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SOLID WASTE MANAGEMENT STUDY FOR PULAU PINANG AND SEBERANG PERAI MUNICIPALITIES

SUPPORTING REPORT

VOLUME III

PRELIMINARY DESIGN OF KUALA MUDA AND PULAU BURONG

AUGUST 1989

JAPAN INTERNATIONAL COOPERATION AGENCY

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ABBREVIATION

ABC	:	Action Plan for a Beautiful and Clean Malaysia
BSDS	:	Bakau Street Disposal Site
BPTS	:	Balik Pulau Transfer Station
CIF	:	Cost, Insurance and Freight
DBKL	:	City Hall of Kuala Lumpur
DID	:	Drainage and Irrigation Department
DOE	:	Department of Environment
EIA	:	Environmental Impact Assessment
ENSEARCH	:	Environmental Management and Research Association of Malaysia
EPU	:	Economic Planning Unit
FTZIP	:	Free Trade Zone Incineration Plant
FTZTS	:	Free Trade Zone Transfer Station
GDP	:	Gross Domestic Product
IKU	:	Public Health Institute
JICA	:	Japan International Cooperation Agency
JKKK	:	Village Development and Security Committee
JMPDS	:	Jelutong Mole Previous Disposal Site
JMTS	:	Jelutong Mole Transfer Station
JPBD	:	Town and Country Planning Department
KEMAS	:	Community Development, Ministry of National and Rural Development
KMDS	:	Kuala Muda Disposal Site
LWL	:	Low Water Level
LA	:	Local Authority
M	:	Million
MC	:	Municipal Council
MMTS	:	Mak Mandin Transfer Station
MPPP	:	Majlis Perbandaran Pulau Pinang
MPSP	:	Majlis Perbandaran Seberang Perai
MOH	:	Ministry of Health
MHLG	:	Ministry of Housing and Local Government
M/P	:	Master Plan
MSWM	:	Municipal Solid Waste Management
NEB	:	National Electricity Board
NEP	:	New Economic Policy
PADS	:	Pantai Acheh Disposal Site
PBDS	:	Plan Burong Disposal Site
PDC	:	Penang Development Corporation
PERDA	:	Penang Rural Development Authority
PHA	:	Public Health Assistant
PHI	:	Public Health Inspector
PICIP	:	Prai Indusrial Complex Incineration Plant
PSD	:	Public Services Department, Prime Minister's Department
JKR/PWD	:	Public Works Department
PPC	:	Penang Port Commission

PPC	:	Penang Port Commission
S/R	:	Suppoting Report
SWM	:	Solid Waste Management
SWMIS	:	Solid Waster Management Information System
TDC	:	Tourist Development Corporation
UDS	:	Urban Drainage System
USD	:	Urban Service Department
USM	:	University Sains Malaysia

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I. Phased Improvement

1.1 Background of Phased Improvement

(1) Design Principles Applied in the Master Plan

The design principles of sanitary landfill development and operation in the Master Plan are established so as to satisfy the following standards, guideline, etc.

a. DOE Standards

- Recommended Code of Practise for the Disposal of Solid Waste on Land.
- Environmental Quality (Sewage and Industrial Effluents) Regulations 1979,Regulation 8 Standard-B.

In Regulation 8, inland waters are divided into two areas, i.e. Standard-A catchment areas and Standard-B catchment areas. Standard-A areas are set for protection of water supply intakes for the purpose of human consumption including drinking. Proposed Kuala Muda and Pulau Burong disposal sites are not located in the upperstream of water supply intakes. Therefore, Standard-B is applicable. The parameter limits of effluent in Standard B are tabulated in Table 1.1-1

b. A Guideline on the Storage, Collection, Transport and Disposal of Solid Waste in Malaysia, Technical Unit of Local Government Division, Ministry of Housing and Local Government.

c. Other aspects considered in the design

i. Social acceptability on noise, littering, Landscape, odor, etc.

ii. Eco-system acceptability

iii. Operational acceptability

Table 1.1-1 Parameter Limits of Effluent of Standard B

Parameter	Unit	Standard B
(i) Temperature	C	40
(ii) pH Value	-	5.5-9.0
(iii) BOD at 20 C	mg/l	50
(iv) COD	mg/l	100
(v) Suspended Solids	mg/l	100
(vi) Mercury	mg/l	0.05
(vii) Cadmium	mg/l	0.02
(viii) Chromium, Hexavalent	mg/l	0.05
(ix) Arsenic	mg/l	0.10
(x) Cyanide	mg/l	0.10
(xi) Lead	mg/l	0.5
(xii) Chromium, Trivalent	mg/l	1.0
(xiii) Copper	mg/l	1.0
(xiv) Manganese	mg/l	1.0
(xv) Nickel	mg/l	1.0
(xvi) Tin	mg/l	1.0
(xvii) Zinc	mg/l	1.0
(xviii) Boron	mg/l	4.0
(xix) Iron (Fe)	mg/l	5.0
(xx) Phenol	mg/l	1.0
(xxi) Free Chlorine	mg/l	2.0
(xxii) Sulphide	mg/l	0.50
(xxiii) Oil and Grease	mg/l	10.0

(2) Request for Phased Improvement

The realization of the sanitary landfill level set up in the Master Plan is highly desirable in view of environmental preservation, social and operational acceptability. It is, however, unavoidable to overcome the following financial difficulties in achieving the Master Plan targets.

a. Large capital investment

The capital investment on the development of Kuala Muda and Pulau Burong sanitary landfills for Phase 1 is to be estimated very large for the Council, i. e. 24.3 million ringgit including cost of landfill equipment.

The Council however, has no financial source available for this this development at present. It is therefore, necessary to obtain financial support from the Federal Government to materialize the development.

b. Great increase of disposal cost

In case sanitary landfill of the Master Plan is introduced in MPSP, disposal cost, which includes depreciation expense and operation/maintenance costs will increase significantly as shown below.

	1987	1992	2005
Annual Disposal Cost ($1,000)	130	2,978	5,546
Unit Disposal Cost ($/per ton)	1.9	22.4	22.4

In view of the above, it should be emphasized that the realization of the planned sanitary landfill within the proposed time frame requires the satisfactory commitment on the following improvements proposed by the Master Plan.

i. Reduction in collection and haulage cost

ii. Reduction in street/drain cleansing cost

iii. Increase in revenue from commercial waste collection collection and disposal fees.

In addition to the realization of the proposed improvement subjects, for the materialization of of sanitry landfill, Federal, State and Local Governments have been discussing about financial problems faced by MPPP and MPSP.
Considering the magnitude of the project cost, it was requested by the Malaysian side at the Technical Committee meeting that the Study Team should examine the possibility of the phased improvement of the Master Plan targets in order to mitigate the financial burden on MPSP.

