Chapter 3. Selection of Candidate Sites

3.1 Site Selection Method

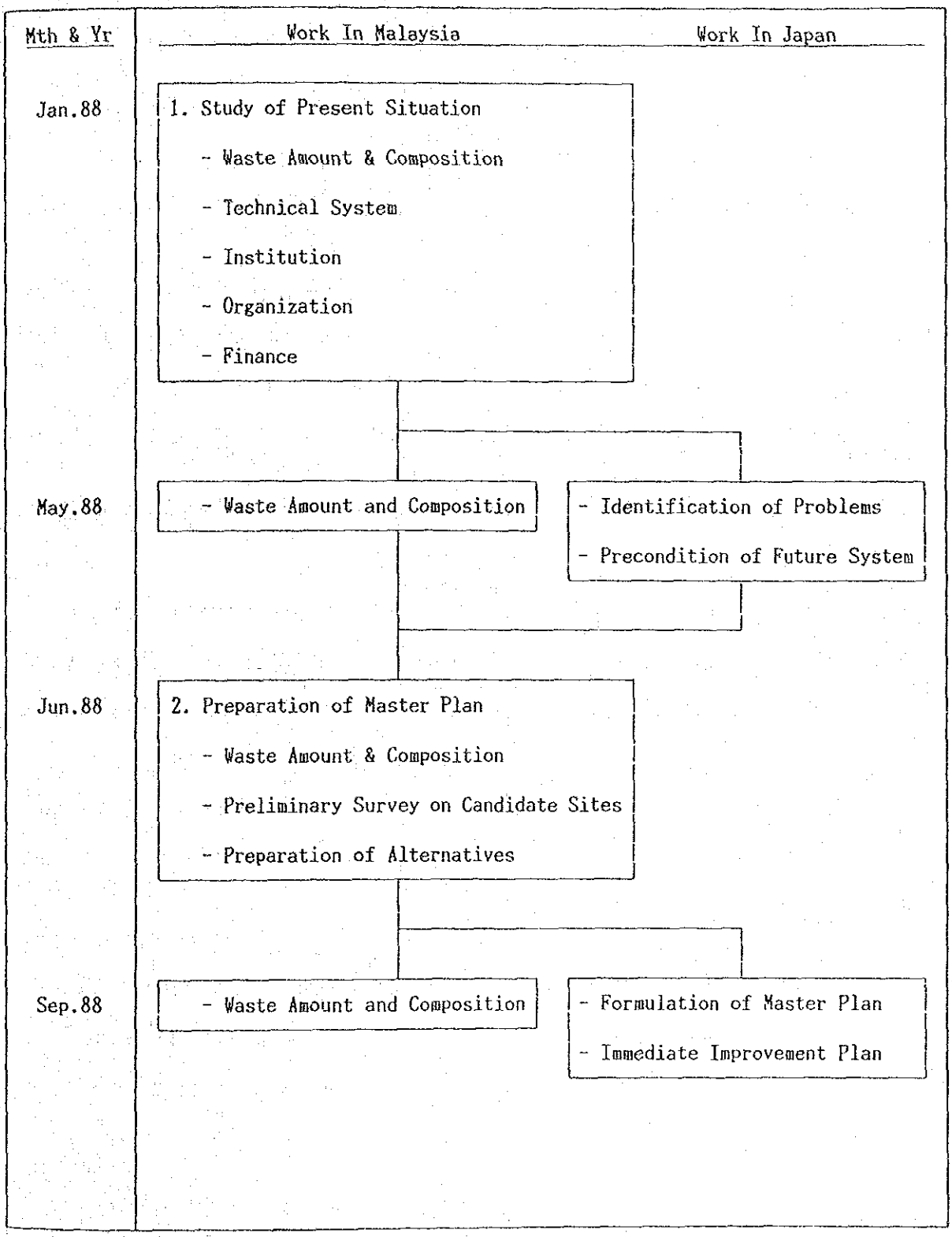
3.1.1 Study Flow

The study is divided into two stages. One is the Master Plan Study Stage and the other is the Feasibility Study Stage.

The study procedure is summarized and illustrated in Fig. 3.1-1.

Fig. 3.1-1 Study Flow

Master Plan Study Stage



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Master Plan Study Stage

… Cont.

Mth & Yr	Work In Malaysia	Work In Japan
Nov.88	3. Feasibility Studies for the First Phase Project - Selection of the Most Favorable Alternatives - Comparison Study of System Components - Detail Site Survey	
Jan.89	- Implementation of Immediate Improvement Plan	- Preliminary Design - Estimation of the Project Cost - E.I.A. - Law & Regulation - Organization - Finance - Public Cooperation - Project Evaluation - Implementation Plan
Mar.89	- Workshop	
	- Comments on Draft Final Report	
Jul.89		- Submission of Final Report

3.1.2 Site Selection Method

Method of site selection for major facilities (disposal site, incinerator, transfer station, etc) is divided into the following stages and illustrated in Fig. 3.1-2.

a. Selection of potential sites (Identification of potential sites)

b. Selection of candidate sites

c. Final site selection (Selection of the most favorable alternatives)

In order to coordinate with the scheduled time of the study, the process of site selection is prepared as shown in Fig. 3.1-3. In the preparation of a master plan and feasibility study, it is crucial that site(s) for major facilities be selected in accordance with the sequent stages in the process of site selection.

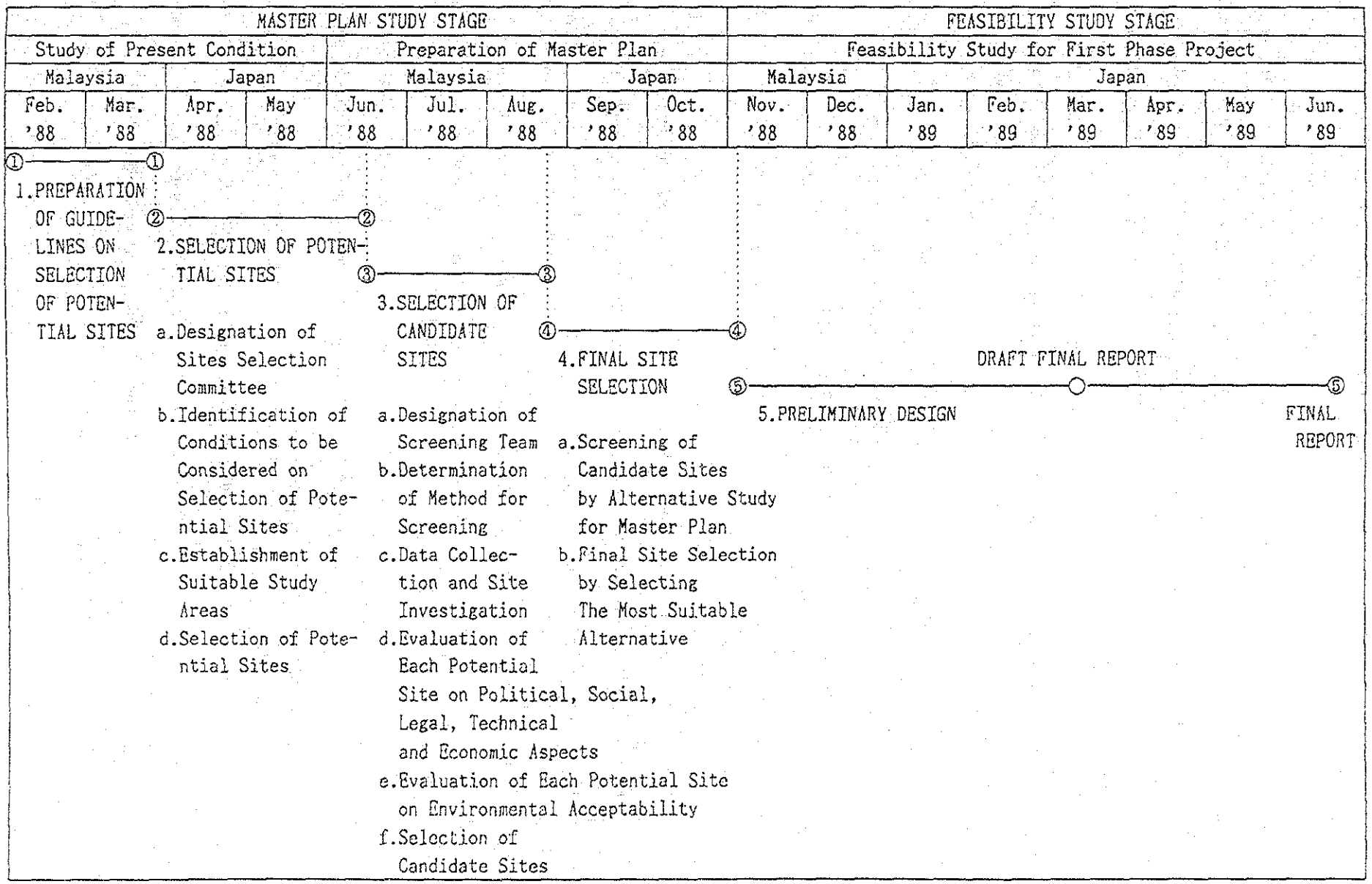
It is the basic understanding confirmed by both the Malaysian side and the JICA Study Team that the Malaysian side should be responsible for the selection of potential sites for major facilities and that the JICA Study Team should be responsible for screening of potential and candidate sites. Subsequently, the final site selection will be done at the consultative meetings with Technical Committee and Steering Committee to be held in November 1988, after which the Study Team will carry out a feasibility study.

The Malaysian side selects potential sites from several view points of political, social and legal aspects in accordance with the guideline on selection of potential sites for major facilities prepared by the Study Team. Consequently, the Study Team undertakes screening of potential and candidate sites with regards to the technical, economic and environmental aspects.

Fig. 3.1-2 SITE SELECTION METHOD

First Stage	Second Stage	Third Stage
SELECTION OF POTENTIAL SITES	SELECTION OF CANDIDATE SITES	FINAL SITE SELECTION
Step 1-1 Designation of Sites Selection Committee	Step 2-1 Designation of Screening Team	Step 3-1 Screening of Candidate Sites by Alternative Study for Master Plan
Step 1-2 Identification of Conditions to be Considered for Selecting Potential Sites	Step 2-2 Determination of Method for Screening	Step 3-2 Final Site Selection by Selecting The Most Suitable Alternative
Step 1-3 Establishment of Suitable Study Areas	Step 2-3 Data Collection and Site Investigation	
Step 1-4 Selection of Potential Sites	Step 2-4 Evaluation of Each Potential Site on Political, Social, Legal, Technical and Economic Aspect	
	Step 2-5 Evaluation of Each Potential Site on Environmental Acceptability	
	Step 2-6 Selection of Candidate Sites	

Fig. 3.1-3 Process of Site Selection



3.1.3 Guideline on Selection of Potential Sites for Major Facilities

In order to describe the method of selection of potential sites and to assist the Malaysian side to carry out the identification of potential sites for major facilities, a guideline has been prepared by the Study Team as follows.

(1) Designation of Site Selection Committee

In order to select appropriate sites for major facilities, the following items are to be considered as key factors :

a. Possibility of land acquisition
b. Possibility of getting neighbouring consensus
c. Compatibility with regional development plan
d. Economic feasibility
e. Environmental acceptability

Although, all the above-mentioned key factors are important in the selection of appropriate sites, but it is emphasized that only items a, b and c will mainly be examined in the selection of potential sites. The reasons for it are as follows :

a. Possibility of land acquisition is the key factor of site selection.

b. In Penang State, all development projects, including public utilities, and development of major facillities, need "Neighbouring Concensus". Therefore, without possibility of getting neighbouring consensus, any development plan for waste disposal would not succeed.

c. In MPPP and MPSP, the Town & Country Planning Act, 1976 (ACT 172) is enforced and both councils have prepared their Draft Structure Plans. Any development plans for the solid waste disposal should be in line with the Structure Plans and other regional development plans.

In other words, the selection of potential sites should rather be considered as "Policy Making Stage" of appropriate sites selection for major facilities of solid waste disposal, while screening of potential and candidate sites are considered as "Technical and Economic Study Stage". Therefore, it is necessary to designate a site selection committee which includes personnels who are familiar with the state policy especially on land matters . The committee may consist of the followings bodies :

a. State Government
   - Town and Country Planning Department
   - Land and Mines Department
   - Northern Regional Office of the Department of Environment

b. Local Government
   - Councillors when necessary
   - Health Department
   - Engineering Department
   - Town and Planing Department

c. Other Members, as required

(2) Conditions to be Considered for Selection of Potential Sites

The site selection committee is requested to consider the following data before starting the identification of potential sites :

a. Possibility of land acquisition
   - Maps showing regulatory constraints on land use (zoning map such as environmentally sensitive areas map, target plan and land use policy plan, national resource reserve map, etc.)
   - Maps showing Federal, State and Local Government lands.

b. Possibility of getting neighbouring consensus

- Political limitations (public reaction, special interest groups, budget management)

c. Compatibility with regional development plans

- Structure plan
- Present land use
- Future land use
- Major development plans

d. Economic feasibility

- Land price
- Summary on present solid waste manegement (collection area and block, amount of solid waste to be collected and disposed of , waste composition, etc.)
- Available maps (topographic map, geological map, road map, soil map, chart, etc.)
- Availability of public utilities
- Availability of covering material

e. Environmental acceptability

- Environmentally sensitive areas
- Vegetation
- Latest aerial photographs
- Meteorological data

(3) Establishment of Suitable Study Areas

It requires a lot of effort to select potential sites within the whole study area. In order to reduce such effort, it is suggested to establish suitable study areas from which unsuitable areas for major facilities are eliminated, using forementioned data.

The work procedure is as follows :

a. To determine maximum radius of study area based on hauling distance from centroid of potential service area.

b. Using transparent papers, to indicate areas which are :
   - Impossible for land acquisition
   - Impossible for getting neighbouring consensus
   - Imcompatible with any regional development plan
   - Unsuitable from economic and environmental points of view

c. To place shaded transparent papers of the unsuitable areas on study area map. The unshaded area may be considered generally suitable for major facilities sites.

(4) Selection of Potential Sites

Based on the establishment of suitable study areas, the site selection committee would select the potential sites for major facilities with consideration on the following factors :

a. Possibility of land acquisition
   i . Land use restrictions by laws and regulations which are shown in the Structions Plan, National Resource Reserve Area and so on.
   ii . Compensation, if required.
   iii . Land ownership

b. Possibility of getting neighbouring consensus
   i . Ways of getting neighbouring consensus
   ii . Increasing attitude of public towards NIMBY (Not In My Back-Yard) syndrome against solid waste disposal facilities because of offensive odour, noise, traffic, unpleasant view, pollution of air and water, security, etc.

c. Compatibility with regional development plans

i. Conformity with the Structure Plans and land use plans

ii. Direction of urbanization towards sites

iii. Major development plans

d. Economic Feasibility

Economic feasibility of each site will be examined in the "Technical and Economic Study Stage" which shall be done by the JICA Study Team. Therefore, the economic feasibility to be done in current stage will be evaluated from only qualitative view point. Specific conditions on the major facilities are as follows :

i. Area of site

If the disposal amount were to be 500 ton/day, area of each facility might be as follows :

Final disposal sites ; more than 20 ha
(life span shall be more than 5 years)

Incinerator ; 4 ha

Compost plant ; 6 ha

Transfer station ; 2 ha

ii. Location of site

Collection and haulage efficiency and cost highly depend on the location of each facility. Items to be considered on the location of each facility are described as follows :

Final disposal site ; distance from collection area, accessibility and availability of cover materials at site or its vicinity

Incinerator ; distance from collection area and user of electric power and other energies to be recovered by incinerator, accessibility and availability of cooling

water.

Compost plant ; Distance from collection area and user of compost and accessibility

Transfer station ; Proximity to collection area and accessibility

iii. Cost of land (acquisition or renting)

iv. Availability of public services (electricity, water, telephone and sewage)

v. Cost of compensation, if any

e. Environmental acceptability

i. Distance from airport, and other public facilities

ii. Water resource conservation (there should be no possibility of polluting drinking water)

iii. Densely populated areas

iv. Unsuitable surface or ground water conditions (flood plains, recharge zones of aquifer)

v. Inappropriate slope

vi. Critical habitats of endangered species

vii. Archaeological or historical significance

In order to fulfill the above-mentioned works, preliminary site investigations, when necessary, are recommended to obtain further information on sites.

Through the works in the identification stage, here, the less desirable sites are eliminated and potential sites are selected. It should be emphasized again that the most important factor to be considered at this stage is the security of land acquisition when the sites are selected for major facilities of solid waste disposal.

3.1.4 Selection of Candidate Sites

(1) Designation of Screening Team

In response to the identification of the potential sites for major facilities according to the guideline, a team for screening potential sites shall be organized.

The screening team undertakes screening of potential sites and then carries out screening of candidate sites with regards to the technical, economic and environmental aspects. Therfore, the team may consist of experts in following fields,

- environmental analysis
- final disposal plan
- intermediate treatment plan

(2) Determination of Method for Screening

Before starting screening work, the screening team shall determine a method for screening of potential sites. An example of method for screening is indicated as follows ;

a. Area identification of each potential site
b. Data collection and site investigation
c. Estimation of life expectancy for each final disposal site
d. Environmental evaluation of each potential site
e. Screening of the potential sites
f. Selection of candidate sites for the Master Plan
g. Execution of preliminary EIA on each candidate site
h. Screening of the candidate sites
i. Final site selection

(3) Data Collection and Site Investigation

After the determination of method for screening, the screening team shall undertake sites investigation and collect data on the sites from various sources such as JKR, DID, PDC, PERDA and so on.

(4) Evaluation of Each Potential Site on Political, Social, Legal, Technical and Economic Aspects

After data collection and site investigation, the evaluation of each potential site on political, social, legal, technical and economic aspects is made for the selection of candidate sites from potential sites. At the same time, the evaluation of each potential site on environmental acceptability is carried out.
A sample of screening sheet of potential site for facility is shown in Table 3.1-1.

(5) Environmental Evaluation of Each Potential Site

Firstly, the following items should be investigated through data collection, reconnaissance of potential sites and discussions with related agencies concerned.

- Usage of surface water
- Usage of groundwater
- Usage of well
- Distance from public facilities
- Distance from the nearest house
- Land use of adjacent areas
- Topographic condition
- Landscape
- Whether it is forest land or not
- Existence of fishery activities
- Existence of historic or religious places

In the next stage, upon consideration of above factors of impact, evaluation of each potential site should be executed.

Table 3.1-1 Screening Sheet of a Potential Site for Major Facilities

Name of Potential Site ; ... 1

Items	Description
1) Possibility of Land Acquisition a. Land use restrictions b. Land ownership c. Necessity of compensation d. Other considerations	
2) Possibility of Getting Neighbouring Consensus a. Necessity of neighbouring consensus b. Necessity for "out of sight" measures c. Necessity for isolation from noise, dust and odour measures d. Other considerations	
3) Compatibility with Regional Development Plans a. Competitive development plan b. Conformity with the Structure Plan and land use plan c. Direction of urbanization towards sites d. Other considerations	

Items	Description
4) Economic Feasibility	
a. Location of site (distance from main waste generation area)(km)	
b. Area of site (ha)	
※ c. Life expectancy (years)	
※ d. Availability of covering earth	
e. Accessibility	
f. Estimated cost of compensation	
g. Availability of public services	
h. Present conditions of site (Land use, type of surface soil, depth of ground water)	
i. Technical considerations	
j. Benefits of site upon completion	
5) Environmental Acceptability	
a. Possibility of drinking water pollution	
b. Impact by surface water pollution	
c. Impact of flooding	
d. Impact by groundwater pollution	
e. Distance from airport and other public facilities	
f. Distance from densely populated area	
g. Dust, noise and odour hazards	

※ In case of an incineration plant, c. is "Existence of possible user for energy recovered by the plant" and d. is not necessary.
In case of transfer station, both c. and d. are not necessary.

Items	Description
h. Land use of adjacent areas	
i. Slope stability	
j. Inshore or river fishery	
k. Terrestrial vegetation and wildlife	
l. Aquatic/Marine flora and fauna	
m. Natural landscape	
n. Historic places or structures	
o. Religious places or structures	

(6) Selection of Candidate Sites

In order to select candidate sites for the Master Plan alternatives from potential sites, the following items are to be considered as key factors :

a. Possibility of land acquisition
b. Possibility of getting neighbouring consensus
c. Compatibility with regional development plans
d. Economic feasibility
e. Environmental acceptability

Potential sites are selected mainly from several viewpoints of political, social and legal aspects in accordance with the guideline on selection of potential sites for major facilities. Screening of candidate sites is mainly done with regards to the technical, economic and environmental aspects.

