3.2.3 Environmental Protection Facilities

The facilities are for the prevention of primary and secondary pollution outbreak during and after completion of landfill operations.

(1) Buffer zone

This will be constructed between the disposal site and the residential area for essentially the following purposes.

- To hide the site from direct view
- To reduce the noise and vibrations emitted during landfilling.
- To reduce odors.
- To balance the site with the natural surroundings in a harmonious fashion.

The buffer zone is hoped to occupy quite a bit of space, however, since this would result in a reduction in landfill volume, the zone is set at a 50m, width.

a. KMDS

i. The buffer zone will be established along the existing road and the forest on the PERDA Housing Development side.

ii. Along the existing road, a forest will be planted and on the PERDA side the existing forest will be left as is.

b. PBDS

i. Because the site is far removed from residential areas, no need was found for the establishment of a buffer zone.

(2) Litter control facilities

Litter control within the landfill site follows the same measure as is taken for disaster and pest control, wherein principally the covering material acts as the main agent. Nonetheless, there looms the inevitability of litter scattering during the landfill operations before the covering material has been placed. As a means of prevention, a movable fence to catch flying litter will be put up.

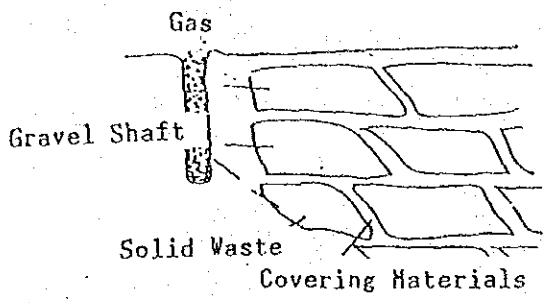
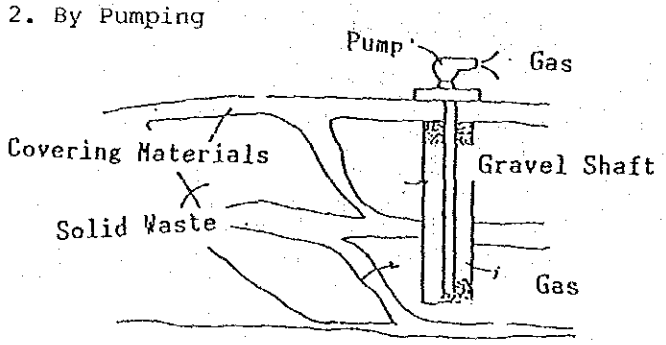
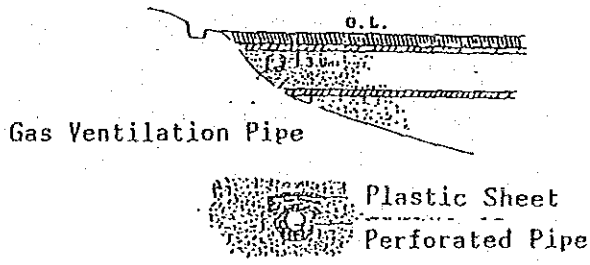
(3) Gas removal facilities

For the organic matters present during landfilling operations, decomposition occurs by loamy microbes and results in the production of water, gas and inorganic clorines. If the landfill structure houses aerobic matters, this gives rise to aerobic bacterial activety. If the decomposition is early, carbon dioxide, water, ammonia etc. are produced, without a problem. On one hand, if the structure houses anaerobic matters, this gives rise to anaerobic bacteria, which slow decomposition, thus odors and combustable gas, such as methane, carbon dioxide, hydrogen sulfide and ammonia, are emitted, badly affecting the environment.

Generally, as for the outbreak of gas in landfill sites, gushing and exhaust are common at the weak points on the boundary surface between landfill sites and surrounding structures. Disaster prevention measures, which are represented by gas removal facilities, are necessary at points where gas unexpectedly gushes and thus produces fires, odors etc.

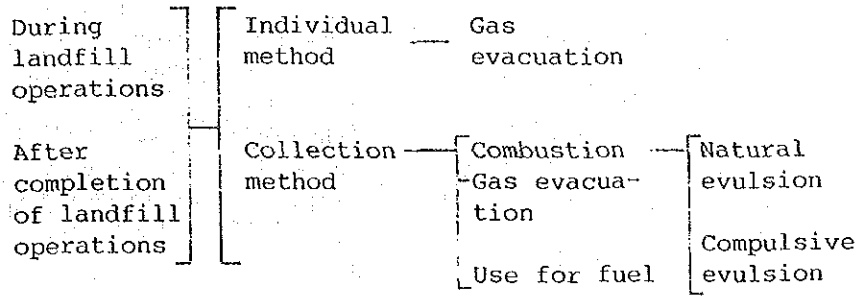
As for gas removal facilities, as shown below, there are three types under consideration : by evacuation, by pumping and by ventilation. Within these designs, the most economical gas remmoval facility, the one by evacuation, has been selected.

Table 3.2-3 Characteristics of Types of Gas Removal Facilities

1. By Evacuation  	By excavating a shaft in the vertical direction and filling it with gravel, the gas is expelled.
2. By Pumping  	By excavating a well and installing a pump, the gas enters the well and is expelled.
3. By Ventilation  	By installing pipe in the horizontal direction and embedding it with gravel, the gas is expelled by forced ventilation.

For these gas removal facilities, joined with the leachate collection facilities, the function of the expansion of the aerobic range within the landfill is expected.

Gas removal facilities by evacuation are set-up as follows.



The waste characteristics, stratum thickness and operational conditions for the design conditins of the gas removal facilities by evacuation are the following.

i waste type .... garbage

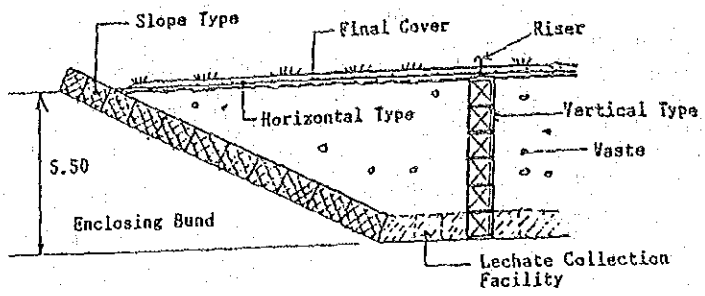
ii landfill layer thickness ..... approx. 6.1m

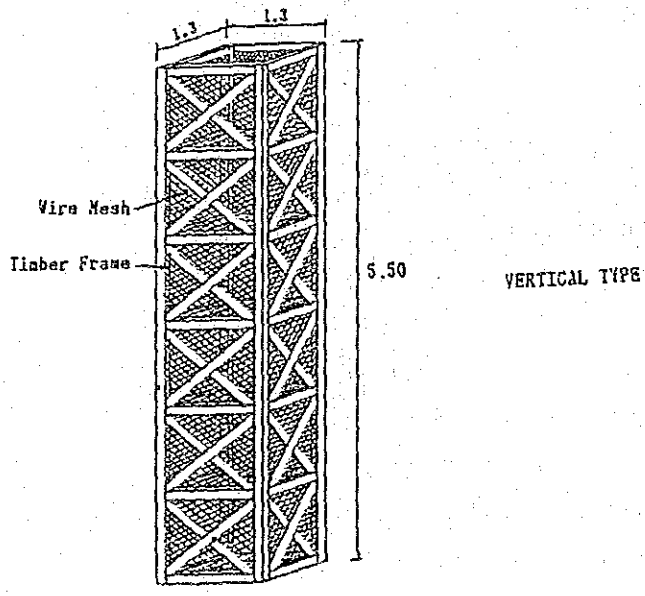
iii operational conditions .... the landfill site area at 9ha at KMDS and 13ha at PBDS, the divider will occupy 1-2ha.

Based on the above conditions, during landfilling operations the individual gas evacuation method is followed and after the completion of landfill, from the point of view of safety and control, the collective gas evacuation method is followed by connecting individual vertical shafts with horizontal shaft.

An outline of the gas removal facilities is shown in Fig. 3.2-10.

The completed landfill site gas removal facilities have been designed at 3-4 positions per hectare. As for disaster prevention measures, the gas removal facilities make prevention quite possible. However, the covering material is the most important factor, as it is necessary to not leave waste exposed over a long term.





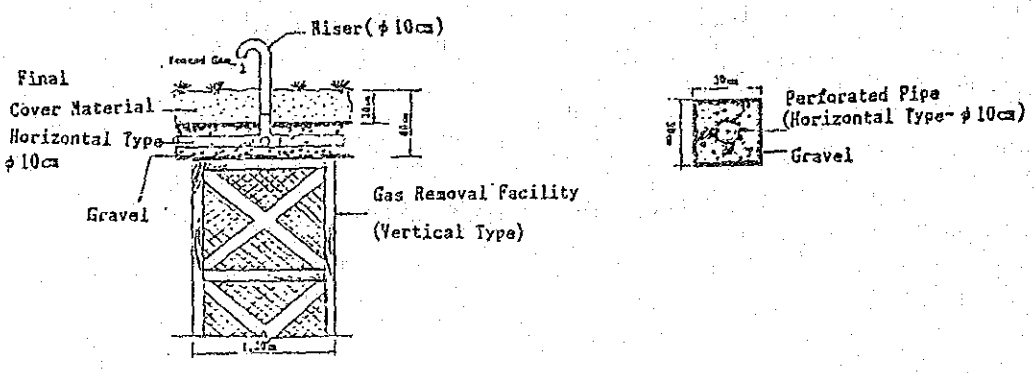


Fig. 3.2-10 Gas Removal Facilities by Evacuation

(4) Leachate collection facilities

a. General

Their purpose is to collect the rainwater contaminated by waste, the water within waste as well as decomposed polluted water and send it to the leachate control facilities. At the same time, they play a shield-like role for the prevention of deterioration of the surrounding areas by the permeation or discharge of contaminated water. Moreover, depending on the joining of the leachate collection facilities to the gas removal facilities, it is also possible to expand the aerobic area within the landfill layer.

As for the leachate collection facilities, depending on the topography, the configuration o the landfill and the structures, there are many combinations considered. The functions are classified below.

i. Horizontal leachate collection

Leachate collection which doesn't allow for leachate to rest in the landfill site is based on a downflowing, natural type of collection. The facilities will be established at the bottom of the landfill site.

ii. Vertical leachate collection

The landfill layer is thick thus suggesting that the time it takes for leachate to reach the bottom of the landfill site for collection is long. In this case, a vertical leachate collection facility will also be established.

iii. Leachate drain pipe

Thiis to discharge the leachate collected by the site's inner facilities to the outside of the site.

The landfill depth is 6.1m and not very profound. However, the slope and the vertical gas removal facilities will be used as a substitute for the vertical leachate collection facilities.

As leachate collection facilities, a drain lined with rubble is provided. However, due to soft ground, unequal settlement is expected, thus a rubble-lined drain which responds to the functuations in the soil will be constructed. As is usual, the gabion method will be employed.

b. Preliminary design

i. Design flow

The purpose of these facilities is

1) for leachate conveyance to leachate cycling facilities
2) to reduce the leachate head (pressure) in the landfill
3) for the expansion of the aerobic area in the landfill layer by their (leachate collection facilities) connection to the gas removal facilities

The following is a flowchart on the design of the leachate collection facilites.

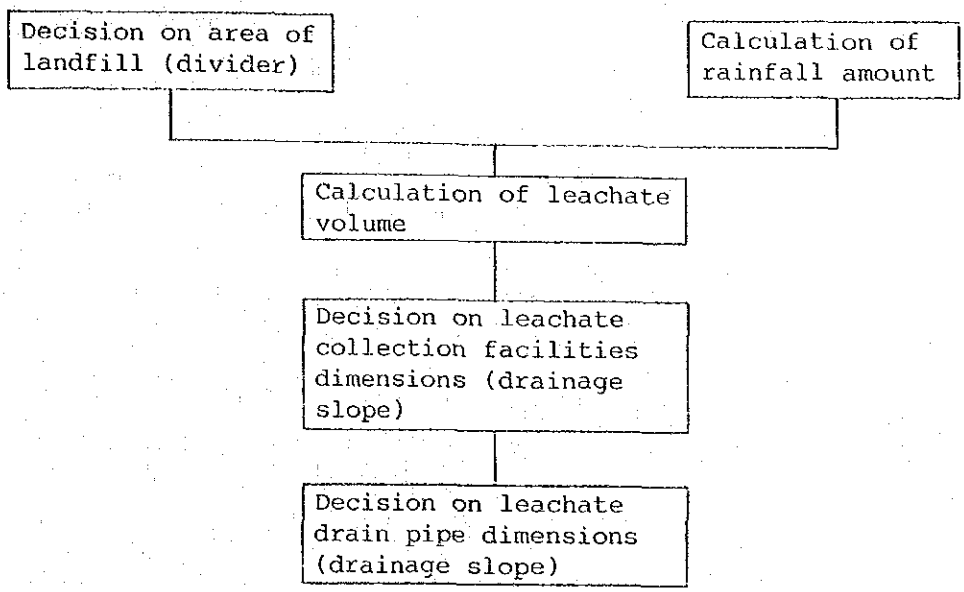


Fig. 3.2-11 Design flowchart of Leachate Collection Facilities

ii. Area of landfill site

The study on the area done in relation to the divider is described as follows:

	KMDS	PBDS
Rainy season (Jul.-Nov.)	1.0ha	1.0ha
Dry season (Dec.-Jun.)	1.5ha	2.0ha

iii. Record on rainfall and evaporation

Table 3.2-4 Daily Average Rainfall and Evaporation (Butterworth)

Butterworth

Category	Month												Remarks
	1	2	3	4	5	6	7	8	9	10	11	12	
1. monthly average rainfall amount(mm)	63.2	73.9	104.2	211.1	211.7	134.1	162.3	184.2	395.5	341.7	216.3	95.9	1969 1985
2. daily average rainfall amount(mm)	2.0	2.6	3.4	7.0	6.8	4.5	5.2	5.9	11.6	11.0	7.2	3.1	
3. daily average Evaporation amount(mm)	3.5	3.6	3.4	3.1	2.8	2.8	2.6	2.4	2.4	2.4	2.4	3.0	1983 1987
4. monthly average defference (mm) (2-3)	-	-	0	3.9	4.0	1.7	2.6	3.5	9.2	8.6	4.8	0.1	

Note: - Evaporation figures were not covered within the Butterworth data, thus were applied from Penang Airport data

- For surface water evaporation, the stepe coefficient of 0.75 was employed

iv. Calculation of leachate volume

The calculation method using a rational formula is shown below.

(Leachate Volume Calculation formula)

$$Q = 1/1000\ (C_1 * A_1 + C_2 * A_2) I$$

$$(A = A_1 + A_2 + A_3)$$

Notes:

Q: leachate volume (m^3/day)

A: landfill site catchment area total(m^2)

A_1: (A_1-A_2-A_3) (m^2), area where there is no direct elimination of surface flow (m^2) (principally, the area of the divider where landfilling is conducted)

A_2: area of completed landfill where surface flow is directly eliminated (m^2)

A_3: area of non-filled side where rainwater is directly eliminated (m^2)

C_1: A_1 divider leachate generation ratio

C_1= 0.4 - 0.7 standard value is 0.5

C_2: A_2 divider leachate generation ratio

I: Largest monthly average rainfall amount daily conversion value (mm/day) - Daily average evaporation amount (mm/day)

At the time of leachate volume calculation, in the completed reclaimed area, after 1 year has elapsed, due to the completion of final the covering of material and of an adequate drainage system, it is expected that the rainwater will entirely discharge outside the area.

Table 3.2-5 Leachate Volume by Season

Site	Season	A_1 (ha)	A_2 (ha)	I (mm/day)	Q (m^3/day)
KMDS	rainy season	1	1.5	9.2	87
	dry season	1.5	1	4.0	42
PBDS	rainy season	1	2.0	9.2	101
	dry season	2.0	1	4.0	52

v. Decision on dimensions of leachate collection facilities

For the leachate collection facilities, not only the effects of collection but also of ventilation are considered, thus allowing for an ample margin of flow capacity. As collection facilities, gabions are constructed of which the dimensions are shown in the below figure.

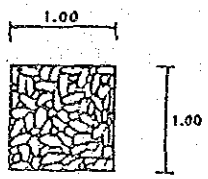


Fig. 3.2-12 Leachate Collection Facility Dimensions

The seepage movement of leachate is calculated using the Darcy Formula. As for the leachate seepage, voids formed by rubble which speed up the flow are abundant thus resulting in turbulent flow as opposed to laminar flow. Accordingly, in both principal and branch drains single lines of gabions will be placed.