1.2 Level of Sanitary Landfill Development and Operation

(1) Presentation of Sanitary Landfill Level

In response to the request made by the Malaysian side at the Technical Committee meeting, the Study Team presented the following four levels of landfill development and operation from present landfill to the Master Plan target. (See Fig.1.2-1, 1.2-2 and 1.2-3)

a. Level 1; Controlled Tipping (Present Level)

i. Target
- Introduction of controlled tipping

ii. Level to be achieved
- Establishment of access to site
- Introduction of cover materials in order to prevent fire and to lessen blown waste and rank odor
- Introduction of inspection, control and operational recording system of incoming waste

b. Level 2; Sanitary Landfill with a Bund and Daily Soil Covering

i. Target

- Introduction of sanitary landfill

ii. Level to be achieved

- Establishment of site boundary in order to distinguish the disposal site and to eliminate scavenging

- Execution of sufficient cover over waste disposed

- Establishment of disposal site by the construction of enclosing bund

- Introduction of divider between present landfill area and working face

- Establishment of drainage system in order to divert stormwater and seepage from surrounding area and to reduce leachate

- Introduction of environmental protection facilities in order to lessen direct impact on surroundings such as buffer zone, litter control and gas removal facilities

- Introduction of semi-aerobic sanitary landfill by the installation of gas removal facilities

- Introduction of amenities for the staff.

c. Level 3; Sanitary Landfill with Leachate Circulation

i. Target

- Establishment of leachate control

ii. Level to be achieved

- Establishment of leachate control by the installation of leachate collection, cycling and monitoring facilities

- Establishment of semi-aerobic sanitary landfill in order to facilitate the stabilization of waste disposed through the active decomposition in semi-aerobic condition

- Establishment of dust prevention system by introducing water sprinkling.

d. Level 4; Sanitary Landfill with Leachate Treatment

i. Target

- Establishment of leachate treatment

ii. Level to be achieved

- Establishment of leachate treatment by the installation of oxidation pond

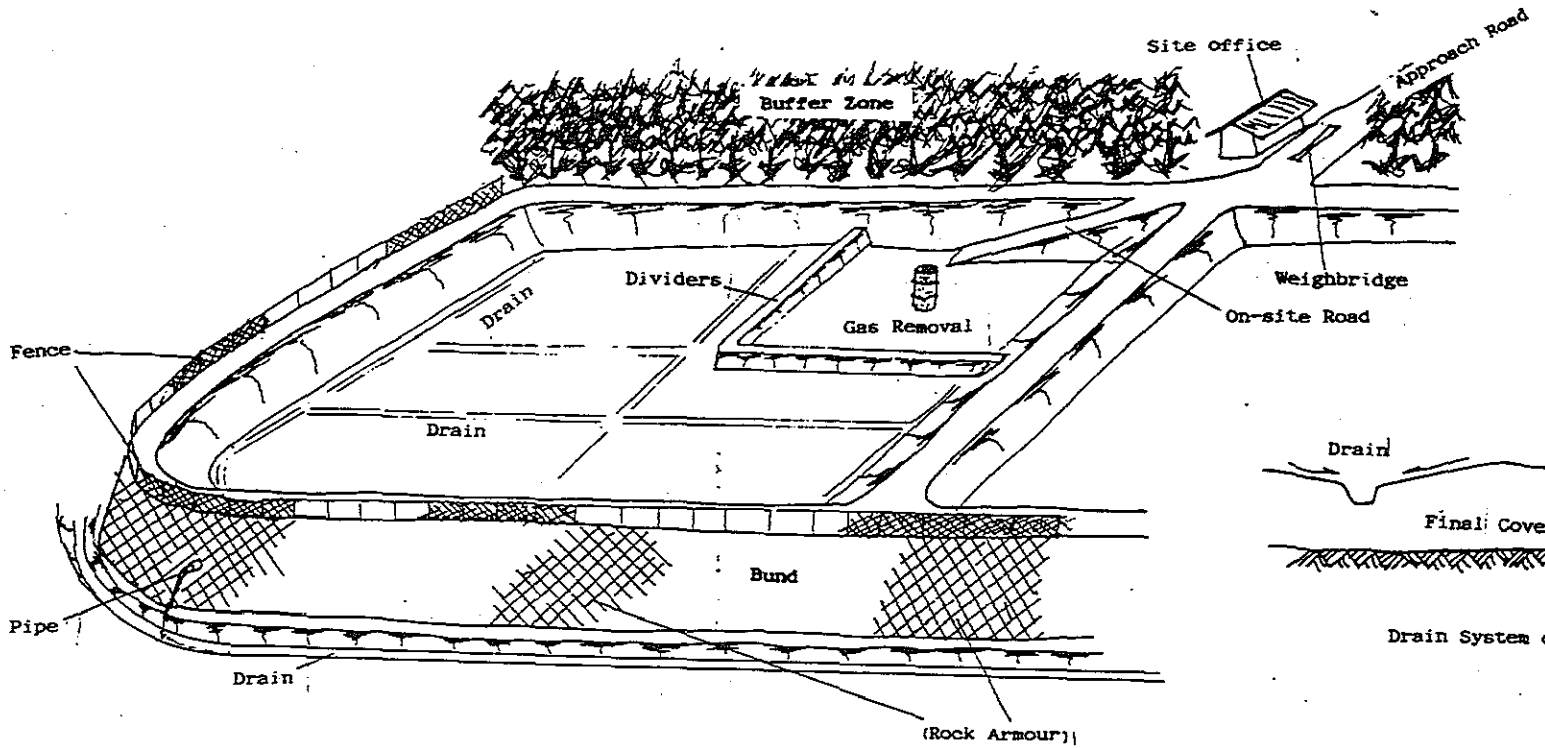
- Establishment of seepage control by the sealand (liner).

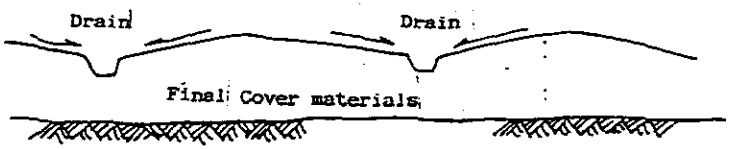
(2) Outline of Sanitary Landfill Development and Operation

The above mentioned level of sanitary landfill development and operation are described and tabulated in Table 1.2-1. The prospective levels of sanitary landfill development and operation in 2nd, 3rd and 4th level are illustrated in Fig.1.2-1, 1.2-2 and 1.2-3 respectively.