Selection of candidate sites is between the selection of potential sites and the screening of candidate sites. For the selection of candidate sites, the evaluation of potential sites shall be carried out with regards to political, social, legal, technical, economic and environmental aspects. The evaluation of potential sites, therefore, is made upon consideration of the above mentioned five key factors without prejudice. It is recommended that an evaluation table of potential sites be prepared for the selection of candidates sites. The evaluation table may include the following evaluation aspects.

a. Possibility of land acquisition
   i . Land use restrictions
   ii . Land ownership
   iii . Necessity of compensation
   iv . Other considerations

b. Possibility of getting neighbouring consensus

i. Necessity of neighbouring consensus

ii. Necessity for "out of sight" measures

iii. Necessity for isolation from noise, dust & odour measures

iv. Other considerations

c. Compatibility with regional development plans

i. Competitive development plan

ii. Conformity with the Structure Plan and land use plan

iii. Direction of urbanization towards sites

iv. Other considerations

d. Economic feasibility

i. Location of site (distance from main waste generation area)(km)

ii. Area of site (ha)

iii. Life expectancy (years)

iv. Availability of covering earth

v. Accessibility

vi. Estimated cost of compensation

vii. Availability of public services

viii. Present conditions of site (Land use, type of surface soil, depth of groundwater)

ix. Technical considerations

x. Benefits of site upon completion

e. Environmental acceptability

i. Possibility of drinking water pollution

ii. Impact by surface water pollution

iii. Impact of flooding

iv. Impact by groundwater pollution

v. Distance from airport and other public facilities

vi. Distance from densely populated area

vii. Possibility of dust, noise and odour hazards

viii. Compatibility with land use of adjacent areas

ix. Slope stability

x. Impact on inshore or river fishery

xi. Impact on terrestrial vegetation and wildlife

xii. Impact on aquatic/marine flora and fauna

xiii Impact on natural landscape

xiv. Impact on historic places or structures

xv. Impact on religious places or structures

3.1.5 Final Site Selection

(1) Screening of Candidate Sites

Screening of candidate sites is made by the alternatives study of the Master Plan. Alternatives for the Master Plan are combinations of various systems in SWM such as discharge and storage system, collection and haulage system, cleansing work system, intermediate treatment system, and final disposal system including institution and organization structure.

All alternatives selected are examined qualitatively and quantitatively. Then, they are screened and evaluated in the following aspects.

- Technical aspects
- Economic and financial aspects
- Social-legal aspects
- Environmental aspects

(2) Final Site Selection

After the screening and evaluation of each alternative, an overall evaluation of the selected alternatives is made. This overall evaluation is made at a consultative meeting with various authorities concerned in SWM. At the meeting, the most suitable alternative for the Master Plan is selected. Finally, the sites for the most suitable alternative are selected.

3.2 Selection of Potential Sites

3.2.1 Designation of Site Selection Committee

(1) Sub-Committee

In response to the decision made at the Steering Committee meeting held on 3rd February 1988, a sub-committee consisting of officers from the following agencies was formed to carry out the selection of potential sites for major facilities :

a. Penang State Town and Country Planning Department ;

b. Penang State Land Office ;

c. Northern Regional Office of the Department of Environment ;

d. Municipal Council of Penang ;

e. Municipal Council of Seberang Perai.

The State Government of Penang was requested to respond quickly to the application for the sites for major facilities.

It was recommended at the Technical Committee meeting held on 21st March 1988 that both the State Geological Department and State Marine Department should be included as members of the sub-committee.

(2) Terms of Reference of the Sub-Committee

Terms of reference of the sub-committee is summarized as follows ;

a. The Sub-Committee shall familiarize itself with the use of "The Guideline on Identification of Potential Sites for Major Facilities" prepared by the JICA Study Team.

b. The Sub-Committee shall carry out the identification of potential sites taking into consideration, among others, the following three factors :

- Possibility of land acquisition ;
- Possibility of getting neighbouring consensus ;
- Compatibility with regional development plan.

c. The Sub-Committee shall complete the task of identification of potential sites and submit a report to the Technical Committee by the middle of June 1988. The report shall include, among others, the location including lot number, size and ownership of potential sites identified as well as the result of evaluation of each site by the Sub-Committee based on the factors outline in item b.

3.2.2 Possible Areas

In order to expedite the work of the Sub-Committee to identify potential sites for major facilities, it was decided at the Technical Committee meeting held on 21st March 1988 that the Study Team should suggest possible areas where these facilities may be located and inform the Sub-Committee. Upon consideration of this information the Sub-Committee would carry out the task to identify potential sites.

(1) Final Disposal

It was reported at the Technical Committee meeting held on 21st March 1988 that it is the policy of the Penang State Government to use solid waste for land reclamation from the sea. This policy shall be taken into consideration on the study when formulating and evaluating various alternative proposals.

In response to the Technical Committee's decision, the possible areas for final disposal were suggested by the Study Team at the end of March 1988 and were shown in Fig. 3.2-1. The list of the possible areas are as follows ;

a. MPPP
   - Jelutong Mole
   - Sungai Dua Kecil

- Batu Maung
- Pulau Betong
- Gemuroh

b. MPSP

- Perusahaan Perai
- Butterworth & Bukit Mertajam
- Kuala Muda
- Pulau Burong

(2) Other Facilities

The possible areas for other facilities such as incineration plants and transfer stations were suggested as follows ;

a. Incineration Plants

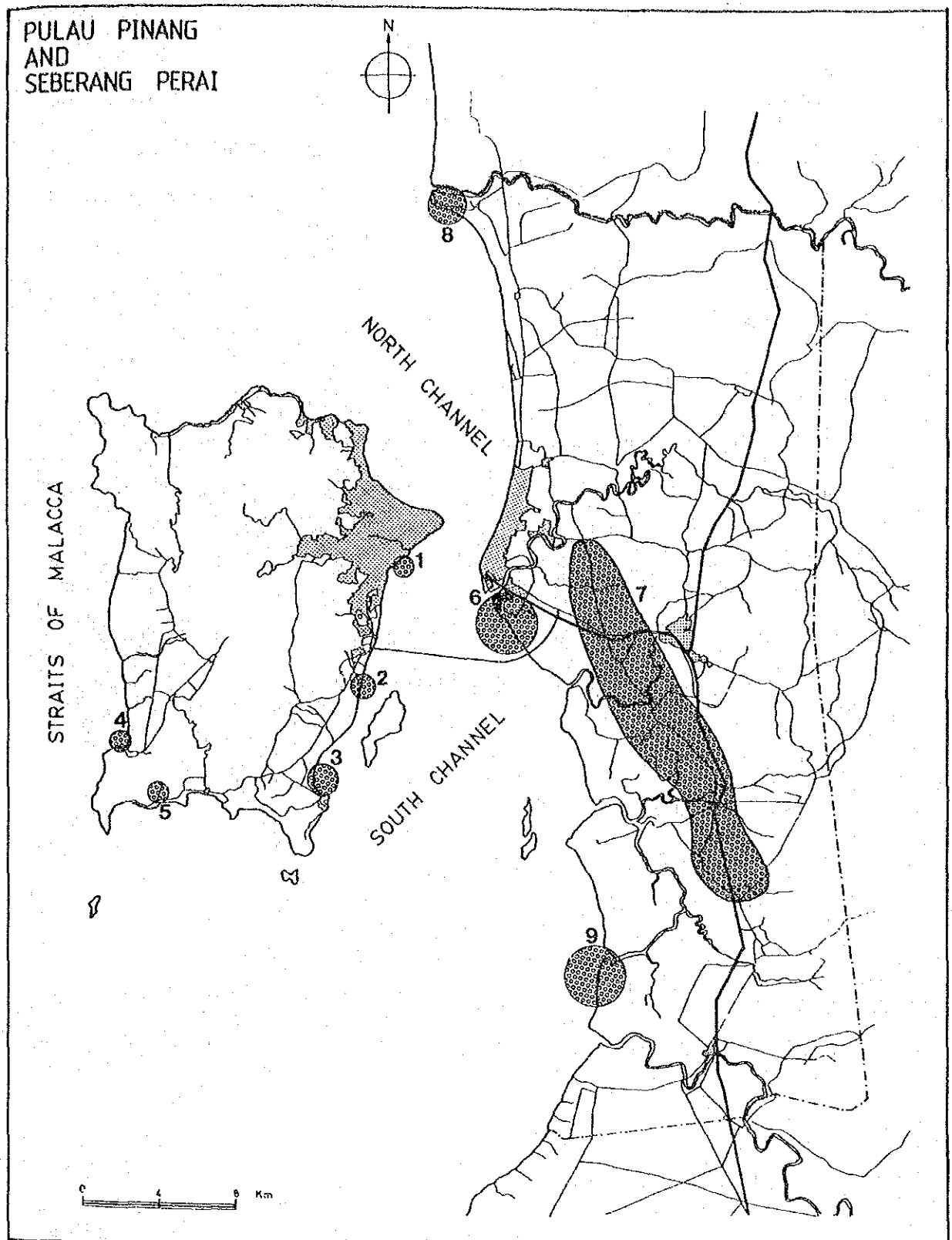
Sites shall be close to collection area and user of electric power and other energies to be recovered by plants. Therefore, the vicinity area to Georgetown and FTZ for MPPP and to Butterworth, Bukit Mertajam and PIC for MPSP were suggested.

b. Transfer Station

Sites shall be in close proximity to main waste generation area. Therefore, the area within Georgetown or it's surrounding for MPPP and that within Butterworth or it's surrounding were suggested.

3.2.3 Potential Sites

The potential sites for final disposal were identified by the Sub-Committee in a meeting held on 15th June 1988.



LEGEND

TOWN AREA

POSSIBLE AREAS FOR DISPOSAL SITES:

1. Jelutong Mole
2. Sungai Dua Kecil
3. Batu Maung
4. Pulau Betong
5. Gemuroh
6. Perusahaan Perai
7. Butterworth & Bukit Mertajam
8. Kuala Muda
9. Pulau Burong

Fig.3.2-1

Potential Sites For Major Facilities

Source : JICA Study Team

POSSIBLE AREAS FOR DISPOSAL SITES IN MPPP & MPSP.

The Solid Waste Management Study For Pulau Pinang And Seberang Perai

After the sub-committee meeting, a few other potential sites for major facilities were identified in the course of discussion between MPPP, MPSP and the Study Team. The location of all potential sites are shown in Fig. 3.2-2. Those sites are listed as follows ;

(1) Final Disposal

a. MPPP

- Jelutong area between proposed coastal road and present coast line
- Middle Bank located in the South Channel between Pulau Pinang and Seberang Perai
- South-Eastern Sea Shore near the Penang Bridge
- Land between Pantai Acheh and Sungai Pinang

b. MPSP

- Kuala Muda in North District
- Kampung Selamat in North District
- Mak Mandin in Central District
- Prai Barrage in Central District
- Prai Industrial Complex in Central District
- Bukit Minyak in Central District
- Gajah Mati in Central District
- Pulau Burong in South District
- Bukit Tambun

(2) Incineration Plant

a. MPPP

- Free Trade Zone

b. MPSP

- Prai Industrial Complex
- Permatang Pauh Present Disposal Site

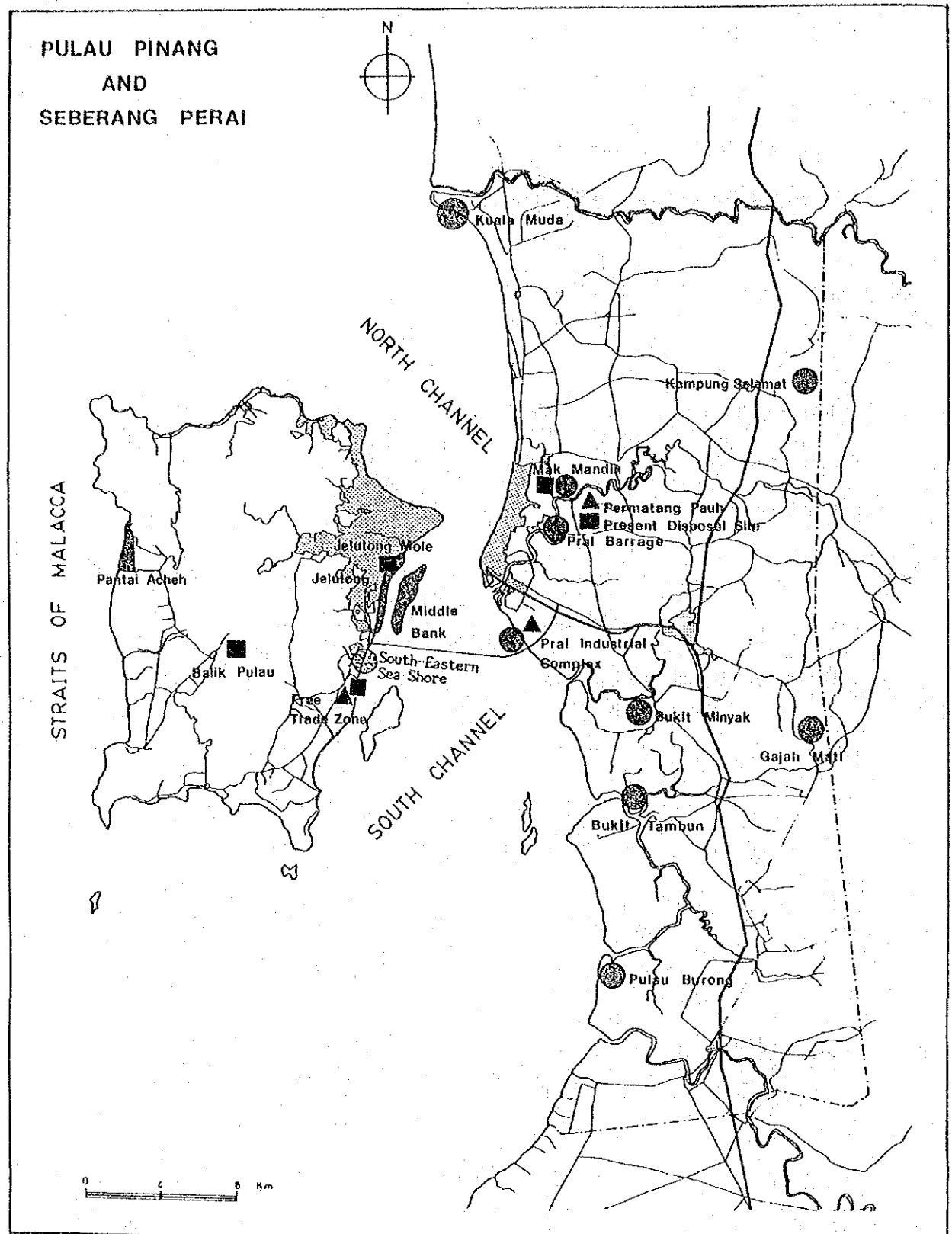
(3) Transfer Station

a. MPPP

- Jelutong Mole (previous disposal site)
- Free Trade Zone
- Balik Pulau

b. MPSP

- Mak Mandin
- Permatang Pauh (present disposal site)



LEGEND

- Urban Area
- Potential Disposal Site
- Potential Site For Transfer Station
- Potential Site For Incineration Plant

Fig. 3.2-2

Potential Sites For Major Facilities

Source : JICA Study Team

3.3 Selection of Candidate Sites

3.3.1 Determination of Screening Method

(1) Screening Team

After the identification of the potential sites for major facilities, a team for screening the potential sites was organized. The screening team consists of experts in following fields ;

- treatment plan
- disposal plan
- facility plan
- environmental analysis

(2) Screening Method

The screening method of potential sites was established according to the following work items :

a. Area identification of each potential site
b. Data collection and site investigation
c. Estimation of life expectancy for each final disposal site
d. Environmental evaluation of each potential site
e. Screening of the potential sites
f. Selection of candidate sites for the Master Plan
g. Execution of preliminary EIA on each candidate site
h. Screening of the candidate sites
i. Final site selection

The work items above-mentioned a,b,c,d,e and f was completed in the middle of August 1988. The work item h, which includes both qualitative and quantitative analysis

will be done by the end of October. It shall be stated in the Master Plan Interim Report.

3.3.2 Screening of the Potential Sites

(1) Area Identification of Each Potential Site

a. Final disposal site

It is indispensable to confirm the precise area for a final disposal site.

Otherwise, the capacity of the site and the life expectancy of the final disposal cannot be determined accurately. The area of each potential site was not identified at the Sub-Committee meeting held on 15th June. The screening team, therefore, had identified it themselves from the following information ;

- Topographic maps
- Cadastral maps
- Marine maps
- Aerial photos
- Maps obtained from other development projects.

b. Incineration plant

Since the sites for incineration plant(s) were not identified by the Sub-Committee, incinerator sites for the study were assumed by the Study Team in the course of discussion to be as follows ;

- FTZ (Free Trade Zone), PIC (Prai Industrial Complex) and PPDS (Permatang Pauh Present Disposal Site) seems to be suitable for the sites of incineration plant
- Both FTZ and PIC have their expansion plans into the sea in the future. It is, therefore, possible to acquire some area for the incineration plant from the expanded area.

- The ultimate use of PPDS has not been decided yet.

The area of each potential site is subject to the size of the plant.

c. Transfer Station

The same assumption mentioned above was considered for the transfer station sites and is described as follows ;

- JMPDS (Jelutong Mole Previous Disposal Site), FTZ, Balik Pulau, Mak Mandin and PPDS seems to be suitable sites of transfer stations.
- There were still no definite land use plans for these areas.

(2) Data Collection and Site Investigation

Following the identification for area of each potential site, site investigations were carried out with reference to the screening sheet. At the same time, data on the sites were collected from various sources such as PDC, JKR, DID, PERDA, etc..

The result of site investigation and data related to each potential site are summarized in the screening sheets mentioned in 3.1.4.

(3) Estimation of Life Expectancy for Each Final Disposal Potential Site

As to final disposal site, it is indispensable for the evalution of each site to estimate its life expectancy. In order to calculate site capacity and to estimate life expectancy of each site, site development concept for each final disposal potential site is prepared.

According to the site development concept, life expectancy of each potential site is calculated using the following assumptions and tabulated in Table 3.3-1 and 3.3-2.

Assumptions :

i) Life expectancy is estimated, assuming that the depth of each site is 5 m.

ii) Daily amount of waste disposed in 1995 for MPPP and MPSP are 560 ton/day and 460 ton/day respectively. (205,000 ton/year and 168,000 ton/year).

iii) Unit weight of landfill waste is 0.8 ton/m^3.

iv) Covering materials share 30% of total landfill volume.

(4) Evaluation of Each Potential Site on Environmental Acceptability

Environmental evaluation of each potential site was carried out with reference to the screening sheet shown in Table 3.1-1.

In Penang State drinking water is supplied mostly to the public by pipes, and the potential sites for final disposal are located in downstream of the catchment area of surface water supply intakes. So implementation of this project would not cause pollution to drinking water. As construction and operation of final disposal site has possible potential of polluting surface water and groundwater, evaluation was executed on the base of whether there are some environmental components subjected to the impact of polluted leachate coming out from the site. It is assumed that the polluted groundwater in the upstream area may give bigger impact on the surroundings than that in the downstream area.

Flooding near the estuary would flow directly into the sea and pollutant would be dispersed quickly in the large volume of water, but flooding in the upstream area would have serious impact upon the surrounding land.

Dust, noise and odour hazards cannot have fatal impact because prevention is possible. Vegetation and wildlife, or flora and fauna, need to be surveyed in detail, but final disposal on Middle Bank would evidently have a fatal impact upon natural landscape and the ecological system.

Table 3.3-1 Potential Disposal Sites for MPPP

Name of Potential Sites	Area (ha)	Life Expectancy (years)	Distance from Main Waste Generation Area	Land Ownership	Remarks
Jelutong Area	92.0	13.8	Approx. 2.5 km from Georgetown	State Government	Present Disposal Site and Sea Coast
Middle Bank	Exceeding 200.0	Exceeding 30.0	Approx. 3 km from Georgetown	State Government	Middle Bank is located in the South Channel between Pulau Pinang and Seberang Perai
South-Eastern Sea Shore	NA	NA	Approx. 10 km from Georgetown	State Government	Proposed PDC Sea Reclamation Area
Pantai Acheh	85.0	12.8	Approx. 35 km from Georgetown	State Government	Land between Pantai Acheh and Sungai Pinang

Table 3.3-2 Potential Disposal Sites for MPSP

Name of Potential Sites	Area (ha)	Life Expectancy (years)	Distance from Main Waste Generation Area	Land Ownership	Remarks
Kuala Muda	Exceeding 78.0	Exceeding 14.3	Approx. 20.0 km from Butterworth	State Government, MPSP and private persons	Sea coast and low-lying land. Part of land owned by private person
Kampung Selamat	75.0	13.7	Approx. 25.0 km from Butterworth	Private land	Low-lying and private land. Agricultural development by FELCRA
Mak Mandin	6.0	1.1	Approx. 2.0 km from Butterworth	MPSP	Part of land already reclaimed
Prai Barrage	18.0	3.3	- ditto -	State Government	River bed
Prai Industrial Complex	35.0	6.4	Approx. 3.0 km from Butterworth	State Government	Proposed PDC sea reclamation area
Bukit Minyak	35.0	6.4	Approx. 12.0 km from Butterworth	Private land	Coconut and pineapple plantations
Gajah Mati	40.0	7.3	Approx. 20.0 km from Butterworth	Private land	Rubber plantation
Pulau Burong	35.0	6.4	Approx. 35.0 km from Butterworth	State Government	Present Disposal Site for South District
Bukit Tambun	39.0	7.1	Approx. 20.0 km from Butterworth	State Government	Low-lying marsh land. A development plan by the State Veterinary Department.

3.3.3 Selection of Candidate Sites

(1) Method of Selection

In order to select candidate sites for the Master Plan alternatives from potential sites, the following items are to be considered as key factors :

a. Possibility of land acquisition
b. Possibility of getting neighbouring consensus
c. Compatibility with regional development plans
d. Economic feasibility
e. Environmental acceptability

For the selection of candidate sites, the evaluation of potential sites shall be carried out with regards to political, social, legal, technical, economic and environmental aspects. The evaluation of potential sites, therefore, is made upon consideration of the above mentioned five key factors without any prejudice.

Each key factor has its own evaluation items as shown below. After the evaluation of their own evaluation items, an overall evaluation on each key factor is made as in the following manners ;

- ○ means that most of evaluation items are cleared at this stage.
- △ means that there are some considerations or further study required for the clearance of some evaluation items.
- × means that there is a critical barrier which cannot be cleared or there are some unsuitable points for a candidate site at this stage.

In case that a potential site has one ×, the site is not recommended as a candidate site.