$Q = VA = KA\ (\triangle h/\triangle \ell)^n$

Q : discharge (m^3/sec) KMDS 0.0010 &
PBDS 0.0012

A : flow area (m^2)

K : permeability coefficient (m/s) 0.1m/s

l : permeable layer length (m) $\triangle \ell / \triangle h = 0.002$

h : loss calculation

n : turbulency coefficient 1/2

* $A = Q/K(\triangle h/\triangle \ell)^n = 0.16m^2$ KMDS $0.22m^2$
PBDS $0.27m^2$

Accordingly, the water depth becomes 0.2 - 0.3m and the width 1m, providing for adequate ventilation.

vi. Drain pipe dimensions

The dimensions of the drain pipe shown below are to clarify the collection and ventilation effectivity. At the transition into leachate collection facilities, the drainage pipe will be placed inside the gabions in order to convey leachate.

$$A = \frac{\pi}{4}D^2 \times \frac{1}{3} - (\frac{D}{2}\cos 60^\circ \times \frac{D}{2}\sin 60^\circ \times 2) \times \frac{1}{2}$$

$$= D^2\ (\frac{\pi}{12} - \frac{\sqrt{3}}{16}) = 0.1535D^2$$

$S = \pi D/3$ $\qquad R = 0.1466D$

$$V = \frac{1}{n}R^{2/3}\ I^{1/2} = \frac{1}{n}(0.1466D)^{2/3}\ I^{1/2}$$

$Q = AV$

- Design conditions

	KMDS	PBDS
Discharge (m^3/Sec);	0.00101	0.00117
Slope (I)	1/500	
Roughness coefficient;	n=0.015(concrete pipe)	

- Calculation results

Pipe Diameter & Flow Capacity

D(m)	A(m)	V(m/sec)	Q(m^3/sec)
0.1	0.00154	0.18	0.00027
0.2	0.00614	0.28	0.00174
0.25	0.00959	0.33	0.00315
0.3	0.01382	0.37	0.00513

Accordingly, the pipe diameter at both KMDS and PBDS is decided as 0.20m. At the transition, in order for the drain pipe to easily collect enough leachate, the pipe is perforated across the top half in areas.

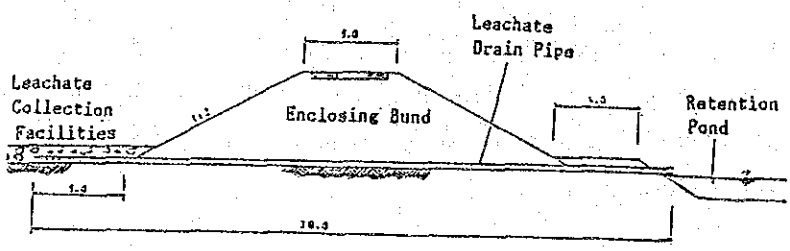


Fig. 3.2-13 Leachate Drain Pipe Profile

(5) Leachate cycling facilities

Leachate discharge into the surface and underground flow is a pollution source for the surrounding environment. The leachate volume is determined in relation to the water supply within the landfill site (rainfall, surface water and spring water). For leachate treatment facilities to meet the Malaysian governmental effluence quality standards requires vast financial resources which could be considered a pecuniary difficultly. With leachate monitoring as a principal objective, based on the effective use of the landfill site structures, the leachate cycling facilities, with the expectation of leachate level control, will be designed.

a. Design flowchart

The design flowchart for leachate cycling facilities is shown in Fig. 3.2-14.

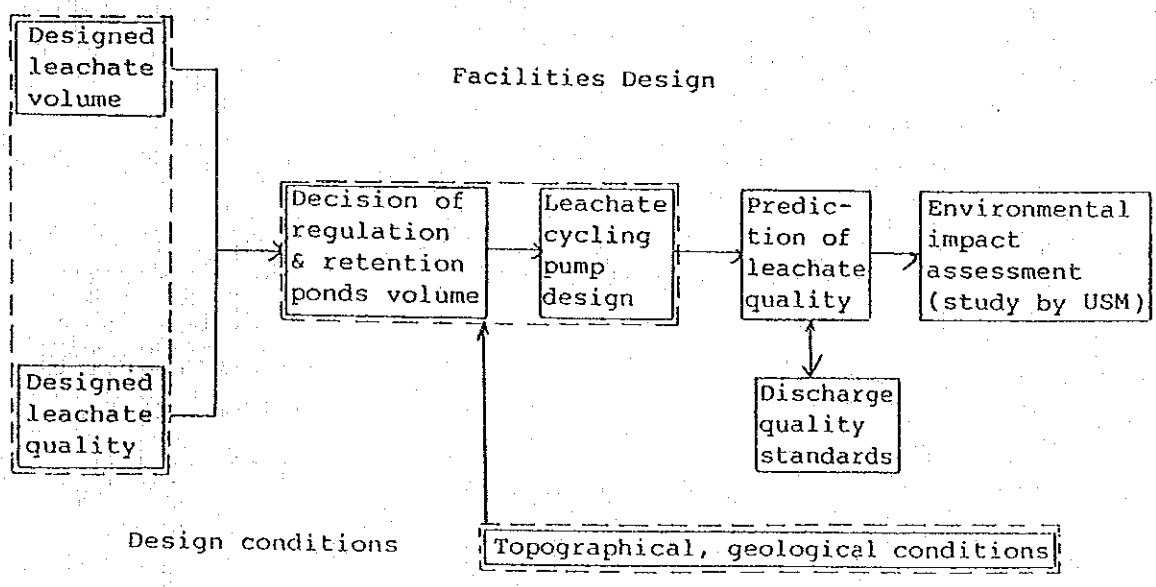


Fig. 3.2-14 Leachate Cycling Facilities Design Flowchart

b. Design conditions

i. Designed leachate volume

The leachate generation volume estimation, based on the study done on the leachate collection facilities, shows the KMDS at $87m^3$/day and the PBDS at $101m^3$/day.

ii. Leachate quality estimation

1) Generation mechanism of leachate

The soild waste to be disposed of at the disposal site consist of,

- construction demolition waste
- glass
- metal
- plastic
- others

Organic substances such as

- garbage (food wastes)
- trees and grass
- paper
- others

Leachate contains pollutants which are the result of rain water passing through soild waste layers and the matter retained in solid waste. The leachate consists of solutions of inorganic substances. The generation mechanism of leachate is summarized and illustrated in Fig. 3.2-15.

Decomposition of organic substances highly depends on,

- Physical and chemical conditions of waste such as types of waste, waste components, water content of waste, temperature, PH, oxygen supply, etc.
- Biological conditions such as symbiosis of micro-organisms, adaptation of them, etc.

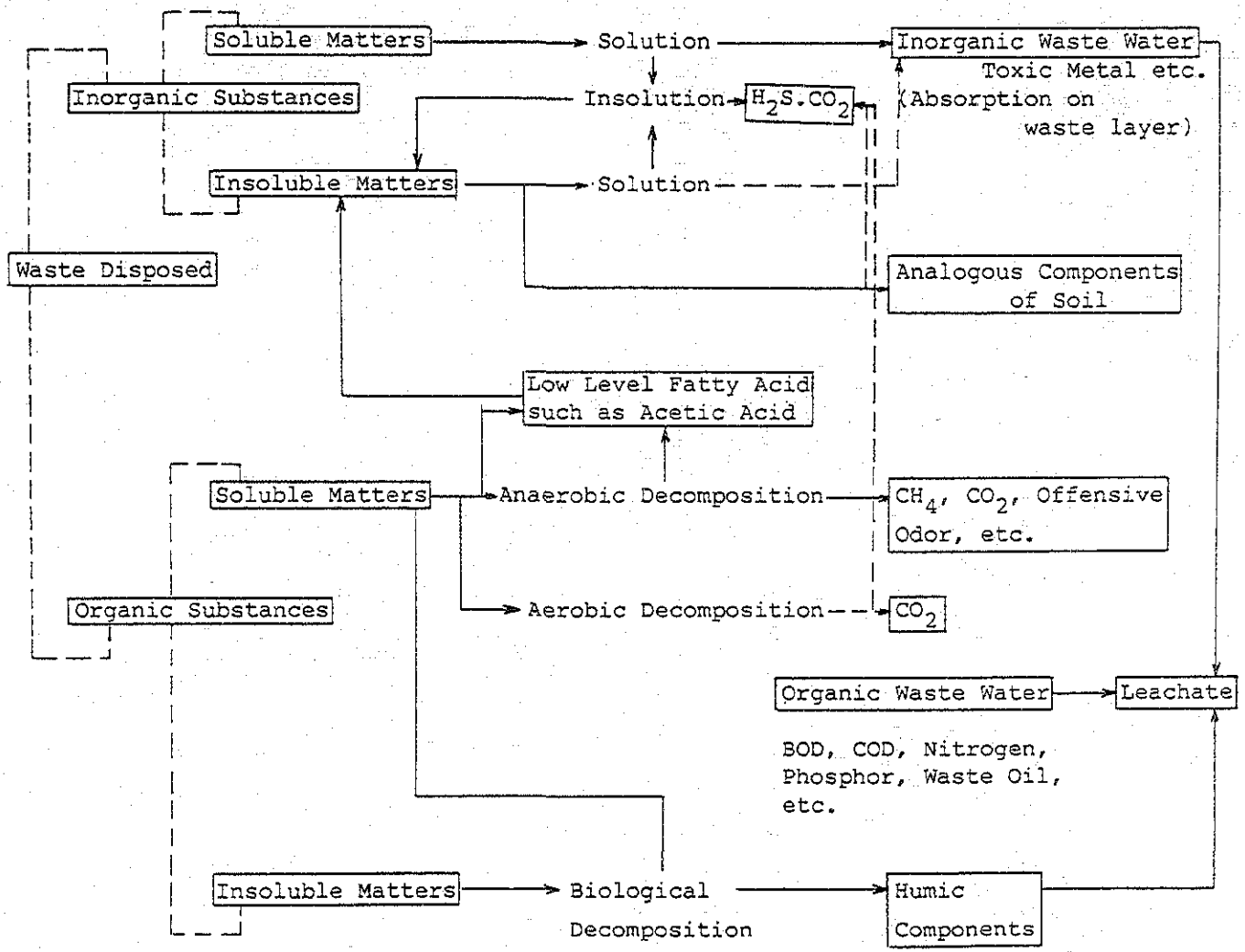


Fig. 3.2-15 Generation Mechanism of Leachate

Thus, the quality of leachate reflects the above indefinable factors.

Furthermore, the quality of leachate improves greatly because of the large amount of precipitation and long stabilization period.

As clearly described in this section, the estimation of leachate quality is very difficult. According to the actual research data in Japan, the quality of leachate at the beginning of landfilling operations, ranges as follows,

BOD ; 2,000 - 40,000 mg/l
COD ; 1,000 - 40,000 mg/l
NH_3-N; 500 - 1,000 mg/l

2) Prediction of leachate quality

The inquiries to DOE, UPM and WHO reveal that no investigation has been done on the leachate quality in Malaysia but only on some underground water quality near the dumping sites.

Therefore, the prediction on the leachate quality in PADS, KMDS and PBDS is based on that acquired in Japan. The conditional differences in between Malaysia and Japan are,

- waste quality
- precipitation and its intensity
- temperature
- landfill height
- landfill operation such as level of compaction, existence of water etc.

Considering the above mentioned aspects, the main points for the prediction on leachate quality in PADS, KMDS and PBDS are summarized as follows.

- The heavy and strong intensity of precipitation in Penang State may dilute leachate making it cleaner, compared with that of Japan
- Depth of landfill is shallower than in Japan. This makes the landfill more aerobic in condition.(the depth of landfill in Japan may be more than 30 to 40m in some cases)
- Compared with Japan, the high, uniform temperatures in Malaysia causes more rapid decomposition of waste. Therefore, the stabilization of waste is achieved more rapidly.

3) Water quality establishment methods

Of the methods outlined below, the most widely used in present cases are 1. and 2..

1. To conduct a survey on actual leachate discharge after landfilling operations.

2. To refer to other survey results on similar conditions at other disposal sites.

3. To predict the water density at the landfill site diluted by rainwater, by referring to contaminated water in waste pits.

4. Although there are many undetermined elements, to assure the volume and decompostion process of the water inflow and outflow and of organic carbon within waste, based on results from inspection, and estimate the water quality density by an accumulation formula.

As for the estimation methods for similar cases at other disposal sites, the following formulas are offered.

$$CA = (SA * HA * \alpha A)/(S'A * NA * VA)$$

$$CB = (SB * HB * \alpha B)/(S'B * NB * VB)$$

Here,

S : landfill site area (m^2)

S': catchment area (m^2)

H : landfill layer thickness (m)

N : landfilling operations period (year)

V : yearly leachate volume (m^3/ year)

α : total BOD discharge volume from $1m^3$ of landfill waste

c : average BOD density

A and B refer to the numerical values at sites A and B. α A/VA and αB/VB are estimated coefficients by waste type and climate where BOD compares with leachate volume and where climate is represented by rainfall amount. Accordingly, the Malaysian and Japanese values of rainfall amount are the following.

	Japan	Penang
Yearly average Rainfall amount (mm)	1,600	2,400

In this case site A is the disposal site in Japan Site B, KMDS or PBDS, can be estimated, using the following formula.

$$CB = CA \times \frac{(SA/SB)(HA/HB)}{(S'A/S'B)(NA/NB)} \times \frac{1600}{2400}$$

Here, general leachate quality for facility design in Japan is tabulated in Table 3.2-6.

Table 3.2-6 Standard Leachate Quality in Japan

Item	Waste (Garbage)	Incinerated Ash
BOD	1200 mg/l	250 mg/l
SS	300 mg/l	300 mg/l
COD	480 mg/l	100 mg/l
NH_3-N (T-N)	480 mg/l	100 mg/l
PH	Where decomposed organic materials are abundant, acidification occurs	Where flamable volume is low, alcalization occurs
No. of colifor groups	Can exceed 3000/cm_3	
F2	F2 : Normally 10ppm H2 : Normally traces (unknown)	
Other Heavy metals	too dangerous to observe	
Color	Brown to yellow	
elution	can exceed	
remaining material after	1000mg/l	

Note: 1) landfill structure ; semi-aerobic landfill
2) landfilling period; 5 years
landfill thickness; 4 m
3) flammable ash volume; 8%

Source: Study on the Leachate Treatment System Development for Landfills, 1979 by Japan Waste Management Association

In Japan, for COD measurement, (KM_nO_4) is used. In Malaysia, ($K_2Cr_2O_7$) is used. There is a difference of a 3 times greater value for Malaysia. Using the above mentioned formula, the following are the measured leachate qualities for KMDS and PBDS.

BOD	1,300 mg/l
COD	1,500 mg/l

As for heavy metals within leachate, from the observation data during landfilling operations at municipal disposal sites in Japan, H_9 and Cd were hardly found. The reason is that waste disposed of was municipal and not industrial and also by covering operations, soil adsorption occurred. However, Fe and Mn, in anaerobic conditions Where liquidation was known, were found. However, within this design, heavy metal treatment is not considered necessary.

a. Leachate cycling facilities design

These facilities consist of:

- regulation pond and retention pond
- leachate cycling pump and pit

i. Regulation pond

This is to hold leachate temporarily. Because the volume fluctuates depending on rainfall, the pond is to be big enough to hold 10 days' volume of the largest monthly rainfall.

Table 3.2-7 Regulation Pond Area

Item	KMDS	PBDS
leachate volume (m^3/day)	87	101
necessary capacity (m^3)	870	1010
water depth (m)	1.0	1.0
pond area (m^2)	870	1010

By operating the regulation pond gate, leachate diluted by rainfall is discharged into the retention pond.
(cf. Fig. 3.2-16)

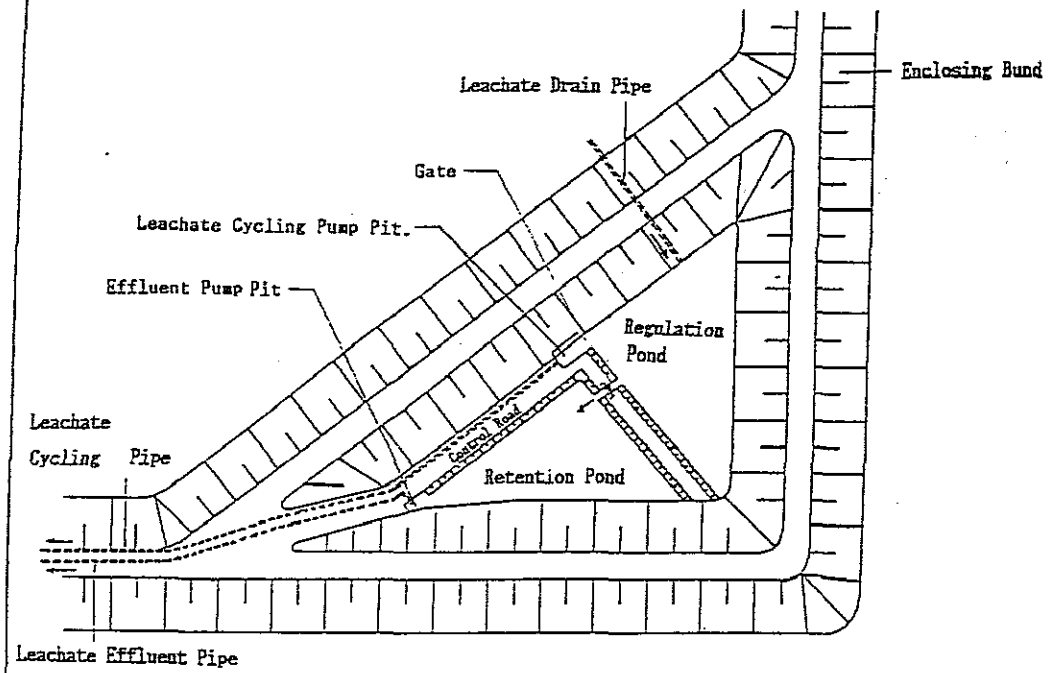
ii. Retention Pond

The capacity of the retention pond is the same as for the regulation pond.