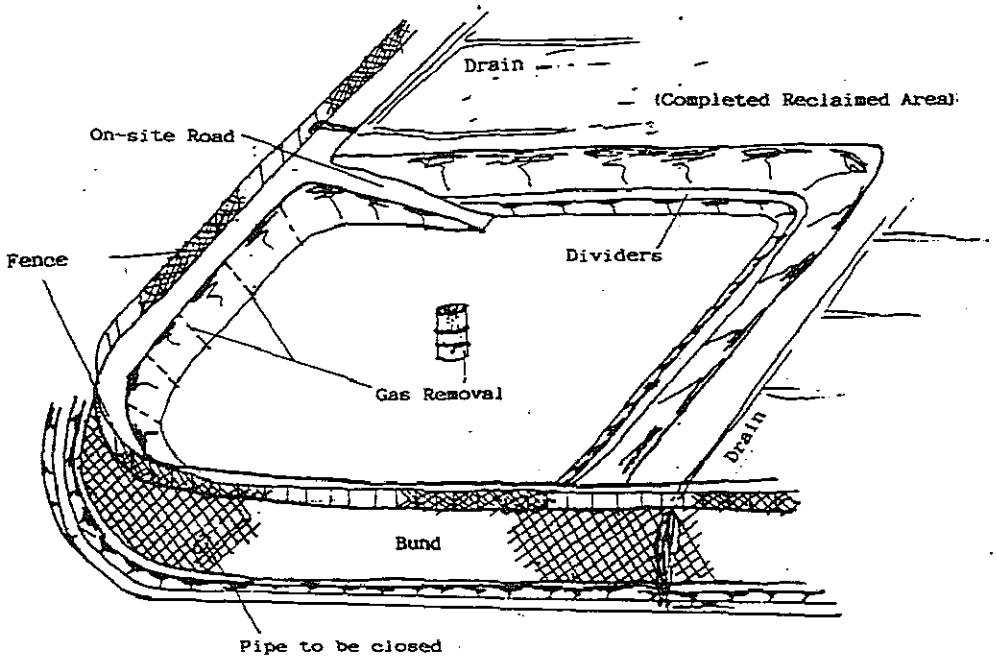
(3) Environmental Issues

A comparison on the environmental level to be achieved by each level of sanitary landfill development and operation is made and tabulated in Table 1.2-2.





Drain System of Completed Reclaimed Area



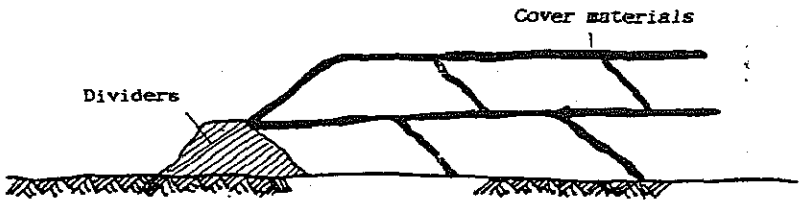


Fig. 1.2-1 Prospective Illustration of Sanitary, Landfill Development and Operation in Second Level

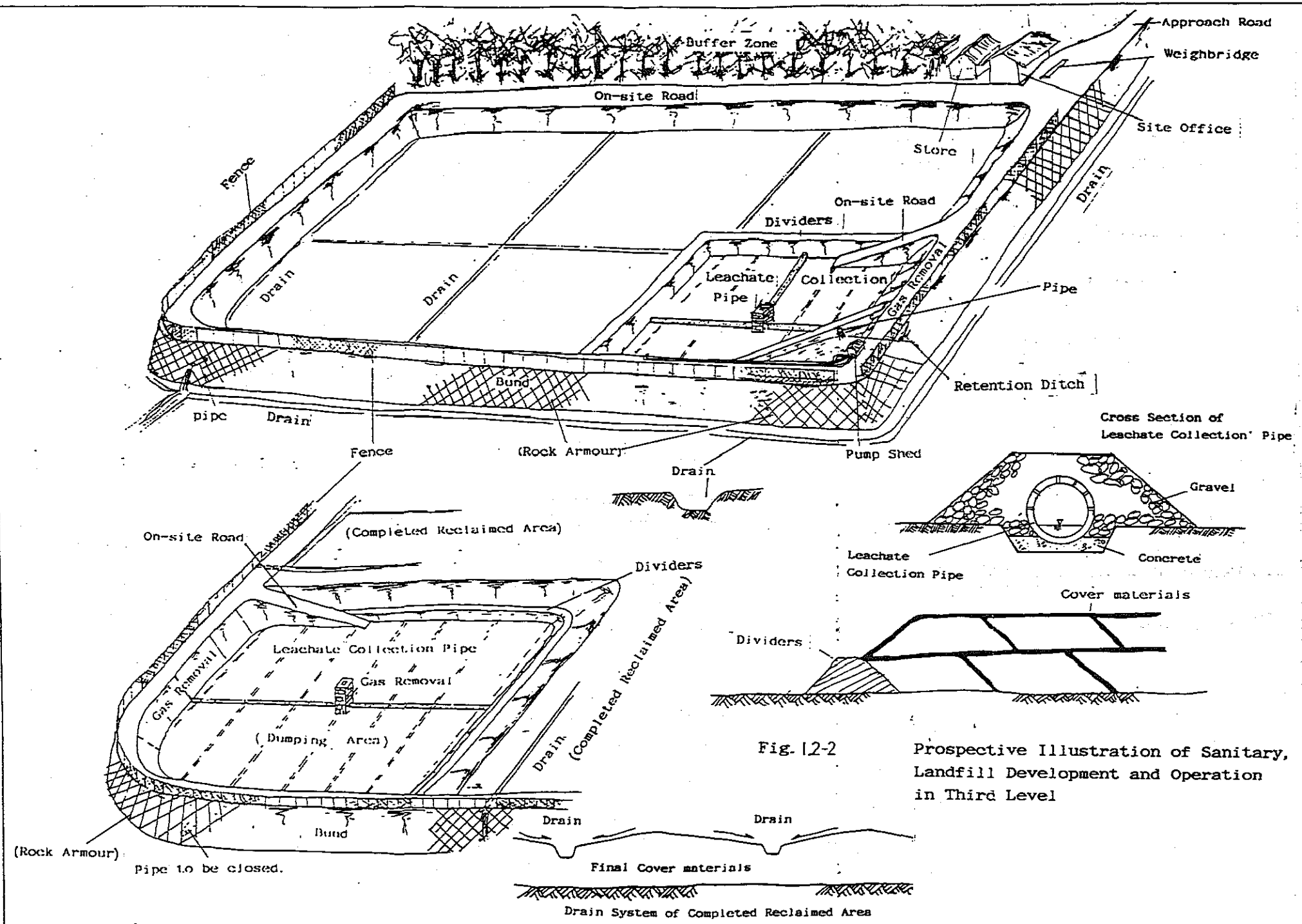


Fig. 12-2 Prospective Illustration of Sanitary, Landfill Development and Operation in Third Level