Evaluation of each key factor is described below.

a. Possibility of land acquisition

This key factor has the following evaluation items ;

i . Land use restrictions

ii . Land ownership

iii . Necessity of compensation

iv . Other considerations

This key factor is given × if one of following items were identified ;

- A potential site is in the restricted area by laws and regulations such as water reserve area.
- A site is owned by many private owners. And the site is, at present, used for other purposes and it seems difficult to acquire the land.
- There are many other items which makes land acquisition very difficult.

b. Possibility of getting neighbouring consensus

This key factor has the following evaluation items ;

i . Necessity of neighbouring consensus

ii . Necessity for "out of sight" measures

iii . Necessity for isolation from noise, dust & odour measures

iv . Other considerations

This key factor is given × in case that one of above items i , ii and iii were evaluated as very high or if there are any other items which makes neighbouring consensus be very difficult to get.

c. Compatibility with regional development plans

This key factor has the following evaluation items ;

i . Competitive development plan

ii . Conformity with the Structure Plan and land use plan

iii . Direction of urbanization towards sites

iv . Other considerations

This key factor is given × if the following items were identified ;

- There are competitive plans on a potential site.
- One of competitive plans is under implementation stage or it comforms with the Structure Plan and land use plan more than the use for SWM facilities.
- The use for SWM facilities is not suitable in view of compatibility with regional development plans.

d. Economic Feasibility

This key factor has the following evaluation items ;

i . Location of site (distance from main waste generation area)(km)

ii . Area of site (ha)

iii . Life expectancy (years)

iv . Availability of covering earth

v . Accessibility

vi . Estimated cost of compensation

vii . Availability of public services

viii . Present conditions of site (Land use, type of surface soil, depth of groundwater)

ix . Technical considerations

x . Benefits of site upon completion

Note ; In case of an incineration plant, item iii . is replaced with "Existence of possible user for energy recovered by the plant" and iv . and x . is not necessary. In case of transfer station, both iii ., iv . and x . are not necessary.

The key factor is given × in case that the area of site is too small as a final disposal site or there is a critical technical barrier in the use of SWM facilities.

e. Environmental Acceptability

This key factor has the following evaluation items ;

i . Possibility of drinking water pollution
ii . Impact by surface water pollution
iii. Impact of flooding
iv. Impact by groundwater pollution
v . Distance from airport and other public facilities
vi. Distance from densely populated area
vii. Possibility of dust, noise and odour hazards
viii. Compatibility with land use of adjacent areas
ix. Slope stability
x . Impact on inshore or river fishery
xi. Impact on terrestrial vegetation and wildlife
xii. Impact on aquatic/marine flora and fauna
xiii. Impact on natural landscape
xiv. Impact on historic places or structures
xv. Impact on religious places or structures

The key factor is given × in case that one of above items were evaluated as "very high" and there were a few items evaluated as "high" or "poor".

(2) Evaluation of Potential Sites

According to the method of selection of candidate sites from potential sites, evaluation tables are prepared and shown in table 3.3-3 and 3.3-4 for final disposal,

table 3.3-5 for incineration plants and table 3.3-6 for transfer stations. Some of the sites are not recommended as candidates sites for the alternative study of the Master Plan. The reasons are described below.

a. Final disposal

i . Jelutong Area in MPPP

- The site is stretched along the Jelutong sea coast which is already urbanized. There are many residents in the inland of the area and the sea coast is occupied by many squatters. It seems to be very difficult to get neighbouring consensus from them.
- Since the site is close to the city center, there are many competitive development plan on it. Those competitive projects are much more in conformity with the regional development than the use as a final disposal site.
- At present, the site is not only a main fishery base but also a place for ocean culture. The impact on inshore fishery is expected to be very high. Besides this, there are other unfavourable aspects. It seems therefore, it is very difficult to obtain environmental acceptability.

ii . Middle Bank in MPPP

- Pulau Pinang is known as an attractive tourist island. In case that disposal operation is done in the site, tourists may have some bad impressions. The view from the Penang Bridge will be very much deteriorated.
- Besides, there are other unfavorable aspects, which make it very difficult to get environmental acceptability.
- A bridge which may need more than 20 million ringgit for construction is required for access to the site from the city.

Table 3.3-3 Evaluation of Potential Sites for Final Disposal (1)

... 1

Evaluation Items	MPPP				MPSP		
	Jelutong Area	Middle Bank	South-Eastern Sea Shore	Pantai Acheh	Kuala Muda	Kampong Selamat	Mak Mandin
1. Possibility of Land Acquisition	△	○	○	○	○	×	○
a. Land use restrictions	Nil	Nil	Nil	Nil	Nil	Nil	Nil
b. Land ownership	State	State	State	State	State, MPSP and Private	Private	MPSP
c. Necessity of compensation	Very high	Low	Nil	Nil	Low	High	Nil
d. Other considerations	Squatters	Fishermen	Nil	Nil	Two or three land owners	Around 100 land owners	Nil
2. Possibility of Getting Neighbouring Consensus	×	△	○	○	△	○	△
a. Necessity of neighbouring consensus	Very high	Low	Low	Low	High	Low	High
b. Necessity for "out of sight" measures	Very high	Fair	Fair	Low	High	Low	High
c. Necessity for isolation from noise, dust & odour measures	Very high	Low	Low	Low	High	Low	High
d. Other considerations	Residents & Squatters	Scenery & Fishermen	Factories	Nil	Residents & Fishermen	Residents	Residents
3. Compatibility with Regional Development Plans	×	△	×	○	○	×	△
a. Competitive development plan	※ CDD 21 & Others	Fishery development & others	PDC reclamation	Nil	Nil	FELCRA development	Sewage treatment plan
b. Conformity with the Structure Plan and land use plan	Poor	Fair	Poor	Good	Good	Poor	Fair
c. Direction of urbanization towards sites	Very rapid	Rapid	Rapid	Slow	Slow	Slow	Rapid
d. Other considerations	PDC & coastal road	Sewage treatment plan	PDC project under implementation	Nil	Nil	FELCRA project on implementation	Nil
4. Economic Feasibility	△	△	○	△	○	○	×
a. Location of site (distance from main waste generation area)(km)	2.5	3.0	10.0	35.0	20.0	25.0	2.0
b. Area of Site (ha)	92.0	> 200.0	NA	85.0	> 78.0	75.0	6.0
c. Life expectancy (years)	13.8	> 30.0	NA	12.8	> 14.3	13.7	1.1
d. Availability of covering earth	Import	Import	Import	Subsequent study	Subsequent study	Subsequent study	Subsequent study
e. Accessibility	Good	Poor	Good	Good	Fair	Fair	Good
f. Estimated cost of compensation	Very high (40 mill$)	Fair	Low	Nil	Low	High	Low
g. Availability of public services	Good	Poor	Good	Poor	Good	Fair	Good

※ CDD 21 ; Central District Development 21st

Evaluation Items	M P P P				M P S P		
	Jelutong Area	Middle Bank	South-Eastern Sea Shore	Pantai Acheh	Kuala Muda	Kampong Selamat	Mak Mandin
h. Present conditions of site (Land use, type of surface soil, depth of ground water)	Sea, sludge sedimentation and suface water	Sea, sea bed and surface water	Sea, sea bed and surface water	Unused lowlying land and marsh	Unused lowlying land, marsh and lagoon	Previous paddy field, sandy silt and no surface water	Unused lowlying land and partly reclaimed
i. Technical considerations	Sea area reclamation and drainage canal outlet	Sea area reclamation and access bridge	Sea area reclamation	Construction of surrounding bund	Partly sea area reclamation	Construction of surrounding bund	Construction of surrounding bund
j. Benefit of site upon completion	Very high	High	High	Fair	High	Low	High
5. Environmental Acceptability	×	×	△	△	△	×	△
a. Possibility of drinking water pollution	Nil	Nil	Nil	Nil	Nil	Nil	Nil
b. Impact by surface water pollution	Low	Low	Low	Low	Low	High	Fair
c. Impact of flooding	Low (If proper plan were prepared)	Nil	Low	Low	Low	Very high	Low
d. Impact by groundwater pollution	Low	Nil	Low	Low	Low	High	Fair
e. Distance from airport and other public facilities	Adequate	Adequate	Adequate in case of strict sanitary landfill	Adequate	Adequate	Adequate	Adequate
f. Distance from densely populated area	Adequate if proper measures were taken	Adequate	Adequate	Adequate	Adequate if buffer zone were prepared	Adequate	Adequate if buffer zone were prepared
g. Possibility of dust, noise and odour hazards	High	Low	Low	Low	Fair	Low	Fair
h. Compatibility with land use of adjacent area	Fair	Poor	Good	Fair	Fair	Good	Fair
i. Slope stability	Good	Good	Good	Good	Good	Good	Good
j. Impact on inshore or river fishery	Very high	High	High	Fair	Fair	Low	Fair
k. Impact on terrestrial vegetation and wildlife	Low	Low	Low	Further study	Further study	Low	Low
l. Impact on Aquatic/Marine flora and fauna	Fair	High	Fair	Further study	Further study	Low	Low
m. Impact on natural landscape	Low	Very high	Low	Fair	Fair	Low	Low
n. Impact on historic places or structures	Low	Low	Low	Low	Low	Low	Low
o. Impact on religious places or structures	Low	Low	Low	Low	Low	Low	Low

Table 3.3-4 Evaluation of Potential Sites for Final Disposal (2)

... 1

Evaluation Items	MPSP						
	Prai Barrage	Prai Industrial Complex	Bukit Minyak	Gajah Mati	Pulau Burong	Bukit Tambun	
1. Possibility of Land Acquisition	○	○	×	×	○	○	
a. Land use restrictions	Nil	Nil	Nil	Nil	Nil	Nil	
b. Land ownership	State	State	Private	Private	State	State	
c. Necessity of compensation	Low	Low	Very high	High	Nil	Nil	
d. Other considerations	Restaurants	Fisherman	Residents & land owners	Land owners	Nil	Nil	
2. Possibility of Getting Neighbouring Consensus	△	○	△	○	○	○	
a. Necessity of neighbouring consensus	High	Low	High	Low	Nil	Nil	
b. Necessity for "out of sight" measures	High	Fair	High	Low	Nil	Nil	
c. Necessity for isolation from noise, dust & odour measures	High	Low	High	Low	Nil	Nil	
d. Other considerations	Residents & Factories	Factories	Residents & farmers	Nil	Nil	Nil	
3. Compatibility with Regional Development Plans	×	×	△	△	○	×	
a. Competitive development plan	PDC Industrial development	PDC reclamation	Nil	Nil	Nil	Livestock development project & others	
b. Conformity with the Structure Plan and land use plan	Poor	Poor	Fair	Fair	Good	Poor	
c. Direction of urbanization towards sites	Very rapid	Rapid	Rapid	Slow	Slow	Slow	
d. Other considerations	MPSP park plan	Landscape from Penang Bridge	Coconut & pineapple plantations	Rubber plantation	Nil	Rehabilitation of drug abuser project	
4. Economic Feasibility	△	○	△	○	△	○	
a. Location of site (distance from main waste generation area)(km)	2.0	3.0	12.0	20.0	35.0	20.0	
b. Area of Site (ha)	18.0	35.0	35.0	> 40.0	> 35.0	39.0	
c. Life expectancy (years)	3.3	6.4	6.4	> 7.3	> 6.4	7.1	
d. Availability of covering earth	Import	Import	Subsequent study	On site	Subsequent study	Subsequent study	
e. Accessibility	Good	Good	Fair	Fair	Fair	Good	
f. Estimated cost of compensation	Low	Low	Very high	High	Nil	Nil	
g. Availability of public services	Good	Good	Good	Poor	Poor	Fair	

Evaluation Items	NPSP						
	Prai Barrage	Prai Industrial Complex	Bukit Minyak	Gajah Mati	Pulau Burong	Bukit Tambun	
h. Present conditions of site (Land use, type of surface soil, depth of ground water)	Previous river, river bed and surface water	Sea, sea bed and surface water	Plantation, sandy silt and no surface water	Plantation, loam and no surface water	Unused lowlying land marsh and little surface water	Lowlying land, bush and no surface water	
i. Technical considerations	River embankment and water area reclamation	Sea area reclamation	Construction of surrounding bund	Construction of enclosing embankment	Construction of surrounding bund	Construction of surrounding bund	
j. Benefit of site upon completion	Very high	High	Nil	Low	High	Low	
5. Environmental Acceptability	×	×	△	△	△	△	
a. Possibility of drinking water pollution	Nil	Nil	Nil	Nil	Nil	Nil	
b. Impact by surface water pollution	Fair	Low	Fair	High	Low	Low	
c. Impact of flooding	Fair	Low	Fair	Nil	Nil	Low	
d. Impact by groundwater pollution	Fair	Low	Fair	High	Low	Low	
e. Distance from airport and other public facilities	Adequate	Adequate	Adequate	Adequate	Adequate	Adequate	
f. Distance from densely populated area	Adequate if buffer zone were prepared	Adequate	Adequate	Adequate	Adequate	Adequate	
g. Possibility of dust, noise and odour hazards	Fair	Low	Fair	Nil	Nil	Nil	
h. Compatibility with land use of adjacent area	Fair	Good	Fair	Fair	Good	Good	
i. Slope stability	Good	Good	Good	Further study	Good	Good	
j. Impact on inshore or river fishery	High	Fair	Low	Low	Further study	Further study	
k. Impact on terrestrial vegetation and vildlife	High	High	Fair	Fair	Further study	Further study	
l. Impact on Aquatic/Marine flora and fauna	High	High	Low	Nil	Further study	Low	
m. Impact on natural landscape	High	Very high	Low	Low	Low	Low	
n. Impact on historic places or structures	Low	Low	Low	Low	Low	Low	
o. Impact on religious places or structures	Low	Low	Low	Low	Low	Low	

Table 3.3-5 Evaluation of Potential Sites for Incineration Plant

... 1

Evaluation Items	KPPP	KPSP					
	Free Trade Zone	Prai Industrial Complex	Permatang Pauh Disposal Site				
1. Possibility of Land Acquisition	○	○	×				
a. Land use restrictions	Nil	Nil	Nil				
b. Land ownership	State	State	KPSP				
c. Necessity of compensation	Nil	Nil	Nil				
d. Other considerations	Nil	Nil	Present disposal site				
2. Possibility of Getting Neighbouring Consensus	○	○	○				
a. Necessity of neighbouring consensus	Low	Low	Fair				
b. Necessity for "out of sight" measures	Low	Low	Low				
c. Necessity for isolation from noise, dust & odour measures	Fair	Fair	Fair				
d. Other considerations	Factories	Factories	Residents				
3. Compatibility with Regional Development Plans	○	○	○				
a. Competitive development plan	PDC reclamation	PDC reclamation	Sports complex				
b. Conformity with the Structure Plan and land use plan	Good	Good	Good				
c. Direction of urbanization towards sites	Rapid	Rapid	Rapid				
d. Other considerations	Nil	Nil	Nil				
4. Economic Feasibility	○	○	×				
a. Location of site (distance from main waste generation area) (km)	10.0	3.0	3.0				
b. Area of Site (ha)	2.2	2.0 (4.3) ※	2.0 (4.3) ※				
c. Proximity to recovered energy user	Good	Good	Fair				
d. Accessibility	Good	Good	Good				
e. Estimated cost of compensation	Nil	Nil	Nil				
f. Availability of public services	Good	Good	Good				
g. Present conditions of site (Land use, type of surface soil, depth of ground water)	Proposed reclaimed area	Proposed reclaimed area	Disposal site, waste and ash				

※ ( ) means in case of intermunicipal treatment.

Evaluation Items	K P P P	K P S P					
	Free Trade Zone	Pral Industrial Complex	Permatang Pauh Disposal Site				
h. Technical considerations	Height of chimney and foundation	Foundation	Soft foundation and gas explosion				
5. Environmental Acceptability	○	○	△				
a. Possibility of drinking water pollution	Nil	Nil	Nil				
b. Impact by surface water pollution	Nil	Nil	Nil				
c. Impact of flooding	Nil	Nil	Nil				
d. Impact by groundwater pollution	Nil	Nil	Nil				
e. Distance from airport and other public facilities	Adequate in case that height of chimney were designed properly	Adequate	Adequate				
f. Distance from densely populated area	Adequate	Adequate	Adequate				
g. Possibility of dust, noise and odour hazards	Low	Low	Fair				
h. Compatibility with land use of adjacent area	Good	Good	Good				
i. Land stability	Good	Good	Poor				
j. Impact on inshore or river fishery	Nil	Nil	Nil				
k. Impact on terrestrial vegetation and wildlife	Nil	Nil	Nil				
l. Impact on Aquatic/Marine flora and fauna	Nil	Nil	Nil				
m. Impact on natural landscape	Low	Low	Low				
n. Impact on historic places or structures	Low	Low	Low				
o. Impact on religious places or structures	Low	Low	Low				

Table 3.3-6 Evaluation of Potential Sites for Transfer Station

... 1

Evaluation Items	M P P P			M P S P			
	Jelutong Kole	Free Trade Zone	Balik Pulau	Mak Mandin	Permatang Pauh Disposal Site		
1. Possibility of Land Acquisition	○	○	△	○	×		
a. Land use restrictions	Nil	Nil	Nil	Nil	Nil		
b. Land ownership	State	State.	Private	MPSP	MPSP		
c. Necessity of compensation	Nil	Nil	Fair	Nil	Nil		
d. Other considerations	Nil	Nil	Nil	Nil	Present disposal site		
2. Possibility of Getting Neighbouring Consensus	○	○	○	○	○		
a. Necessity of neighbouring consensus	Low	Low	Low	Fair	Fair		
b. Necessity for "out of sight" measures	Low	Low	Low	Low	Low		
c. Necessity for isolation from noise, dust & odour measures	Fair	Fair	Fair	Fair	Fair		
d. Other considerations	Residents	Factories	Residents	Residents	Residents		
3. Compatibility with Regional Development Plans	△	○	○	○	○		
a. Competitive development plan	PDC development	PDC reclamation	Nil	Sewage treatment plan	Sports complex		
b. Conformity with the Structure Plan and land use plan	Good	Good	Good	Fair	Good		
c. Direction of urbanization towards sites	Rapid	Rapid	Slow	Rapid	Rapid		
d. Other considerations	Future land use of the area	Nil	Nil	Nil	Nil		
4. Economic Feasibility	△	○	○	○	△		
a. Location of site (distance from main waste generation area)(km)	2.5	10.0	1.0	2.0	3.0		
b. Area of Site (ha)	2.4	1.0	1.0	1.8	1.8		
c. Accessibility	Good	Good	Good	Good	Good		
d. Estimated cost of compensation	Nil	Nil	Fair	Nil	Nil		
e. Availability of public services	Good	Good	Good	Good	Good		
f. Present conditions of site (Land use, type of surface soil, depth of ground water)	Vacant land and previous disposal site	Proposed reclaimed area	Vacant land	Unused lowlying land and partly reclaimed	Disposal site, waste and ash		
g. Technical considerations	Soft foundation and gas removal	Impediment and acquisition of sea route	Nothing special	Foundation	Soft foundation & gas explosion		

Evaluation Items	M P P P			M P S P			
	Jelutong Mole	Free Trade Zone	Balik Pulau	Mak Mandin	Permatang Pauh Disposal Site		
5. Environmental Acceptability	△	○	○	○	△		
a. Possibility of drinking water pollution	Nil	Nil	Nil	Nil	Nil		
b. Impact by surface water pollution	Nil	Nil	Nil	Nil	Nil		
c. Impact of flooding	Nil	Nil	Nil	Nil	Nil		
d. Impact by groundwater pollution	Nil	Nil	Nil	Nil	Nil		
e. Distance from airport and other public facilities	Adequate	Adequate	Adequate	Adequate	Adequate		
f. Distance from densely populated area	Adequate if proper measure were done	Adequate	Adequate	Adequate	Adequate		
g. Possibility of dust, noise and odour hazards	High	Low	Fair	Fair	Fair		
h. Compatibility with land use of adjacent area	Fair	Good	Fair	Good	Good		
i. Land stability	Fair	Good	Good	Good	Poor		
j. Impact on inshore or river fishery	Nil	Fair	Nil	Nil	Nil		
k. Impact on terrestrial vegetation and wildlife	Nil	Nil	Nil	Nil	Nil		
l. Impact on Aquatic/Marine flora and fauna	Nil	Nil	Nil	Nil	Nil		
m. Impact on natural landscape	Low	Low	Low	Low	Low		
n. Impact on historic places or structures	Low	Low	Low	Low	Low		
o. Impact on religious places or structures	Low	Low	Low	Low	Low		

iii. South-Eastern Sea Shore in MPPP

- The PDC reclamation project on site is now in the implementation stage. It seems to be impossible to acquire land for a final disposal site in the project area.

iv. Kampong Selamat in MPSP

- The land is presently owned by about 100 farmers. This makes acquisition of the land very difficult.
- The site has been designated for agricultural development by FELCRA. The development work is scheduled to start this year.
- The site is a lowlying area and it way would as a regulation pond when Sungai Jarak overflows. Therefore, the landfill and reclamation of the site may induce impact of flood on other area along Sungai Jarak.

v. Mak Mandin in MPSP

- Total area available for a final disposal site is quite small (6 hectares). If all waste collected by MPSP were disposed of at the site, the life expectancy of the site is only 1.1 years.

vi. Prai Barrage in MPSP

- PDC has an industrial complex development plan on the site, and MPSP has a plan to use the site as a recreational park. Those plans seems to comform with the regional development more than the use as a final disposal site.
- The operation of final disposal on the site may give high impact on river fisher y,terrestrial vegetation, aquatic flora and natural landscape. These make it very difficult to get environmental acceptability.

vii. Prai Industrial Complex in MPSP

- PDC has the expansion plan of Prai Industrial Complex, and it will be implemented in near future.
- The disposal operation of the site will deteriorate the beautiful and attractive scenery from the Penang Bridge. Moreover, it may give high impact on terrestria l vegetation and marine flora and fauna.

viii. Bukit Minyak in MPSP

- At present the site is used as coconut and pineapple plantations and is owned by many private people. Even houses of the landowners are scattered in the site. It seems to be very difficult to acquire the land from them.

ix. Gajah Mati in MPSP

- Although the site has many advantages from the technical view points such as availability of covering soil at the site, it seems to be little benefit to acquire the land from private land owners who are presently using this site as rubber plantations. Since unfavourable aspects on the environmental acceptability can be cleared by proper measures in construction and operation of landfill site, it is recommended to use the site in case that the land acquisition is secured.

x. Bukit Tambun in MPSP

- The Penang State Veterinary Department has a livestock development plan on the site. The experimental pasture land has already been developed and its extension project is scheduled to commence in this year. There is also a rehabilitation facility plan for drug abuser. It seems to be difficult to share some of the area for final disposal in the same site.

b. Incineration plant

i . Permatang Pauh Disposal Site in MPSP

- The site is being used as a main disposal site in MPSP and there is no other site identified as the replacement of this site so far.
  It is impossible to construct an incineration plant in the waste landfill area.
- Since the site has been used as a main disposal site for many years, the waste layer has considerable thickness. The plant should take precautions against main problems related to completed landfill such as settlement and gas generation. It is not recommended to construct heavy structures like an incineration plant on such a weak and dangerous ground.

c. Transfer station

i . Permatang Pauh Disposal Site

- For the same reasons mentioned for an incineration plant, even if a transfer station is a lighter structure than it, it is not recommended to use the land as a transfer station.

