constant temperature input, homogeniety of inlet gases and absence of unburned material, low volumetric gas flow and low particulate loading.

At the exit of the waste heat boiler, the cooled waste gases from the regenerative towers are combined with the exiting flow from the waste heat boiler and are ducted to the gas cleaning system.
The gas cleaning system is a hot gas electrostatic precipitator of conventional design.

d. Situation on Technology

Since 1975 up to 1983, more than 10 of commercial plants of slagging pyrolysis have been built and were operating in Europa, Japan and USA. These plants have been built based on the know-hows for 4 years operation results obtained from the demonstration plant developed in USA.
However, some plants among these in Europa have already been closed by the reasons of technical and economical problems that the plant consumes large amount of aditional fuel for melting inert material contained in wastes, and has many difficulties to keep the continuous operation through the

year, etc.

In case of Japan, four commercial plants have been built by different three manufactures and still are operating, however other new project, similar to the above type of slagging pyrolysis plant are not proceeding after that. The major reasons are the high construction cost, large consumption of additionalfuel/energy and dificulty of operation,etc.

e. Advantages and Disadvantages

-Advantages are:

i. Waste volume reduetion in this system is 95 to 97%, therefore this system has the best reduction effect comparing with any other treatment systems.

ii. The fritted, glassy aggregate obtained form this plant is completely sterile, therefore the problems of leachate from the landfill site is not considered.
Further efforts to develop a usefull end-use are being followed as to concrete aggregate, building blocks, road way base and filter base.

iii. The production of energy in the form of steam and / or electrical power is available.

-Disadvantages are:

i. Large capital investment cost.

ii. High operation cost. Inert materials contained in wastes have to be melted into molton slag, therefore a large amount of additional fuel is required which causes high operation costs.

iii. Difficulty of operation. It is rather difficult to keep stabilized and continuous operation. In this system, skillful operators are required.

(5) Incineration

Incineration of municipal solid wastes is being practiced by many municipalities across Japan. For those installations currently in existence, a general observation would indicate that incinerators may be feasible where land available for landfilling is scarce, expensive or very remote from the actual solid waste generation center.

a. Types of modern incinerators

A modern incinerator consists of a number of basic components. Typical of these will include an unloading area, a refuse feed device, burning grate area, combustion chamber, an air supply system, a residue quench and disposal system and flue-gas scrubber and water treatment systems and a stack. Selection and design of these basic components will be the deciding factor in differentiating one incinerator from another. Performance of an incinerator will also be very closely controlled by these component parts.

Major differences in typical modern incinerators are noted in both refuse feed systems and grate designs. Feeding of refuse may be accomplished by either batch or continuous mode. Batch feed is accomplished by a crane or similar device with a given quantity of refuse deposited to be burned at designated time intervals. Batch feed of refuse has experienced a declining use rate in recent years in favor of continuous feed methods.

Continuous feed, as the name implies relays refuse to the incinerator in a constant stream. In most cases, continuous feed is accomplished by a hopper and refractory lined or water cooled gravity chute. The refuse in the chute acts as an air seal and prevents sudden influxes of air which may cool the combustion process, thus resulting in less efficient combustion with higher rates of emission.

Various grate designs are in use for refuse burning. Each of these designs functions to perform a number of tasks. A grate is designed to satisfy the following objectives: provide support for the refuse; distribute underfire air through grate openings; transport the refuse from feed chute to ash quench; agitate the bed to break up clumps; and redistribute the burning mass.

A major new development in refuse burning involves the application of fluidized-bed technology. Fluidized-bed incineration has been employed to some extent. High heat transfer and reaction rates achieved in such a unit have demonstrated favorable characteristics for the incineration of refuse with good burnout of residue.

A typical fluidized-bed reactor consists of a bed of small solid particles through which a gas is passed vertically upward. With sufficient upward gas velocities, the solid particles begin to move in more-or-less random motion and expand the bed vertically.
As such, the entire bed acts as a fluid mass much like a boiling liquid. Typical beds used for incineration of refuse have been sand with air being supplied at the bottom of the unit. The fluidized sand bed acts as an accumulator for heat produced in combustion. Refuse is generally shredded and then fed to the bed where it is quickly brought to ignition temperature and combustion is both rapid and complete. Heat generated is rapidly transferred to the sand particles which are in a fluid state. Construction cost and power consumption of this type incinerator are generally higher than other conventional types.

b. Residue disposal

After combustion, there still will remain some residue, consisting of small fractions of both combustible and non-combustible items. Typically residue from incineration includes ash, clinkers, tin cans, glass, ceramic and little amount of unburned organic matter.