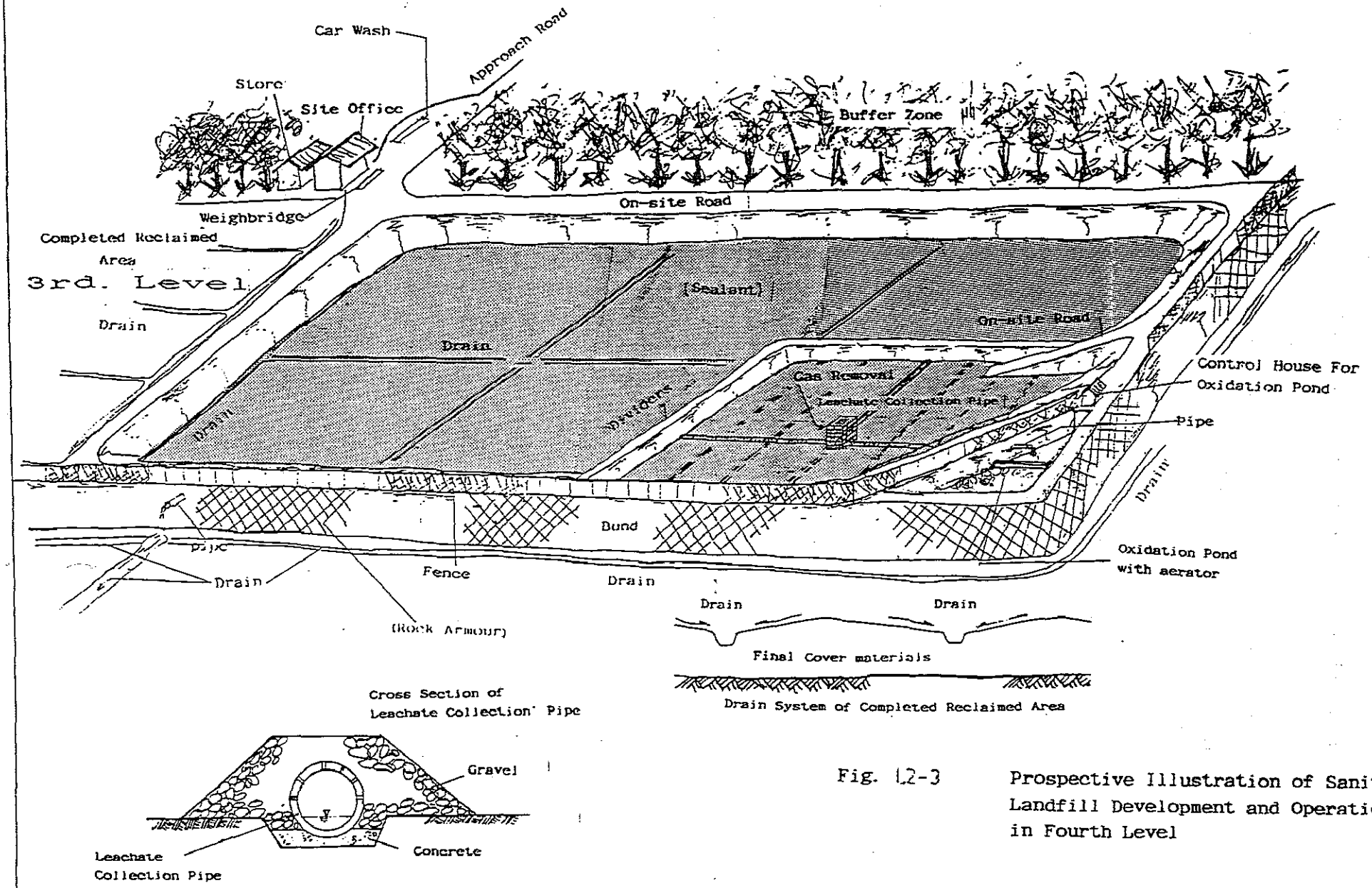


Fig. 12-3 Prospective Illustration of Sanitary, Landfill Development and Operation in Fourth Level

Table 1.2-1 Outline of Sanitary Landfill Development and Operation

Items	Level of Sanitary Landfill				Remarks
	1st Level	2nd Level	3rd Level	4th Level	
1. Site Development Works					
1.1 Main Facilities					
a. Enclosing Structure					
i. Enclosing Bund		O	O	O	
ii. Divider		▲	O	O	▲ means that a bund is made of construction demolision and earth
b. Drainage System					
i. Surrounding Drain		O	O	O	
ii. On-site Drain (Surface Water)		O	O	O	The drain is for the site which is not used for landfill
iii. On-site Drain (Underground Springs)		O	O	O	If necessary
iv. Drain for Reclaimed Area		O	O	O	
c. Access					
i. Approach Road	O	O	O	O	
ii. On-site Road	O	O	O	O	
iii. Others	O	O	O	O	Improvement of existing road network for accessing to the site

Note: O means the facility is necessary.

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Items	Level of Sanitary Landfill				Remarks
	1st Level	2nd Level	3rd Level	4th Level	
1-2 Environment Protection Facilities					
i. Buffer Zone		O	O	O	
ii. Litter Control Facilities		▲	O	O	Movable fence, etc.
iii. Gas Removal Facilities		▲	O	O	
iv. Leachate Collection Facilities			O	O	
v. Leachate Cycling Facilities			O	O	
vi. Seepage Control Facilities				O	
vii. Leachate Treatment Facilities				O	
1-3 Buildings and Accessories					
i. Site Office	▲	▲	O	O	
ii. Weigh Bridge	O	O	O	O	
iii. Storage Building			O	O	
iv. Safety Facilities		O	O	O	Gate, fence lights, etc.
v. Fire Prevention Facilities		▲	O	O	Watertank, extinguisher, etc.
vi. Monitoring Facilities			O	O	Monitoring well, etc.
vii. Car Wash			O	O	

Items	Level of Sanitary Landfill				Remarks
	1st Level	2nd Level	3rd Level	4th Level	
2. Equipment					
i. Landfill Equipment	O	O	O	O	
ii. Others			O	O	Water truck, Inspection Vehicles, etc.
3. Operation and Maintenance					
3-1 Operation					
a. Personnel	O	O	O	O	
b. Cover Material	▲	O	O	O	▲ means insufficient operation
c. Utility					
i. Fuel	O	O	O	O	
ii. Water		O	O	O	
iii. Electricity		Nil	O	O	
d. Chemicals					
i. Insecticide	O	O	O	O	
ii. Monitoring Chemicals			O	O	
e. Others		O	O	O	Devider, drain for reclaimed area, leachate collection pipes, etc.

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Items	Level of Sanitary Landfill				Remarks
	1st Level	2nd Level	3rd Level	4th Level	
3-2 Maintenance					
i. Main Facilities		O	O	O	
ii. Environment Protection Facilities		O	O	O	
iii. Buildings and Accessories	O	O	O	O	
iv. Equipment	O	O	O	O	

Table 1.2-2 Comparison of Environmental Level to be Achieved by Each Level of Sanitary Landfill Development and Operation

Cont./...

Items \ Level	Level of Sanitary Landfill Development and Operation			
	First Level	Second Level	Third Level	Fourth Level
1. Landfill Structure				
1-1 Landfill structure	- Anaerobic Landfill	- Improved Anaerobic Sanitary Landfill	- Semi-aerobic Sanitary Landfill	- Semi-aerobic Sanitary Landfill
1-2 Achieved Condition	- Leachate generated in solid waste layers is seldom drained but remained within, and always keeps landfill in an anaerobic state. Generally, the quality of leachate is not improved over a long time. - Because of inactive decomposition of wastes, prompt stabilization of a landfill is not achievable.	- Through gas removal facilities, the quality of leachate is slightly improved as compared with the First Level. Almost all of the solid waste, however, is still kept in an anaerobic state. - The rate of decomposition is also slightly improved.	- Leachate accumulated at landfill bottom is promptly discharged through drain pipes (leachate collection pipes). The pipes also permit the natural inflow of air. - This structure facilitates the decomposition of solid waste because of semi-aerobic condition made by the drain pipes. The quality of leachate is much improved and generation of offensive odor is reduced further. - Water content of solid wastes disposed is lower than the Second level.	- Same as the Third Level
2. Leachate and It's Impacts on Surroundings				
2-1 Leachate Generation Amount	- Leachate is freely discharged out from both landfilling and reclaimed areas because enclosing structure is not set up. - Rain water flows into the landfill from catchment area and it incresses leachate amount.	- As for the reclaimed areas, surface water is drained and discharged out. - Rain water from catchment area is diverted into surrounding drains. - A divider limits the area for leachate generation to the working area. - As mentioned above, since the area for leachate generation is limited, leachate amount is also limited to the precipitation on the certain area.	- Same as the Second Level	- Same as the Second Level