(3) Selection of Candidate sites

Through the evaluation of potential site, some of the unsuitable sites are omitted and are described (2) of this section. The candidate sites for the alternative study for the Master Plan are selected as follows.

a. Final Disposal

- Pantai Acheh in MPPP
- Kuala Muda in MPSP
- Pulau Burong in MPSP

Note ;

As for Kuala Muda, there seems to be considerable difficulties on getting neighbouring consensus and on environmental acceptability because the site is in proximity to the fishery villages and part of it is a lagoon. With regards to the former aspect, it is necessary to confirm the possibility of getting neighbouring consensus from the residents and fishermen or to ensure the administrative consensus of bearing finacial burden for some compensation and construction cost of environmental protection measures before proceeding into the feasibility study.

As for the latter aspects, the impact on inshore fishery, terrestrial vegetation and wildlife is to be studied further.

b. Incineration Plant

- Free Trade Zone in MPPP
- Prai Industrial Complex in MPPP

c. Transfer Station

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

4. Previous Study and Relevant Project

4.1 Master plan on SWM of MPPP

(1). Brief Description of Report (Dangroop Report)

As the previous study on solid waste management that was implemented in the Study area, a proposal that was submitted by Dangroup in September, 1986 is considered. The outline is summarized below.

a. This report is a pilot feasibility study of a masterplan for solid waste management in Majlis Perbandaran Pulau Pinang (MPPP).

b. The total generation of solid waste (not including from mining, construction and agriculture) in Penang Island (1985) is summarized in Tab.4.1-1 and the quantities termed, key-figures for solid waste generation, are shown in Tab.4.1-2

Tab.4.1-1 Generation of solid waste on Penang Island, 1985.

Origin	1985	Processable Waste
Households	75,800 tons *1	100%
Trade and services	50,600 tons *1	80%
Industries	5,300 tons *2	50%
Bulky waste	10,000 tons *2	20%
Total	141,700 tons	85%

Notes :

*1 Registered amount at the weighbridge in Kampung Jawa.

*2 Estimated amount of direct haul to Jelutong landfill site.

Tab.4.1-2: Key-figures, Solid Waste generation, Penang.

Household waste	145 kg/capita/year
Trade and services	500 kg/employee/year
Industries	115 kg/employee/year
Bulky waste	20 kg/capita/year
Total	270 kg/capita/year

c. Estimated solid waste generation in Penang State (in 1985 and 2000) are shown in Tab.4.1-3 and assumption is made about 85% of waste could be processable in the incinerating plant.

Tab.4.1-3: Estimate of solid waste generation in Penang State.

	1985 $\times 10^3$ tons	2000 $\times 10^3$ tons
Penang Island Seberang Perai	141.7 113.0	206.9 163.9
Total	254.7	370.8
Processable	216.5	315.2

d. According to the composition data of solid waste analized in 1980, an assumption of water content as to 60%, average calorific value of processable waste is assumed to be 1500 kcal/kg. But this figure has not been verified during the study, so, the comfirmation by further investigation have to be done.

e. This study examines four models; A through D, as shown below. (Tab. 4.1-4)

Tab. 4.1-4 Definition of model A, B, C and D

Service Area	Incineration and Sanitary Landfill	Solely Sanitary Landfill
penang Island, MPPP	Model A	Model B*
Penang State, MPPP and MPSP	Model C*	Model D*

Notes: The model marked with * contains the installation of transfer station.

For these four models, the scale of the incineration plant, transfer station and the scale of the landfill were examined, and a candidate sites for each facility were proposed for each model. (Tab. 4.1-5)

f. Tab.4.1-6 shows the cost calculation of the incineration plant that are included in the model A and C. In this table, yearly energy production, electricity production cost ($/kwh), competitive cost which will be obtained from oil firing boiler/turbine-generator (fuel cost only), etc, . are shown.

g. For the four models through A to D, the initial investment cost, total average cost per annum, expected income and yearly average cost ($/ton), etc. are summarized in Tab.4.1-7

h. Conclusion and recommendation;

- The conclusion of this report is that the cheapest alternative of solid waste masterplan for Penang Island is direct disposal of all solid waste at a controlled landfill and that the total cost per ton waste introducing incineration with power production will increase; from 66$ per ton (collection) + 16$ per ton (transportation

and disposal) = 82$
to 66$ per ton (collection) + 27$ per ton (together with incineration) = 93$.

- This increase equals approximately 15%, which will tend to decrease with increasing oil prices or shortage of electricity. The benefits of this increased expenditure are environmental protection, technology transfer, 40-50 new jobs and energy savings.

- From a strictly economic point of view it is recommended to establish a controlled or sanitary landfill as soon as possible, and if a sufficient landfill area can be found, to make this the only solid waste plant in the future solid waste management system.

- Although incineration is the only acceptable solution on long-term basis, many examinations as well as a more detailed economic evaluation of the project will be necessary.

Tab.4.1-5 Scale of Facilities and Candidate Sites for each Models.

	MPPP		MPPP + MPSP	
	Model A	Model B	Model C	Model D
Total Solid Waste Generation(t/d) *1	388t/d---1985 (567t/d---2000)		698t/d---1985 (1015t/d---2000)	
a. Incineration Plant	380t/d *2 (2x8t/h/unit) *3	---	690t/d *2 (3x10t/h/unit) *3	---
[Candidate Site]	Bayan Lepas Free trade zone	---	Perai Industrial Area	---
b. Transfer Station	--	65t/h *4	65t/h	65t/h
[Candidate Site]	--	Kampung Jawa	Kampung Jawa or	

			Jelutong Reclamation Area	
c. Area of Landfill Site [Candidate Site]	20 ha	80 ha	35 ha	145 ha
	South or West Coast		South of Bridge in MPSP	
Average Volume/ year *5	70,000 m^3	270,000 m^3	120,000 m^3	480,000 m^3
Total Volume in 15 years	$10X10^6$ m^3	$4X10^6$ m^3	$1.8X10^6$ m^3	$7.2X10^6$ m^3

Remarks:

*1. Total amount of wastes are obtained from Tab. 4.1-3

*2. Scale of incineration plant is planned for processable wastes.

*3. Future extention of one unit at each location is concerned, (in the period of 1990-2000).

*4. Transfer station is capable of 400t/d wastes in 6 to 6.5 hrs' operation. Future extention is also concerned.

*5. Landfill volumes per ton after compaction and daily covering with soil are assumed to ;

1 ton processable waste 1.6m^3

1 ton non-processable waste 1.2m^3

1 ton processable waste (after incineration) 0.2m^3

Tab. 4.1-6 Capital & Operational Cost, Incineration Plant with Power Generation

(Price Level in 1986)

	MPPP	MPPP + MPSP
	Model A	Model C
Capacity of Incinerator	380 t/d (2x8t/h/Unit)	690 t/d (3x10 t/h/Unit)
Total Capital Cost ($)	55,000 x 10^3	90,800 x 10^3
Total Operation Cost ($)	2,560 x 10^3	4,170 x 10^3
Amortization, pay back (for 20 years)	4,050 x 10^3	6,680 x 10^3
Sub Total ($)	6,610 x 10^3	10,850 x 10^3
Energy Production per year*1	28,200 Mwh	53,000 Mwh
Electricity Production Cost by Incinerator	0.23 ($/kwh)	0.20 ($/kwh)
(Potential Revenue) *2	(0.14) ($/kwh)	(0.14) ($/kwh)

Remarks:

*1. These figures show surplus energy available to be sold.

*2. Potential revenue ($/kwh) means competitive electricity cost obtained from oil firing boiler/turbine-generator. (oil prices only).

Tab.4.1-7 Comparison of 4 Models

	MPPP		MPPP+MPSP	
	Model A	Model B	Model C	Model D
(1) Initial Investment Cost ($\times 10^3$ \$)				
Incineration Plant	55,000	———	90,800	———
Landfill	575	1,500	945	2,555
Transfer Station	———	4,300	4,300	4,300
Total	55,575	5,800	95,045	6,855
(2) Total Average Cost Per Annual ($\times 10^3$ \$) for 20 years				
Capital / Running	Capital / Running	Capital / Running	Capital / Running	Capital / Running
Incineration	4,050 / 2,560	— / —	6,680 / 4,170	— / —
Landfill	240 / 180	780 / 390	390 / 300	1,330 / 660
Transfer Station	— / —	320 / 520	320 / 520	320 / 520
Transport MPPP	— / 770	— / 360	— / 380	— / 360
	4,290 / 3,510	1,100 / 1,270	7,390 / 5,370	1,650 / 1,540
Total Cost	7,800	2,370	12,760	3,190
Income *1	3,900	———	7,300	———
Net Cost	3,900	2,370	5,460	3,190
(3) Yearly Average Cost Per ton for MPPP (\$)*2				
Capital / Running	30/24	7/9	29/23	7/9
Total Cost	54	16	52	16
Income	27	———	27	———
Net Cost	27	16	25	16

Note :

*1 Unit price of electricity salable is estimated as to 0.14\$/kw.

*2 Yearly average costs in Model C & D are calculated for MPPP under assumption that the Transfer Station is owned by MPPP and that all other expenditures except transportation costs are split between MPPP and MPSP proportional to amount of vaste delivered.

(2). Comments

After the review of Dangroup Report, it is suggested that reconsideration and further study shall be done on the following points.

a. Quality of refuse

For both MPPP and MPSP, an estimate is made on a calculation basis in which water content is 60% and refuse calorific value is 1500 kcal/kg. It is a matter of course, there values shall be reconsidered according to the waste composition analysis now under way.

b. Incineration with power generation

In the report presented, electric power generated per ton of refuse is estimated higher and power consumption of plant is assumed lower than the values which considered necessary in normal operation. Therefore, the figure of surplus electricity seems to be estimated higher.

Higher rate of power generation is usually obtained in the case of water cooled vacuum condencing turbine system usually used in commercial power plants. But, as already shown in the examination it is found that this system has some problems, for example, higher construction cost of water intake facility, higher maintenance cost, and difficulty for the selection of possible plant sites,etc.

Taking these factors into consideration, as an alternative, we now propose an air cooled condencing system which may be slightly lower in power generation, but has several advantages, such as simple construction, low plant cost, and free from locating restrictions.

c. Income by selling of electric power

The unit prices of surplus electric power given in the reports are different and unclear.
(0.05 $/ ... Klang Valley Report, 0.14 $/ ...Dangroup Report)
The income by selling of superfluous power is a very important factor having a great effect on refuse disposal cost. Therefore, before drawing up an estimate, it is suggested to

confirm the possibillty of acception of surplus power and the purchase price, which shall be defined by NEB Head Office.
(The purchase unit price will be variable according to the value of surplus power evaluated by NEB. The value depends on plant reliability, rate of operation, quality of generated power (fluctuation of power being generated), construction costs of high-tension power transmission cable which vary with locating conditions, and other factors).

d. Construction cost

In this report, the construction cost is estimated at 145×10^3 - 126×10^3 $ (at plant capacity of 380 - 720 t/d), but breakdown of the construction cost is not presented. At present, it remains unclear how much money is considered for pollution control system, automatization, stabilization of power supply, etc. Based on data of Southeast Asian countries, it is now essential to reconsider the costs, concerning the availability of local materials and equipment.

4.2 Structure Plan of MPPP

(1) General

The local Planning authority of MPPP publicized the Draft Structure Plan of MPPP in September 1987 following the enforcement of the Town and Country Planning Act/1976 by the State of Penang in 1985.

Nest step will be "Consideration and hearing of public objections".
The goal of the Penang Island Structure Plan is "To Maintain and improve the social, economic and physical well-being of the community in Penang Island by ensuring an environment conductive for living, working and playing.

Subjects described in the Structure Plan are housing, industry, commence and services, tourism, agriculture, community facilities, recreational amenities, public utilities, environmental quality, transportation urban form, townscape and landscape, bumiputra participation, and finance and organization.

Points of direct concern to solid waste management are as follows;

- Required number of housing unit for every year is 3,300 in average
- The amount of land required for housing until the year 2000 is about 1,300 hectares
- For industrial purposes the overall amount of land required by the year 2000 will be bout 262 hectares
- Future industrial activities shall be located within designated areas such as in Jalan Brick Kiln, Jalan Sungai Pinang, Jalan Sungai, Jalan Lines, Jalan Jelutong, Bayan Lepas and Bayan Baru.
- It is estimated that the total commercial building floor space required by the year 2000 will be about 1.20 million m. Bayan Baru and Tanjung Tokong shall be sub-regional centres.

- The western part of the Penang Island is envisaged to be maintained as an agricultural belt of the island.

- The MPPP shall continue in its effort to maintain and improve its quality of service of solid waste disposal and management. Ways in which this to be done include:

  i) Close monitoring and supervision of the work of the "Collectors" and contract labourers to ensure a higher standard of cleanliness;

  ii) Proper dumping of rubbish, spraying of insecticides, land filling, and bunding at the dumping site to prevent the unsanitary conditions, water ponding, smell and pollution of the sea;

  iii) Continuous stringent enforcement of Section 47 of the Street, Drainage and Building Act, 1974, to prevent the indiscrimination throwing of rubbish by the public in public places;

  iv) Ensuring that households and firms put their rubbish in proper bags and bins for easier collection and a cleaner environment;

  v) Regularly conducting public education programmes to instill civic-mindedness and clean habits into the public;

  vi) Continuing to examine better and more modern ways of solid waste disposal and management to improve efficiency and cut down cost;

  vii) Cooperating with the Department of Environment to monitor the discharge of toxic wastes from industries.

(2) Survey Report of Structure Plan on Solid Waste Disposal and Management of MPPP

Survey report is part of the structure plan of MPPP; No. 14 study report "Public Utilities Study" which describes on solid waste management in MPPP. This study was carried out in September 1983 to 1984 and situation of that time reflects to this report. The situation of that time is described as follows;

"Solid waste disposal and management in the island is generally recognized as in adequate. Littering is still a common occurrence and its omnipresence is quite often taken for granted. Litter and much larger waste are disposed of into drains, rivers, sea, etc. with ease and without any conscience. Certain areas are affected more intensely than others and such areas are marked by strong offensive smell."

"Disposal methods in operation at the Jelutong Mole Tip Site was far from satisfactory even though dumping is the main form of solid waste disposal in Penang Island."

"During the initial period of study, problems faced by Conwaste (PP) Sdn. Bhd. were given publicity in the Press. Basically, the problems were the inefficient services provided and the inappropriateness of the system to our narrow streets in parts of the city."

Based on the above mentioned situation, this report mainly concerns to the immediate improvement plan and recommendations. After the study, situation of solid waste management was changed in many ways and bring a drastic improvement in following manner.

a. Almost all of refuse collection is contracted out to private companies. Refuse collection methods is mainly by side-loader system which is one of a single handling system. Some municipal officers say that contractor basically provide a good service at present except a few problems.

b. Present final disposal site is Baku street dumping site located beside the Jelutong Mole which was expected to last until 2000 and but is closed already.

c. Estimated waste amount in 2000 was 140,000 ton/year, which is about same as in 1987. Actually because of rapid increase of waste amount and due to improvement of collection service, the result of forecast does not suit the present situation and a revisition on it is necessary.

This survey report recommends to improve the solid waste management immediately on monitoring of waste amount and composition, disposal site, enforcement and control. Some of recommendation were conducted as follows.

a. Monitoring

- Waste amount	A weighbridge with recording machine was installed in May, 1987 at the entrance of the present disposal site
- Waste composition	There were no studies after 1980

b. Disposal

The following facilities were recommended

- Fence and gate	No fence and gate
- Weighbridge station with recording	A weighbridge was installed
- Tree and shrub	No tree and shrub
- A bank between sea and site	No bank
- Covering	In 1987, about 10,000 ton/year of red earth and quarry remaining was used for covering the solid waste

d. Enforcement and control

- Education through campaigns, etc.	Not executed
- Educating through strict enforcement of anti-litter low	Not executed

There are Issues consisting of 4 points which will be studied.

a. New methods will have to be found if the cost is to be reduced. Separation of different types of rubbish at the source of generation, and recycling may be some of the solution.

b. New sites or other methods of waste disposal, such as incineration, will have to be found.

c. The land filling method of waste disposal along the coast if poorly done is a source of pollution to the sea.

d. There have been high occurrence of indiscriminate dumping of rubbish into open drains, streams, vacant land and the sea. And also the often indifferent attitudes of the public in leaving all responsibility for rubbish disposal and cleansing to the MPPP, without involving themselves, does not work well towards the improvement of the environment.

4.3 Development Plan (Structure Plan) of MPSP

Currently Report of Survey of MPSP is in publicity. Public representation will be made by the middle of March 1988. Structure Plan is expected to be ready in few months time.

General recommendations in the Report of Survey are:

- To balance developments among towns and settlements by upgrading less developed towns and settlements.

- Distribution of basic facilities, educational opportunities and government services to settlements.

Items directly related to solid waste treatment are:

Waste collection and disposal
Problem and main issues

a. Present dumping grounds are swamps and unsuitable for use. Suitable sites are difficult to get due to high cost of land and limited choices.

b. Currently there is only one dumping ground in the study area thus causing high transportation cost and inefficiency in service.

c. Crude dumping method is unsuitable and not encouraged. To have proper controlled tipping requires large quantities of earth and this is costly.

d. Natural flat terrain of the study area has made it difficult for proper drainage system. High water table causes disposal by trenching though not practical.

e. No proper or specified site for toxic waste disposal.

f. Attitude of people who lacks in gygiene conscious.

g. Industrial waste discharged into drains are dangerous as these wastes may be toxic to water life.

As recommendations it says:

a. New dumping grounds should be provided to cater the refuse from every district. Site selection should be based on guidelines set by DOE other than those practised by MPSP.

b. Recycling or salvaging re-usable materials should be studied for review by MPSP for further action.

c. Centralized toxic waste disposal system including complete disposal facilities should be provided to serve the industries in Penang state.

d. A waste disposal system that does not pollute and modernise street cleaning should be prepared to cater for future needs.

e. Waste discharged from industries into central sewers should be treated properly.

f. MPSP should consider the usage of incinerator for waste. It seems a suitable long term investment.

4.4 Klang Valley Environmental Improvement Project

This report was prepared by Engineering Science Inc. and SEATEC International for the Klang Valley environmental improvement project, in April 1987 (6). The intermediate treatment facilities described in Chapter 5 "Solid Waste Management" are outlined below.

(1)General

The current solid waste collection situation in each type of area in the Klang Valley District is assessed as follows.

Urban Areas	generally satisfactory
Rural Areas/New Villages	improvement required
Traditional Kampongs	solid waste is usually burnt in the vicinity, causing air pollution
Squatting Areas	collection is only partially conducted and most of the solid waste is either illegally dumped in the river or on neighouring public sites

Apart from use of the Shah Alam disposal site, the final disposal method employed in the district is unsanitary open dumping. Improvement of this situation is the most crucial problem for the district.

The solid waste amount forecast was made on the basis of the following assumptions. As the table below shows, unit generation rates were assumed for the categories of domestic, commercial, market and industrial waste and changes in these unit rates were assumed for the future. However, in the case of industrial waste, a unit rate of 0.20kg/capita/day was used as the basic rate but was adjusted for special conditions in certain areas based on public policies with respect to the location of heavy industries in the Klang valley

Unit Generation Rate by Year (kg/c/d)

	1985	1990	1995	2000	2005
Domestic Waste	0.50	0.53	0.55	0.58	0.60
Commercial Waste	0.25	0.26	0.27	0.29	0.30
Market Waste	0.15	0.13	0.12	0.11	0.10
Industrial Waste	0.20 or special rate adopted				

The introduction of an efficient system which assigns multiple collection routes with priority orders to each crew and which can cope with the absence of drivers and/or collection workers is proposed so that improved, regular collections can be implemented.

With regard to the intermediate treatment method, both the composting and incineration methods have been rejected on the grounds that there is no suitable market for compost and that the incineration treatment cost is five or six times higher than that of sanitary landfill.