Residue disposal is most generally accomplished by landfilling. When deposited at the landfill, care should be taken in the same manner as raw wastes, to see that leachate production is minimized. Although, generally of a more inert nature than raw refuse, residue still contains soluble constituents which may result in both organic and inorganic leachate.

c. Heat utilization

The waste heat utilization of municipal refuse incineration plants has a long history for twenty years in Japan. The steam is supplied by the bleeding of turbine steam, and another type is to use the boiler main steam, or the exhaust steam from backpressure turbine.
The steam pressure and temperature of waste heat boiler is usually selected about 20 to 23 kg/cm^{2}g (saturated or superheated steam) by the reason for preventing corrosive gas and dust, and the pressure of turbine exit was more than 1 kg/cm^{2}g, but the condensing type has been gradually used for getting the higher thermal recovery efficiency.
Surplus steam is used for outside heat utilization such as, district heating and cooling, air conditioning, hot water supply for residences, direct steam supply to industries, etc.
By the Ministry of Health and Welfare Japan, the status of waste heat utilization in municipal refuse incineration plants was investigated. Among 780 municipalities investigated, 164 municipalities had used the waste heat, and as uses of the waste heat, 81.7% of the facilities were applied to room air-conditioning, hot water supply, followed by welfare facility for dwellings, and power generations. And in 1986, number of power generation facility is counted to about 73 including under-construction, those which have recently smaller capacity of 300 t/d or less, compared to the older ones having a larger capacity of more than 300 t/d, and the generated power is not only consumed in the plant, but also to sell it to an electric power company is increasing aiming the positive power generation.

d. Construction, Maintenance and Operating Costs

A major factor contributing to the disfavor of incineration as an economical disposal solution is the high capital requirement. Total capital requirement per ton will generally decrease with increasing capacity, however unit values are typically higher than other disposal alternatives, especially sanitary landfilling.
Therefore, detailed cost evaluation have to be made on the construction cost, annual running and maintenance cost, versus expected income which is obtained from electricity or heat supply.

e. Advantages and Disadvantages

- Basic advantages are:

i. The system has wide range of availability. Almost all kind of waste except bulky inert materials can be treated.

ii. High reduction in bulk volume and weight in lower transportation costs and landfill requirements.

iii. Heat can be recovered by incineration. Turbine driving system for auxiliary equipment in the plant has an advantage to reduce operation cost.

iv. Revinue will be expected from the sale of surplus electricity by means of power generation in the plant (in case of higher heating value of waste).

- Disadvantages of incineration include:

i. Sizable fixed costs and high operation and maintenance costs.

ii. The total disposal problem is still remained. A portion of the incinerated wastes(15% by weight is ash) must be landfilled elsewhere

iii. Increasedair pollution control requirements call for substantial additional capital outlays.

(6) Crushing or Shredding

a. Characteristics of Crushing or shredding process.

Shredding halves the volume of waste carried into the final disposal site. The shredded waste, as compared with the non-shredded one, will be settled more quickly when used for a sanitary landfill.
It is said that the sanitary landfill land composed of the shredded waste will increase in price, since the land is suitable for a variety of uses. The land users near the sanitary landfill make little complaint about the landfill, because the landfill work progresses sanitarily. In addition, fewer fires will break out during the landfill work. Fewer rodent and insect hatch, so that less insecticide and raticide are needed.
The shredded waste causes less damage to the rolling machines and trucks for the sanitary landfill work than the non-shredded waste. The shredded waste has a less subsidence than non-shredded one because of its high settlement.
The term "crush" is used in various meanings, i.e., shredding, milling, pulverizing, grinding, cutting, tearing, ripping, etc., for which appropriate machines are developed, respectively.
For example, an ordinary hammer mill where a swing hammer attached to the horizontal or vertical shaft rotates very fast, waste is dumped from above, and discharged from the opening at the bottom after pulverized by shear force of the cutting board.
The grindability depends upon the substances to be crushed, and the size required for the purpose of each treatment system.
The pulverizing process will be combined with sieving if necessary. The crusher is classified into various types, which are outlined in Table.9.6-1

b. Advantages and Disadvantages

- Several advantages can be described as follows:

i. Shredding is well adapted to the local conditions and intended plans because (1) shredding reduces volume by about 50 percent thus making transportation by truck easier and more efficient;

(2) shredded material spreads more easily, compacts better in the sanitary landfill and thus takes up less space making the landfill area last longer.

ii. Shredding makes for more compact and ultimately more stable sanitary landfill and hence, the ultimate value of land after filling would be great.

iii. Since shredding compacts the materials more, it is less apt to burn and there have been fewer experiences of fire on such operations praticularly if solid fills is used for final cover. Any problems of flies and rodents would be greatly minimized if not entirely or satisfactorily eliminated by using insecticides and the poisoning for satisfactory control.

iv. Shredding definitely increases compaction thus making landfills denser and reduces the percentage of settlement.

v. Shredding also virtually eliminates salvage on the landfill site since materials is finely ground and all intermixed thus leaving nothing to be salvaged.

Shredding has some disadvantages as follows:

i. In case of rotary type hammer crusher, usually high power electric motor is required, therefore a large quantity of electricity is consumed to destroy the bulky waste.

ii. Damages due to explosion caused by inflamable matter contained in waste, might occur frequently. Therefore strict checking and sorting out of dangerous matter have to be done.

iii. According to tremendus wear of mechanical parts such as hammer beaters, shear blades, etc., frequent maintenance work, repairing or replacement of damaged parts shall be necessary.