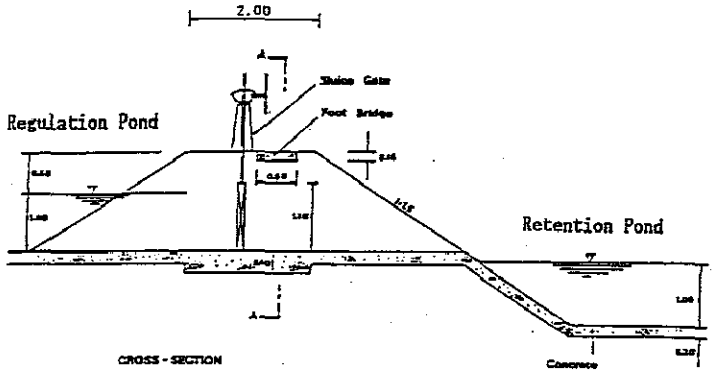
iii. Leachate cycling pump

The pump partially purifies the leachate in the regulation pond which, before entering the retention pond, is continuously cycled back to the landfill area.

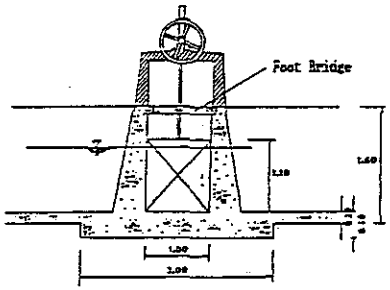
Since the leachate volume is about the same at the KMDS and the PBDS, that of the PBDS will be used to represent both. It takes 10 hours to cycle back to the landfill area one day's volume of leachate. The length of the cycling pipe is 500m with a 15m head water. The design is for an immersed pump with mouth diameter of 50mm and generating power of 57.5kw.

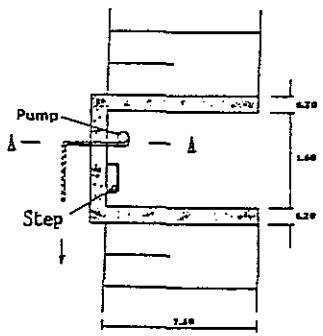


Detail of Gate

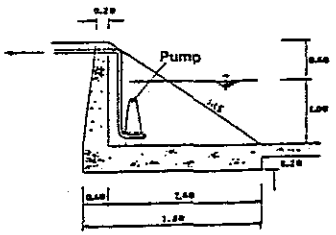


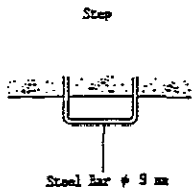
A - A





A - A





Leachate Cycling And Effluent Pump Pit

LEGEND	Fig. :
	Detail Of Leachate Cycling Facilities
	For KMDS And PBDS
	:
	Source : JICA Study Team
	Scale : As Shown
	Date of Drawings :

THE SOLID WASTE MANAGEMENT STUDY FOR PULAU PINANG AND SEBERANG PERAI

Fig. 3.2-16 Leachate Cycling Facilities

b. Effluent standard

According to the DOE, an effluence standard is established for Malaysia. The disposal site is located in the ocean area. Accordingly, the effluence standard is within standard B. The standard value of principal items is shown below.

	standard B
PH	5.5 - 9.0
BOD	50mg/l at 20°C
COD	100mg/l

c. Effluence leachate quality estimation

i. The system of partial purification of the leachate cycling facilities

To actively partially purify the leachate by bacterial material within the landfill area joined by gas removal facilities. Oxygen supply is provided and aerobic reproductive expansion is measured. Leachate, by leachate cycling facilities, in being cycled back again and again to the landfill site, is partially purified.

ii. Leachate quality estimation

Estimation on leachate quality after cycling is difficult because data on leachate quality from other sites is inexistant.

Leachate is diluted by 20% by direct rainfall into the regulation and retention ponds. Leachate is further purified through cycling where the BOD content is improved by 20%.

The value after dilution and purification of leachate in terms of BOD and COD are as follows.

BOD	40%
COD	20%

Then, the estimated final leachate quality is as below.

BOD	800 mg/l
COD	1200 mg/l

(6) Leachate effluence facilities

The KMDS is inland from the road and close to the Muda River. Nonetheless, as for leachate effluence, for the environment's sake, rivers cannot be used. Thus, the pipe is to be extended across the national road and placed so as effluence is out into the sea across from the lagoon. For the PBDS, as it is bordered on 2 sides by the sea and 1 side by the Tengah River and since just as for the KMDS, discharge in the river is unthinkable, the pipe is placed so as effluence is out into the sea on the other side of the Mangrove Forest.

The effluence outlet is situated where, even at low tide, there is guarantee of water depth.

a. Design conditions

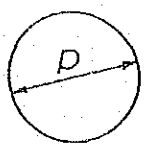
Designed effluence volume	;	KMDS 870m^3, PBDS 1010m^3
Effluence time	;	discharge every 5 days, in operation 10hrs. a day
Velocity in pipe	;	approx. 1m/sec (to avoid sedimentation)

b. Pipeline design

i. Pipe diameter

Since there is no great difference in the leachate volume at the KMDS and the PBDS, to be on the safe side, that of the PBDS will be used in the designing. The velocity of sending leachate, in order to avoid sedimentations is desgined and guaranteed to be over 1m/s.

Pipe Profile



$$A = \frac{\pi}{4}D^2$$

$$Q = AV$$

$$A = \frac{Q}{V} \qquad D = 2\sqrt{\frac{Q}{V\times\pi}}$$

A : flow area of pipe (m2)

V : velocity (m/sec)

Q : leachate effluence volume (m3)

D : diameter (m)

The leachate sending pipe is

$$Q = 1010 /(5\times10\times60^2) = 0.00561 m3/s$$

Accordingly, the pipe diameter is

$$D = 2\sqrt{\frac{0.00561}{1\times3.1416}} = 0.084 = 0.10m$$

ii. Pipeline

Following these conditions,

- shallowness of ocean (0 m to 1 m),
- soft ground (marine clay) and
- fishery activity,

the pipeline is installed 1m under the seabed.

A system of flags, for example, to warn fishers, etc., of the placed pipe below will be established.

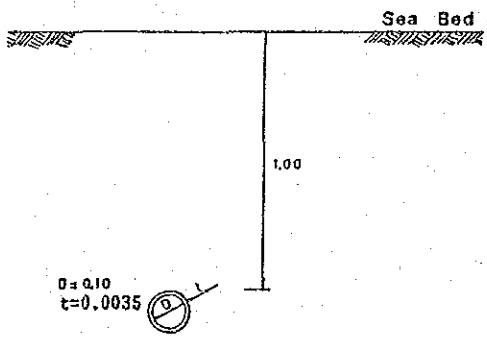


Fig. 3.2-17 Typical Cross Section of Pipeline Setting Out

b. Effluence outlet

If the outlet is placed in the sea it risks being clogged by inflowing sand. Thus, the outlet is designed to be placed above sea level where it is independent from the tides. The effluence outlet structure is shown in the following.

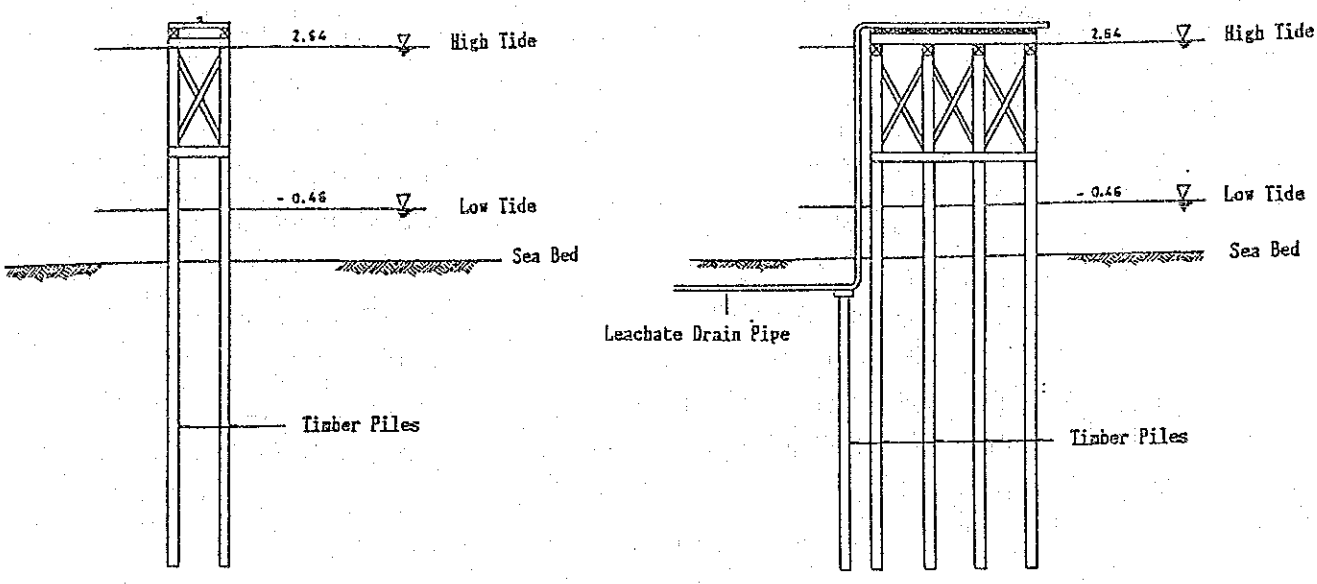


Fig. 3.2-18 Profile of Effluence Outlet

c. Leachate effluence pump

i. Leachate effluence volume

$Q=101m^3/day \times 1/24 \times 1/60^2 = 0.00117m_3/s = 70\ell/min.$

ii. Pump head

Head loss (H) is calculated by the Darcy formula.

$$H = f\frac{LV^2}{D2}(m)$$

	KMDS	PBDS
L: pipeline length (m)	1,000	1,000
D: pipeline diameter (m)	0.10	0.10
V: flow velocity (m/s)	1.0	1.0
g: acceleration of gravity (m/s)	9.8	9.8
f: head loss coefficient	0.035	0.035

(KMDS)

$H_1 = 0.035x1000/0.10 \times 1.0^2/2x9.8 = 17.9m$

(PBDS)

$H_2 = 0.035x2000/0.10 \times 1.0^2/2x9.8 = 34.8m$

Considering the head loss is caused by bends, the entry, expansion, contraction, branching and the valve and pipe ends, the total head loss at KMDS is 20m and PBDS is 35m.

Total pump head = total head loss + actual head

The design calls for an immersed pump, with diameter of 40mm for both and generating power of 52.2kw for the KMDS and 57.5kw for the PBDS.

(7) Monitoring Facilities

The monitoring facilities are to be monitoring wells constructed at both disposal sites in order to monitor groundwater quality.

3.2.4 Building and Accessories

(1) Site office

This will be established for the weighing of waste and for the administration of the disposal site. The principal functions will be carried out in the spaces categorized below.

- weighing office
- administration office
- operator's break room
- guard's room
- shower room
- kitchen
- lavatory
- storage room

This structure will be constructed by the SRC (steel reinforced concrete).

(2) Weigh bridge

Incoming waste must be weighed for proper operations within the disposal site. The covering material will be kept in balance with the landfill design. Records on weighing of waste are necessary data in determining the fees for incoming individual waste and future disposal site planning. The calculation conditions for the number of necessary weigh bridges to be constructed are the following,

- Collection vehicles (vehicle/day); 63 vehicles for the KMDS and 75 for the PBDS in 1996
- peak ratio ; 15%
- procedure time ; weighing time (3 min.)

One weigh bridge is to be constructed at each of the sites, the weigh bridge consists of a load-cell type a 4-point support system, a digital counter (separated from the main body), an underground system and has a weighing capacity up to 30 tons.

(3) Fire prevention facilities

A fire extinguisher and reserve water pond are to be assured for the site office and other facilities for the prevention of fire.

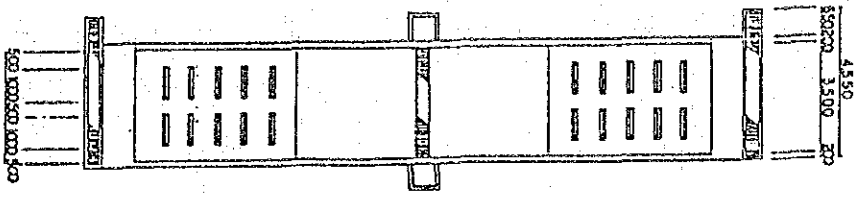
(4) Storage building

A storage building is to be constructed at each disposal site for the housing and repair of landfill equipment and materials.

(5) Others

In order to prevent anyone from illegally entering the site, a gate and fence are to be constructed. Flashlights will also be provided for the guard. A parking lot will be constructed for visitors and the staff. In order to prevent dirtying of public roads by collection vehicles, a car wash should be provided.

PLAN



CROSS SECTION

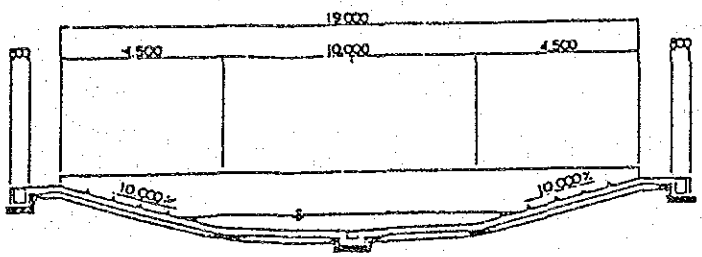


Fig. 3.2-19 Car Wash

3.3 Operation and Maintenance Plan

3.3.1 Landfill Plan

(1) Basic Policy

The following basic policy is sustained for preparation of landfill plan.

a. Solid wastes are spread and compacted sufficiently.

b. The scattering of solid wastes is minimized.

c. The diffusion of offensive ordor is minimized.

d. Stabilization of wastes as early as possible is arranged.

Compaction of solid wastes is necessary for lengthening the service life of the landfill site, which also is helpful in lessening settlement after completion of landfill. Furthermore, the prevention of scattering of solid wastes and diffusion of offensive odor is required in order to conserve the surrounding environment. For ultimate use of the completed landfill site, early stabilization is necessary for landfill purposes.

(2) Landfill Structure

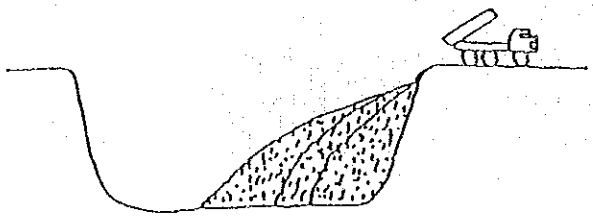
Regarding landfill structuring, the semi-aerobic landfill method is selected. The reasons are listed below.

a. for rapid stabilization of waste
b. for the reduction of leachate
c. for the reduction of odors and gas
d. because the cost is only a bit higher than that of modified anaerobic sanitary landfill.
e. because leachate monitoring is possible

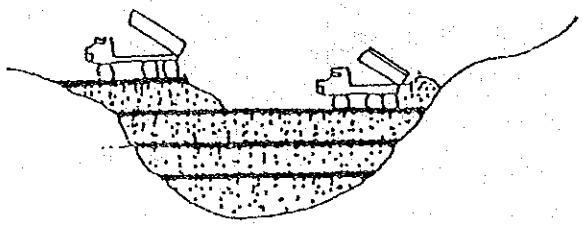
(3) *Landfill method*

The landfill method includes an open dumping, a sandwich and a cell method. The open dumping method has coventionally been carried out at many dumping site in Malaysia but, by this method, a highly-compacted landfill cannot be expected, nor can be prevented the scattering of waste, the generation of offensive odor or the breeding of vectors and insects.

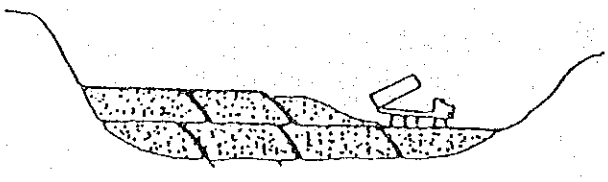
The sandwich method is applied by landfilling solid wastes horizontally, and covering the ground with soile, by which to form different layers. Where the landfill site is narrow, this method is effective, but if the site is wide, solid wastes are left uncovered for a couple days, resulting in unfavourable offensive odor and so on. The cell method is applied by laying soil on solid waste every day. Through this method a highly-compacted landfill can be expected and it is considered possible to prevent scattering of solid waste thus, generation of offensive odor and the breeding of vectors and insects. Since the landfill site is wide at both the KMDS and the PBDS compared with the landfill volume, if the sandwich method is applied, the exposure time period of solid waste could possibly be long. Therefore, the cell method should be applied.