It is concluded that the sanitary landfill system with the construction of 3 sanitary landfill sites and transfer haulage is the best alternative. The most critical problem in the promotion of the Project, however, it is the difficulty of securing these sanitary landfill sites.

The federal government should, therefore, be adequately compensated for the use of its public land by the regional disposal organizations, irrespective of these organizations being public or private. Compensation can be negotiated in several ways and may include, for example, any or all of the following.

- Rental fees paid by regional disposal organizations for their use of public land for the period used as landfill sites.

- Concessionary rates for the disposal of solid waste for those areas in which regional landfill sites are located.

- Establishment of a sinking fund to ensure that enough money is available once filling is completed to undertake the landscaping of the landfill sites for whatever purpose decided by the federal government, including open recreational areas, public parks, sports facilities and housing or industrial complexes, etc.

(2) Composting

For composting, its background or previous study is not described.

As a comment on introduction of the compost system into the Klang Valley Project, the report describes :

Composting is not considered to be a feasible alternative for the present and in the immediate future because it will result in an insufficient treatment and it is hard to obtain a sufficient market.

(3) Incineration

—Technically, there are there types of incineration ; (1) Mass incineration, (2) Refuse derived fuel, and (3) Pyrolysis.

In terms of technical reliability and stability, mass incineration is only the successful application.

—In application of incineration in the Klang Valley :

The calorific value of waste in Klang Valley is 3315 Btu/lb(approximately 1,800 Kcal/kg). As to obtain 243 kwh/ton/day power, the followings were calculated for two alternatives, 250 tons/day and 500 tons/day.

- Capital cost
- Operation and maintenance cost
- Amortization of capital
- Revenue from electricity.

As a result it is reported that the treatment cost per ton is M$45/ton for the 500 tons/day plant.

This cost is much higher than the solely sanitary landfill cost.

Should the capital cost be halfed, the treatment cost would be M$18 per ton, and total cost is to be M$ /ton which is still more expensive than that of the solely sanitary landfill cost M$ /ton.

—Conclusively, the incinerator requires a high cost, so it cannot be recommended as the solid waste management

program for the Klang Valley area at present.
This conclusion, however, should be examined in future because factors such as the waste quality, energy cost, etc. may change.

(4) Material Recovery

In lieu of the scavenging practice that is currently performed in the landfill site, a simple method is proposed that collects the salvageable materials on the belt conveyor by hand picking.
For realization of this method, the market size, quality, price, and market stability should be evaluated for each salvageable material. After the pilot test, prototype system should be designed and constructed.

(5) Transfer Station

Relating of the long-distance haul from urban area to the expected new landfill site, cost evaluation between direct haul and transfer haul was examined under the several assumptions, such as the scale of transfer station, size of vehicle, and distance of haul, etc.

4.5. The Incineration Plant in Kuala Terengganu

4.5.1. General

(1) Outline of Visit and Plant

a. Date of Survey

12th July 88 - Plant Survey
13th July 88 - Meeting with Kuala Trengganu Officers

b. Information obtained are:

a. Proposal document of suppliers
b. Present situation confirmed through site observation
c. Informations obtained through discussion

c. Information not available are :

- Specification drawings, operation manual electrical control sequence diagram, etc

- Operation record (daily or monthly)
  eg. . treated amount of wastes
  . electricity generated
  . data related to environmental nuisance, such as air pollution

- Record charts on gas temperature, generated steam amount, etc

There are no documents except aforementioned in (2)a, and these materials have not been handed over to the officers at the Kuala Trengganu City Council. No technical training on plant operation has been given by supplier.

In this case, all information related to this plant are very limited, and not disclosed.

d. Grade of Mechanization/Automation :

- Handling of waste:- By a shovel loader
- Sorting out of bulky or incombustible waste:- Manually
- Control:- Automatic controllers are mounted to incinerator and waste heat boiler (W.H.B.). The automatic controllers were however, under adjustment.

e. Countermeasures of Pollution :

- There are no dust collector, no deodourizer, no waste water treatment equipment, and no silencers

f. Environmental condition and claims by inhabitants :

Only several factories are located around the incinerator plant, and no claim has arised.

g. Power Generation :

During the period of 2-months at full operation, electricity generated by steam-turbine generator was for in-plant use, but, selling of the excess electricity to NEB (National Electricity Board) was not implemented yet.

h. Construction of Facility :

The site was selected in 1986. Construction work lasted 15 months, before completion in July 1987.

Plant Cost - $6.5 Million
(1.2 Million - Civil Works)
(5.3 Million - Mechanical & Electrical and Assembly Works)

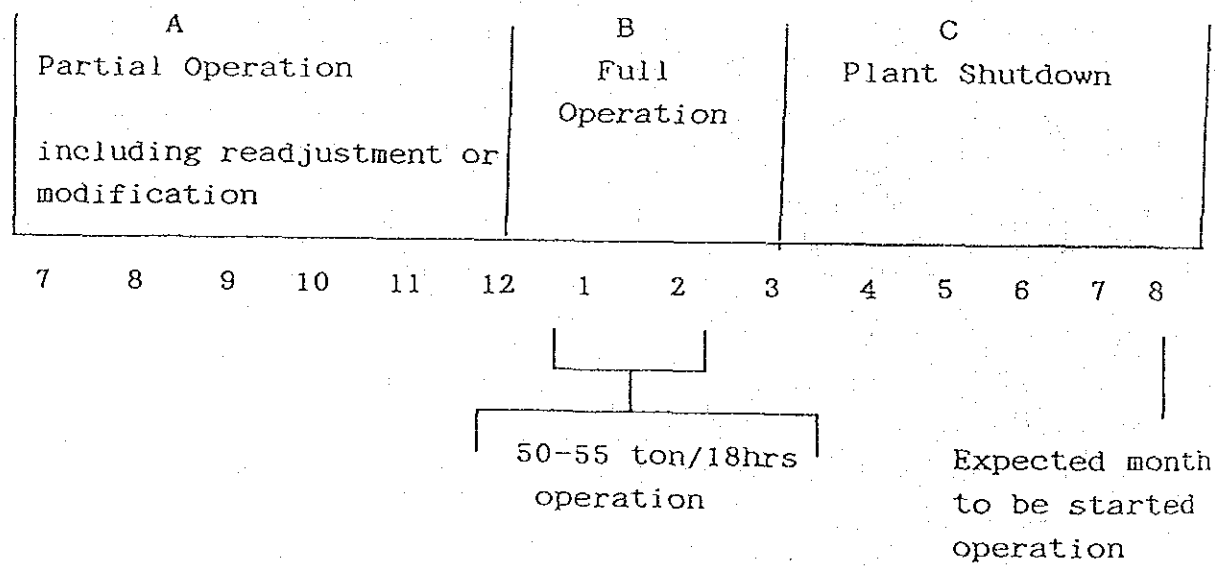
2. Purpose of Incinerator Project and Construction Progress

- A 40 acres landfill site is available for the disposal of municipal waste. Its life expectancy is about 20 years even if all raw waste are disposed at this site.

- The reason why the incineration plant had to be introduced is that present landfill site was initially planned for temporary use, therefore only hygenically incinerated ash was allowed to be disposed off at the site under the request of nearby residents.
- According to the repayment schedule of the investment, it will be possible to expect revenue of $750,000 per year by selling excess electricity to the NEB.
- Progress of incinerator project are as follows:-
  - 1982 commencement of feasibility study
  - 1985 materialization of construction plans
  - 1986 commencement of construction work
  - 1987 (July) completion of incineration plant

  After completion of the plant, the engineering department of MPKT has been engaged in the operation.

3. Record of Plant Operation



a. Duration of Partial (ON-OFF) Operation (about 6 months)
   - Above shown Period A

After completion of the plant, trial operations were done partially. In this stage, the plant was shut down several times due to readjustment or modifications.

b. Full Operation Period (about 2 months)
   - Above shown Period B

In January and February 1988, full operation was relatively successful.

. Amount of waste incinerated was 50 - 55 tons/day

. Operation hours was 18 hours/day or less

c. Duration of Plant Shut-down (about 5 Months)

- Shown above in Period C

- Whole plant is now being shut-down due to several kinds of failure.

- It is said that the worst problems are due to damage of inverter and failure of the automatic control system. Recommencement of plant operation is expected in August, 1988.

4. Process flow of plant

Process flow initially proposed and furnished by contractor is as shown in Fig.4.5-1 however, some parts (marked *) has already been replaced to improve the system during the trial operation period in order to assure more stable operation.
Replacements done are:

* Belt transfer:- replaced by apron conveyor system

* Screw conveyor:- replaced by hydraulic ram-feeder system.

* Ash screw conveyor:- replaced by scraper conveyor system

* Shredding machine:- relocation of the shredder to allow easy delivery of shredded waste.

5. Constituent and Rough-Specification of the Plant

Since no drawings are available, 3 drawings are prepared through physical observation of the plant. Fig. 4,5-2, 3, 4 each shows a Schematic Flow of the Incineration Plant, Skeleton Diagram of Steam & Electricity, and the Approximate Plant Layout.

Major facilities and equipment are as follows.

a. Refuse feeding & ash discharger

- At the refuse reception yard, bulky waste and incombustible waste (ferrous or non-ferrous metals) are sorted-out manually. Wastes are then pushed into the receiving hopper of apron conveyor by a shovel loader.

- Incinerated ash obtained from the end of the rotary-kiln is discharged to a container, then disposed at landfill site.

b. Incinerator

- Capacity: 90 tons/24 hours*
- Type: Rotary Furnace Pyrolitic Incinerator Model 8 x 36
- Manufacturer: Bumi Enercon Sdn Bhd, Malaysia
  Licencee of U.E.I. (Universal Energy International (Incorporation), USA)

*Note : It is said that the Kuala Trengganu plant has a capacity of 100 tons/24 hours but the proposal submitted to the Kuala Trengganu City Council states that the capacity of this plant is 90 ton/24 hours.

c. Secondary Combustion Chamber

- Stationary, Cyclone Type with inner castable refractory lining.

d. Waste Heat Boiler

- Type: 2-drum type water tube boiler
- Manufacturer: IBAE (International Boiler & Allied Equipment), Malaysia
- Specification
  - . Evaporation 27,000 lb/h
  - . Pressure 250 psi
  - . Steam temperature about 270 ° c
  - . Exit gas temperature 258 ° c

e. Steam Turbine/Generator (With Reduction Gear)

- Steam Turbine (imported from West Germany)
  - . Maximum output 1700 kw
  - . Normal output 1579 kw

- Steam Condition

  - . Inlet pressure 22 Bar. abs
  - . Inlet temperature 270 ° c
  - . Exhaust pressure 0.25 Bar. abs

- Generator (imported from West Germany)
  - . Capacity 1,500 kw, 1,875 KVA
  - . Voltage 400 volts

f. Diesel Alternator (imported from France)

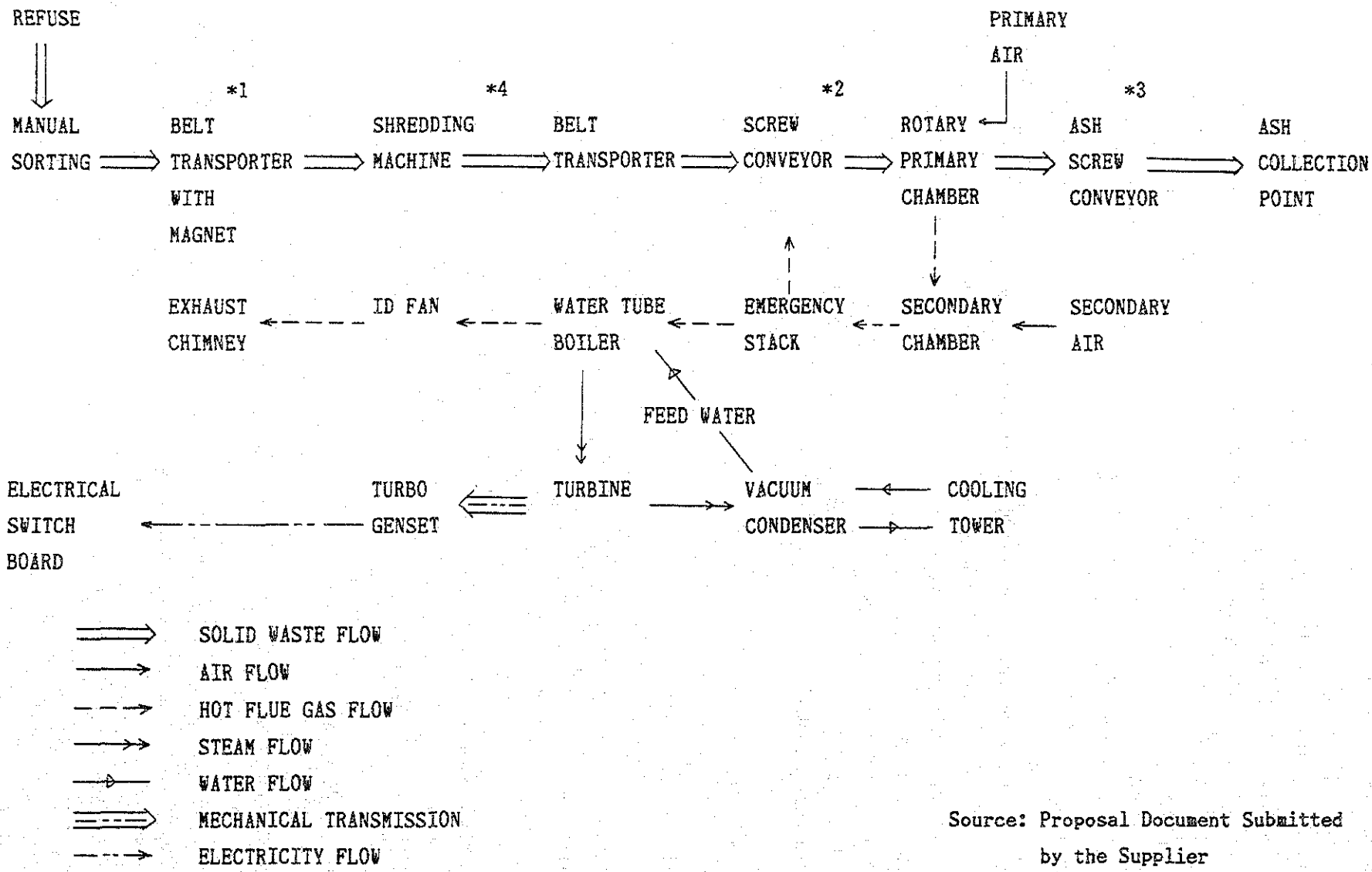
- Capacity 268 kw (335 KVA)

g. Steam condenser (Maiaysian made)

- Type Air-cooled Condenser with assist of water spray

h. Boiler Feed Water Treatment System
Deaerator, water purifier etc. are provided.

i. Waste Water Treatment System
All are not provided.



Source: Proposal Document Submitted by the Supplier

Fig. 4.5-1 Process Flow Chart of 1.5MW Incineration Plant for KUALA TERENGGANU MUNICIPALITY

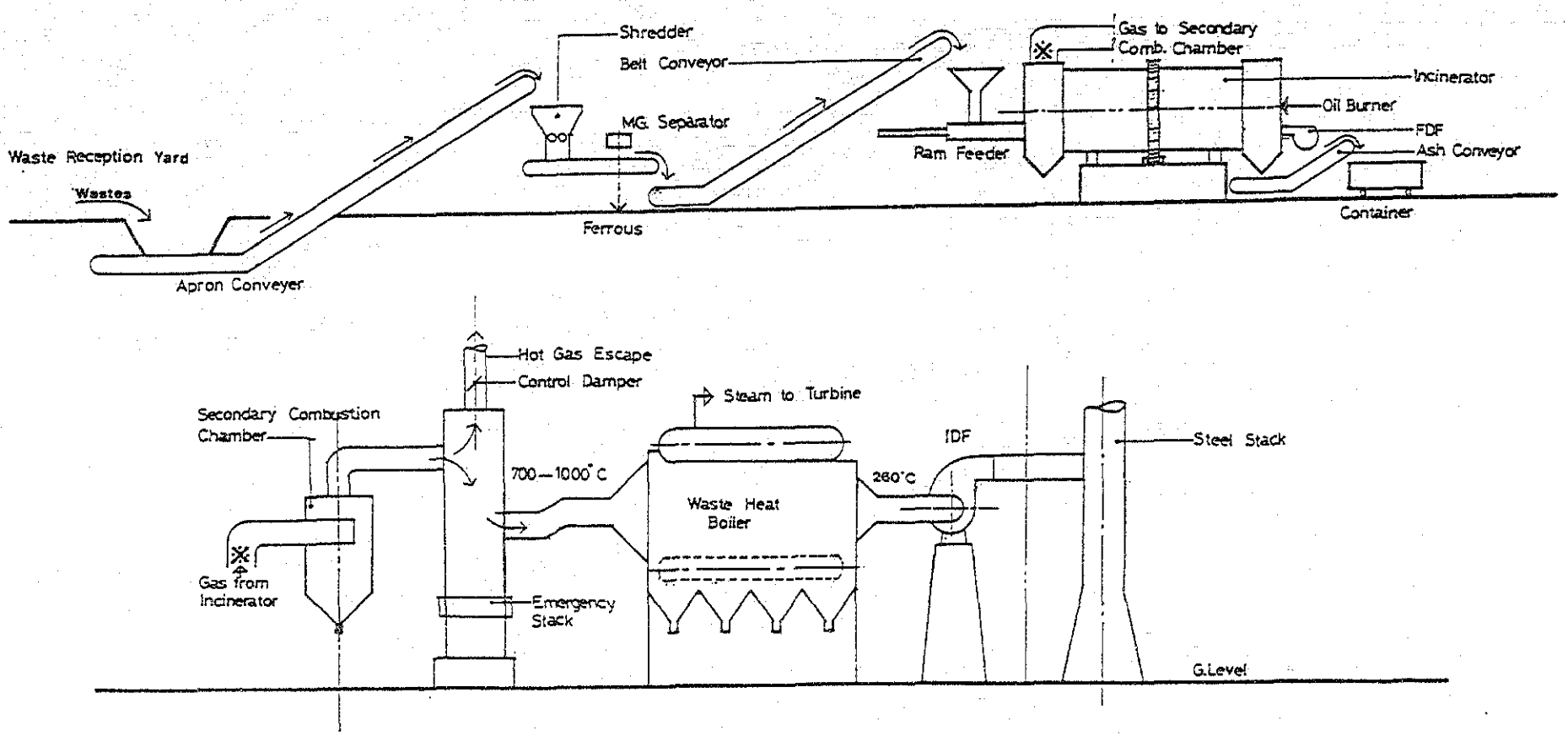
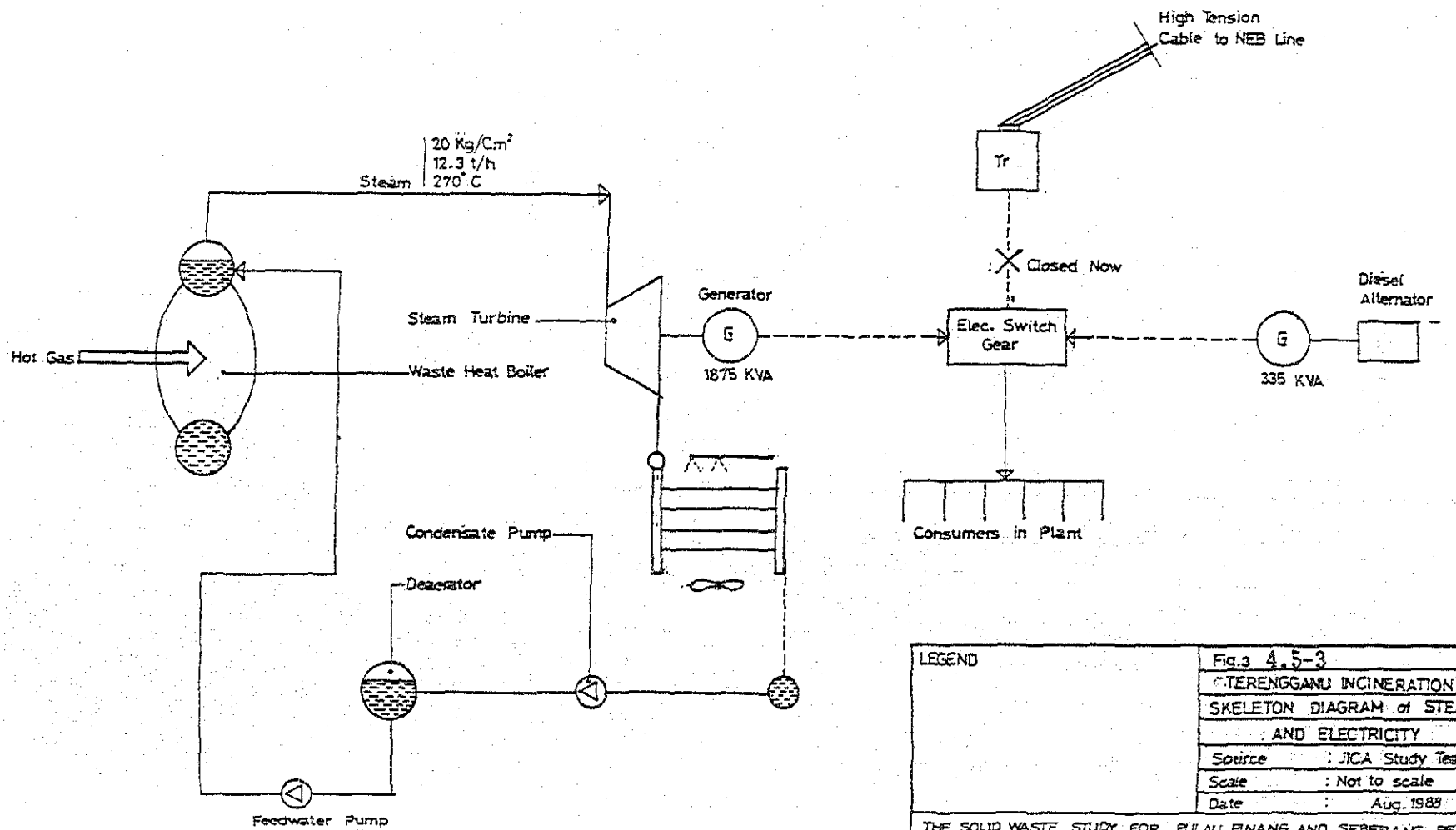