Items \ Level	Level of sanitary Landfill Development and Operation			
	First Level	Second Level	Third Level	Fourth Level
2-2 Leachate Control Facilites	- None	- Enclosing bund and divider prevents direct discharge of leachate.	- In addition to the facilities for Second Level, there are leachate cycling and monitoring facilities. - Leachate is discharged only during heavy rain from regulating pond. Leachate discharged is therefore, diluted.	- Same as Third Level except for effluent which is constantly treated and discharged from oxidation pond.
2-3 Leachate Treatment Facilities	- None	- None	- Retention and regulating ponds may work as oxidation pond.	- Leachate is treated in an oxidation pond with aerator so as to satisfy the DOE effluent Standard B.
2-4 Leachate Quality	- Amount of leachate is high and it's quality is worse than any other levels. Besides that, there shall be negligible improvement on the quality after a long period of time.	- Amount of leachate is limited because of bund and divider. However, the quality of leachate is not improved after a long period of time.	- Amount of leachate is limited as in Second Level. - The quality of leachate is improved much faster than Second Level because of semi-aerobic landfill condition. - Leachate cycling facilitates self purification of the wastes disposed. - Since leachate is discharged only during heavy rain, it is therefore, diluted.	- Amount of leachate is limited as in Second Level. - The quality of leachate to be discharged satisfies the DOE effluent Standard B ; i.e. BOD less than 50mg/l, COD less than 100mg/l, etc.

Items \ Level	Level of sanitary Landfill Development and Operation			
	First Level	Second Level	Third Level	Fourth Level
2-5 Impacts by Leachate a. Impacts on Underground Water	- The impacts are dependent on the permeability of bottom soil. - If it is a permeable bottom soil, the impacts on underground water is very high because of high pressure head and large amount of leachate.	- The impacts are dependent on the permeability of bottom soil. - The amount of leachate is less than First Level. However, the impacts are still high in the case of permeable bottom soil.	- The impacts are dependent on the permeability of bottom soil. - Since amount and pressure of leachate is limited, permeance of leachate into underground water is reduced. - The quality of leachate is better than Second Level. However, possibility of underground water contamination still exists.	- Sealant is laid so as to prevent underground water from leachate seepage. - There is very little underground water contamination.
b. Impacts on Surface Water	- Because of free discharge of leachate from a landfill site, the impacts on to surrounding water area is very high.	- Discharge of leachate may occur when the divider is overflown and through seepage. - Although leachate amount is limited, impacts on to surrounding water area is still high because of uncontrolled and unimproved leachate.	- Discharge of leachate is made only during heavy rain. - Leachate can be monitored. In case leachate to be discharged would affect the surroundings, the construction of leachate treatment facility is encouraged.	- Effluent from landfill site satisfies the DOE Standard B.
3. Others				
3-1 Vector control	- Great generation of flies, insects and rodents. - Great crow gathering.	- Vector control is achieved and it is much improved compared to First Level.	- Same as Second Level.	- Same as Second Level.
3-2 Odors and Gas Production	- Odors are constantly generated. - Occational fires occur due to spontaneous ignition.	- It is much better than First Level. - No occurance of fire	- Due to semi-aerobic landfill structure, it is better than Second Level.	- Same as Third Level.
3-3 Others	- Litter of wastes and dust. - Deterioration of landscape. - Noise. - Existence of scavengers.	- It is improved in all aspects.	- In addition to the condition achieved at Second Level, dust problem is improved by water sprinkler.	- Same as Third Level.

1.3 Phased Improvement

(1) Preliminary Estimates of Project Cost

After the selection of the most suitable alternative for the Master Plan, Pre-EIA and soil investigations were carried out on KMDS and PBDS. As a result, the following major aspects are realized regarding the development of KMDS and PBDS.

a. It is suggested by Pre-EIA that a leachate effluence outlet from a retention pond should be set up in the sea (LWL should be deeper than 50cm.) out of the lagoon and mangrove forest so as not to have effect on fauna which lives in the lagoon and forest.

b. The result of soil investigation shows that there is more than 10m depth of marine clay layer that exists under the bottom of KMDS and PBDS. The permeability coefficient of marine clay is very low ; i.e.10^{-6} to 10^{-7} cm/sec. This indicates that seepage control facilities at the bottom of KMDS and PBDS are not necessary.

Taking the above aspects into consideration, a rough estimate of the First Phase project cost is made as follows.

- Second Level 7.6 million ringgit
- Third Level 8.1 million ringgit
- Fourth Level 23.5 million ringgit

However, this estimate has been based on the cost utilized in the Master Plan. Detailed estimates are shown in the Chapter 3.

(2) Selection of Sanitary Landfill Level

A Technical Committee meeting was held on the 21st February 1989 in Kuala Lumpur to mainly discuss the draft Preliminary Environmental Impact Assessment (Pre-EIA) report for the project prepared by the University Sains Malaysia (USM) incorporating the findings of JICA Study Team.

After much discussion on the subject, the Committee decided that the 3rd level sanitary landfill was acceptable and that the 4th level would be introduced accordingly: for MPSP, it would be introduced from Phase 3 onwards.

The reasons are described as follows:

a. The USM Study Team presented the draft preliminary EIA report concerning the proposed disposal sites of Kuala Muda and Pulau Burong. The Team concluded that the ecological and social impact from the implementation of the 3rd level sanitary landfill as prepared by the JICA Study Team would be minimum in light of the organic loading of predicted effluent and the mitigation measures to minimise the impact taken by the JICA Study Team.

b. Fourth level is set up to satisfy the design principles such as the DOE standards.
According to the financial evaluation, even if improvements in collection and cleansing works proposed by the Study Team are achieved, it is not feasible to materialize fourth level of landfill for the first phase project of KMDS and PBDS..

c. In case that the improvements to collection and cleansing works proposed are achieved, it is financially feasible to execute third level for the first phase project of both KMDS and PBDS.

d. There is no significant financial difference between second and third level of landfill. However, the environmental level to be achieved by each level of landfill will be significantly different.

e. In addition to the above, because of low permeability of bottom soil in KMDS and PBDS, there would be very little impacts on underground water.

f. Furthermore, leachate is able to be monitored. In case leachate to be discharged affects the surroundings, the construction of leachate treatment facility is encouraged.

(3) Concept Plan of Proposed First Phase Project

a. Alternatives

Prior to the preliminary design, a concept plan of the first phase project should be made to ensure efficient usage of the site up to year 2005. The basic conditions for the preparation of the concept plan are summarized as follows.