Open Dumping Method



Sandwich Method



Cell Method

Fig. 3.3-1 Landfill Method

(4) Covering Materials

In order to conduct landfilling by the cell method, covering materials are to be supplied in a stabilized manner in balance with the landfill disposal.

a. Objectives for covering materials

i. to prevent gas leakage

ii. to prevent disaster

iii. to prevent the scattering of waste

iv. to support vehicle flow

b. Covering material amount

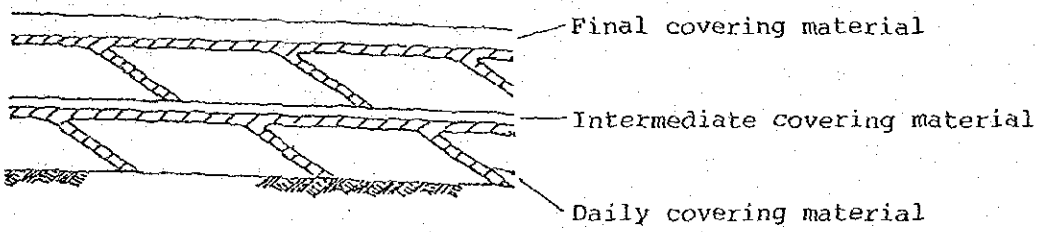


Fig. 3.3-2 Covering by Cell Method

Daily covering material	20cm thick
Intermediate covering material	30cm thick
Final covering material	60cm thick

In 1996, the landfill volume is estimated to reach, at the KMDS, 308m^3/day and, at the PBDS, 364m^3/day.

The study on covering material is conducted using the estimated PBDS volume and shown as follows.

Daily covering material

$$(12.3 \times 8.7 + 12.3 \times 2.4 \times \sqrt{10}) \times 0.2 = 40.0 m^3$$

Intermediate covering material

$$12.3^2 \times 0.30 \times 1/2 = 22.7 m^3$$

Final covering material

$$12.3^2 \times 0.60 \times 1/2 = \underline{45.4 m^3}$$

$$108.1 m^3$$

Accordingly, the covering material will be placed in a 30% ratio to the disposal volume of waste.

c. Guarantee of covering material

As for the quality of the covering material

Daily covering material; sandy soil for good ventilation

Intermediate and final covering material; clayey silt of a small permeability coefficient, and for good vegetation in final covering.

As the topography in the landfill areas is low and flat, there is no natural material available for use as covering material. Thus, imported material will basically be used.

(5) Landfill equipment plan

a. Planning conditions

Judging from topographical and geological conditions as well as the quality of solid waste at the KMDS and the PBDS, it is essential to consider the following conditions to prepare the landfill equipment plan.

i. Equipment should be of a type which functions even over poor ground.

ii. The landfill material consists of combustibles and non-combustibles, some of which necessitate crushing. Therefore, equipment with a certain capacity for crushing is required.

iii. Since a large amount of garbage will be disposed of at the site, it is essential to carry out covering every day.

iv. Not only for the ultimate use of the completed site, but also for the preservation of sanitary conditions as well as the lengthening of the life span of the disposal site, equipment with a high capacity for compaction is necessary. The content of the work concerning each type of landfill equipment at the site is shown in Table 3.3-1.

Table 3.3-1 Content of the Work for Landfill Equipment

Waste Handling	Cover Material Handling	Other
pushing (moving)	excavation	leveling (site access road & unloading site
crushing	loading, hauling, spreading and leveling	site maintenance
compaction	compaction	

The features of each type of equipment necessary for the above are indicated in Table 3.3-2.

Table 3.3-2 Comparison of Landfill Equipment Performance

Machine type	Waste Handling			Soil Covering		
	Leveling	Compacting	Trenching	Leveling	Compacting	Trenching
Crawler-dozer (Bulldozer)	Excellent	Good	Fair	Excellent	Good	Poor
Crawler-loader (Tractor shovel)	Good	Good	Excellent	Good	Good	Poor
Wheel-dozer	Excellent	Good	Fair	Good	Good	Poor
Wheel-loader	Good	Good	Fair	Good	Good	Poor
Scrape-dozer (Scraper)	Poor	Poor	Good	Excellent	Poor	Poor
Power shovel	Poor	Poor	Excellent	Fair	Poor	Poor
Landfill compactor	Excellent	Excellent	Poor	Good	Excellent	Poor

b. Equipment selection

The following equipment is selected for efficient operation and maintenance of landfill.

i. Bulldozer

For leveling and compaction of covering material, a bulldozer excells in leveling and compaction of waste and covering material and has various other uses. For example, it can be used in maintenance of the facilities, the enclosing bund and the on-site road. Considering that the area over which the bulldozer will be operating is soft ground, a bulldozer for swamp use and a 21-ton class weight should be selected.

ii. Back hoe (Hydraulic excavator)

For drain excavation, a back hoe is inferior in loading capacity to a crawler-loader, but is excellent in excavation.

c. Selection of number of equipment

i. Bulldozer (21-ton class)

The equipment needs to be capable of handling $240m^3$ of landfill in 8hrs. per day. According to the 1996 daily landfill estimations, 2 vehicles will be necessary for the estimated $364m^3$.

ii. Back hoe (Hydraulic excavator)

For principally drain excavation, one will be necessary.

(6) Landfill operations

The landfill operations are outlined in the following.

a. The waste is filled in places directed to the driver by the staff.

b. The dumped waste is spread and crushed by a bulldozer into a flat horizontal layer for sufficient compaction.

c. After the completion of landfill operations, the covering operations will be performed on a daily basis by the cell method.

d. Intermediate covering material will be laid on the first layer of landfill when it has extended as far as the divider.

e. A second layer of landfill will be laid on the the first layer in the same manner, extending to the divider.

f. Final covering material will be laid on top of the second layer of landfill.

g. A divider, gas removal facilities and leachate removal facilities will be constructed in the adjacent area for the next landfill operations.

(7) Landfill plan

This is summanized in the following.

a. Divider

The divider should be constructed on a small scale during the rainy season (July - Nov.) and on a large scale during the dry season (Dec. - June) following the increase and decrease of leachate. The divider should always be constructed directly adjacent to the soon-to-be completed landfill area.

b. Construction work

Private contractors will perform the construction of the following.

- divider
- leachate collection facilities
- gas removal facilities
- on-site road
- site ditch

c. Configuration of completed landfill area

To insure the immediate discharge of rainwater on the completed area, the following work will be completed by the MPSP.

- leveling
- temporary drain construction
  main ..... concrete lined
  branch .... unlined

d. Procurement of covering material

The covering material will be procured by a bidding process involving selected suppliers.

3.3.2 Facilities Maintenance

(1) On-site maintenance

In order to execute landfilling in a safe, sanitary and effective manner, the final disposal site facilities must be kept in the best condition by proper maintenance.

a. On-site and approach roads

The on-site roads in the final disposal site are to be constructed following the landfill operation. The on-site road is to be paved with gravel and compacted and the approach road with asphalt to avoid any problems for vehicles.

b. Fire prevention measures

The conceivable cause of fire at the final disposal site can be the ignition and explosion of combustible gases such as methane, the spontaneous combustion of combustibles by the effect of lens glass waste, the ignition and explosion of fuels for landfill equipment and so on. Although the method of burning combutible gases such as methane can be applied, it should not be the policy to install spontaneous combustion equipment for gas because the gas removal facility to be installed at the disposal site is cabable of removing enough generated gas. Spontaneous combustion caused by the effect of lens on glass wastes should be prevented by timely covering materials.

c. Sanitation control

Rodents, flies, mosquitoes, vectors and birds very often swarm at the final disposal site, which causes a problem to be tackled. Therefore, it is essential to work out a measure to prevent breeding of vectors, insects and so forth as mcuh as possible. The most effective measure is to carry out daily covering of materials by the cell method, and it is important to prohibit solid wastes from being exposed and standing water from being produced.

Only when absolutely necessary should insecticides be used and only very sparsely.

A conceivable cause of offensive odor is solid wastes themselves and decomposition of wastes after landfilling. The odor caused by anaerobic fermentation is said to be more offensive than that caused by aerobic fermentation because of volume and quality of generated gas. An effective measure is to throughly cover organic solid waste, which is the cause of offensive odor, and to keep the inside of the landfill site in a good aerobic state by immediately draining rain water.

d. Waste scattering prevention

A fence will prevent waste from scattering outside the site, In addition, scattered waste within the site will be constantly checked and collected.

e. On-site maintenance (equipment)

The following is necessary equipment for effective on-site maintenance.

- disaster prevention .... water sprinkler truck
- on-site patrol ..... inspection vehicle

(2) Main facilities maintenance

At the final disposal site, the main facilities are the bund structure, drainage facilities and the leachate collection facilities. These facilities must be maintained in top condition as one breakdown could effect all of them, resulting in mass damage.

a. The bund must be checked for any breaks or holes.

b. The drainage system should be constantly checked and cleaned out as it can be stopped up by sand, leaves, weeds and other objects.

c. The leachate volume should be checked daily. In case of sudden increase or decrease, the leachate collection facilities could become stopped up and cause leachate to discharge outside the landfill site. Also, the existence of spring water in the landfill site should be investigated.

(3) Equipment Maintenance

In order to perform maintenance for effective operatations, if during periodic investigation problems are discovered, they should be analyzed and equipment should be repaired by only skilled engineers. Necessary spare parts should be kept in stock.

(4) Hygiene and safety control

a. Hygiene control

As the final disposal site operations are outdoors, dust, odors, landfill gas and other things can badly affect the staff working in this already tenuous environment. Hygiene control, as well as safety control, are assured by grasping the working conditions and improving certain aspects when necessary. Periodic health check-ups are performed and medicine is given for any possible accident. In addition, the staff will possess full knowledge of hospital location and access in case of any emergency.

b. Safety control

Methane outbreak and fuels for landfill equipment should strictly be controlled, and, in order to prevent fire caused by carelessly thrown cigarettes, a measure such as a no-smoking rule should be taken at the landfill site. In addition to the above various measures, it is planned to purchase a water sprinkler truck equipped with a fire-fighting pump for emergencies. Of course, the staff will be well educated on disaster prevention.

3.3.3 Personnel Plan

(1) Organization structure

This is the following

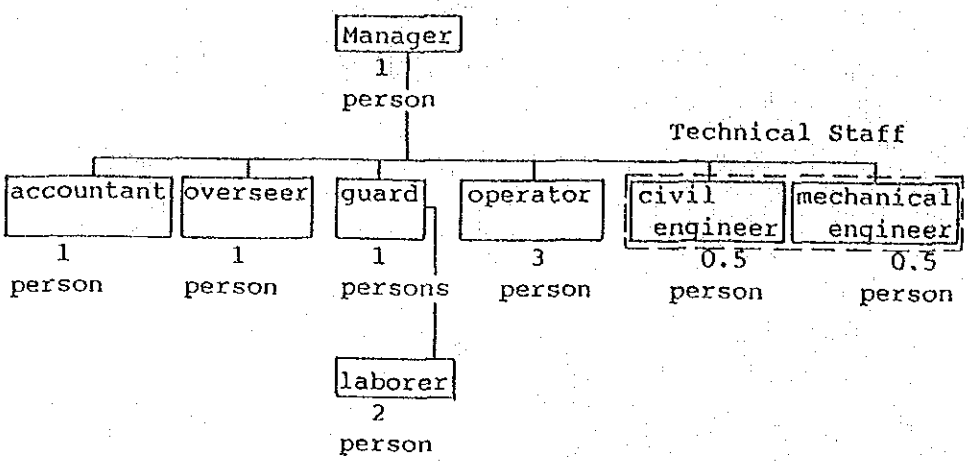


Fig. 3.3-3 Organization Structure

Staff will be placed at each disposal site. However, for the technical staff, only 1 type of engineer will cover both sites.

(2) Personnel

a. Manager --- 1 person

Representative of the final disposal site who controls the entire structure and manages the work of the entire staff.

b. Accountant --- 1 person

Work includes the whole phase of accounting work at the disposal site, including calculation of fee on direct-hauled waste.

c. Overseer --- 1 person

Work includes weighing and inspection of hauled waste and daily patrol of disposal site facilities.

d. Guard --- 1 person

Their work covers supervision for illegal entry and dumping, as well as night-time patrol.

e. Operator --- 3 persons

Work includes levelling and compaction of hauled solid waste. Leveling and compaction of covering materials, driving of the water sprinkler truck for fire prevention, construction and maintenance of site access road and maintenance of gas removal facility, as well as daily maintenance of equipment, and excavation of reclaimed area drainage.

f. Civil engineer --- 0.5 person

Work includes preparation and supervision of the landfill plan and especially calculations of required covering materials, safety control of landfilling operations of required covering materials, planning and supervision of construction work tendering, guidance for maintenance and repair of on-site and approach road, as well as examination of environmental conservation measures, and planning of drainage for reclaimed areas which will be excavated by the operator.

g. Mechanical engineer --- 0.5 person

Their work includes maintenance and repair work of equipment and leachate monitoring.

h. Laborer --- 2 persons

Work covers guidance for collection vehicles, maintenance of gas removal facility, fire prevention control as well as other necessary work for operations at the disposal site and drain cleaning out.

3.3.4 Environmental Monitoring

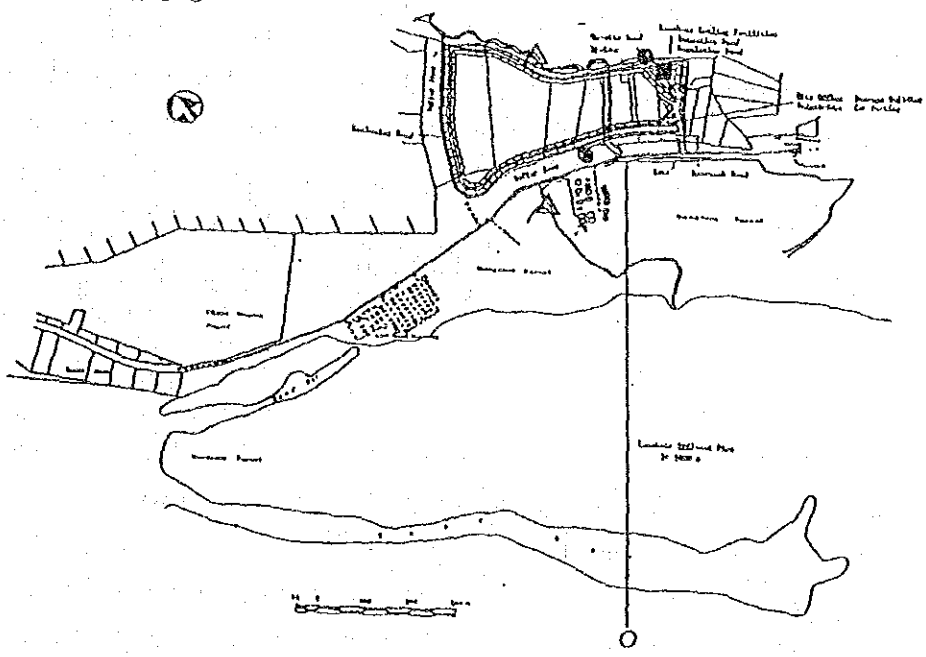
In the process of carrying out landfill work, they should prepare a monitoring (or supervision) plan, which includes water quality inspection and scattering of solid wastes, in order to conserve the enivironmental conditions of the final disposal site.

(1) Water Quality Monitoring

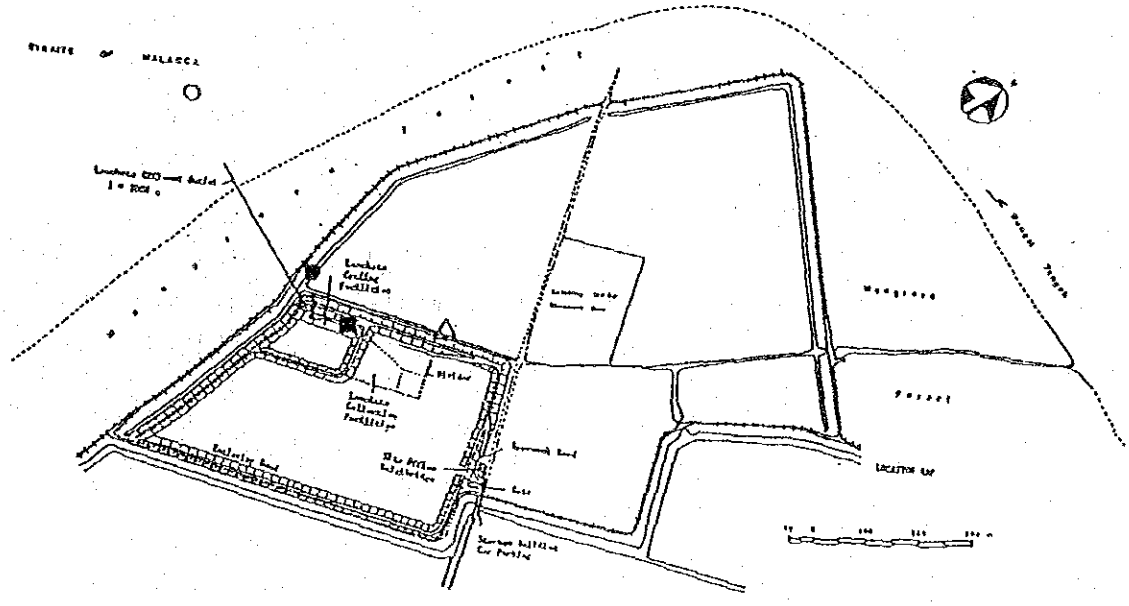
The following monitoring methods shall be effected for sample control.

a. monitoring of groundwater by monitoring well,
b. monitoring of surrounding drain surface water,
c. monitoring of regulation pond leachate,
d. monitoring of leachate at the effluence pump and at the effluence outlet.