Fig.4.5-2 SCHEMATIC FLOW OF INCINERATION PLANT

LEGEND	Fig .4.5-2
	TERENGGANU INCINERATION PLANT
	SCHEMATIC FLOW of PLANT
	Source : JICA Study Team
	Scale : Not to scale
	Date : Aug. 1988
THE SOLID WASTE MANAGEMENT STUDY FOR P.PINANG & S.PERAI	

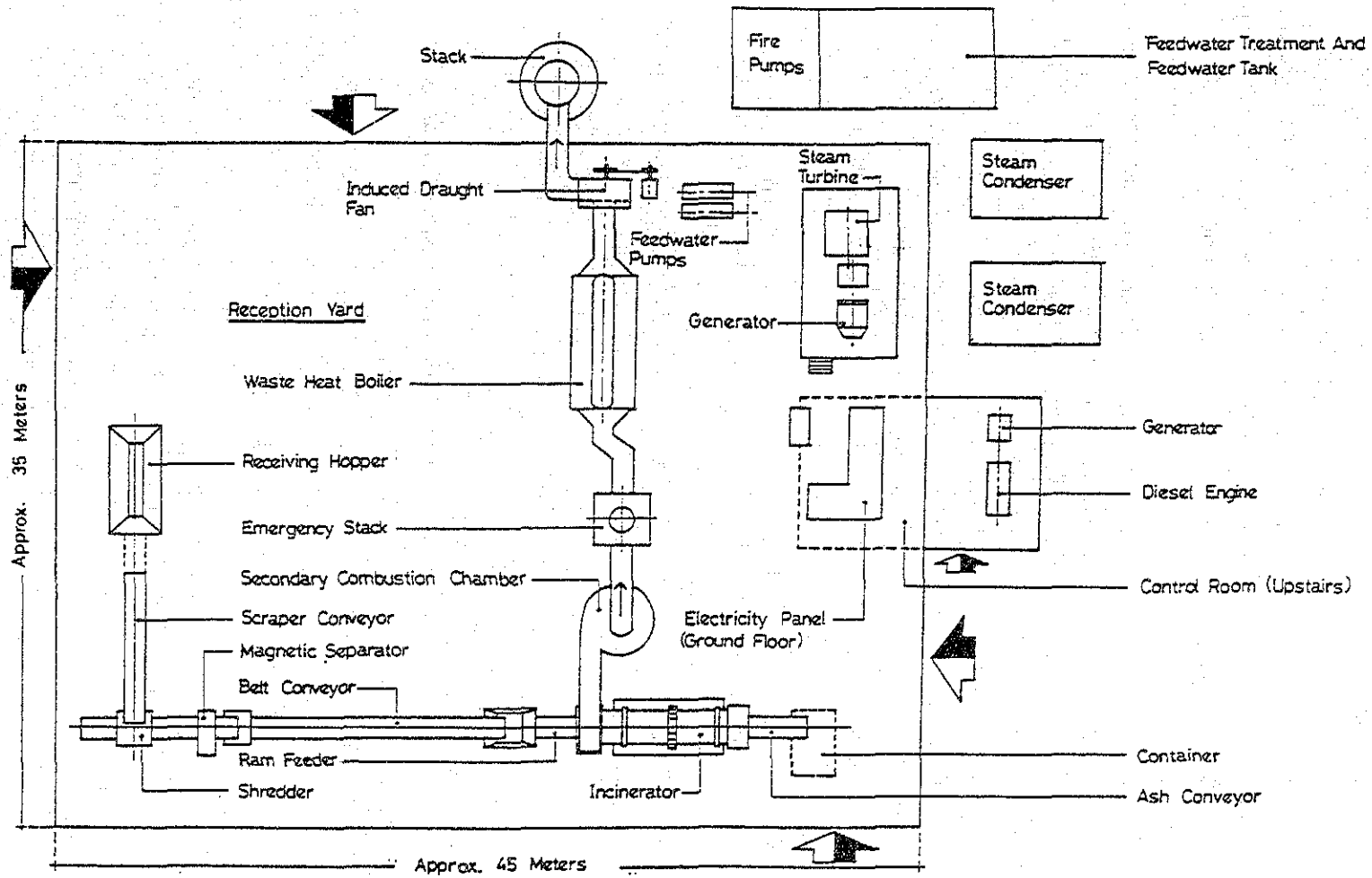
Fig.4.5-3 SKELETON DIAGRAM OF STEAM & ELECTRICITY



LEGEND

Fig.3 4.5-3
TERENGGANU INCINERATION PLT.
SKELETON DIAGRAM of STEAM
AND ELECTRICITY
Source : JICA Study Team
Scale : Not to scale
Date : Aug. 1988

THE SOLID WASTE STUDY FOR PULAU PINANG AND SEBERANG PERAI



LEGEND	FIG. 4.5-4
	SOURCE : JICA Study Team
	SCALE :
	DATE :
THE SOLID WASTE MANAGEMENT STUDY FOR PULAU PINANG AND SEBERANG PERAI	

Fig.4.5-4 PLANT LAYOUT of TERENGGANU INCINERATION PLANT

4.5.2. Problems and Recommendation

(1) Related to the Contract

(a) All useful references, such as, specification of the plant, detailed drawings, operation manuals, etc., were not handed over to the Municipality. Therefore, it seems that operators will not be able to do anything during plant failure.

(b) Prior to the commencement of operation, training or technical transfer to the plant operators has to be given by the supplier, but the complete training has not been done yet.

(c) Due to frequent plant failure, expected revenue obtainable from sale of surplus electricity is still not available.

(2) Related to technical points

(a) Reception and feeding of waste

i) As for receiving and feeding of wastes, originally, pit and crane system is most recommended. Present plant has been planned and constructed cost wise, which has several problems such as:
   (1) Diffusing odour
   (2) Unhygienic and unsafe working condition
   (3) Easily corroded electrical parts due to dusty and humid environment.

ii) Supposing if this feeder system is still to be utilized, some revision will have to be made to assure continuous and stable operation.
   1) modification of apron conveyor - much wider and stronger.
   2) modification of shredder - bigger and stronger type with higher power.
   3) modification of belt conveyor - wider and thicker belt, and a measure to avoid spillage of waste.

Incinerator

i) According to the proposal document submitted by supplier, this incinerator is designed as "Starved air pyrolizing combustion system". Since only poor primary air is introduced into the furnace (rotary kiln) in this type of combustion, the ash obtained from the incinerator-end still contains large amount of carbonaceous object similar to charcoal.
Therefore, compared to conventional mass burning stoker system, this incinerator in Kuala Trengganu has lower combustior efficiency, higher ignition loss, and much more amount of residue which results to poor volume-reduction rate.

ii) Check-up or examination onto the shape and dimension of waste feeder chute and ram feeder in order to avoid the clogging and to allow continuous waste feeding. These dimensions seem to be too small.

iii) Related to electricity generation

Currently, for starting up operations, the diesel alternator set has to be operated daily, and this consumes engine fuel everyday. To save expenditure and for easy plant operation, it is recommended that electricity should be allowed to be freely delivered or freely consumed.

iv) Evaporation Control System

Emergency stack is provided before the entrance of waste heat boiler, and, it seems that there are several disadvantages that exist on the steam generation control system.

- Energy losses to the atmosphere
- Possibility of fire around the plant
- Possibility of air pollution
- Poor control (existance of time-lag)

It is recommended that the energy available from waste would be recovered perfectly by not using such kind of emergency escape stack.

4.5.3 Questions and Answers

List of questions to and answers from the MPKT officer are as follows.

(1) Plan and Specification

- Drawings including flow sheet and plant layout (plan & elevation)
  . Not available upon request.

- Amount and types of waste
  . Incinerator capacity: 100 ton/24 hours *
  . Type of waste: Municipal solid waste.

- Specification of plant
  . The exact specification is not available except for brief description submitted by supplier during proposal stage.

- Procedures needed for the plant construction
  . Closed tender system

- Contractor, manufacturer and period of construction
  . Contractor: Bumi Enercon Sdn. Bhd.
  . Manufacturer of incinerator: -ditto-
  . Manufacturer of W.H.B: IBAE
  . Others: refer to page described in this report

* It is claimed that the plant has 100 ton/day capacity but proposal document states its capacity as 90 tons/24 hours.

(2) Construction and Operation & Maintenance Cost

- Construction cost with the following breakdown
  . Civil Work: $1.2 million
  . Mechanical & Electrical Work: $5.3 million
  (installation included but not including spare parts)

Total Cost: $6.5 million

- Operation & Maintenance cost
  - .Operation Costs: $13,000/month
  - .Maintenace: $130,000/yr
  - (Breakdown is not available)

(3) Operation

- Record of treated waste amount (daily and monthly)
  - . No record is available
  - . January/February 1988, 50-55 tons of waste was treated daily (in 18 hours/day or less)

- Waste composition
  - . There is only a data sheet that has analyzed by a UK consultant (G.I.E.) in 1983, as shown below. In monsoon season, more than 70 % of moisture content will exist.

REFUSE ANALYSIS

Date	19 October 1983
Refuse Condition	Dry, two days old
Weather Conditions	Slight rain
Total weight of sample	900 kg
Total volume of sample	3.5cu yds/2.67cu m
Area	Tekukur, Belakang Naza, Lorong Datok Bakar

CONSTITUENT	WEIGHT-kg	WEIGHT-%	VOLUME CU FT	VOLUME %
Vegetable/putrescible	596	66%	41	43.5%
Paper	98	11%	21	22.0%
Plastic	31	3.5%	12	13.0%
Metal	103	11.5%	16	17.0%
Glass	62	1%	3	3.0%
Textiles	10	1%	1.5	1.5%
Cinder	-	-	-	-
Unclassified	-	-	-	-
	900	100%	94.5	100%

DENSITY = 257 kg/cu yd or 337 kg/cubic meter

- Daily or monthly operational records on amounts of generated steam which include hourly incinerated waste amount.
  . No record is available

- Generated power, power consumption, auxiliary fuel consumption, etc.
  . No record is available

- Actual measured data of dust content in flue gas
  . No data is available because there is no measuring device but it passed inspection by D.O.E.

- Data on repairing and maintenance work
  eg:. Major parts which were overhauled
  . Cost of the overhaul
  . Maintenance system
  . Tender procedure
  Details are not available due to the partial and irregular operation.

- Stock of spare parts
  . Almost no spare parts are furnished by supplier.

(4) Organization, Revenue and Expenditure for Incineration Plant

- Organization(s) responsible for operation
  . Mechanical Engineering Department, MPKT

- Number of personnel according to work category

  . 1 Mechanical Engineer (university graduate)
  . 2 Technical Assistants (diploma level)
  . 3 Electrical Chargemen
  . 3 Boiler Operators
  . 6 Mechanical Fitters
  .12 General Laborers
  . 1 Weighbridge Operator

  Total:28 (3 shift operation)

- Planned revenue and expenditure

Expected income	$750,000/year
Maintenance	$130,000/year
Operation	$156,000/year

- Training and education programs of personnel
  . No training and education received

(5) Others

-Comments on the possible modifications for improvement

. They are now considering the following improvement plans:-
  - For reception, storage, drying and feeding of waste, additional reception yard with roof and another one stream of conveyor system have to be prepared.
  - Use of saw mill waste as a supplementary fuel is being considered.
  - Installation of larger and stronger shredder with effective separator.
  - Injection of waste oil and/or waste liquid is under consideration.
  - Employing consultant for the operation of plant might be necessary.

- Comments on generation of electricity

According to the contract with NEB, surplus electricity generated from the plant can be sold to NEB with unit price of:-

$0.14 /kWh for peak hour (14hours/day)
$0.05 /kWh for off-peak hour (10 hours/day)

- Enviromental issues
  . No claims has arisen in this stage.

4.6 Technical Information on Waste Treatment and Disposal in Singapore

4.6.1 General Condition

(1) Preface:

It is considered that it will be good reference to recognise the present situation of waste treatment currently practiced in a developing country in South Easte Asia.

With this objective in mind, we have chosen Singapore as an example.

The following are technical information summaried, according to the available references and other materials.

Information as shown below include:-

- General condition of waste treatment in Singapore
- Amount of waste and their treatment
- Brief information of facilities
- Responsible organization
- Technical information on Tuas incineration plant and Kim Chuan transfer station

(2) General condition of Waste Treatment in Singapore

a. Area and Population

- Land area	approx 581 km^2
- Total Population	2,550,000
- Density of Persons	approx 4400 persons per km^2

b. Waste Quantity

In 1985, 918,000 tons of municipal waste was collected by the Ministry of Environment (MOE) and 580,400 tons of industrial and commercial waste was collected by private sectors, giving

an approximate sum of 1.5 million tons of waste collection that year.

Trend of annual waste generation is as shown in Fig.4.6-1

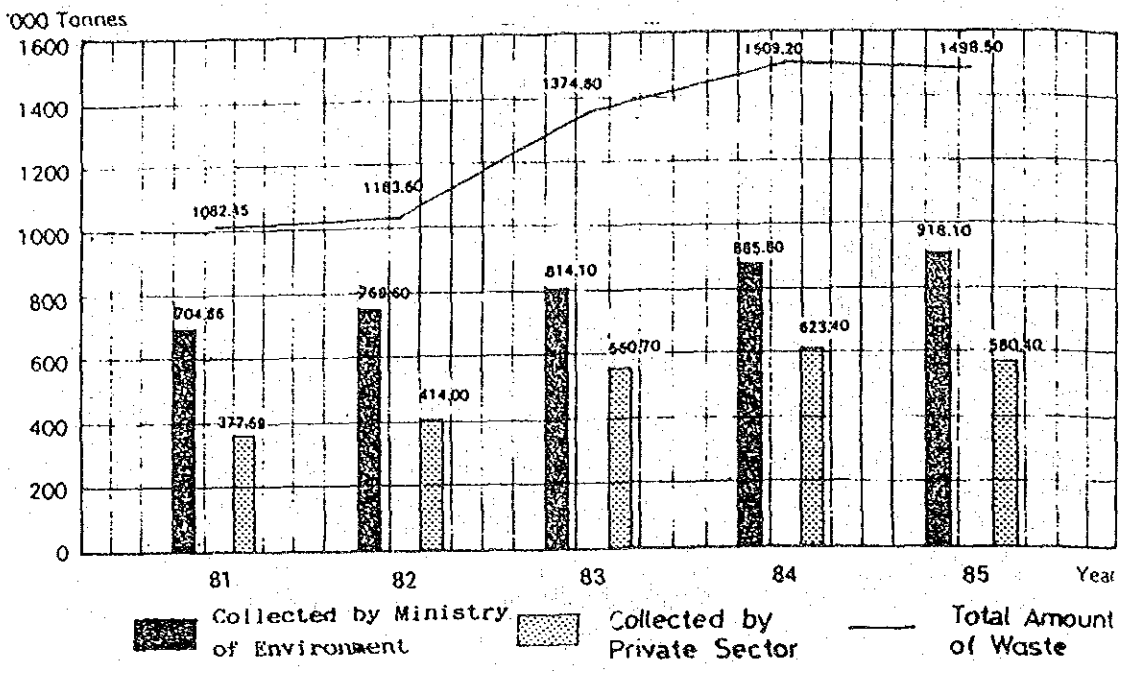


Fig.4.6-1 Trend of annual Waste Generation

(3) Brief Information of Facilities

a. Incineration Facilities

Currently there are two incineration plants operating in Singapore. i.e. Ulu Pandan incineration plant which has a capacity of 1,600 tonnes per day, and the other is the new Tuas incineration plant which is capable of incinerating 2,760 tonns of waste per day.

Following these plants, construction plant for a third incineration plant at Senoko is now proceeding. After completion of the Senoko plant, it is expected that all waste generated in Singapore will be incinerated perfectly.

b. Composting Facility

A miror amount of the waste, (less than 4,000 tones in 1985), was treated in a composting plant which is situated in Tou Tak Road near Ulu Pandan district. It is said that the capacity of the plant is only based on a pilot scale.
Management and operation is being done by private company

c. Transfer Station

Due to the constraint on site availability for an incineration plant, to execute economical and effective transport of waste from the eastern part of the island to Tuas incineration plant, Kim Chuan transfer station which has the capacity of 1500 tonnes per day, was built so as to meet the time of completion of that incinerator.

d. Landfill Facilities

There are two landfill facilities; one is at Lorong Halus and the other is at Lim Chu Kang. The quantity of waste includind incinerated ash disposed off to these sites in 1985 were 604,500 tonnes and 363,800 tonnes, respectively.

According to another source of information, further extension of works at Lorong Halus fill was contracted and is now under way.

Lcation of the above mentioned facilities are shown in Fig.4.6-2.

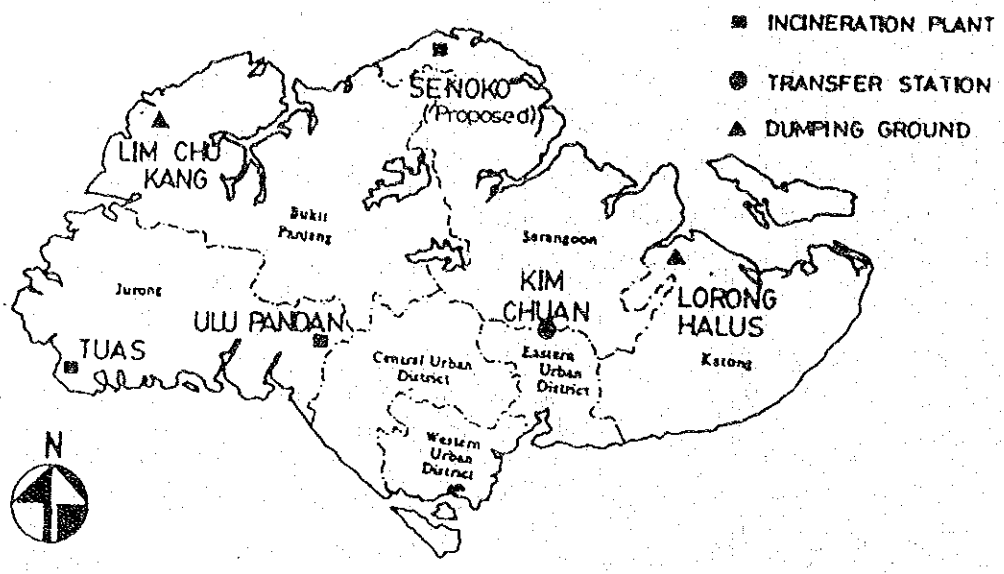
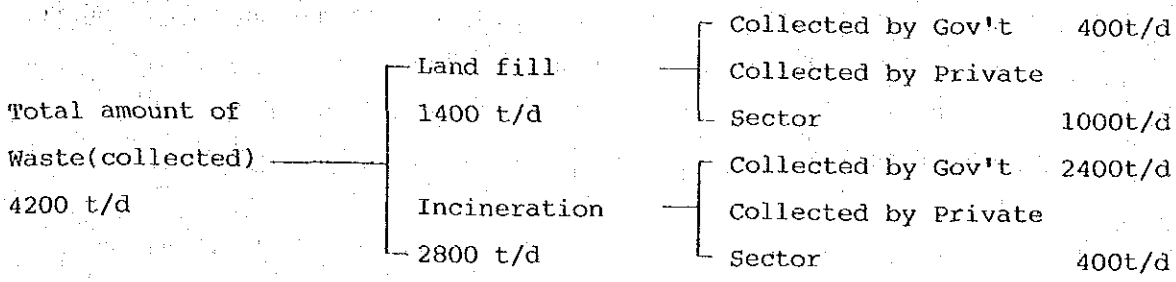


Fig.4.6-2: Location of Incineration Plants, Transfer Station and Landfill Sites.

(4) Quantity of waste and Treatment

Amount of waste collected and treated or disposed of are approximately as stated below:-



(5) Organization for Waste treatment

Organization who shares waste treatment responsibilities belongs to the Ministry of Environment (MOE).

Technical matters related to waste treatment are executed by the Environmental Engineering Division. This division has three departments and one unit as listed below:-

- Sewage Department
- Drainage Department
- Engineering Services Department
- Anti Pollution Unit

Particularly, the Engineering Services Department as shown above, has the following responsibilities:

- Plans and develops refuse disposal facilities.
- Operates the refuse incineration plant.
- Provides engineering services for environmental and public health projects.
- Maintains the Ministry's fleet of vehicles.
- Calls tenders and processes the contracts.