Items		KMDS	PBDS	Remarks
Area of Site (ha)	Lagoon	60	29.1	
	Inland	17.9		
Disposal Volume ($1000m^3$)	Phase I 1992-1996	560	664	including cover soil
	Phase I 1997-2005	718	850	including cover soil
	Phase III 2002-2005	697	823	
Required Area for Phase I(ha)		17.9	16.7	
Level of Landfill		3	3	
Construction Plan		3 stages		1991,1996 and 2001

Based on the above mentioned planning conditions, the following alternatives of concept plans for KMDS and PBDS are proposed and illustrated in Fig.1.3-1 and 1.3-2 respectively.

i. KMDS

Plan 1

- Development and operation starts from the inland area.

- A leachate outlet is planned to be set up in the sea out of the natural bund.

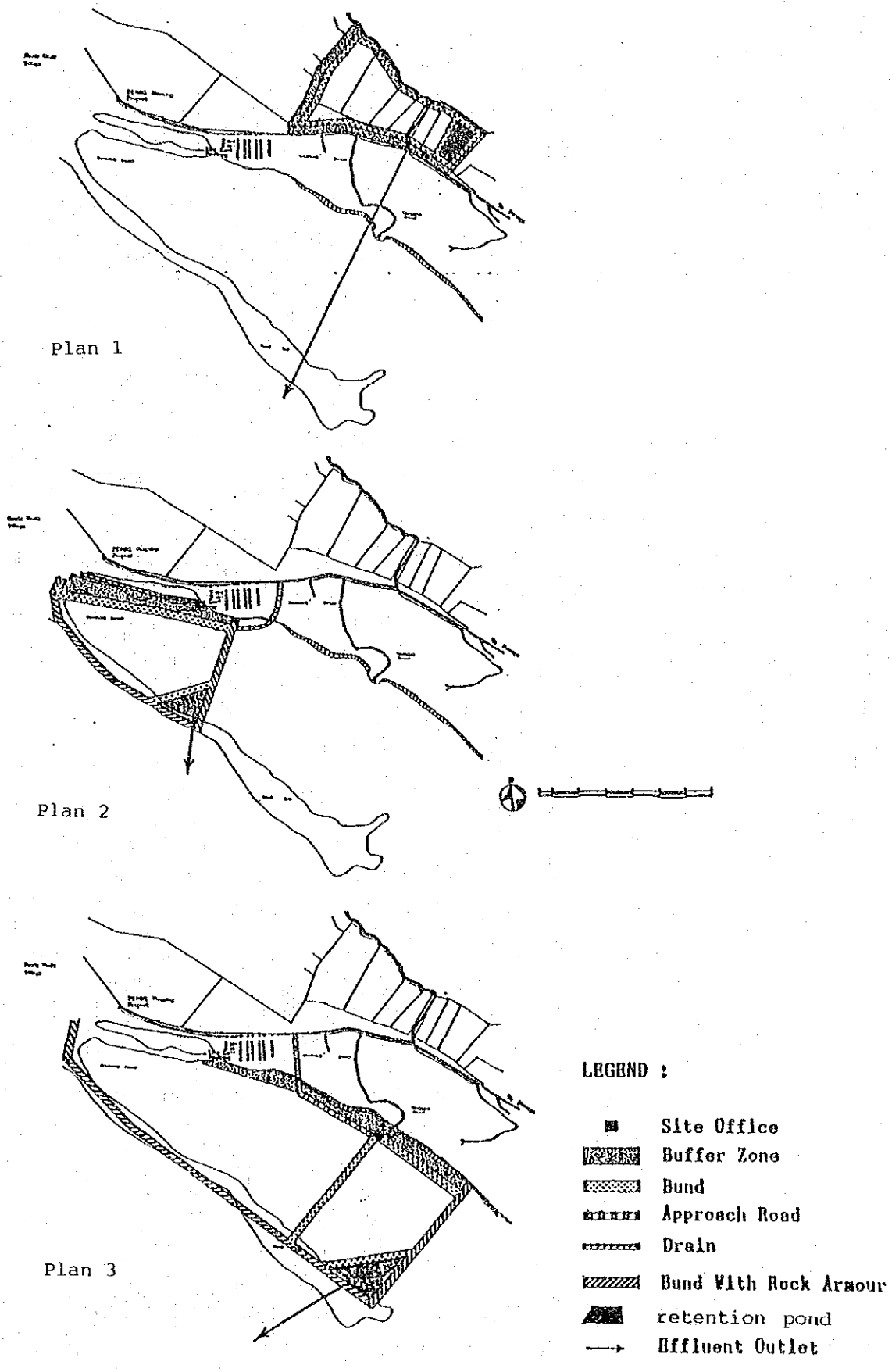


Fig.1.3-1 Concept Plan for First Phase Project of KMDS

Plan 2

- In order to maximum use of the lagoon site, development and operation starts from the western part of the lagoon.

- An enclosing bund is planned to be constructed only for the use of Phase I.

Plan 3

- Since it may be relatively easy to obtain neighbourhood consensus, development and operation starts from the eastern part of the lagoon site.

- An enclosing bund is planned to be constructed to be used in Phase I,II and III.

ii.PBDS

Plan 1

- Development and operation starts from the northern part of the BFR (Byram Forest Reserve)

- Required height of landfill up to 1997 is 7.5 meters.

- Leachate outlet is planned to be set up in Sungai Tengah.

Plan 2

- Development and operation starts from the southern part of the BFR.