KKDS



PBDS



LEGEND
- ● Monitoring Well
- △ Surface Water Sampling
- □ Leachate Sampling
- ○ Effluence Sampling

Fig. 3.3-4 Location of Water Monitoring System

(2) Waste monitoring

a. Monitoring of direct-hauled waste by the private sector, in particular, checking of unacceptable industrial waste by refering to the scheduled waste inventory list, by the D.O.E survey on industrial toxic waste,

b. Monitoring of scattered waste outside the site,

c. Monitoring of illegal dumping.

Based on the results from the above tested monitoring, the following counter measures will be taken in the event of any problem.

i. Deterioration of leachate quality

On a short term scale, the discharge of leachate will be stopped and will be kept cycling for partial purification. On the long term scale, an oxidation will be constructed.

ii. Toxic waste appearance

If the level of toxins exceeds the limits according to the D.O.E standards, as in the above i., discharge will be stopped and toxins will be chemically treated by coagulation settling.

iii. Fluctuation in leachate volume

Fluctuation is due to leachate collection facilities breakdown, insufficient drainage of the reclaimed area or main facilities breakdown. Accordingly, equipment relating to this should be inspected.

3.4 Ultimate Use

3.4.1 Basic Conditions on Ultimate Use

The following are basic considerations necessary for ultimate use of completed landfill sites;

- problems related to settlement
- problems related to gas generation
- maintenance of completed landfills

(1) Settlement;

Settlement of the landfill is dependent on the dept of the fill, composition of wastes, compaction of the material, moisture content, and other factors. Studies have indicated that approximately 90 percent of the ultimate settlement will occur in the first 5 years. The final 10 percent will occur over a much longer period.

Settlement is classified into the following two types:

- settlement of refuse layers
- settlement of soft sub-soil layers

a. Settlement of refuse layer

Settlement of refuse layer is caused by two factors namely;

- compaction
- decomposition

Compaction is caused by surcharge such as upper layer and vehicle weight. The amount of settlement by compaction varies according to materials and water content.

Little information is available on the decomposition of buried material in sanitary landfill. It is extremely difficult to predict the time required for complete decomposition. Many items, particularly paper, have been found unchanged in landfill that had been completed 15 to 25 years previous. The rate of decomposition is primarily dependent upon the moisture content and generally takes place at a very slow rate.

b. Settlement of soft sub-soil layer

Settlement of soft sub-soil layer is classified intothe following.

- immediate settlement
- settlement by consolidation

The amount of settlement depends on the following factors;

- characteristics of sub-soil
- depth of sub-soil layers
- weight of surcharge

Based on the soil data obtained by soil testing, the amount of settlement on both the KMDS and PBDS is calculated as 50cm.

(2) Gas Generation

Decomposition of the wastes will result in the production of gases, principally methane, carbon dioxide, nitrogen, hydrogen, and hydrogen sulfide. The rate of gas production will usually reach a peak within the first 2 years and then slowly taper off. Methane gas causes the most concern because of its explosive character.

A counter measure for gas generation is construction of gas removal facilities such as installation of perforated pipes and gravel.

(3) Maintenance

Completed landfill operations generally require maintenance because of differential settlement. Maintenance consists primarily of resloping the surface to maintain good drainage and filling in small depressions that result fron uneven settlement.

3.4.2 Ultimate Use Plan

(1) Law and regulations

The following law and act prohibit the construction of buildings on completed landfill sites unitl the site has become innocuous;

- Uniform Building By-law (1984) Part 6
- Street, Drainage and Building Act (1974)

(2) Possible Ultimate Use

As for the ultimate use of the completed site, the land used immediately after reclamation is in the form of a car park, golf links, farmland, park, playground and so forth. On the reclaimed land many years later, one-storey rambling-type buildings can be constructed. From a standpoint of plant growth, tall trees which spread roots soon after completion of reclamation work are hard to grow due to gasses such as methane and sulfureted hydrogen contained under the reclaimed land and changes in temperature; on the other hand an underbrush like turf grows fast. It is essential to sufficiently study the thickness of the final covering material, following the objective for ultimate use of the completed site.

a. Ultimate use as farmland

A number of ultimate use cases for the completed site are intended for farmlands by reclaiming swamp and mountainous area (valley) to a levelled grounds suitable to farmland through landfilling wastes. In order to use the land as a farmland, it is required, in most cases, to select a final covering material suitable to farming, and to make the thickness of the material approximately 1 - 2m. Additionally, in order to prevent crops from being affected by generated gas, it is essential to install a gas removal facility. Periodical inspection and maintenance are necessary because of distortion, and impairment of gas removal pipes and rain water drains due to settlement of the foundation, and specially, because of the clogging of the causes the spread of generated gas over the farmland and wither crops to death. In order to obviate negative effects caused by gas, a periodical examination of conditions of generated gas should be conducted, and, thereby, a necessary measure should be worked out.

b. Ultimate use as sporting facilities and parks

A number of disposal sites are used ultimately as soccer ground, sports facilities and a park. In order to use the site for these facilities, it is easy and simple to decide the nature and thickness of covering materials, as compared to that for farmland.

Considering that a number of people including children and the elderly use these facilities more often than they would farmland, it is prerequisite to pay attention to the handling and location of generated gas. The generated gas is treated by diffusing it into air and burning it, but, if the releasing height of gas diffusion and exhaust gas by burning is low, those gases remain in the utilized facilities, depending on climatological conditions such as wind direction, which in turn displeases people by production of offensive odor. It is necessary to take the aesthetic aspects into account.

c. Ultimate use as car park

As for the ultimate use of the completed site as a car park, although there still remain the problem of the handling of rust produced on cars by gas, the improvement work for this use is easy compared with that for farmlands and parks. Inspection of gas removal facilities and generated gas should be conducted in the same manner as that in other uses, however there still arise a small number of problems, such as settlement, in comparison with other methods of ultimate use.

(3) Recommendations on ultimate use

Due to settling and gas problems, construction of buildings on completed landfills site is not recommended for at least up to a certain amount of years (over 15 years). Thus, the following ultimate uses are recommended.

a. For the KMDS, a park for the surrounding inhabitants is recommended.

b. For the PBDS, farmland use is recommended by alternating the completed landfill on the former site of Byram Forest Reserve with the farmland in Pulau Burong.

The reasons are

c. For the KMDS

A park is

- a great contribution to the surrounding residents,
- in harmony with the existing landscape,
- compatible with the surrounding land use,
- one of the least expensive methods of land use.

d. For the PBDS

This is

- the provision of alternative farmalnd
- compatibility with the existing land use
- a low cost method
- Because this area is fairly separated from establishments of any kind.

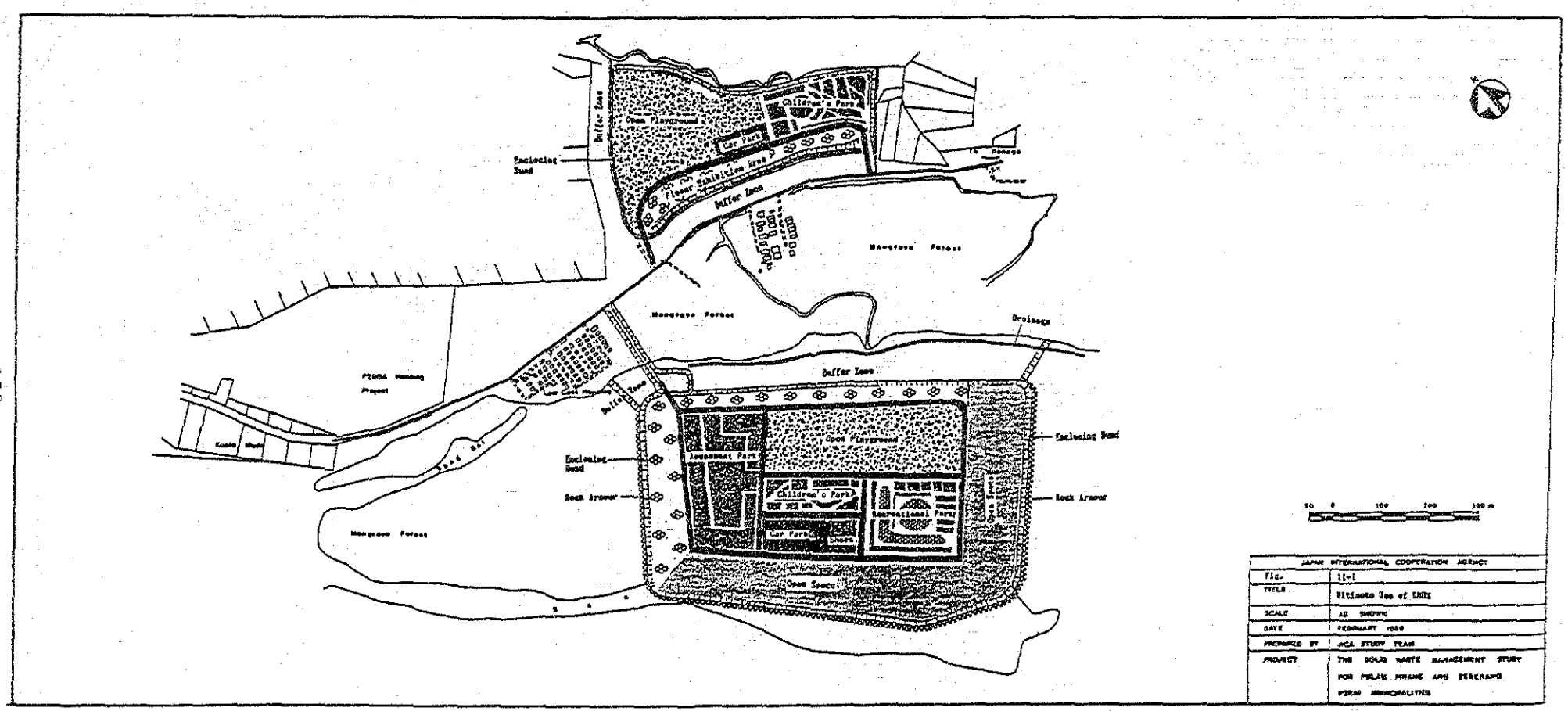


Fig. 3.4-1 Ultimate Use Plan for KMDS

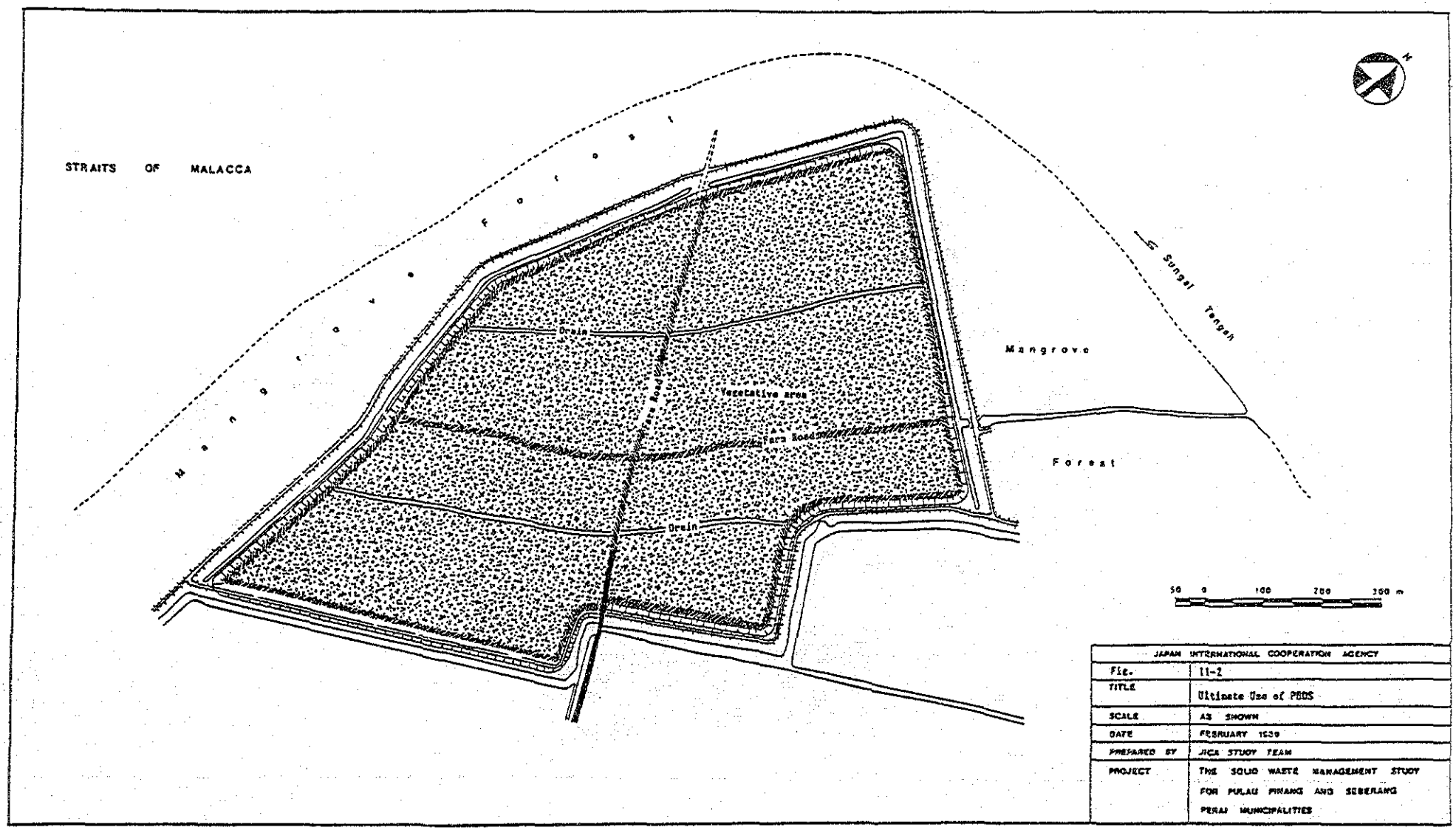


Fig. 3.4-2 Ultimate Use Plan for PBDS

3.5 Cost Estimation

KMDS and PBDS first phase site development project cost is estimated and tabulated in Table 3.5-1. Operation and maintenance cost are estimated and tabulated in Table 3.5-2.

Table 3.5-1 KMDS and PBDS First Phase Site Development Project Cost

I T E M S	Unit	Unit Price (M$)	K M D S		P B D S		TOTAL	REMARKS
			Quantity	Amount (1000)	Quantity	Amount (1000)	Amount (1000)	
A. Site Developement Works				2206		2511	4716	
1. Clearing	Ha	15000	16	240	20	300	540	
2. Main Facilities				1391		1655	3046	
a. Enclosing Structure				1276		1348	2624	
i. Enclosing Bund	m	670	1900	1273	2000	1340	2613	
ii. Divider	m	30	100	3	250	8	11	
b. Drainage System				62		40	102	
i. Surrounding Drain	LS	-	1	43	1	18	61	
ii. On-Site Drain (Surface)	LS	-	1	19	1	22	41	
iii. On-Site Drain (Underground)	m	-	-	-	-	-		
iv. Drain for Reclaimed Area	m	-	-	-	-	-		
c. Access				53		268	320	
i. Approach Road	m	360	100	36	100	36	72	
ii. On-Site Road	m	210	80	17	160	34	50	
iii. Pavement of Existing Road	m	180	-	-	1100	198	198	
3. Environment Protection Facilities				305		285	590	
i. Buffer Zone	m	100	600	60	-	-	60	
ii. Litter Control Facilities	m	32	1400	45	1700	54	99	
iii. Gas Removal Facilities	LS	-	1	8	1	8	16	
iv. Leachate Collection Facilities	m	-	1	40	1	45	85	
v. Leachate Cycling Facilities	LS	-	1	110	1	110	220	
vi. Leachate Effluent Facility	LS	-	1	32	1	58	90	
vii. Monitoring Facilities	LS	-	1	10	1	10	20	
4. Building and Accessories				270		270	540	
i. Site Office	No.	60000	1	60	1	60	120	
ii. Weighbridge	No.	150000	1	150	1	150	300	
iii. Storage Building	No.	25000	1	25	1	25	50	
iv. Safety Facilities	LS	-	1	15	1	15	30	Gate,Fence,Lights & etc.
v. Fire Prevention Facilities	LS	-	1	10	1	10	20	
vi. Utility	LS	-	1	10	1	10	20	Electricity,Telephone & Water
B. Equipment				1137		1137	2274	
a. Landfill Equipment				1002		1002	2004	
i. Bulldozer	No.	366000	2	732	2	732	1464	
ii. Hydraulic Excavator	No.	270000	1	270	1	270	540	
b. Environmental Equipment				135		135	270	
i. Water Truck	No.	100000	1	100	1	100	200	
ii. Inspection Vehicle	No.	35000	1	35	1	35	70	

Table 3.5-2 KMDS and PBDS First Phase Operation and Maintenance Cost

I T E M S	Unit	Unit Price (M$)	K M D S		P B D S		TOTAL	REMARKS
			Quantity	Amount (1000)	Quantity	Amount (1000)	Amount (1000)	
C. Operation				403		467	870	
1. Personnel			10	104	10	104	208	
Manager	No.	21700	1	22	1	22	43	
Technician	No.	15400	1	15	1	15	31	
Accountant	No.	11300	1	11	1	11	23	
Overseer	No.	11300	1	11	1	11	23	
Operator	No.	8300	3	25	3	25	50	
Laborer	No.	6500	3	20	3	20	39	
2. Landfill				283		346	629	
Divider	LS	-	1	5	1	12	17	
Drain for Reclamed Area	m	18	880	16	1300	23	39	
Site Ditch	m	34	500	17	380	13	30	
On-Site Road	LS	-	1	28	1	51	79	
Gas Removal Facilities	LS	-	1	12	1	10	22	
Leachate Collection Facilities	LS	-	1	60	1	67	127	
Cover Materials	1000m3	5000	29	145	34	170	315	
3. Utility				16		16	32	
Water	1000m3	520	NIL		NIL			
Electricity	Mwh	210	26	5	26	5	11	
Fuel	1000l	468	23	11	23	11	22	
D. Maintenance				124		129	253	
1. Civil Works	LS	-	1	33	1	38	71	
2. Equipment	LS	-	1	91	1	91	182	

4. Immediate Improvement Plan and Interim Measure.

4.1 Immediate Improvement Plan

4.1.1 Presentation of Immediate Improvement Plan

Fig. 4.1-1 shows an immediate improvement plan for the PPDS. (Permatang Pauh Disposal Site)

a. Improvemen of on-site road in the PPDS

Presently the internal road from the Jalan Permatang Pauh is not properly prepared and maintained. The road is not paved and is very uneven at certain areas which makes it very difficult for truck drivers to manoeuvre their vehicles. Specially during rainy days, the road is very slippery and it is very difficult ot reach a working face. The vehicles used for garbage disposal, therefore, are subjected to frequent damages.