4.6.2 Incineration Plant

(1) Tuas Incineration Plant

Following the construction of Ulu Pandan incineration plant, Tuas incineration plant was completed in 1986. Information regarding the incineration plant are summarized below:-

a. General Outline

i.	Design Capacity	2760 tons/day
ii.	Average Throughput	2000 tons/day (365 days)
iii.	Owner	Ministry of Environment, The Government of Singapore
Construction Schedule		M & E contract concluded Nov 83 Field construction started Sep 84 Plant ready for testing Jul 86 Completion of work Oct 86
iv.	Consultant	Fichtner Consulting Engineers, West Germany
v.	Plant Manufacturer	Mitsubishi Heavy Industries, Ltd
vi.	Type of Contract	Turnkey Basis
vii.	Total cost	Approx S$ 220 Million
viii.	Site Area	Approx 6.4 ha

b. Refuse combustion

i.	Type of system	: Mass-burning with water wall boilers
ii.	Operation	: 24 hours per day, 7 days per week
iii.	Calorific value of refuse	: 1720 (Min) 2580 (Ave) 3440 (Max) tu/lb
iv.	Process lines	: 5 x 552 tons per day
v.	Plant daily capacity	: 2760 tons
vi.	Average Throughput	: 2000 tons per day (365 days)
vii.	Feed system	: Overhead refuse cranes
viii.	Grate design	: Martin type Reverse-Active Stoker Grate
ix.	Waste volume reduction	: 90 %

x. Material Recovered : Ferrous materials

c. Air Pollution Control

i.	Type of equipment	: Dry lime injection system with Electrostatic Precipitator
ii.	Dust removal efficiency	99.75 %
iii.	HCL removal efficiency	85 %
iv.	Height of stack	150 m tall

d. Energy Production

i.	Type of energy	Electric power
ii.	Steam flow to turbine	115.2 tons per hour per unit (35 bar/390 C)
iii.	Electric-power generator capacity	23 MW x 2 & surplus electricity is sold to PUB (Public Utilities Board)

e. Control & Monitoring

i.	Type of control	Direct digital control

f, Incineration Process

i. Process chart of the plant is as shown in Fig. 4.6-3

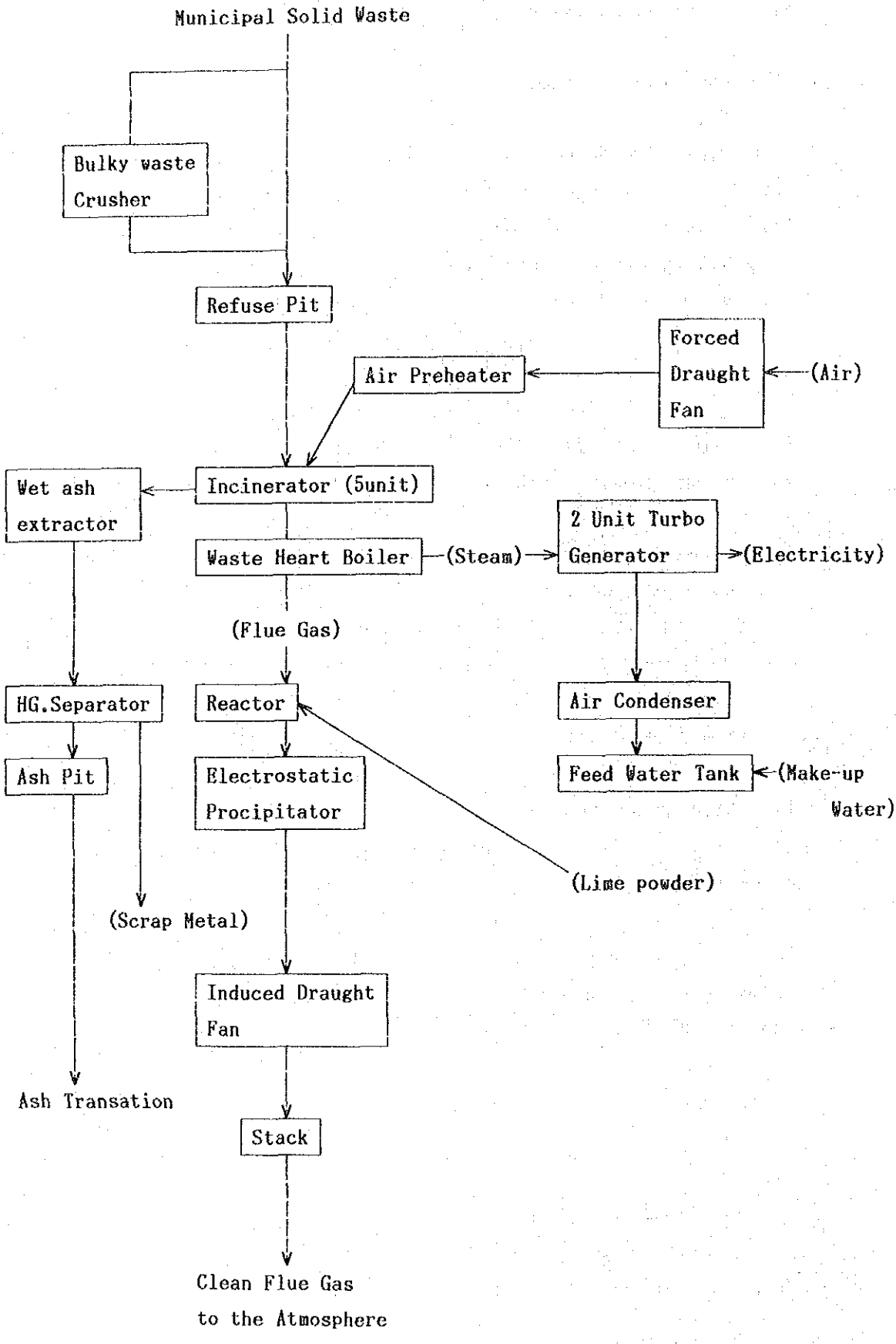


Fig. 4.6-3 Process Chart of Tuas Incineration Plant

g. Quality of Waste

i. An example of average waste composition is as shown below.

	Weight (%)
Garbage	47.56
Textile Leather	2.38
Paper	22.99
Wood, Cardboard	7.07
Plastic	12.37
Metal (Ferrous)	3.31
Metal (Non Ferrous)	0.56
Glass	3.12
Ceramic	0.64
Others	
Water Content %	53.18
In-combustible %	12.96
Combustible %	33.86

(August 1985 Data)

4.6.3 Kim Chuan Refuse Transfer Station

(1) Brief description of the plant

According to the brochure published by the Engineering Service Department of DOE, outline of Kim Chuan Transfer Station is introduced as follows:-

Kim Chuan Transfer Station (KCTS) is the first refuse transfer station built in Singapore. The station was built in 1986, on a 2.5 ha site at Kim Chuan Road.

Due to height constraints, the two incineration plants have to be sited away from the eastern part od Singapore. Without a transfer station, refuse collection vehicles from the eastern sector would have to travel considerable distances to dispose of their loads at the Tuas Incineration Plant. This would result in the need for more refuse collection vehicles and consequently increase in fuel consumption and manpower to man the vehicles. Consequently, KCTS was constructed to overcome these problems.

The Transfer Station is designed to handle 1,500 tonnes of refuse a day. Refuse collection vehicles dispose of their loads into one of six compaction units where the refuse is compacted and loaded into 20-tonne capacity container-trailers which transport it to the Tuas Incineration Plant. Each container-trailer is able to take the load of 3 to 4 refuse collection vehicles, thus saving manpower and operation cost.

KCTS was built at a cost of about $30 million.
Schematic Diagram of Refuse Transfer Operation is as shown in Fig. 4.6-4.

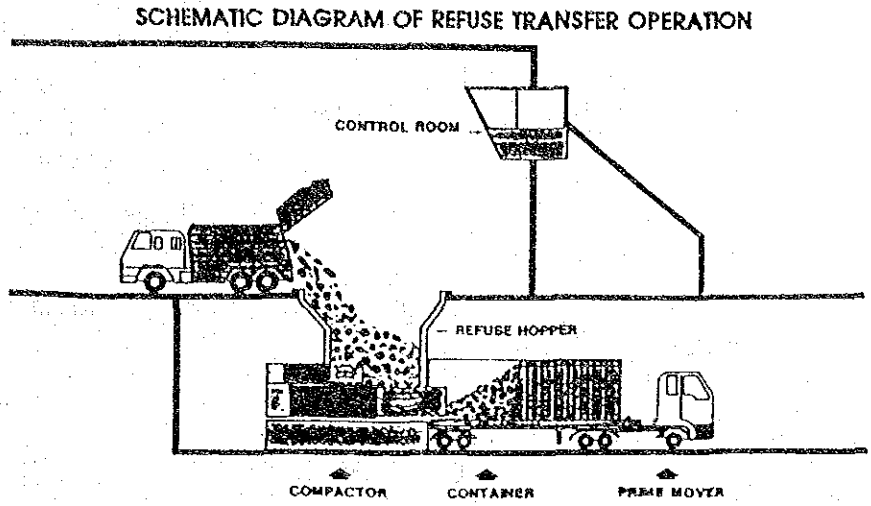


Fig.4.6-4 SCHEMATIC DIAGRAM OF REFUSE TRANSFER OPERATION

(2) Details on this Station Design

i.	Completion of Plant	Sep. 1986
ii.	Plant Cost	approx S$ 30 million
iii.	Station Capacity	1500 tons/day
iv.	Handling Capacity during peak hour	280 tons/day
v.	Peak refuse vehicle incoming rate	70 vehicles/hour
vi.	Refuse vehicle discharge time	6 minutes
vii.	Average time of vehicles in the station	8 minutes

(3) Major Equipment

a. Refuse Handling

i. 2 weighbridges of 40 tonnes capacity
ii. 6 compaction units (500m^3/each)

b. Transportation

i. 40 prime movers of 40 tonnes GCW
ii. 60 container-trailers of 20 tonnes payload
iii. 4 station prime movers

(4) List of contractors

	Name of contractor	Contract Sum(S$)
Civil and Building Works	Sembawang Construction Pte Ltd.	11,887,130
Refuse Compaction and Transfer Equipment	Mitsubishi Corporation	16,973,000
Weighbridges	SAC (Pte) Ltd	350,732
Total		29,210,862

(5) Function and Operation of Plant

Refuse collection vehicles are first weighed at the weighbridges before they are permitted to discharge the refuse into the hopper of one of the compaction units.

A station prime mover positions an empty container-trailer next to the compaction unit. The container-trailer is then coupled and locked onto the compaction unit by the operator in the control room and the compactor then fills the container.

The weight of refuse is monitored by the operator. When a load of 20 tonnes is reached, the contailer is uncoupled from compactor. High pressure water jets flush the tailgate of the container to get rid of possible remnants of refuse outside the container. The flush water is discharged into the sewer.

A station prime mover moves the loaded container-trailer to the parking yard. Subsequently, a prime mover tows the container-trailer to Tuas Incineration Plant.

Air from the reception hall and compaction area is extracted and passed through bag filters and an activated carbon columnto remove dust and adour.

An automated vehicle washing system has been installed to wash the vehicles. To reduce consumption of water, the wash water is recycled and rain water is used.

References :-

1. Annual Report 1985, by Ministry of the Environment, Singapore

2. Kim Chuan Transfer Station by Engineering Services Department, Ministry of the Environment

3. Report on cleansing Activity in Singapore, by Shouich Hayami, JICA Expert of HDB singapore, July 1986

4. Catalogne of Tuas Incineration Plant, by MHI

5. Papers presented in the conference of JSME Dec. 1986

5. Estimation of Future Conditions

5.1 Priority Operational Area

(1) Definitions of Priority Operational Area

Priority Operational Areas is difired as the areas to be provided cleansing service at the target year 2005.

It is not practical to provide the same level of services to households which are isolated and remote from an agglomeration of a town considering limited amount of resources and time, although the Operational area of Penang State covers the entire area of the state. The Priority Operational Area should cover urban area 1 towns and village which have high population density. It is also acceptable in the low population density area that residents dispose of their waste themselves according to the manner guided by the municipality.

(2) The Priority Operational Area in MPPP

In MPPP 55% of the land is 30 meters above sea level and at the same time the slope is steeper than 5%. Most of the agglomerations of population are in the flat land along the coast of east and north of the island. In the west there are towns of Sungai Pinanag, Balik Pulau, Pekan Genting, Pulau Butung, Kg. Bakar Kapur, Teruk Kumba and Gertak Sanggul.

Population of these agglomerations covers more the 93% of the total population of MPPP in 1985. and are provided cleansing service at present. In future it is assumed to cover more than 97% of the total population of MPPP. Therefore, these area are the Priority Operational Area of MPPP for the solid waste management.

(3) The Priority Operational Area in MPSP

In South district there are towns and agglomerations of Nibong Tebal, Sungai Bakap, Permatang Tok Mahat, Sungai Kecil, Tasek, Kampung Besar, Changkat and

Bukit Tambun. The population is 11,239 in these towns and 29,369 in the surrounding areas. 48% of the total population of South district is within the agglomeration areas. The population density of the agglomeration areas is 24 persons/ha, while 2 persons/ha in the rest of the district.

As a whole, the population within the agglomeration areas in MPSP is 357,236, which is 70% of the total population of MPSP. This agglomeration area is regarded as the priority operational area. Population density within the priority operation area is 28 persons/ha, while 2.5 persons/ha in the rest of MPSP.

It is assumed that the tendency of organization with population concentration towards built-up areas will continue in future as it is now in Penang state. Accordingly, the population concentration in the priority operation area, which is 70% in 1985, is assumed to be 85% in 2005 for this Study.

Fig. 4.1-1 shows the area of priority operational area. Table 4.1.4 shows the population composition within this area.

Municipality of Seberang Perai is approximately 51 km long in north south direction and approximately 18 km wide in east west direction. The area of municipality is as wide as 738 km2. North east arterial road runs through the middle of the municipality like a spine. Along this arterial road the agglomerations of population are scattered. In MPSP there are 32 towns and surrounding agglomerations of population. Topography of MPSP is flat except a hilly area of Bukit Mertajam. The municipality is divided into approximately equal size of three districts, i.e. North district (262 km2), Central district (235 km2) and South districts (241 km2).

In North district there are towns and agglomerations of Butterworth, Kepala Batas, Tasek Gelugor, Sungai Dua, Penang and Kuara Muda. the population is 95,930 in these towns and 54,000 in the surrounding areas in 1985. This means 64% of total population density of the agglomeration areas is 33 persons/ha, while 4 persons/ha in the rest of the district.

In Central district there are towns and agglomerations of Bukit Mertajam, Perai, Permatang Tinggi, Juru, Permatang Pauh, Machang Semang, Sungai Lembu, Bukit Tengah and Kebang Semang. The population is 60,760 in these towns, and 105,938 in the surrounding areas in 1985. This means 84% of total population of Central district is concentrated within the agglomeration areas. The population density of the agglomeration areas is 26 persons/ha, while 1.5 persons/ha in the rest of the district.

5.2 Population Projection

(1) General

Population projection of Malaysia in 2000 is 22,428,000 according to the Central Office of Statistics, While population projection of Peninsula Malaysia is 18,116,700. Annual population growth rate of Malaysia is 2.45% between 1980 and 2000, whereas Peninsula Malaysia is 2.31%. According to the draft Structure Plan of MPPP and MPSP the projected population in 2000 is 667,000 and 691,900 respectively, which makes Penang State population in 2000 1,359,300.

This annual average growth rate of Penang State is 1.78%, which is much lower than the national average growth rate. In fact the annual growth rate between 1980 and 1985 is even lower with 1.61% in MPPP and 2.2% in MPSP.

Georgetown, the largest agglomeration in Penang State, has been losing its population since 1970. In 1970 it was 267,924, whereas 256,700 in 1985. Therefore, the state of Penang has quite different characteristic compared with other states in Malaysia.

(2) MPPP

The Population projection of the municipalities and districts of MPPP have been made by the Structure Plan Unit. In MPPP the projection was made till 2000 according to 35 planning zones.

The population projection of MPPP for 2005 was 718,000 which was projected by applying the average annual growth rate between 1980 and 2000. This 718,000 was divided into Georgetown and the rest of MPPP according to the proportion of figures obtained by applying the average annual growth rate of Georgetown and the rest of MPPP between 1980 and 2000. The result is 287,900 for Georgetown and 430,100 for the rest in 2005. These figures were distributed to each planning zone basically by the proportion of the population of year 2000 with considering the growth rate of each planning zone. Table 5.2-1 shows the projected population in MPPP by planning zone.

Table 5.2-1 Population Projection by Planning Zone in MPPP

PLANNING ZONE	1980	1985	1987	1990	1995	2000	2005
1	40,568	40,600	40,600	40,600	40,600	40,600	40,600
2	16,686	16,700	16,700	16,700	16,700	16,700	16,700
3	47,034	49,400	51,300	52,000	53,600	54,800	56,500
4	34,311	33,600	33,200	33,300	35,700	38,400	39,100
5	19,919	18,000	17,000	16,600	18,900	21,500	21,700
6	36,501	35,000	34,100	33,700	37,300	40,900	41,600
7	13,975	14,000	14,000	14,000	14,000	14,000	14,000
8	15,018	14,700	14,600	14,500	15,400	16,300	16,500
9	12,306	12,200	12,100	12,100	12,700	13,200	13,300
10	2,399	2,400	2,400	2,400	2,400	2,400	2,400
11	8,656	7,300	6,400	6,100	8,500	11,800	12,600
12	12,827	12,800	12,900	12,900	12,900	12,900	12,900
Total for Georgetown	260,200	256,700	255,300	254,600	268,700	283,500	287,900
13	38,059	39,774	38,700	37,900	38,900	39,400	39,700
14	15,182	16,713	16,500	16,300	17,000	17,400	17,600
15	11,492	13,223	13,300	13,300	14,400	15,300	15,400
16	10,754	12,059	12,000	12,000	12,600	13,100	13,200
17	4,322	5,077	5,200	5,200	10,200	19,600	25,800
18	738	2,010	3,700	4,700	7,000	10,100	14,900
19	1,898	1,904	1,800	1,800	1,800	1,800	1,800
20	23,299	31,100	35,200	36,600	41,500	46,300	49,400
21	4,534	5,395	5,600	5,700	7,000	8,500	9,200
22	2,846	3,385	3,500	3,500	4,100	4,700	4,900
23	9,489	19,569	25,200	27,700	34,100	41,200	53,400
24	23,510	24,435	24,000	23,500	24,600	25,400	25,800
25	7,485	8,145	8,000	7,800	8,000	8,100	8,100
26	1,265	1,269	1,200	1,200	1,200	1,200	1,200
27	20,664	22,531	22,000	21,600	23,400	24,800	25,100
28	7,696	18,406	31,300	38,800	41,800	44,200	61,400
29	12,335	13,752	13,700	13,600	15,500	17,300	17,500
30	2,213	2,221	2,200	2,100	2,100	2,100	2,100
31	11,596	12,271	12,100	11,900	13,300	14,700	14,900
32	4,639	4,760	4,600	4,500	4,500	4,500	4,500
33	4,322	4,654	4,600	4,600	4,600	4,600	4,600
34	12,862	13,223	12,800	12,500	12,500	12,500	12,500
35	6,747	6,982	6,800	6,600	6,900	7,100	7,100
Total for Rest of MPPP	237,948	282,858	304,000	313,400	347,000	383,900	430,100
Total for MPPP	498,184	539,558	559,300	568,000	615,700	667,400	718,000

Source: Structure Plan Unit, M and Dept. of Statistics, Penang State
Year 2005 projection by Study Team

(3) MPSP

The population projection of the municipality and districts of MPSP have been made by the Structure Plan Unit till 2005. In MPSP the projection has been made according to 32 selected towns and cities till 2005 also. However, this represents the population within the gazetted town limits only. In fact development took place beyond the gazetted town limit of these selected towns. Therefore, in the Study for the use of projecting the waste amount, the population has been projected according to Mukimus. This projection was made considering the followings:

- Projected populations of each District in the draft Report of Survey
- Projected populations of selected towns and cities which were stated in the draft Report of Survey
- Degree of urban development outside the gazetted town limits, which is obtained through the discussion with the Structure Plan Unit
- Population growth rate of each Mukimu

The population projection of MPSP for 2005 is 754,100.

Table 5.2-2 shows the projected population in MPSP by Mukim.