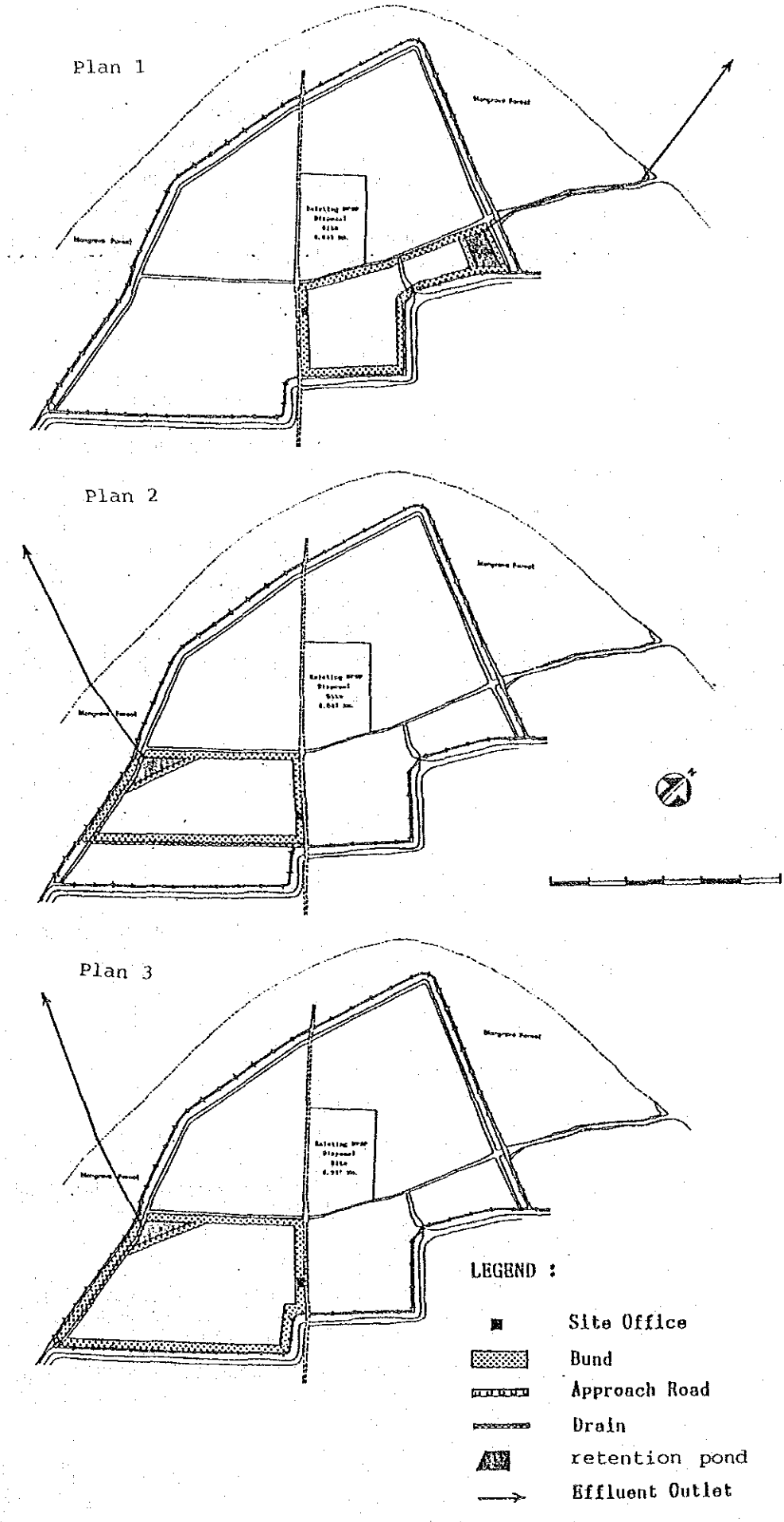


Fig.1.3-2 Concept Plan for First Phase Project of PBDS

- This is a plan which uses the BFR site until year 2005. Required height of landfill in Phase I is 10 meters.

- Leachate outlet is set up in the sea out of mangrove forest.

Plan 3

- Landfill starts from the southern part of the BFR.

- However, landfill height for Phase I (up to 1997) is maintained at 5 meters.

- Leachate outlet is set up in the sea out of the mangrove forest.

b. Comparison of alternatives

Comparison of alternatives for concept plans for KMDS and PBDS are made and tabulated in Table 1.3-1 and 1.3-2 respectively.

c. Selection of concept plan for KMDS

Based on the comparison, Plan 1 is selected as the concept plan for the first phase project of KMDS.
The reasons are summarized as follows.

i. It requires the least capital investment in the first phase. It is therefore, the most suitable plan for MPSP which is suffering from financial problems at this moment.

Table 1.3-1 Comparison of Concept Plan for KMDS First Phase Project

Item	Plan 1	Plan 2	Plan 3
① Possibility of Land Acquisition	- It is necessary to acquire the private owned land within the site.	- In order to construct 200 meter length of approach road, it is necessary to acquire new land.	- In order to construct 200 meter of approach road, acquisition of new land is necessary.
② Possibility of Getting Neighbouring Consensus	- Since the site is relatively far from residential area, it is rather easy to obtain neighbourhood consensus.	- Since the site is in close proximity to low cost housing and PERDA housing development project, it may be difficult to acquire neighbourhood consensus.	- Since the site is relatively far from residential area, it is rather easy to obtain neighbourhood consensus.
③ Compatibility with Regional Development Plan	- No special plan	- PERDA is developing a housing complex in the opposite side of the road to Kuala Muda.	- No special plan
④ Economic Feasibility	- Rough estimate of site development cost is 2.3 million ringgit.	- Rough estimate of site development cost is 4.1 million ringgit.	- Rough estimate of site development cost is 6.2 million ringgit.
⑤ Environmental Acceptability	- Since discharge of leachate into Sungai Muda is not accepted environmentally, leachate outlet is in the sea, out of the natural bund. - Buffer zone is necessary in the western and southern part of the site.	- Due to extremely poor ground condition, sanitary landfill operation in the lagoon may be quite difficult. - Buffer zone is necessary in the northern part of the site. - Leachate outlet is in the sea, out of the natural bund. - Special measure is required for the prevention of environmental hazard to the low cost housing.	- Due to extremely poor ground condition, sanitary landfill operation in the lagoon may be quite difficult. - Buffer zone is necessary in the northern part of the site. - Leachate outlet is in the sea, out of the natural bund. - Special measure is required for the prevention of environmental hazard to the low cost housing.

ii. Although part of the site is owned by private persons, it is rather easy to get neighbourhood consensus because the site for Phase I is relatively far from residential area.

iii. Sanitary landfill operation at the lagoon may be quite difficult because of extremely poor ground condition. It is therefore, recommended for MPSP, which has no experience in sanitary landfill opera tion, to obtain as much experience as possible at the inland site where operation is relatively easier.

iv. Objections may come from the residents in Kampong Kuala Muda in Phase II and III project.
Experience obtained from the first phase project can be utilized fully to face such objections.

d. Selection of concept plan for PBDS

Based on the comparison, Plan 3 is selected as the concept plan for first phase project of PBDS. The reasons are summarized as follows.

i. It requires the least capital investment and operational cost in the first phase. It is therefore, the most suitable plan for MPSP which suffering from financial problems at this moment.

ii. If the ultimate use of completed landfill at the BFR is a farm and is able exchange it with the existing farm in Pulau Burong, all of Pulau Burong site is then able to be used, in addition to the BFR.

Table 1.3-2 Comparison of Concept Plan for PBOS First Phase Project

Item	Plan 1	Plan 2	Plan 3
① Possibility of Land Acquisition	- Nothing special	- Nothing special	- Nothing special
② Possibility of Getting Neighbouring Consensus	- Nothing special	- Nothing special	- Nothing special
③ Compatibility with Regional Development Plan	- Since only the BFR is used as landfill site in the plan, the completed landfill will be 7.5 meters higher than the surrounding area.	- Since only the BFR is used as landfill site in the plan, the completed landfill will be 10 meters higher than the surrounding area.	- If the exchange of the completed landfill with the existing farm in Pulau Burong is realized, it is possible to reclaim both sites up to the same level. - After completion of the landfill, reclaimed land will be higher than the sea level. Thus, the tidal gate becomes redundant.
④ Economic Feasibility	- Rough estimate of site development is 2.7 million ringgit. - Due to higher mount of enclosing bund, operation cost is relatively high.	- Rough estimate of site development is 3.0 million ringgit. - Due to higher mount of enclosing bund, operation cost is relatively high.	- Rough estimate of site development is 2.7 million ringgit. - Since landfill height is the same as bund height, operational cost is relatively low.
⑤ Environmental Acceptability	- Effluent from leachate outlet into Sungai Tengah may affect the fishery lives.	- Leachate outlet is set up in the sea, out of the mangrove forest.	- Leachate outlet is set up in the sea, out of the mangrove forest.

iii. In case that the above-mentioned exchange is materializes the BFR site is able to be reclaimed to the same height as that of Pulau Burong. Thus, it is not necessary to reclaim the BFR site 10 meters higher than the surrounding area.

iv. Leachate outlet is set up in the sea, out of the mangrove forest so as to avoid discharging leachate into Sungai Tengah.