It is strongly recommended that the present on-site road be improved in the following manners;(refer to Fig. 4.1-1

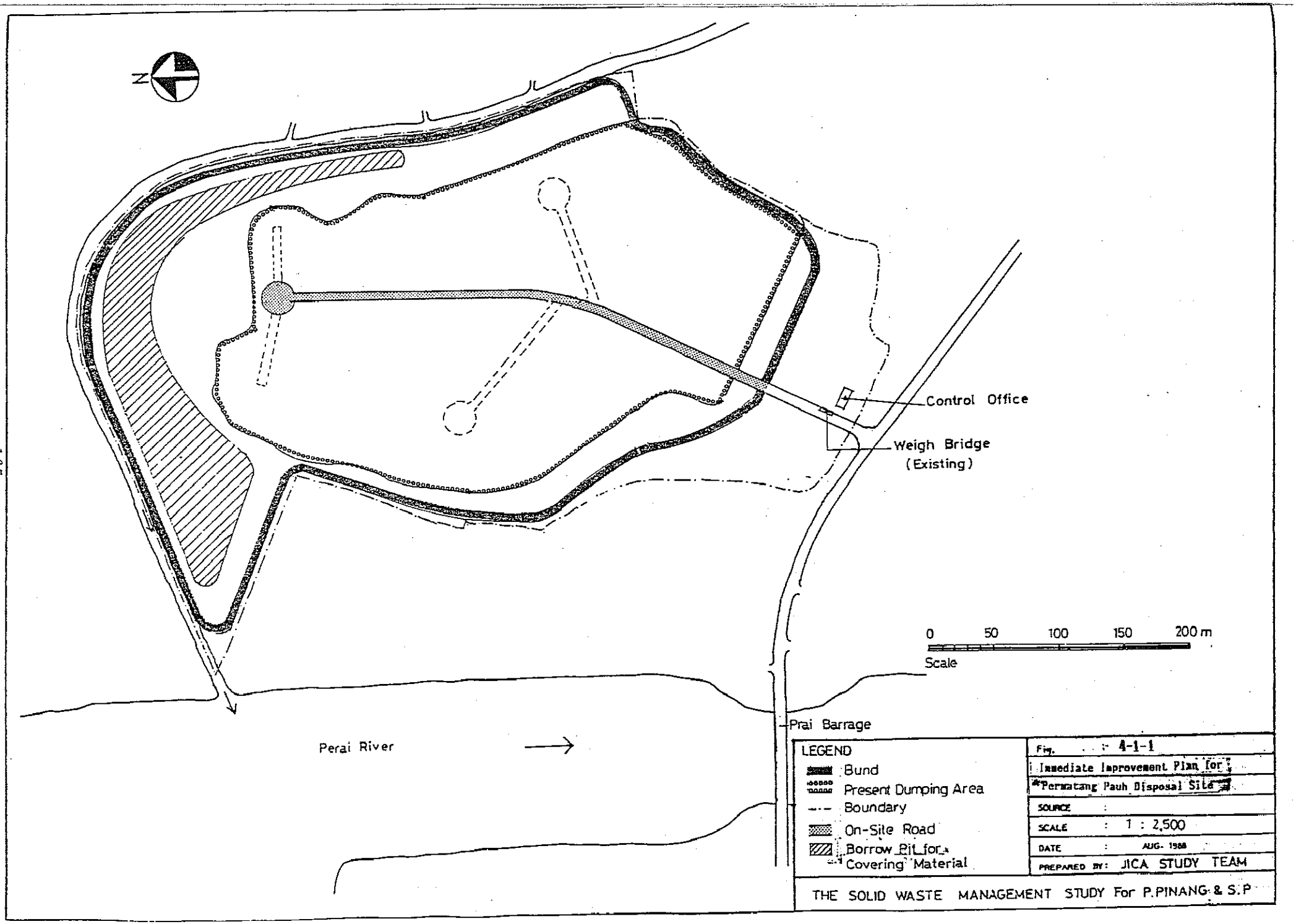
- Remove saw dust from on-site road
- Compact and level the wastes
- Cover the compacted and levelled waste with soil
- Execute gravel metalling and prepare one lane carriage way
- Provide laybyes at intermediate internals along the carriageway and turning space for vehicles at working face
- Provide branch roads according to the above mentioned manners

b. Application of cover

The cover is necessary to prevent insect and rodent infestation, blowing of paper, fires, the attraction of wildlife, and the release of gases and odors.

In respect to the application of cover, it is recommended to examine the possibility of using the soil and naturally burned wastes at the site as cover material and for the bund using excavator, tipper truck and bulldozer.

It should stop using saw dust as cover material because it is inflammable and its compaction is very difficult.


N
Control Office
Weigh Bridge
(Existing)
0 50 100 150 200 m
Scale
Prai Barrage
Perai River
LEGEND
Bund
Present Dumping Area
Boundary
On-Site Road
Borrow Pit for Covering Material
Fig. : 4-1-1
Immediate Improvement Plan for
Permatang Pauh Disposal Site
SOURCE :
SCALE : 1 : 2,500
DATE : AUG. 1988
PREPARED BY: JICA STUDY TEAM
THE SOLID WASTE MANAGEMENT STUDY For P.PINANG & S.P

c. Preparation of an operational plan

In order to achieve sound operation, operational efficiency and to lengthen life expectancy, preparation of an operational plan is needed.

These includes the following aspects;

i . On-site road
ii . Working face
iii . Special operational area such as areas for wet-weather and special wastes
iv . stockyards of cover materials

d. Establishment of disposal site boundary at the PPDS

Actual physical identificantion of the exact boundaries of the disposal site shall have to be made. It is of great help if tree are planted on the boundary so as to allow minimum view from surrounding areas.
Identification of site boundary will also help to facilitate disposal of garbage on site because management of site can be done.

In order to prevent the surounding area from being affected by the PPDS, site boundary shall be established according to the following manners;(refer to Fig.4.1-2)

- Clear, compact and level the site boundary
- Construct an enclosing bund using burn-out wastes and soil available at the site
- Cover it with soil

e. Preparation of topographic map of the site.

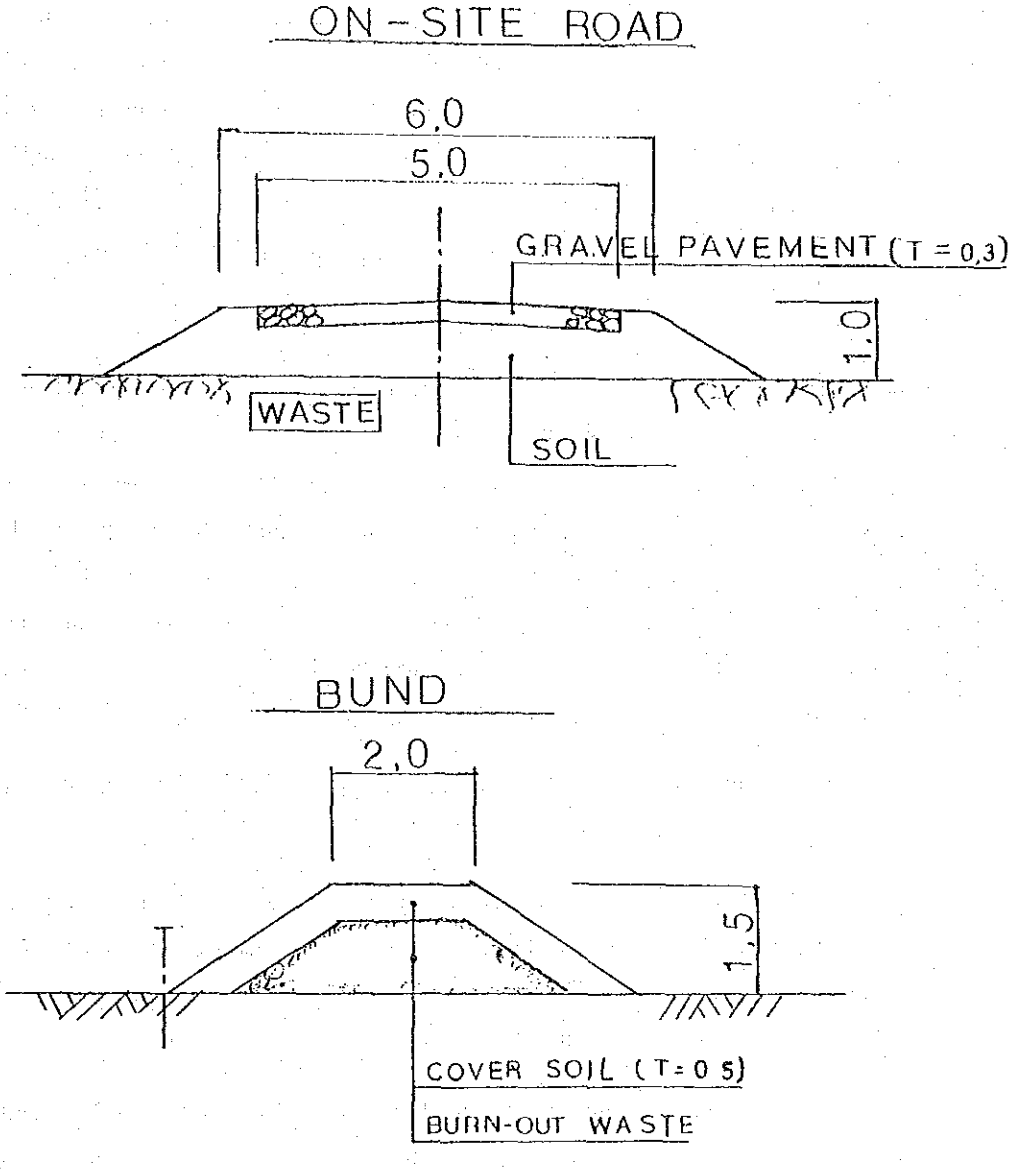
f. Preparation of an ultimate use for the completed landfill so as to decide the final ground elevations.

g. Execution of more strict inspections on incoming materials in order to avoid toxic and hazardous wastes disposal at the site.

h. Execution of regular topographic surveys

The incoming-material data and the topographic surveys can be used to determine the amount of compaction, efficiency, and to estimate on the degree of decomposition and eventual settlement.

Fig.4.1-2 On-Site Road and Bund



(2) Others

a. Strengthening of the present organization of final disposal.

A clean, orderly and economic operation requires proper site and operation plan, constant and competent supervision. It is also important to employ experienced or adequately trained personnel to operate the sanitary landfill. In the case where a civil engineer for final disposal is not easily available, it is recommended to ask for cooperation from other department such as engineering department.

b. Close cooperation with other department

The operation of a sanitary landfill requires heavy equipment such as a bulldozer, back-hoe, tipper truck, dragline, etc. It is not easy and not economic for the municipality to get all equipments required. It is, therefore, recommended to borrow or share those equipments from other departments. This idea of such inter departmental collaboration should be applied to overcome the shortage of adequately trained personnel. The concept of which all municipal employees are under the same umbrella is important.

c. Recognition on the importance of sanitary landfill for final disposal and consensus for the increase in final disposal cost.

Disposal is the final functinal element in the solid waste management system and is the ultimate fate of all solid waste. Even after the introduction of an incinerator, a disposal site for ash and residue of the incinerator and incombustible wastes is necessary.

The council administrators and councilors, are requested to consider these issues, because the operational side presently is suffering a lot of complaints from residents nearby, specially due to the fire and thick smoke from the PPDS.

There is a possibility that in the near future, MPSP will have no disposal site arising from these objections and consequently wastes generated in the urban area will be left in the streets or dumped into drains.

In case that MPSP intends to use the PPDS continuously, considerable environmental protection measures should be taken.

(3) Project Cost

Project cost is calculated and tarbulated in Table 4.1-1 .

Table 4.1-1 Project Cost

On-Site Road	m	75	400	30,000	Gravel metalling (t=0.3m)
Bund	m	16	1,500	24,000	Burn-out waste and cover soil
				54,000	

4.1.2 Progress of Immediate Improvement Plan

The present problems on the final disposal system in MPSP are identified.

In response to the present problems, the immediate improvement plan without large investment on final disposal system in MPSP is discussed and proposed by the Study Team.

In this section, the present status of the proposed items is described below.

Fig. 4.1-3 shows an immediate improvement plan for the PPDS (Permatang Pauh Disposal Site)