Fig. 5.2-1 shows the population growth of MPPP and MPSP

Table 5.2-2 Population Projection by Mukimu in MPSP

MUKIMU NORTH DISTRICT	1970	1980	1985	1987	1990	1995	2000	2005
1	5,317	6,293	6,600	7,000	7,600	8,700	9,800	11,100
2	5,176	5,994	6,100	6,300	6,700	7,500	8,200	8,900
3	6,525	8,238	8,500	8,900	9,600	10,600	11,800	13,100
4	4,991	5,932	6,400	6,800	7,500	8,800	10,100	11,700
5	6,104	7,029	7,200	7,500	8,100	9,200	10,200	11,400
6	10,807	13,522	14,000	14,700	15,800	17,700	19,700	21,800
7	8,458	12,012	13,000	13,800	15,200	17,400	20,000	22,700
8	6,384	7,672	7,800	8,100	8,700	9,700	10,800	12,000
9	7,232	11,491	13100	14,300	16,200	19,900	24,100	28,600
10	3,245	3,916	4,100	4,300	4,700	5,300	6,000	6,800
11	6,738	8,356	8,500	8,800	9,400	10,200	11,200	12,100
12	13,442	16,085	16,200	16,800	17,800	19,400	21,200	22,800
13	4,129	4,705	4,900	5,200	5,800	6,800	7,900	9,100
14	39,771	57,195	62,000	63,800	66,000	69,600	72,900	74,500
15	29,841	35,472	50,000	52,000	54,900	59,700	64,500	68,000
16	3,364	4,860	5,482	6,000	6,800	8,500	10,400	12,800
Wayfarers								
Total North	161,524	210,310	233,882	244,300	260,800	289,800	318,800	347,400

CENTRAL DISTRICT	1970	1980	1985	1987	1990	1995	2000	2005
1	3,330	20,238	39,000	41,000	44,000	49,300	54,600	59,600
1A	7,680	9,303						
2	3,913	4,562	4,700	4,800	5,000	5,200	5,400	5,500
3	3,402	4,354	4,400	4,500	4,700	4,900	5,100	5,200
4	5,873	7,605	8,900	9,300	9,900	11,000	12,000	12,900
5	2,838	3,529	3,600	3,700	3,800	4,100	4,300	4,400
6	4,099	6,126	6,300	6,500	6,800	7,300	7,800	8,100
7	1,691	2,211	2,300	2,400	2,600	3,000	3,300	3,700
8	10,201	11,614	12,000	12,400	13,100	14,300	15,400	16,300
9	9,206	11,954	12,600	13,000	13,700	14,800	15,800	16,600
10	19,601	24,598	26,400	27,600	29,400	32,600	35,600	38,300
11	5,108	9,054	10,900	11,800	13,300	16,200	19,500	23,000
12	2,789	3,358	3,400	3,500	3,700	4,000	4,300	4,600
13	2,684	3,505	5,200	5,800	6,900	9,000	12,000	15,500
14	6,191	7,939	8,000	8,200	8,600	9,100	9,600	9,900
15	9,616	16,532	18,000	18,700	19,700	21,500	23,100	24,500
16	5,577	6,645	6,800	7,000	7,300	7,700	8,100	8,400
17	1,170	2,502	3,000	3,300	3,700	4,500	5,500	6,600
18	1,415	1,750	1,820	1,900	2,100	2,300	2,600	2,900
19	2,205	2,486	2,500	2,600	2,800	3,200	3,500	3,800
20	6,396	8,581	8,600	8,800	9,000	9,400	9,700	9,900
21	2,391	2,911	3,000	3,100	3,200	3,500	3,700	3,800
Total	117,477	171,357	191,420	199,900	213,300	236,300	260,900	283,500

SOUTH DISTRICT	1970	1980	1985	1987	1990	1995	2000	2005
1	2,071	2,492	2,600	2,700	2,800	3,000	3,200	3,400
2	1,132	1,224	1,300	1,300	1,400	1,500	1,600	1,700
3	445	534	600	600	700	900	1,100	1,300
4	4,413	3,903	4,000	4,100	4,200	4,700	5,200	5,700
5	3,652	4,895	5,600	5,800	6,100	6,800	7,600	8,300
6	628	579	572	600	600	700	800	900
7	3,801	5,099	6,600	7,000	7,700	9,700	12,200	14,700
8	2,550	2,594	2,700	2,800	2,900	3,200	3,500	3,800
9	5,903	7,426	9,250	9,700	10,500	12,000	13,700	15,200
10	7,507	8,494	8,700	8,800	8,900	9,200	9,500	9,700
11	16,131	19,303	20,800	21,100	21,800	22,900	23,900	24,700
12	2,262	3,119	3,800	4,000	4,300	5,200	6,400	7,800
13	1,554	1,840	2,000	2,100	2,200	2,400	2,600	2,800
14	4,641	5,606	6,100	6,300	6,500	7,200	8,100	9,100
15	5,980	8,416	9,600	10,000	10,500	11,600	12,800	13,900
16	956	204	200	200	200	200	200	200
Wayfarers								
Total	63,626	75,766	84,422	87,100	91,300	101,200	112,400	123,200
MPSP Total	342,625	457,434	509,724	531,300	565,400	627,100	691,900	754,100

N.B. 1970 and 1980 from Malaysia population census
Projected population of Districts are from Technical Report
Distribution to Mukims by Study Team (1985-2005)

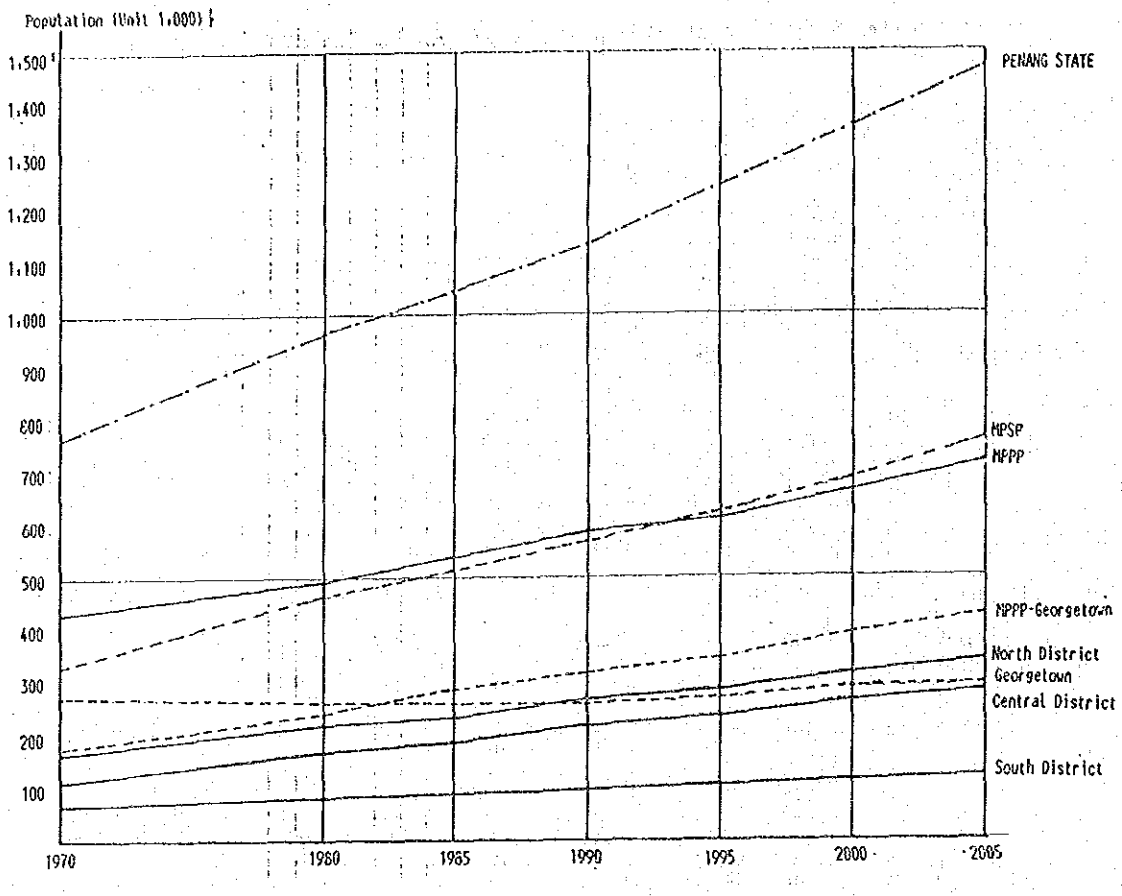


Fig. 5.2-1 Population Growth

5.3 Estimation of Future Solid Waste Amount

5.3.1 Present Solid Waste Amount

(1) MPPP

The waste collection service of MPPP covers more than 95% of population. 410 t/d of solid is disposed of at Bakau disposal site. Table 5.3-1 shows the per capita waste generation rates in MPPP in 1987.

Table 5.3-1 Amount of Solid Waste Collected and Per Capita Generation Rates in MPPP (1987)

	GEORGE TOWN AREA		RURAL AREA		TOTAL	
	WASTE COLLECTED (ton)	PER CAPITA (Kg)	WASTE COLLECTED (ton)	PER CAPITA (Kg)	WASTE COLLECTED (ton)	PER CAPITA (kg)
Domestic Waste	158.9	0.62	124.9	0.46	283.8	0.53
Commercial Waste*	40.4	0.16	36.8	0.13	77.2	0.15
Factory Waste	7.4	0.03	17.3	0.06	24.7	0.05
Others	11.9	0.05	12.8	0.05	24.7	0.05
Total	218.6	0.86	191.8	0.70	410.0	0.78
Service Ratio	100%		90%		95%	
Population Served	255,300		273,600**		528,900	

* Waste amount collected through Bulk-bin and Multi lift systems are assumed as commercial waste.

** 273,600 of the rural population served is 90% of the total rural population, 304,000.

The generation rates are 0.86 Kg/capita/day in George Town and 0.70 Kg/capita/day in rural area.

The rural of solid waste generated in MPPP is estimated at 432 t/d based on the above generation rates in 1987 as shown in Table 5.3-2.

The total amount of domestic waste and commercial waste generated is 378 t/d of which 361 t is collected.

Table 5.3-2 Estimated Waste Generation Amount in MPPP (1987)

(PER DAY)

	GEORGE TOWN AREA		RURAL AREA		TOTAL	
	(TON)	(%)	(TON)	(%)	(TON)	(%)
Domestic Waste	158	(72.1)	140	(65.7)	298	(69.8)
Commercial Waste	41	(18.6)	40	(18.6)	80	(18.5)
Factory Waste	8	(3.5)	18	(8.6)	26	(6.0)
Others	13	(5.8)	15	(7.1)	28	(6.5)
Total	220		213		432	

(2) MPPP

196.2 t/d of solid waste is brought into Permatang Pauh disposal site at which solid waste collected at North and Central districts is disposed of. The population of MPSP is scattered in large area. The collection service in MPSP is presumed to be provided for only 60% of the total population since the collection service in some served areas is not sufficient. The per capita generation rates are assumed to be same as those found in the rural area in MPPP because it is difficult to estimate generation rates based on data of MPSP which has large area served insufficiently.

The amount of solid waste generated in MPSP is estimated at 370 t/day as shown in Table 5.3-3.

Table 5.3-3 solid Waste Generation in MPSP (1987)

(PER DAY)

	NORTH	CENTRAL	SOUTH	TOTAL	PER CAPITA GENERATION
Domestic Waste	112 (65.0)	92 (63.7)	40.0 (73.4)	244 (65.7)	0.46
Commercial Waste	29 (16.9)	23 (16.2)	6 (10.6)	58 (15.7)	0.11
Factory Waste	19 (11.)	19 (13.2)	4 (7.9)	42 (11.4)	0.08
Others	12 (7.1)	10 (6.9)	4 (8.1)	26 (7.2)	0.05
Total	172	144	54	370	0.70
Per Capita Generation Rate (Kg)	0.71	0.72	0.63	0.70	
Population	244,300	199,900	87,100	531,300	

Total amount of domestic and commercial waste generated in North and Central Districts is 256 t/d of which 155.7 t/d is collected.

5.3.2 Method and Condition of Estimation on the Future Solid Waste Amount

(1) Estimation Method

The future solid waste amount is estimated according to the process shown in Fig. 5.3-1.

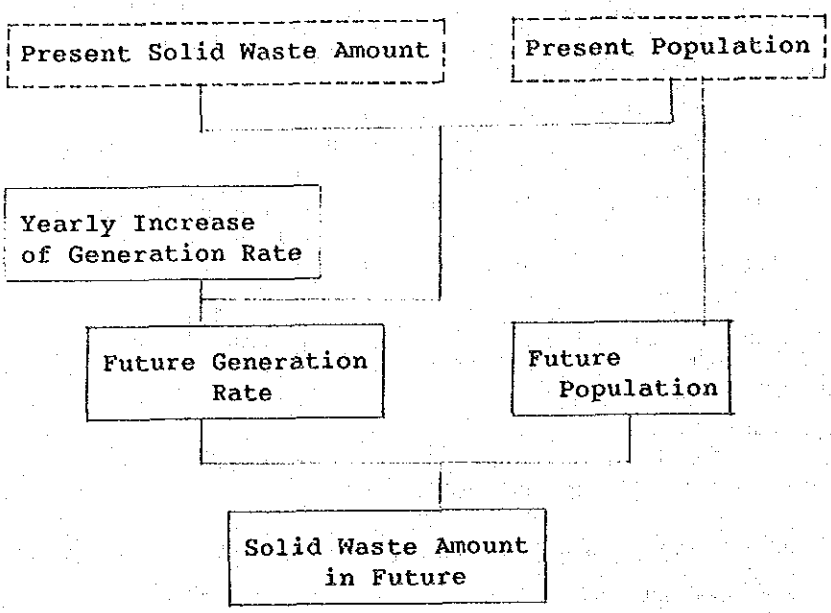


Fig. 5.3-1 Estimation Process of Future Solid Waste Amount

(2) Future Per Capita Generation Rates

Per capita generation rates increase with a rise in the living standard and an increase in commercial activities. The study of changes in composition of domestic waste shows that the increase of solid waste is mainly due to an increase of paper and plastic used as package materials.

The increase rate of 2% will be used for the estimation of the future solid waste amount. The per capita generation rates are estimated as shown in Table 5.3-4.

Table 5.3-4 Estimated Future Per Capita solid Waste Generation Rates

(kg/capita/day)

		1987	1990	1995	2000	2005
MPPP	City	0.86	0.91	1.01	1.11	1.23
	Rural	0.70	0.74	0.82	0.90	1.00
	Total	0.78	0.83	0.91	1.01	1.11
MPSP	North	0.71	0.75	0.83	0.92	1.01
	Central	0.72	0.76	0.84	0.93	1.03
	South	0.63	0.67	0.74	0.81	0.90
	Total	0.70	0.74	0.82	0.90	1.00

(3) Future Population

Future population is assumed to be the one projected in Section 5.2.

5.3.3 Future Solid Waste Amount

Based on the above conditions, future solid waste amount in the study area is estimated as shown in Tables 5.3-5 and Tables 5.3-6. The total solid waste amount in MPPP and MPSP will be 1,538 t/d in 2005 which is 1.9 times as large as the present amount.

Table 5.3-5 Future Solid Waste Generation Amount in MPPP and MPSP

(t/d)

		1987	1990	1995	2000	2005
MPPP	City	219	232	271	315	354
	Rural	213	232	285	345	430
Sub	Total	432	464	556	660	784
MPSP	North	173	196	240	293	351
	Central	145	162	199	243	292
	South	54	61	75	91	111
Sub	Total	372	419	514	627	754
Total		804	883	1,070	1,287	1,538

Table 5.3-6 Future Solid Waste Amount by Type of Solid Waste

MPPP CITY	1987	1990	1995	2000	2005	COMPOSITION IN 2005
Domestic	158.3	167.1	195.7	226.9	255.3	0.721
Commercial	40.8	43.1	50.5	58.5	65.9	0.186
Factory	7.7	8.1	9.5	11.0	12.4	0.035
Others	12.7	13.4	15.7	18.3	20.5	0.058
Total	219.6	231.7	271.4	314.7	354.1	1.000

MPPP RURAL	1987	1990	1995	2000	2005	
Domestic	139.7	152.4	186.9	226.8	282.6	0.657
Commercial	39.6	43.1	52.9	64.2	80.0	0.186
Factory	18.3	19.9	24.5	29.7	37.0	0.086
Others	15.1	16.5	20.2	24.5	30.5	0.071
Total	212.7	231.9	284.5	345.2	430.1	1.000

MPPP	1987	1990	1995	2000	2005	
Domestic	298.1	319.4	382.6	453.7	537.9	0.686
Commercial	80.4	86.2	103.4	122.7	145.9	0.186
Factory	26.0	28.1	34.0	40.7	49.4	0.063
Others	27.8	29.9	35.9	42.8	51.1	0.065
Total	432.3	463.6	555.9	659.9	784.2	1.000

MPSP NORTH	1987	1990	1995	2000	2005	
Domestic	112.4	127.1	155.9	190.6	228.1	0.650
Commercial	29.2	33.1	40.5	49.6	59.3	0.169
Factory	19.0	21.5	26.4	32.3	38.6	0.110
Others	12.3	13.9	17.0	20.8	24.9	0.071
Total	172.9	195.6	239.9	293.3	350.9	1.000

MPSP CENTRAL	1987	1990	1995	2000	2005	
Domestic	92.0	103.3	126.8	154.5	186.0	0.637
Commercial	23.4	26.3	32.2	39.3	47.3	0.162
Factory	19.1	21.4	26.3	32.0	38.5	0.132
Others	10.0	11.2	13.7	16.7	20.1	0.069
Total	144.5	162.1	199.0	242.6	292.0	1.000

MPSP SOUTH	1987	1990	1995	2000	2005	
Domestic	40.0	44.9	55.0	66.8	81.4	0.734
Commercial	5.8	6.5	7.9	9.6	11.8	0.106
Factory	4.3	4.8	5.9	7.2	8.8	0.079
Others	4.4	5.0	6.1	7.4	9.0	0.081
Total	54.5	61.2	74.9	91.0	110.9	1.000

- continue -

MPSP	1987	1990	1995	2000	2005	
Domestic	244.4	275.3	337.7	412.0	495.5	0.657
Commercial	58.4	65.8	80.7	98.5	118.4	0.157
Factory	42.4	47.7	58.6	71.5	85.9	0.114
Others	26.7	30.0	36.8	44.9	54.0	0.072
Total	371.9	418.9	513.8	626.9	753.8	1.000

MPPP+MPSP	1987	1990	1995	2000	2005	
Domestic	542.5	594.7	720.3	865.7	1033.4	0.672
Commercial	138.8	152.0	184.1	221.3	264.2	0.172
Factory	68.4	75.8	92.5	112.2	135.3	0.088
Others	54.5	59.9	72.8	87.7	105.1	0.068
Total	804.2	882.5	1069.7	1286.8	1538.0	1.000

The total of domestic and commercial waste to be generated in 2005 will be 684 t/d in MPPP and 614 t/d in MPSP which are 19.8 times and 3.4 times as large as the amounts collected in MPPP and MPSP respectively at present.

5.4 Estimation of Future Solid Waste Composition

5.4.1 Present Solid Waste Composition

The Result of solid waste analyses conducted in Feb. 1987 is shown in Table 5.4-1. Table shows the average of domestic waste and commercial waste (9 samples for each municipality).

Table 5.4-1 Composition of Solid Waste in MPPP and MPSP

	DOMESTIC WASTE		COMMERCIAL WASTE	
	WET	DRY	WET	DRY
Composition (%)				
Paper	25.2	26.1	36.3	35.6
Textile	2.1	3.0	1.7	1.7
Plastic	11.2	13.2	10.8	12.2
Rubber	1.0	2.1	0.9	1.2
Wood	17.3	15.1	7.4	4.5
Garbage	30.6	24.7	29.5	26.4
Metal	3.1	4.6	3.3	8.8
Glass	1.1	3.3	1.6	3.6
Stone	0.3	0.6	1.2	0.3
Others	8.1	7.4	7.3	5.7
Total	100.0	100.0	100.0	100.0
Density (Kg/m^3)		182		172
Moisture Content (%)		52.4		48.2
Ash Content (%)		9.5		13.9
Organic Content (%)		38.1		37.9
Net Calorific Value (Kcal/Kg)		1,300		1,400

From the above data, solid waste of MPPP and MPSP may be characterized as follows:

- Proportion of plastic is as high as that found in developed country.
- Proportion of metal and glass which include reusable materials is low (less than 5%).
- Density is very low, moisture content is not high, and net calorific value is high enough for self burning.

5.4.2 Future Solid Waste Composition

With the rise of the living standard, proportions of paper, plastic and non-combustible will increase, while those of wood and garbage will decrease. As a result of these changes, density and moisture content will decrease.

The solid waste composition in future is estimated based on the following conditions.

- Rate of increase of paper and plastic 1% per year
- Rate of increase of non-combustibles 3% per year
- Rate of decrease of wood and garbage 1% per year

The result of the estimation is summarized in Table 5.4-2.

Table 5.4-2 Composition of Future Solid Waste

DOMESTIC WASTE	1987	1990	1995	2000	2005
Composition(%)					
Paper	25.2	26.0	27.2	28.5	29.8
Textile	2.1	2.1	2.1	2.1	2.1
Plastic	11.2	11.5	12.1	12.7	13.2
Rubber	1.0	1.0	1.0	1.0	1.0
Wood	17.3	16.8	15.9	15.1	14.0
Garbage	30.6	29.7	28.2	26.6	25.1
Metal	3.1	3.4	3.9	4.4	4.8
Glass	1.1	1.2	1.4	1.5	1.7
Stone	0.3	0.3	0.3	0.3	0.4
Others	8.1	8.0	7.9	7.8	7.7
Total	100.0	100.0	100.0	100.0	100.0
Density (Kg/m^3)	180	180	180	180	180
Moisture Content (%)	52.4	52.1	51.5	50.9	50.3
Ash Content (%)	10.7	11.0	11.6	12.1	12.7
Organic Contents (%)	36.9	36.9	36.9	37.0	37.0
Net Calorific Value (Kcal/Kg)					

COMMERCIAL WASTE	1987	1990	1995	2000	2005
Composition(%)					
Paper	36.3	37.4	39.2	41.0	42.8
Textile	1.7	1.7	1.7	1.7	1.7
Plastic	10.8	11.1	11.7	12.2	12.7
Rubber	0.9	0.9	0.9	0.9	0.9
Wood	7.4	7.2	6.8	6.5	6.1
Garbage	29.5	28.6	27.1	25.6	24.2
Metal	3.3	3.6	4.2	4.7	5.2
Glass	1.6	1.7	1.9	2.2	2.4
Stone	1.2	1.3	1.5	1.6	1.8
Others	7.3	6.5	5.0	3.6	2.2
Total	100.0	100.0	100.0	100.0	100.0
Density (Kg/m^3)	170	170	170	170	170
Moisture Content (%)	48.2	47.8	47.0	46.4	45.7
Ash Content (%)	12.0	12.3	12.9	13.4	14.0
Organic Content (%)	39.8	39.9	40.1	40.2	40.3
Net Calorific Value (Kcal/Kg)					

Note: 1) The future desities are assumed to be the same as the present one, although solid waste density, in general, has a tendency of decreasing year by year. The reason for having made this assumption is that the present figures seem to underrepresent the real densities.

2) The future calolific values are also assumed to be the same as the present one because the expected future increase in ash content will cause the calolific value to decrease, while the expected future decrease in moisture content will cause the calolific value to increase.