Table.6.5-1 Classification and Application of various type of Crusher

Symbol	Crusher type	Crushing capacity & characteristic	Application	Non-application
1	Impact crusher	A machine which has a powerful impact destructive power through crushing action by high speed rotor stroke blade and collision board in crushing room. Inferior in shear capacity.	Combustible bulky waste, metal, glass, rubbish, ordinary waste.	Ductile plastics, cloth, foaming plastics, rubber
2	Hammer shredder Vertical type & horizontal type	A machine which destroys waste by impact of rotor swing hammer, and shear between anvil and grade bar of the main body. Application range is wider than 1). Superior in crushing capacity, but inferior in heavy hammer wear, noise, and vibration.	Applicable for wide range of waste, bulky industrial waste, as well as ordinary waste.	Ductile plastics and things which twine.
3	Plane cutter crusher	A machine which performs crushing by shear between rotary blade and main body. Superior in shear strength, but inferior in impact. Suitable for crushing of waste inapplicable for 1) and 2). Rotary blade wears heavily for metal, etc. Suitable for a single item treatment.	Plastics, can, bottle, wood, paper, animal-bone, fish-bone, fish-intestines, rubber, tire, ordinary waste.	Concrete, metal
4	Reciprocating cutter crusher	A machine which compresses and shears waste by reciprocating a V-shape hydraulically-operated reciprocating blades composed of several comb-like fixed blades and reciplocating blades which are facing to each other with their bottom edges as axes. Less trouble, noise, and dust because of simple structure. Limited application for hard materials in addition to relatively rough crushing size.	Applicable for bulky waste as well as wide range of waste. Ordinary waste is also acceptable.	Hard metal, concrete, things long and narrow.

Symbol	Crusher type	Crushing capacity & characteristic	Application	Non-application
5	Squeezer	A machine which compresses and crushes waste by using upper and lower caterpillars which rotate at the same speed and in the same direction. Not provide any impact and shear.	Concrete, insulator, plastic, and furniture capable of being compressed and crushed.	Metal products and rigid materials
6	Compressed shear crusher	A machine which compresses, shears, and crushes by using wing pusher, stamper, vertical blades (some of them are horizontal blades) which are put into a set of actions hydraulically. All waste are acceptable. Less noise, dust, and vibration. Crushing size is limited. Some are improved in this limitation, and have the function of 4.	Applicable for bulky waste such as wooden furniture, mattress, rubber-tire,etc.	Hard metal, concrete, etc

(7) Sorting

An important point to be considered in both the treatment and disposal is that a system for recovery of the resource such as paper, glass, metal, plastics, etc., must be provided in the early stage of planning. The most desirable method is a system which allows the waste features to be utilized to the fullest at the lowest cost, and not causing any secondary environmental pollution.
The essentials of the resource recovery system are the salvage with or without shredding. Generally, a waste truck, weighed at the entrance of a plant, dumps the waste into the hopper. The dumped waste is then carried to a salvage yard on the salvage conveyor. The valuables are sorted there by machinery or by hand. Magnetic materials are sorted out by a magnetic separator installed behind the salvage conveyor, and carried to the crusher, as required.

a. Type of salvage process

The major purposes of the salvage are to recover the valuables. For metal, non-ferrous metal, paper, cardboard, glass, plastics, rag, leather, etc., to be recovered as valuables, used is mainly a dry classifier which uses wind power, magnetic saparator, vibration, and human power in accordance with each characteristic of the valuables. Dry classifying is usually performed in air. In addition to this method, available are the wet classification by means of liquid and the semi-wet classification by means of less liquid.
Both the dry classifier and the wet classification have a wide range of application in accordance with their characteristics.

i. Wind power sorting (Pneumatic Sorting);
Since the separation efficiency of the wind power salvage varies with the waste size, moisture content, size, surface condition, weight, etc., pre-shredding, drying, and sieving shall be prepared if necessary.

ii. Vibration sieving (Vibrating Screen);

This method uses the upstream air passing through a slanting porous board. Sieving is generally performed in three stages, i.e., upper, middle, lower. Some sieving systems are provided with baffle boards at appropriate places for increase in the sieving efficiency.

iii. Magnetic salvage;

In this method, magnetic materials mingled with the waste or shredded waste are attracted for salvage by the magnetic separator which is placed over the belt or at the head of the conveyor.

iv. Aluminium sorting;

This machine sorts out non-ferrous metal such as aluminium from the wastes. There are various types such as electrostatic method, heavy-media separation by specific gravity difference, magnetic fluid separation and induction eddy current method.
Among these methods, the induction eddy current method adopts the following principle: When the nonferrous metal (conductor) is moved relatively in the ununiform magnetic field, eddy current is produced. Interaction of this current and the magnetic field produces electro-magnetic force.

v. Optical Sorting;

This method is being uses experimentally. In this method, glass is shredded in accordance with the color, and with a difference in the transmittancy converted to the resiliency, the shredded glass pieces are scattered so as to classify them according to their hop distance.

vi. Human power (Manual Sorting);

No matter how much the classification and salvage by means of ,achinerry may develop, human power will remain essential. There is a system where several persons, standing by the salvage conveyor, pick up their specified valuables or admixtures to throw them into the recovery boxes arranged near the conveyor, or apply them, if necessary, to the compressor to make them transportable.
The problem of the human power salvage is the industrial hygiene. The insects and offensive odor accompanying the transported waste are extremely bad for the health of the persons engaged in the salvage. Thus, efforts must be made to improve the working environment with an investment aggressively made in deodorization.

b. Adavantages and Disadvantages

-Advantages of sorting systems are:

i. With the adoption of sorting devices such as pneumatic, mechanical, magnetic, etc., sorting out operation is executed effectively under hygenic environmental condition.

ii. Many sorting systems are relatively simple and easy to operate. Furthermore, technically those devices are stable.

iii. Investment cost, utility cost and maintenance cost are usually cheaper than other systems.