(1) Operation

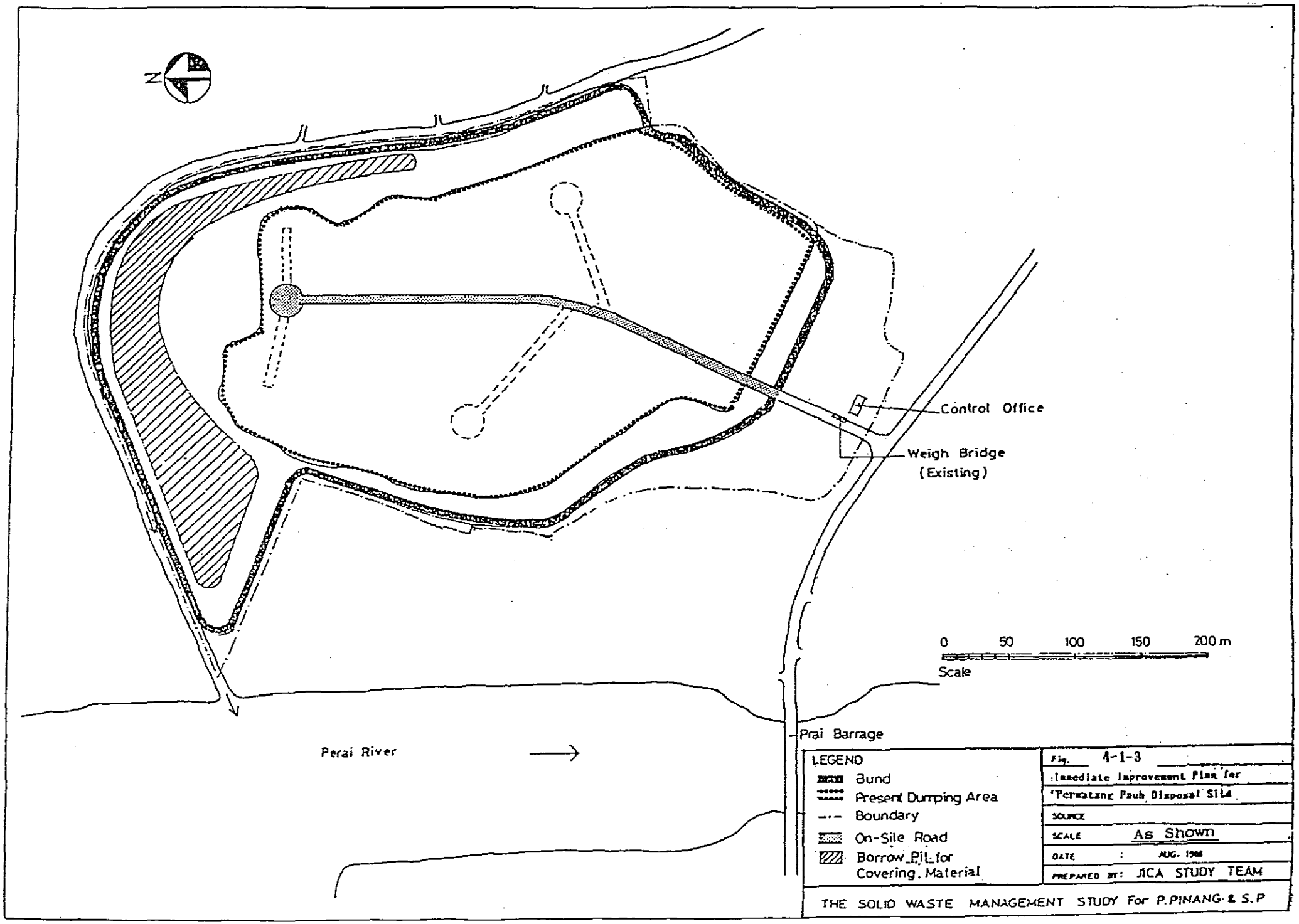
a. Improvement of on-site road at PPDS

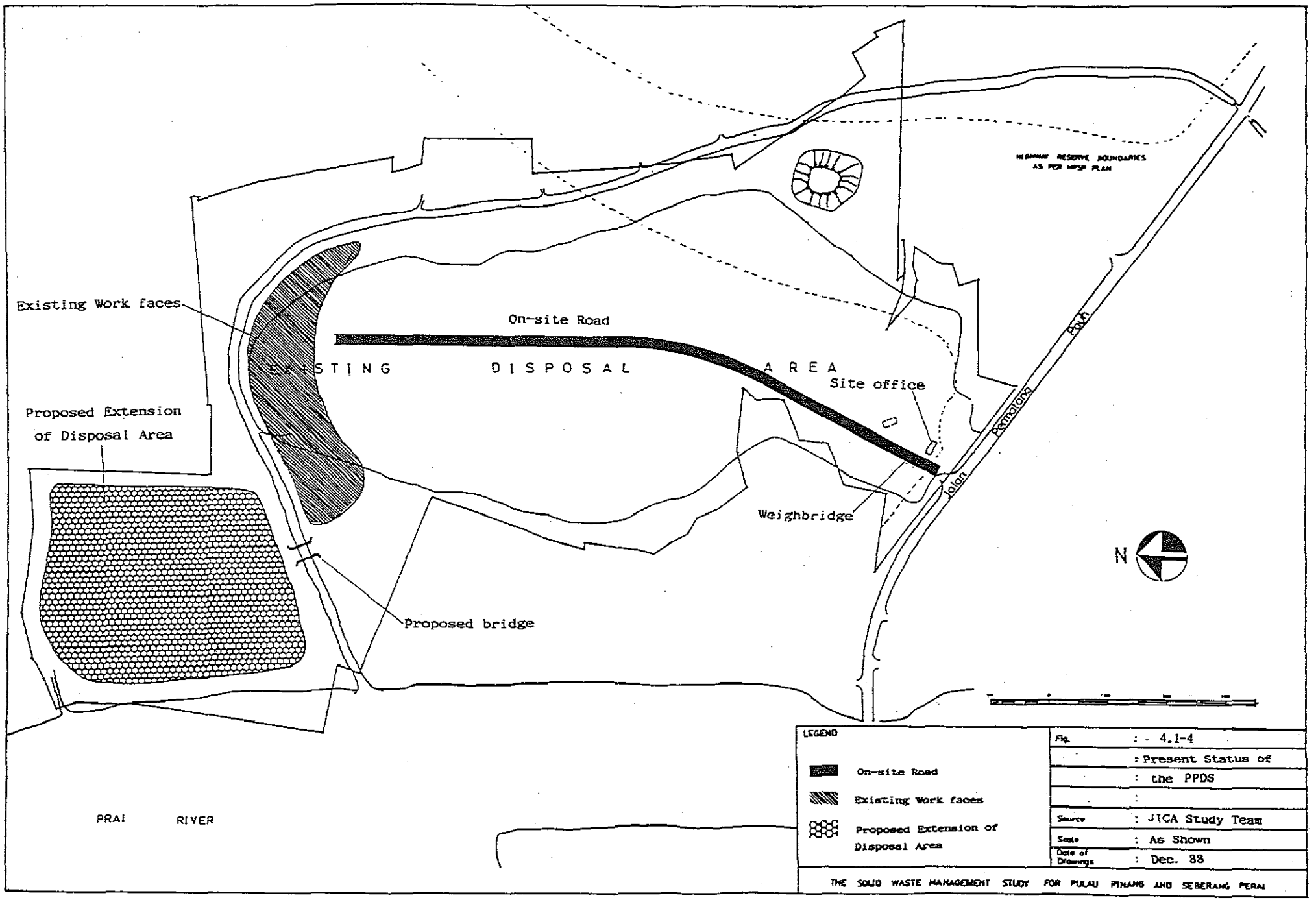
Improvement of the on-site road commenced in late August 1988. Fig. 4.1-4 indicates the extent of the improved on-site road.

Earth for construction of the on-site road was obtained from a borrow pit at the proximity of PPDS.

Waste along the line of the proposed on-site road was initially levelled and compacted and then earth was transported from the borrow pit and compacted.

Work areas are presently concentrated at the furthest end of PPDS and as such branch roads as proposed earlier was not constructed because they were not of immediate necessity. Please refer to Fig. 4.1-4 .


N
Control Office
Weigh Bridge
(Existing)
0 50 100 150 200 m
Scale
Prai Barrage
Perai River
LEGEND
Bund
Present Dumping Area
Boundary
On-Site Road
Borrow Pit for Covering Material
Fig. 4-1-3
Immediate Improvement Plan for
'Pernatang Pauh Disposal Site
SOURCE
SCALE As Shown
DATE : AUG. 1988
PREPARED BY: JICA STUDY TEAM
THE SOLID WASTE MANAGEMENT STUDY For P.PINANG & S.P


Existing Work faces
On-site Road
EXISTING DISPOSAL AREA
Site office
Proposed Extension of Disposal Area
Weighbridge
Proposed bridge
Jalan Permatang Pauh
HIGHWAY RESERVE BOUNDARIES AS PER MPSP PLAN
N
PRAI RIVER
LEGEND
On-site Road
Existing Work faces
Proposed Extension of Disposal Area
Fig. : 4.1-4
: Present Status of
: the PPDS
:
Source : JICA Study Team
Scale : As Shown
Date of Drawings : Dec. 88
THE SOLID WASTE MANAGEMENT STUDY FOR PULAU PINANG AND SEBERANG PERAI

b. Application of Cover

MPSP accepted and recognised the importance of covering material for prevention of insect and rodent infestation, blowing of paper, fires, attraction of wildlife and the release of gases and odours. At the same instance, MPSP has managed to identify a borrow pit at the proximity of the PPDS as a source of earth supply.

Unfortunately, the obvious limitation in this respect is the provision of a transporting vehicle - a tipper, which is required to be permanently stationed at PPDS just for this purpose.

Presently, MPSP is carrying out the 'Trenching Method' at the current work areas whereby trenches are dug daily, deposition of garbage in the trenches and covered. This may be possible due to the availability of work areas but it may not be such when the time comes for mounting up measures. Therefore MPSP shall have to solve the problem of acquiring a mode of transporting vehicle the soonest possible.

c. Preparation of an Operational Plan

So far no proper operational plan was adhered to at PPDS. It is therefore strongly recommended for the MPSP to prepare a comprehensive operational plan which includes:-

i. On-site road
ii. Working faces
iii. Special operational area such as areas for wet weather and special wastes
iv. Stockyard for cover materials

Sound operation achievement, efficiency and lengthening of life expectancy are the direct benefits of having a comprehensive operation plan.

d. Establishment of disposal site boundary at PPDS

Actual physical identification of the exact boundaries of the PPDS is acknowledged to be of great importance.

Lack of finance is the obvious limitation which hindered the process of implementation especially the construction of the perimeter bund.

e. Preparation of topographic map of PPDS

Currently the only available topographic map on PPDS was the one prepared by MHLG dated March 5th, 1988. The accuracy of the map obviously cannot be taken into consideration because of the continuous usage for disposal of solid wastes at PPDS.

MPSP is requested to undertake a topographic survey on the current ground level of PPDS and to follow-up with topographic surveys at every 3-4 months interval.

Continuous monitoring of the levels is necessary for proper management of PPDS.

f. Ultimate use of PPDS

So far, there has been no ultimate plan of usage for PPDS. One factor is that the land belongs to the State Government, who should undertake the preparation for the ultimate use of PPDS.

g. Execution of strict inspection on incoming materials

MPSP is currently undertaking the inspection and monitoring of incoming materials to PPDS, especially industrial wastes.

(2) Others

a. Strengthening of the present organization of final disposal
b. Close operation with other departments
c. Recognition on the importance of sanitary landfill for final disposal and consensus for the increase in final disposal cost.

The Council administrators and Councillors acknowledged and understood the importance of sanitary landfill for final disposal. Reorganization of MPSP has been planned which involve few of the related departments i.e. the Health Department, Engineering Department etc.

This shall involve reorganization for a more orderly and economic operational plan, supervision, mobilization of equipment and manpower, materials and all other necessary factors that need to be taken into consideration for a better and comprehensive solid waste management.

4.1-3 Improvement and Results after the Execution of Immediate Improvement Plan

Some of the proposed immediate improvement subjects have already been practised. Some of the improvements and results after the execution of immediate improvement plan are described in this section.

a. Reduction of the time required for a collection vehicle at the PPDS

There is a marked improvement on the time requirement of each collection vehicle at the PPDS. However, the actual reduction is being studied using data collected at the weighbridge.

b. Reduction of number of complaints from nearby residents

There used to be frequent outbreak of fire at PPDS which caused emission of thick smoke into the air. At the same time the disposal area was infested with insect and rodents. These were the two main grouches from nearby residents besides the normal complaints of foul odour emitted from disposal sites like PPDS.

Since some measures of immediate improvement was undertaken and implemented in August 1988, there has been no complaints from the nearby residents. There is a marked reduction in the population of flies as can currently be observed. This may be due to the trenching method currently being practiced which has also contributed to emission of less foul odour into the air.

c. Operational efficiency of landfill equipment

The operational efficiency of landfill equipment is the one of expected benefits from the execution of immediate improvement plan. However, it has yet to be confirmed.

d. Improvement in working condition by monitoring number of complaints from workers at PPDS

Travelling from the weighbridge to the actual work faces used to be the major complaint by the workers at PPDS especially the drivers.

Eversince the construction of the on-site road, there has been no more complaints from the drivers. Menouvering of vehicles on site is presently very much easier.

e. Number of vehicles sent for repairs or breakdown and frequency of malfunctioning of landfill equipment

The on-site condition at PPDS contributed much to the frequency of malfunctioning of vehicles as well as landfill equipment. Once the access on site was improved, naturally the frequency of malfunctioning of vehicles is reduced. But unfortunately it cannot be said to be true as far as the bulldozer is concerned. It is a very old equipment and improvement of the on-site road has not been able to give a true reflection of the expected reduction of frequency of malfunctioning of the bulldozer. Perhaps better comparison can be made once MPSP manages to secure a replacement for the present bulldozer at PPDS.

f. Fuel and oil consumption of vehicles and other landfill equipment

Data showing increase or decrease in fuel and oil consumption of vehicles and other landfill equipment can only be obtained if comparison is made between the same route before and after the improvement of the on-site road. In this respect, after the improvement of the on-site road, the vehicles and equipment have been venturing into new work faces. Therefore no clear indication can be obtained to determine the decrease or increase in both fuel and oil consumption of the vehicles. But basically there has been a decrease in fuel and oil consumption of the vehicles and equipment after the improvement of the on-site road.

4.2 Interim Measure

4.2.1 Proposed Sites

(1) Interim Period

Prior to the study on the interim measures, the interim period is defined as a preparatory period for the first phase project of the Master Plan. It is the period from now upto the openning of the proposed KMDS (Kuala Muda Disposal Site) and PBDS (Pulau Burong Disposal Site). The proposed openning date will be January 1992. It is a transitionary period from the present system (i.e. open dumping) to the future system (i.e. sanitary landfill).

(2) Proposed Sites

In response to the request made by the Malaysian side at the Steering Committee meeting held on November 5, 1988, a study on the interim measures that need to be undertaken by MPSP prior to the implementation of the Master Plan was made through the close cooperation and discussion between the JICA Study Team and the Malaysian side.

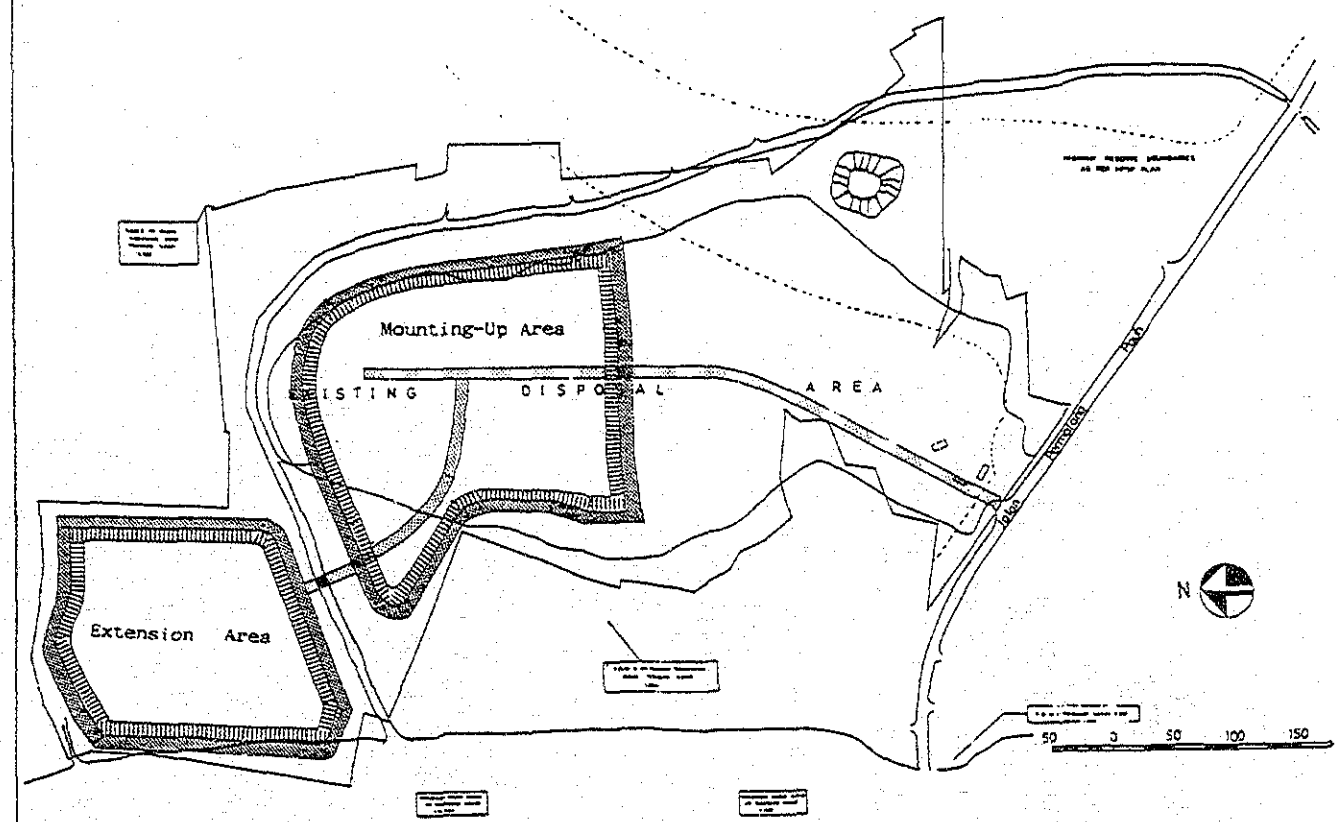
As for the preparation of a final disposal plan, it is critical to identify the location and number of final disposal sites available. Through the discussions, the sites for the interim period are identified as follows:

a. Use of present PPDS (Permatang Pauh Disposal Site)

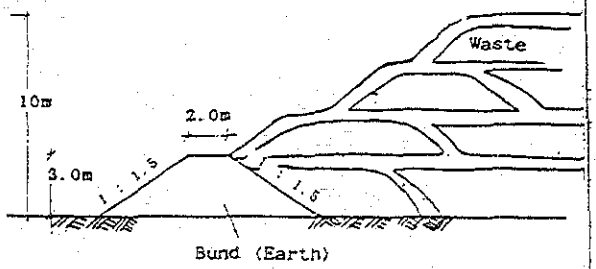
Basically the PPDS is used for the disposal of wastes from the North and Central District. The use of the PPDS is classified into the following two ways.

- Mounting up of the present disposal area
- Use of the extension area of the PPDS

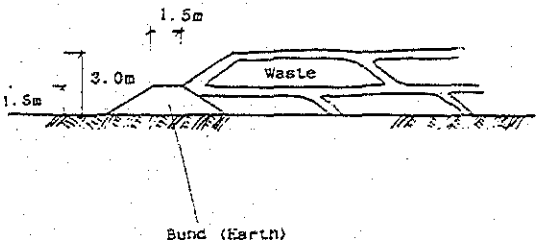
Location of proposed site is shown in Fig. 4.2-1.



Enclosing Bund for Extension Area



Bund for Mounting-Up Area



LEGEND

- Existing Road
- Bund
- Dumping Yard
- Pipe Culvert
- On-site Road

Fig.	: 4.2-1
	: Interim Measure of
	: PPDS
	:
Source	: JICA Study Team
Scale	: As Shown
Date of Drawings	: Dec. 88

THE SOLID WASTE MANAGEMENT STUDY FOR PULAU PINANG AND SEBERANG PERAI

b. Use of present PBDS (Pulau Burong Disposal Site)

At present, the disposal of waste from South District is done at the PBDS. For the interim period, operation follows the present manner.

Location of site is shown in Fig. 4.2-2.

c. Use of PBCS (Prai Barrage Candidate Site)

In response to the request made by MPSP, site investigation on the Prai Barrage Candidate Site for final disposal in MPSP was done by Prof. Matsufuji, JICA Expert attached to the Technical Unit, MHLG.