-Disadvantages are:

i. The suitable wastes to sort in this system are generally limited such waste that are relatively dry and with rich inert material content. Therefore not so much contribution will be expected for waste volume reduction.

ii. Rejected objects which is remained after sorting of usable materials have to be haul to landfill site again.

iii. Generally, quality or purity of materials which are obtained by mechanical separation device is insufficient, compared with manual sorting.

For example, light fraction such as plastic films and papers are recovered as a mixture by pneumatic divice but can not separate each fraction completely because the specific gravity of both materials are almost same specific weight, thus selling market price will be reduced.

6.5.2 Selection of System Components

At present, in Penang state solid waste is disposed of at disposal sites without any kind of intermediate treatment. In view of increasing difficulties in acquiring disposal sites and environmental protection, it is necessary to examine the possibility of gradual introduction of appropriate intermediate treatment systems.

There are many types of intermediate treatment systems. In order to select appropriate systems for Master Plan Alternatives, screening work is carried out in this section.

(1) Purpose of Intermediate Treatment

The selection of specific intermediate treatment systems for solid waste management system depends on the following three main purposes to be achieved.

a. Volume reduction of solid waste

In order to extend the life span of disposal site, the volume reduction of solid waste has to be considered.

b. Resource recovery

There are two ways of resource recovery from solid waste. One is the extraction of economically usable materials from solid waste, and the other is the extraction of energy from waste.

c. Protection of environmental pollution

In order to prevent the surrounding environment from being polluted by land fill operation without treatment, proper treatment system has to be considered.

(2) Possible Intermediate Treatment System

In response to the purposes mentioned in 6.5.2 (1), the following intermediate treatment systems are discussed in this Report ;

- Incineration
- Composting
- RDF (Refuse Derived Fuel)
- Pyrolysis Gasification
- Slagging Pyrolysis
- Crushing and Shredding
- Sorting

Each system can be used independently or in combination with others. Each system has advantages and disadvantages.

It is therefore important to select an optimum system or an optimum combination of systems, taking into account of the following points:

- Construction, operation, maintenance and repair cost
- Acceptability of various kinds of wastes
- Volume reduction effects for final disposal
- Marketability and price stability in markets of recovered materials
- Ease in operation
- Reliability and stability of treatment plants
  (Degree of technical development and operation results, etc.)
- Impact on surroundings and its intensity
- Simplicity in design of plants
  (pre-treatment, back-end treatment, etc.)

Table 6.5-2 shows characteristics of possible intermediate treatment systems.

Table. 6.5-2 Characteristics of Possible Intermediate Treatment Systems

Intermediate Treatment Facilities	Recovered Material	Main Purpose of System	Contribution to Landfill			Special Cautions								Remarks
			Volume Reduction	Harmless	Stabilization	Reliability of Technology	Pre-treatment	Back-end treatment	Rejected Substances	Acceptability of Refuse Quality	Initial & Operation Cost	Marketability of Recovered Material or energy	Environmental Impact	
① Composting	Compost	Conversion to Fertilizer	△	△	△	◎	△	△	Glass, Stone, Plastic, Dry Cell	△	△	△	△ (Odor)	·Stability of product market is crucial ·Pre-treatment and Back-end treatment are necessary ·Limited to qualities of waste
② R D F Plant	Solid Fuel	Conversion to Fuel	△	△	△	△	△	△	Incombustible	△	△	×	△ (Noise & dust)	·Marketability of products ·Pre-treatment are back-end treatment are necessary ·Limited to qualities of waste
③ Pyrolysis Gasification	Gas or Oil		○	○	○	△	△	△	Incombustible, Carbon	△	×	×	○	·Incomplete technology ·High initial/running cost ·Pre-treatment are back-end treatment are necessary ·Limited to qualities of waste
④ Slagging Pyrolysis	Gas and Slag	Volume Reduction & Prevention of Water Pollution	◎	◎	○	△	△	○	—	○	× (Additional Fuel Expenses)	△	○	·Large consumption of supplementary fuel ·Difficulties in operation ·Pre-treatment when required only ·Back end treatment not necessary
⑤ Incineration	Heat (Residue) → Ash (cover soil) → Ferrous (Reuse)	Volume Reduction & Energy Conversion	○	○	○	◎	○	○	—	◎	△	△ (Electricity and heat)	○	·High initial/running cost ·Possibility to get revenue ·Need to find users of heat if no buyer for electricity is found ·Pre-treatment and Back-end treatment are not necessary
⑥ Crushing & Shredding	Ferrous etc.	Volume Reduction	△	△	○	○	△ (Extraction of Explosive Objects)	△	Discarded Material	△	△	△	△ (Noise & dust)	·Large consumption of electricity ·High expenses for maintenance ·Possibilities of explosion ·Limited to qualities of waste
⑦ Sorting (Mechanical or Manual)	Ferrous, Glass Paper, Plastic etc.	Recycling	△	△	△	◎	△	△	Discarded Material	△	△	○	○	·Stability of market for salvaged material is important ·Pre-treatment when required only ·Back-end treatment is necessary ·Limited to qualities of waste

Regent
◎ : Excellent
○ : Good
△ : Fair or ( ) to be considered
× : Poor and ( ) shows reason

(3) Relationship between Treatment Systems and Solid Waste Quality

The intermediate Treatment systems should be selected according to qualities of waste. Table 6.5-3 shows the general characteristics of various kinds of solid wastes (percentage of organic materials, water content, inorganic materials and calorific value), and types of wastes most effectively treated by the respective intermediate treatment plants.

Each intermediate treatment facility and its characteristics are described below :

a. Composting

In general, suited for domestic waste, other similar types of waste and some kinds of commercial waste.

b. RDF

Commercial waste especially rich in paper content might be processable.

c. Pyrolysis gasification plant

Limited only to the waste with low moisture content and high calorific value.

d. Slagging pyrolysis

Suited for a wide range of waste including inert materials.

e. Incineration

Suited for a wide variety of waste except for incombustible bulky waste.
Waste from hospital and carcass are low in calorific values, but from a sanitary viewpoint, it is recommended to incinerate them in special furnace.

f. Crushing & shredding

For bulky waste.

Table. 6.5-3 Kinds of Waste and Availability to Intermediate Treatment System

	3-Elements of Waste				①	②	③	④	⑤	⑥	⑦
	Organic Substances B	Moisture Contents W	Inorganic Substances A	Calorific Value of Waste	Composting	R D F	Pyrolysis Gasification	Slagging Pyrolysis	Incineration	Crushing & Shredding	Sorting
Municipal Waste											
· Domestic Waste	Fair	Fair	Less	Middle	○			△	○		
· Commercial Waste (mainly from Offices and Shophouses)	Much	Less	Fair	High		○	○	○	○		○
· Commercial Waste (Mainly from Markets)	Much	Much	Less	Low	○				○		
· Carcasses	Much	Much	Less	Low					○•		
· Other Wastes Grass Cutting Street Waste Beach Cleaning	Much	Much	Less	Middle	○			△	○		
Industrial Waste (Non Toxic)	Fair	Less	Fair	High			△	○	○	△	△
Bulky Waste											
Combustible bulky waste	Much	Less	Less	High			△	○	○	○	△
Incombustible bulky waste	Less	Less	Much	—				△		○	○
Hospital Waste	Much	Much	Less	Low					○		

Remarks
- ○ Suitable
- △ Processable
- ○• Suitable for special purpose

Ranking System for 3-Elements of Waste:
- · Much
- · Fair
- · Less
- · Low

Ranking System for Calorific Values of Waste:
- · High
- · Middle
- · Low

g. Sorting plant (mechanical or manual)

Suited for inert waste.

(4) Preliminary Evaluation

In order to select proper intermediate treatment systems for the alternatives of Master Plan, preliminary evaluation on each treatment system is carried out based on the followings ;

a. It is advisable to select a system which can be adapted to as many types of wastes as possible. From such a point of view, incineration and slagging pyrolysis are picked up.

   But, the slagging pyrolysis lacks technical stability, consumes a lot of energy in operation and does not have many favorable operation records in the past. The system,therefore, should be omitted from this project.

b. As to the pyrolysis gasification, there are only a few results in a pilot scale operation. So, this system still remains to be developed further. The system, therefore, should not be picked up.

c. As to RDF, types of processable waste are very limited. RDF (refuse derived fuel) will not have so much demand as substitute fuel. The system should also be omitted.

d. The difficulties of introducing composting is the marketability of compost (and limitation of processable material). Therefore, a study is required to determine the marketability of compost from solid wastes and to find out a suitable collection system for composting.

e. As to the crushing and shredding for bulky wastes, further study have to be made on its effect on the volume reduction and resource recovery. It is, however, considered that there is no need to introduce this system by the target year (2005) because the generation of bulky waste would not be large enough to necessitate it.

f. According to the waste composition study made in the first field study, the amount of reusable materials in solid waste is not so much. The volume reduction through introduction of sorting system is not expected to be so great. Besides, the prices of reusable materials are not stable. The introduction of a sorting system as an intermediate treatment system in Penang State, therefore, is not recommended.

Based on the results of the evaluation, the following systems are redundant and omitted ;

- RDF plant
- Pyrolysis gasification plant
- Slagging pyrolysis plant
- Crushing
- Sorting plant

While the followings are retained for further study :

- Composting plant
- Incineration plant

6.5.3 Compost Market Study

(1) Purpose of Study

The purpose of organic material restoration into soil is to help the soil condition and to form a well-balanced ecological system. Composting is now being considered from both view points of intermediate treatment of municipal solid waste and reutilization of the organic component of municipal solid waste.

The major aim of a composting project is to convert the major proportion of solid wastes into a marketable product. Thus, marketability and demand for compost are the protruding aspects in determining its viability, concurrently also the purpose of this Study.

The preliminary data gathered from the Penang State Agriculture Department has shown that there has never been any compost from garbage ever produced locally on commercial basis. The various types of organic fertilizers utilized are Bio-5, Kagayakihumus, Srivel, bat droppings, imported peat moss, barnyard manure, etc.

As a guide-line, some of the organic fertilizer identified in Penang State are shown below.