A site investigation report was done by him and the Report evaluated the PBDS as follows.

Evaluation of the Report;

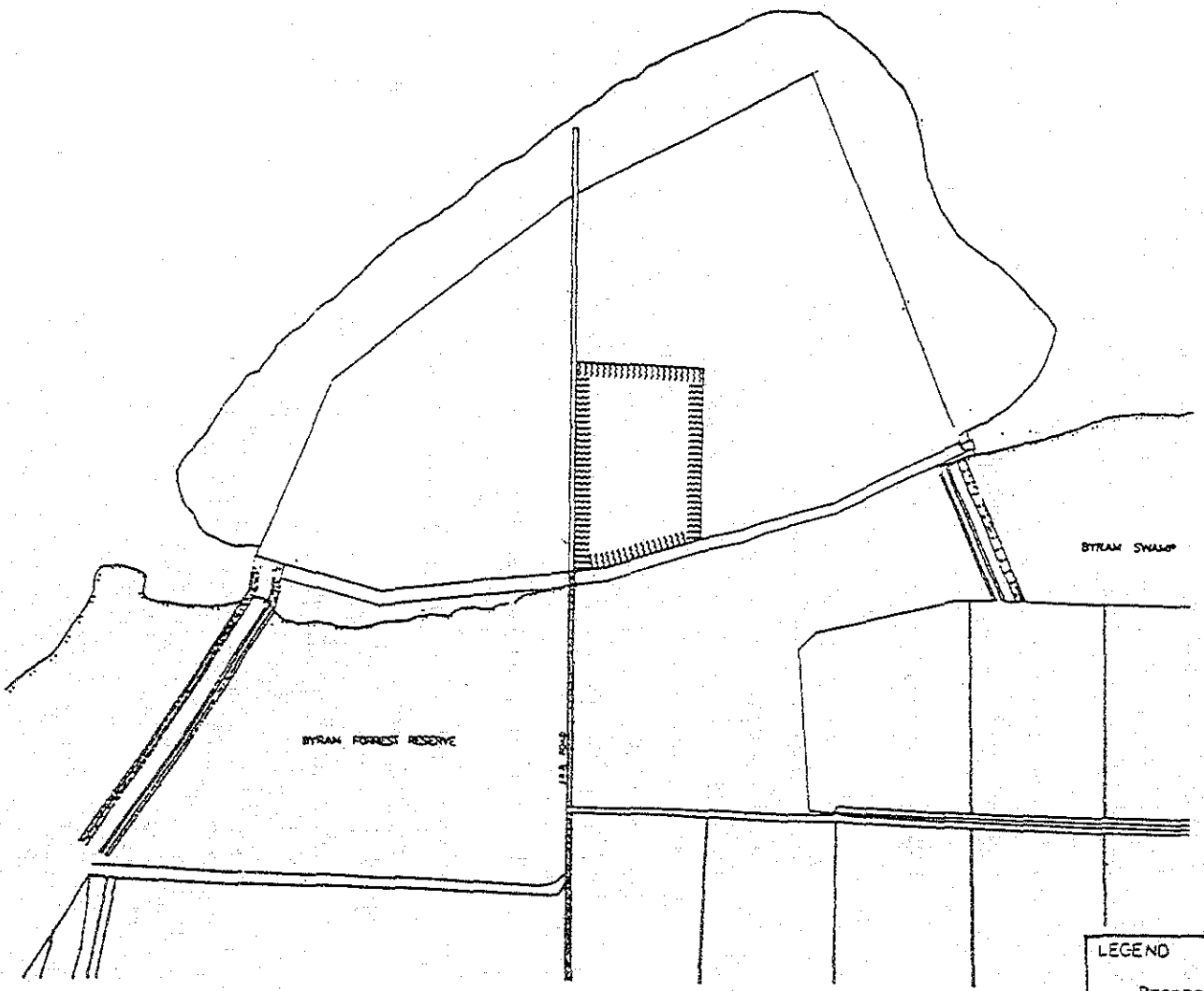
To use the site as a sanitary landfill in MPSP even for interim period (i.e.1989-1991) is not fully recommended. At present, it seems to be more suitable to use the present Permatang Pauh disposal site from the technical and economics aspects if mounting-up is permitted in view of the ultimate use of the completed site. The reasons are as follows;

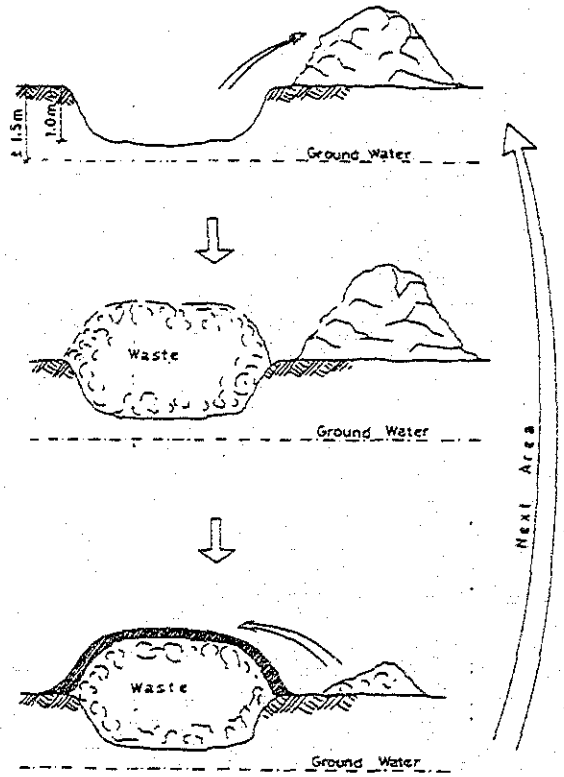
i) Site development cost

Total annual disposal cost and disposal cost per ton in 1987 are:

- Annual disposal cost in 1987 ; $130,000/year

- Disposal cost per ton in 1987 ; $1.90/ton





TRENCH METHOD

LEGEND

Proposed site for interim Period (Present PBDS)

SCALE AS SHOWN
DATE AUG. 1988
PREPARED BY JICA STUDY TEAM

THE SOLID WASTE MANAGEMENT STUDY For P PINANG & S P

Fig. 4.2-2 Interim Measure of PBDS

Whereas the site development cost are as follows:

- Site development cost with oxidation pond ; $4,371,000

- Site development cost without oxidation pond ; $2,529,000

Based on the landfill volume of the upstream site (i.e. 292,000 ton), disposal costs per ton are:

- Disposal cost per ton with oxidation pond ; $14.97/ton

- Disposal cost per ton without oxidation pond ; $8.66/ton

As clearly shown in the costs mentioned above, the sanitary landill, which is necessary for the utilization of the site, will give considerably financial burden to MPSP. The construction of a bund along the Prai River alone will be triple of annual disposal cost in 1987.

ii) Difficulty in obtaining neighbouring consensus

Supposing that the present open dumping is applied in the operation of site, it will be considerable difficult to secure neighbouring consensus because the site is in proximity to the residential area, shophouses and food factories.

iii) Non-compatibility with regional development plan

Since reclaimed area by solid waste is not suitable for building use, the ultimate use of the reclaimed area is not compatible with the PDC industrial development plan.

4.2.2 Proposed Measures

(1) Required Area

Disposal sites for the interim period are identified as follows;

- Mounting up and extension of PPDS area
- Extension of PBDS area

Based on the assumptions stated below, the extension and mounting up area required for the waste disposal in the PPDS and the PBDS interim period shall be

- 5.5 ha for the mounting up use of PPDS
- 3.6 ha for the extented usage of PPDS
- 3.2 ha for the extended usage pf PBDS

Assumptions;

i) Landfill volume is estimated, assuming that the depth of the extension area is 10m, and the height of mounting-up area is 3m in the PPDS and that the depth of the extension area is 2.0m in the PBDS.

ii) Daily amount of waste disposed in 1990 for PPDS and PBDS are 283 ton/day and 34 ton/day respectively (103,000 ton/year and 12, 410 ton/year).

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

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

(2) Proposed Measures

a. Mounting up on PPDS area

In order to use the extension area of the PPDS, it is necessary to provide an approach road (which crosses over a small stream), cleaning of the site and construction of a enclosing bund.

Six months will be required for the construction of the approach road. During this 6 months, further mounting up operation of the present reclaimed area is necessary.

b. Extension Area of the PPDS

Extension area of the PPDS shall be developed as shown in Fig. 4.2-1.

c. Extension Area of the PBDS

A trench method of landfill is to be applied in the operation of the extension area at PBDS.

4.2.3 Cost Estimation of Interim Measures for Final Disposal in MPSP

A preliminary design of the interim measures for final disposal in MPSP is carried out and estimation of cost needed during the interim period is made based on the following major items.

(1) Site Development Works

Cost of site development works is estimated considering following aspects and tabulated in Table 4.2-1

a. Site clearing.

b. Construction of a new on-site road.

c. Construction of an access (a pipe culvert) over a tributary of the Prai River to reach the proposed extension area.

d. Construction of an enclosing bund at the proposed extension area

e. Mounting-up of garbage at the proposed extension area.

(2) Landfill Equipment and Cover Material Requirement

Costs of landfill equipment and cover material for PPDS and PBDS are calculated and tabulated in Table 4.2-2 and 4.2-3 respectively.

(3) Consultancy Service

Expenditure for the implementation of the Feasibility study phase I is estimated to be $6,000,000.00 (Ringgit Six Million Only). Then, consultancy fees is expected to be 5% of the estimated cost of it i.e. $300,000.00 (Ringgit Three Hundred Thousand Only).

This estimated cost includes the preparation of detailed design for the site development of proposed KMDS and PBDS, preparation of bill of quantity and all other related supervision works.

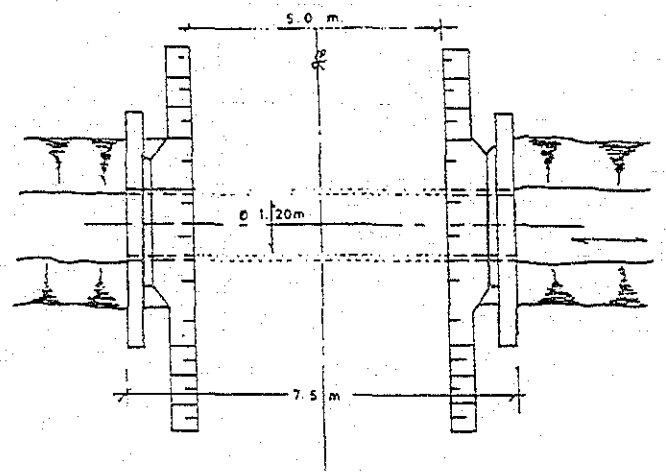
Summary of the related expenditure is specified and tabulated in Table 4.2-4

However, the cost shown in the Table 4.2-4 was estimated in December 1988 in order to ask budget allocation of the year 1989. The cost was estimated again and the revised cost is available in the Main Report Volume I Section 7.3.4.

Table 4.2-1 Site Development Cost Estimation For Interim Measures In PBDS

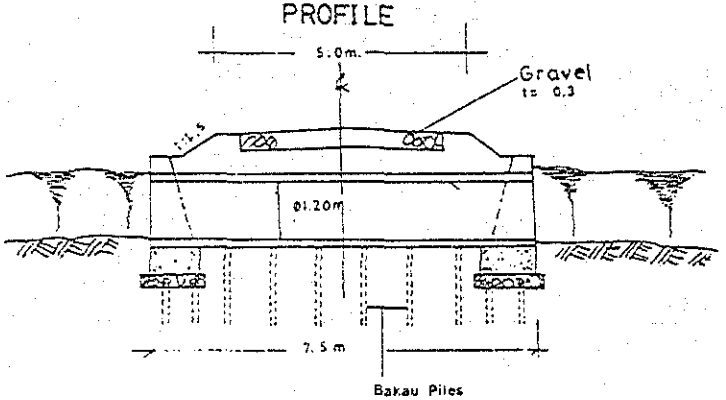
	Unit	Unit Price ($)	Quantity	Amount
a. Site Clearing	m^2	-	40,000	$ 1,500.00
b. On-Site Road	m	$ 75.00	250	$ 18,750.00
c. Pipe Culvert				
i. Concrete	m^3	$120.00	15.51	$ 1,861.00
ii. Formwork	m^2	$ 12.00	46.9	$ 562.00
iii. Gravel	m^3	$ 27.00	3.28	$ 88.00
iv. Pipe Culvert	m	$300.00	7.5	$ 2,250.00
v. Bakau Piling	No	$ 16.00	36.0	$ 576.00
d. Bund				
i. Extension	m^3	$ 5.00	15,600	$ 78,000.00
ii. Mounting-up	m^3	$ 5.00	5,600	$ 28,000.00
Total				$131,587.00

PLAN

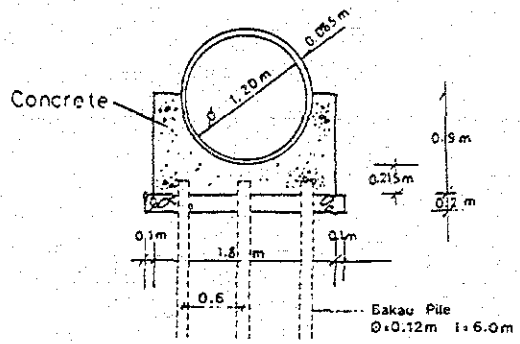


scale 1:100

PROFILE

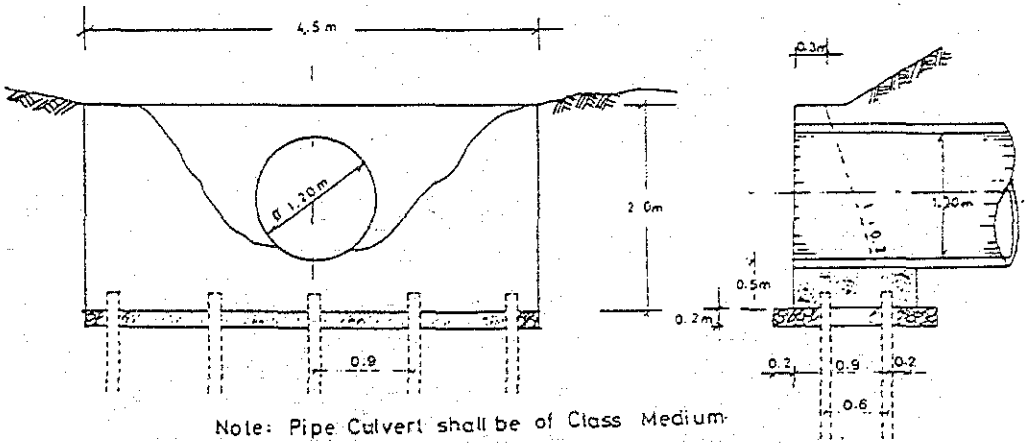


TYPICAL CROSS SECTION



DETAIL OF PARAPET

scale 1 : 50



Note: Pipe Culvert shall be of Class Medium.

LEGEND	Fig.	: 4-2-3
		: PIPE CULVERT
		:
		:
	Source	: JICA Study Team
	Scale	: As Shown
	Date of Drawings	Dec. 1988

THE SOLID WASTE MANAGEMENT STUDY FOR PULAU PINANG AND SEBERANG PERAI

Table 4.2-2 Landfill Equipment And Cover Material Requirement For Permatang Pauh Disposal Site

Description	Unit Price	Requirement For 1989		Requirement For 1990	
		Quantity	Price	Quantity	Price
1. Hydraulic Track shovel (Bulldozer) 18 ton class	$366,000.00	1	$366,000.00	-	-
2. Hydraulic Excavator 24 ton class	$270,000.00	1	$270,000.00	-	-
3. Tipper 12 ton class	$ 65,000.00	1	$ 65,000.00	-	-
4. Covering Material	$4.00 per m^3	36,800 m^3	$147,200.00	38,700 m^3	$154,800.00
	Sub-Total		$848,200.00		$154,800.00
Total				$1,003,000.00	

Table 4.2-3 Landfill Equipment And Cover Material Requirement For Pulau Burong Disposal Site

Description	Unit Price	Requirement For 1989		Requirement For 1990	
		Quantity	Price	Quantity	Price
1. Hydraulic Track shovel (Bulldozer) 18 ton class	$368,000.00	-	-	-	-
2. Hydraulic Excavator 24 ton class	$270,000.00	1	$270,000.00	-	-
3. Tipper 12 ton class	$ 65,000.00	-	-	-	-
4. Covering Material	$4.00 per m³	-	-	4,800 m³	$ 19,200.00
	Sub-Total		$270,000.00		$ 19,200.00
Total			$289,200.00		

Table 4.2-4 Summary of Cost Estimation

Description		1889	1990
1. Site development works			
a. Site Clearing	PPDS	$ 1,500.00	
b. On-Site Road		$ 18,750.00	
c. Pipe Culvert		$ 5,337.00	
d. Bund		$106,000.00	
Total		$131,587.00	
2. Landfill equipment, cover materials and other related items	PPDS	$848,200.00	$154,800.00
	PBDS	$270,000.00	$ 19,200.00
Total		$1,118.200.00	$174,000.00
3. Consultancy Fees For Feasibility Study Phase I		$300,000.00	
Total		$1,549,787.00	$174,000.00

JICA