Table 6.5-4 Common Organic Fertilizer

Compost Brandname/ Organic Fertilizer	Price	Source
1. Baja Bio 5	$3.00/kilo	Palm oil waste
2. Kagayakihumus 8 N, 8% P, 8% K, 3% Mg	$2.00/kilo	Unknown
3. Srivel N:3.21, KO:3.62 P:0.96, CG:1.79	$2.00/500g	Unknown
4. Organic Fertilizer	$2.00/pak	Unknown
5. Peat Moss (imported)	$2.50/kilo	Peat Imported
6. Organic Fertilizer	$4.00/kilo	Bat Dropping
7. Compost	$2.00/3kilo	Burnt soil
8. Pelletised Organic Fertilizer	$1.00/pak/ 500g	Sheep's Dropping

Source : Penang State Agriculture Department

Details on the various types of typical crops and its planted areas are attached as references for the study. These data are for the State of Penang.

Table 6.5-5 Cultivated Agricultural Crops (Penang)

Crops	Area (Hectares)	Remarks
Rubber Oil Palm Cocoa	19,186.4 10,936.9 1,781.6	Commercial crop cultivated on large scale plantations.
Durian Rambutan Chempedak Mango	1,629.2 640.5 162.3 162.3	Fruit trees. Mostly planted on non commercial basis and in mixed planting with other crops, except for durian.
Paddy Maize Pineapple Banana	16,222.6 102.2 736.2 616.1	Staple crops which are planted on commercial basis.
Various kinds of vegetables	533.7	Planted on commercial and non commercial basis. Size of farmland varies according to organizations.
Spices	731.2	Planted on commercial basis. Concentration of estates are in Penang Island.

Source : Penang State Agriculture Department

The approximate nutrient contents of organic fertilizer derived from barnyard manure, bonemeal and compost are shown below.

Table 6.5-6 Approximate Nutrient Content of Organic Fertilizers

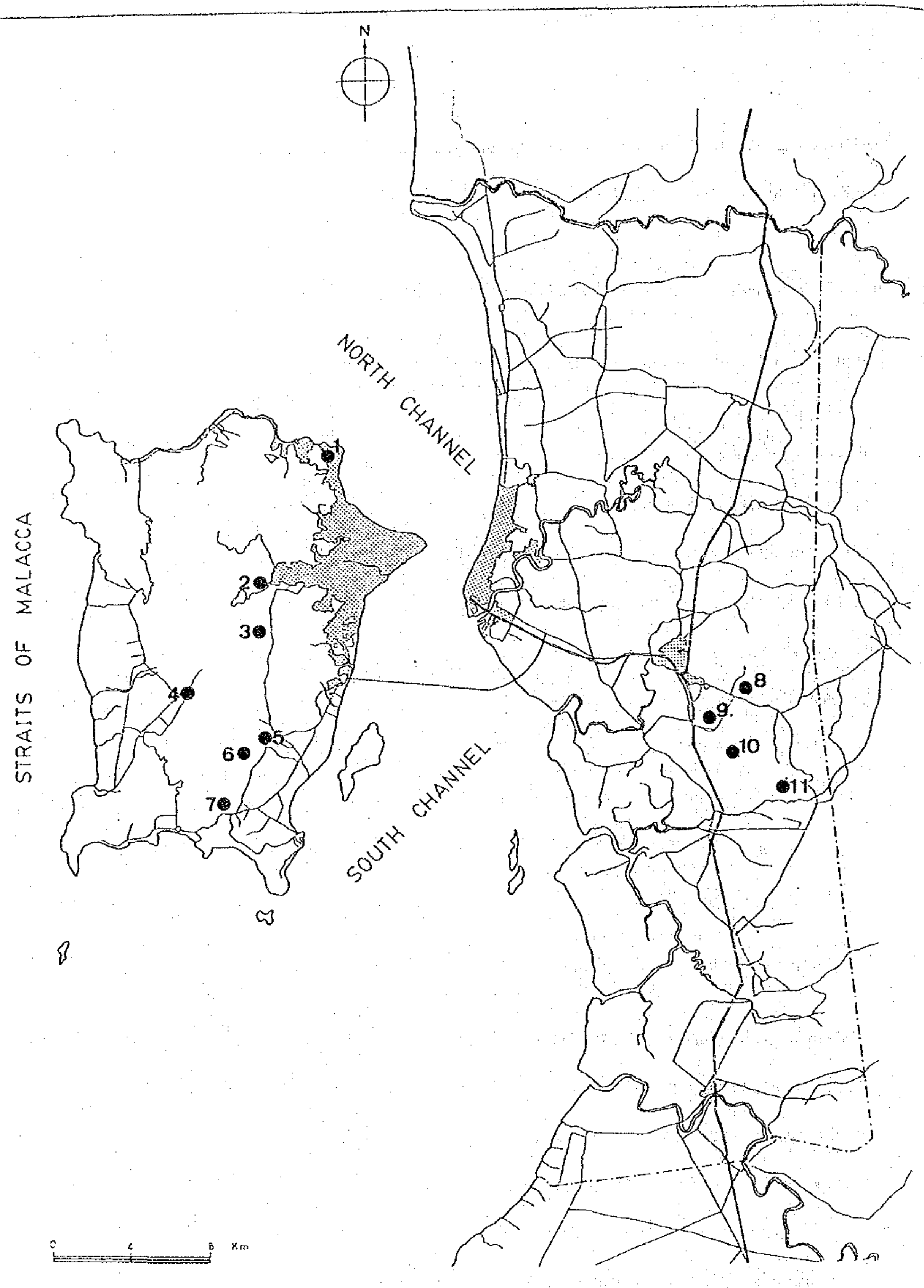
Type/Source	% N	%P205	%K20
1. Cattle dung	1.0	0.4	0.5
2. Poultry dung	2.1	1.6	1.0
3. Poultry (Pelletised)	5.0	3.3	1.5
4. Horse dung	0.7	0.4	0.5
5. Pig dung	1.1	0.7	0.1
6. Bonemeal	3.0	10.9	0.0
7. Blood/Bonemeal	6.0	7.0	0.0
8. Compost from garbage	0.9	1.04	1.06

Source : Items 1-7: Penang State Agriculture Department

Item 8: Bangkok Metropolitan Administration (BMA) compost nutrient components.

(2) Interview Survey on Compost Marketability

To determine the current usage of fertilizers and investigate the possible users of compost, preliminary studies on the possible users were made through consultations with the State Agricultural Department. Apart from the above mentioned information given by the State Agriculture Department, they have also identified the possible users of organic fertilizers are various kinds of vegetable farmers and possibly some fruit orchards. All existing data on possible users of compost, cultivated areas, etc were compiled and target areas for the survey were identified and mapped out as shown in Figure 6.5-3.



LEGEND

1. Tanjung Tokong
2. Air Itam
3. Paya Terubong
4. Balik Pulau
5. Relau
6. Sungai Ara
7. Bayan Lepas
8. Cherok To' Kun
9. Alma
10. Taman Selamat
11. Bukit Teh

Figure 6.5-3
Compost Survey Areas.

Source : JICA Study Team

The interview survey was then executed with the primary objectives of finding the possible compost users set in the questionnaires. Among the questions asked during the interview included types of crops planted, types of organic and chemical fertilizers utilized, distance of farmland from source of fertilizer, area of farmland, means of cultivation of crops and transportation of fertilizer and produce, rate of application of fertilizer and compost, willingness to try compost from municipal waste, etc.

A total of 34 farmers were randomly selected during the interview survey. From this total, 29 interviewees were vegetable farmers, 4 were fruit orchard and plantation farmers and 1 nursery farmer. Since there has not been any records on compost from garbage commercially being produced or used, the willingness to 'trial-out' the compost was detailed out.

(3) Results of Interview Survey

The survey identified that all vegetable farmers utilize barnyard manure and chemical fertilizers. The more popular types of manure are derived from chicken and pig droppings which are abundantly found from the barns that exist in the region. These manure are bought at source by the farmers or sometimes from a stockyard and hauled to their farms using various means of transport vehicles ranging from tricycles to lorries.

Manure being low in nutritive values are used in combination with chemical fertizers to give optimum benefits to the crops. The rates of application of these organic and chemical fertilizers varies from types of crops. The cropping pattern varies which results to the fluctuation in demand of the fertilizing materials.

The size of vegetable farms also varies widely. Vegetable farms owned by individuals are normally very much smaller in area compared to those owned by associations or corperatives. Generally, the size of an individual owned farmland ranges between 0.25 acres to 4 acres (0.1 ha to 1.6 ha), with the average size of individually owned vegetable farmland being 1.6 acres (0.63 ha).

The various types of vegetables that may utilize organic fertilizer derived from manure include choy sam, lady's finger, kangkong, green lettuce, spinach, brinjol, long beans, cucumber, bitter gourd, spring onion, kailan, etc. Generally, most types of leafy vegetables may utilize manure effectively and are suitable for their growth. These vegetables are normally sold to the wholesalers and retailers in the local markets for domestic consumption.

While the vegetable farms utilize organic and chemical fertilizers, fruit orchards and plantations mainly consume chemical fertilizers. The results has that fruit orchards and plantations of commercial crops do not utilize organic fertilizer due to its low nutritive values and the significant labour and transportation costs involved, while other fruit plantations such as durians, are generally sceptical of the effects of organic fertilizers on their crops.

Staple crops such as paddy do not utilize organic fertilizer as it is unsuitable and has low nutritive values, besides being non-economical to use compared to chemical fertilizer.

Generally, almost all vegetable farmers have relied on manual labor and traditional methods of farming. Mechanization in small agricultural fields are negligible. However, large scale plantations have utilized mechanical means to cultivate and transport their produce.

The survey conducted revealed that 85% of the vegetable farmers interviewed are only willing to try out compost from garbage. Actual utilization of compost from garbage largely depends on the effects it has on the crops, yeild and the price at which it is sold.

Table 6.5-7 shows the average rate of applications of fertilizers on crops.

Table 6.5-7 Average rate of application of fertilizer per month

Area	Rate of Application ($kg/m^2/month$)	
	Compost for Vegetable	Chemical fertilizer for Fruit Trees
Pulau Pinang (Average)	0.30	5.93×10^{-4}
Seberang Perai (Average)	0.55	3.71×10^{-3}
Average	0.425	2.15×10^{-3}

The average rate of appplication of organic fertilizer from manure for Penang State is 0.425 kg/m^2/month or 4.25 t/ha/month.

The average rate of application of chemical fertilizer on fruit orchards and plantations for Penang State is 0.0021 kg/m^2/month or 0.021 t/ha /month.

(4) The Most Optimistic Demand for Compost from Garbage based on the Results of Survey.

As mentioned earlier since compost derived from garbage has not been utilized here before, thus the estimate on the most optimistic demand for compost will be based on the following assumptions obtained from several sources :-

a. The quality of compost from solid waste is similar to organic fertilizer from manure being utilized currently in terms of the nutritive N-P-K values and yeild from crops. (Refer table 3.5-5).

b. Rate of application of compost is equated to average rate of application of barnyard organic fertilizer i.e. 0.425 kg/m^2/month. (4.25 t/ha/month).

c. 85% of the identified possible consumers of compost are vegetable farmers and they will utilize this material only.

d. The sale price of compost is competitive with the price of organic fertilizer.

e. The increase in transportation and labor cost involved in utilization of compost compared to other organic fertilizers are ignored by the users.

f. 30% of incoming waste is converted to fine compost.

Based on the assumptions, the demand for compost can be deduced as follows :-

User:	% of user willing to try compost.	total area cultivated (ha)	Rate (t/ha/month)	Demand (t/month)
Vegetable farmers.	85 %	533.7	4.25	1,928

The estimated amount of the most optimistic compost demand is 1,928 tons per month (64.2 tons per day). This is equivalent to 214 tons of waste per day required to produce the compost, based on assumption f.

The 1987 statistics on solid waste quantity, approximately 550 tons of garbage are collected by MPPP and MPSP. From this quantity, about 165 tons of fine compost could be produce daily.

Thus, based on the above findings, "the most optimistic demand" for compost is about 38% of the total possible production of compost. A better opinion on the actual demand would have to be based upon comparisons and considerations experienced in the past from other studies of composting.

(5) Composting

a. Influential factors

Influential factors mainly among others, important to the composting treatment process are described as follows ;

i . Moisture Content

Moisture content is an influential factor to fermentation temperature. Suitable moisture content of solid waste for fermentation depends on composition of solid waste. Moisture content and oxygen content are in inverse relation ; when moisture content is excessive, oxygen becomes short so that compost material becomes unable to maintain an aerobic condition, producing rank odour.

Generally, suitable moisture content for fermentation is in a range of 40 to 60%. When it drops to 30% or less, the decomposition function of compost material (solid waste) ceases.

Content of materials which cannot be decomposed and fermented to compost should not exceed 50% (on dry weight basis) at the moisture content of 60%.

ii. Temperature

Temperature is, as in the case of a chemical reaction, an important factor to control the speed of biological reactions. An external factor such as climate influences compost material to a depth of 20 cm from its external surface so that decomposition of compost material is active in the hot climate. Proper turn-over of compost material is effective to heal the shortage of oxygen and in crease its temperature.

In general, primary fermentation progresses in a temperature range of 60 to 70℃ for positively decomposable materials which decompose in a relatively short time. In the secondary fermentation, fabric materials or cellulose are converted into lower molecular materials in the secondary fermentation on around 50℃.

iii. Carbon-Nitrogen ratio

Composting treatment makes use of biological reaction, therefore, the ratio between carbon, as an energy source, and nitrogen, as a nourishing source for forming protoplasm, has significant relation with compost quality. C/N ratio of many municipal solid waste varies greatly from 40 to 80 depending on the ratio of paper and cellulose contained in the solid waste. C/N ratio decreases to 20 to 30 as fermentaion progresses. C/N ratio of well-fermented compost on 20 or less.

b. Classification and pulverization

Classification is carried on before or after fermentation process. However, it is advantageous to classify unsuitable materials before fermentation process from the aspect of equipment efficiency, putting aside the aspects of sanitation and working environment.

A method of classification is affected when pulverization of solid waste is involved. It should be noted that selection of materials for composting is important because mechanical separation cannot achieve the complete removal of unsuitable materials at the present level of technique and the improvement of separation effect involves the increase of equipment cost.

When the adoption of handsorting is determined depending on collection system and composition of solid waste, it greatly improves the product quality. Pulverization is useful for promoting aerobic decomposition condition but it increases the heavy metal content in some cases.

c. Waste composition

Now that the limits of composting have been highlighted, it is necessary to study the waste composition of Penang State according to the criterias in b. i , ii and iii in suiting out the composting method.

i . Moisture Content :

Basically, the solid waste in Penang State has suitable moisture content for composting i.e. ranged about 50% to 55% for both commercial and domestic wastes.

ii . Temperature :

The favorable climatic conditions such as temperature in the study area will naturally promote active biological reactions.

iii. Carbon-Nitrogen ratio

The carbon-nitrogen ratio of the solid waste under study is 43:1, thus showing that it is in the proper range and chemically suitable for composting.

Table 6.5-8 gives the summary on average solid waste composition for the study which were obtained during the sampling analysis carried out in February, April and July 1988.

Table 6.5-9 gives the chemical analysis and carbon : nitrogen content of the solid waste under study based on results obtained in Table 6.5-8.

Table 6.5-10 shows the future solid waste composition (on wet weight basis), moisture content, and bulk density of Penang, estimated by the Study Team.

Table 6.5-11 summerizes the future solid waste composition (on wet weight basis), moisture content and bulk density of Bangkok, extracted from the Bangkok solid waste management study.