(4) Phased Improvement

As mentioned above, the 3rd level sanitary landfill selected for the First Phase of the KMDS and PBDS.

Furthermore, it is unrealistic from the financial viewpoint to construct all the facilities related to the KMDS and PBDS, which will cater for the disposal demand upto 2005, in Phase 1. therefore, the master plan for MPSP will be implemented in the following three phases.

a. Phase 1

The plans for KMDS and PBDS are shown in Fig. 1.3-3 and 1.3-4 respectively.

Level of Sanitary Landfill	:	Third Level
Construction Completion Year	:	1991
Commencement Year of Landfill	:	January, 1992 Operation
Final Year of Landfill Operation	:	December, 1996
Design Disposal Amount	:	KMDS: 210 tons/day (1996)

	:	PBDS: 250 tons/day (1996)
Design Landfill Volume	:	KMDS: 0.56 million m3
	:	PBDS: 0.66 million m3 (total volume between 1992 and 1996 including covering soil)
Landfill Site Area	:	KMDS: 17.9ha (In land) PBDS: 16.7ha
Site Development Cost (including equipment)	:	KMDS: 3.3 million ringgit PBDS: 3.6 million ringgit
Unit disposal Cost (excluding depreciation)	:	6.7$/ton

b. Phase 2

The plans for KMDS and PBDS are shown in Fig. 1.3-5 and 1.3-6 respectively.

Level of Sanitary Landfill	:	Third Level
Construction Completion Year	:	1996
Commencement Year of Landfill	:	January, 1997 Operation
Final Year of Landfill Operation	:	December, 2001
Design Disposal Amount	:	KMDS: 264 tons/day (2001)
	:	PBDS: 312 tons/day (2001)
Design Landfill Volume	:	KMDS: 0.72 million m3
	:	PBDS: 0.85 million m3 (total volume between 1997 and 2001 including covering soil)
Landfill Site Area	:	KMDS: 30ha (lagoon) PBDS: 23.7ha (Pulau Burong included)

Site Development Cost (including equipment)	:	KMDS: 4.3 million ringgit PBDS: 1.5 million ringgit
Unit disposal Cost (excluding depreciation)	:	6.8$/ton

c. Phase 3

The plans for KMDS and PBDS are shown in Fig. 1.3-7 and 1.3-8 respectively.

Level of Sanitary Landfill	:	Fourth Level
Construction Completion Year	:	2001
Commencement Year of Landfill	:	January, 2002 Operation
Final Year of Landfill Operation	:	December, 2005
Design Disposal Amount	:	KMDS: 311 tons/day (2005)
	:	PBDS: 368 tons/day (2005)
Design Landfill Volume	:	KMDS: 0.70 million m3
	:	PBDS: 0.83 million m3 (total volume between 2002 and 2005 including covering soil)
Landfill Site Area	:	KMDS: 30 ha (lagoon) PBDS: 23.7 ha (Pulan Burong included)
Site Development Cost (including equipment)	:	KMDS: 7.9 million ringgit PBDS: 9.5 million ringgit
Unit disposal Cost (including depreciation)	:	11.7 $/ton

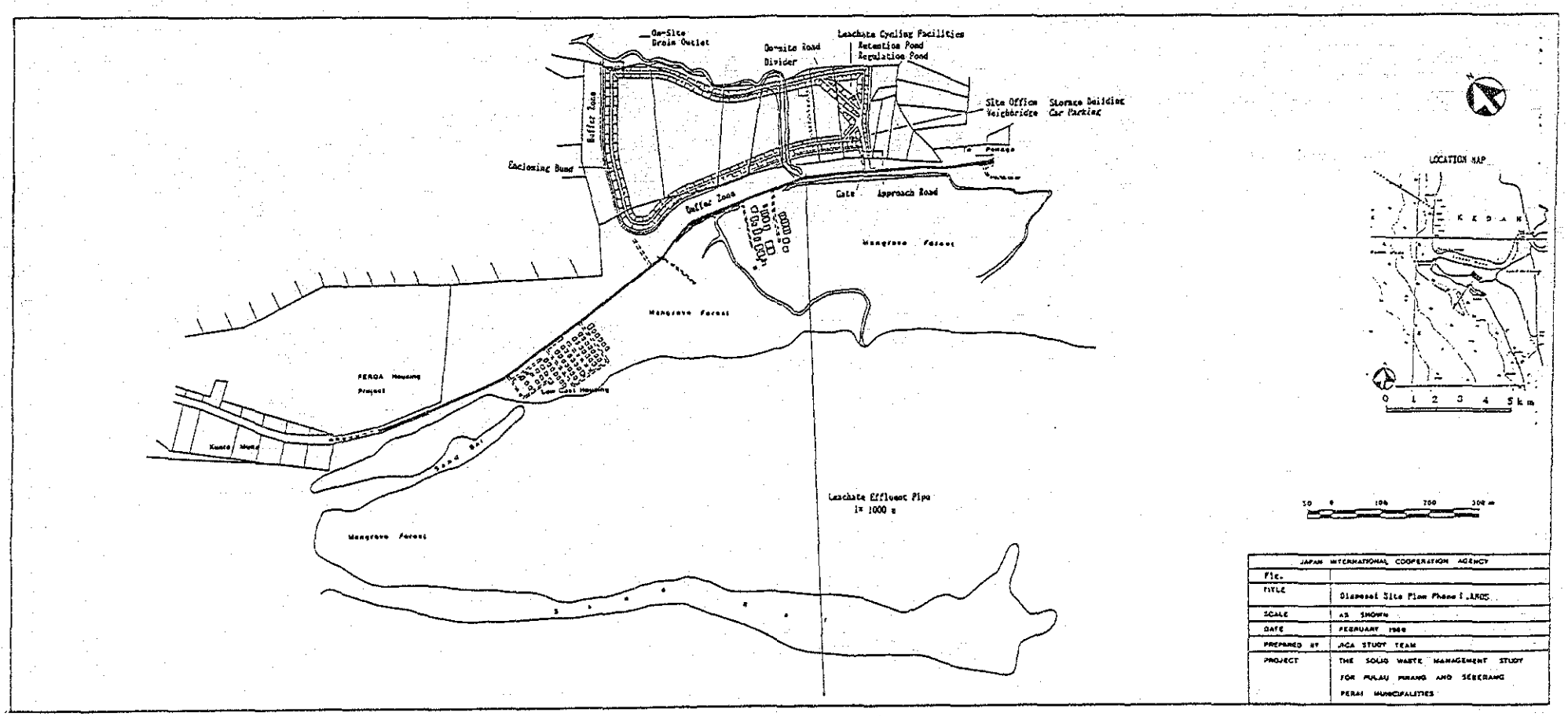


Fig. 1.3-3 First Phase Project of KMDS

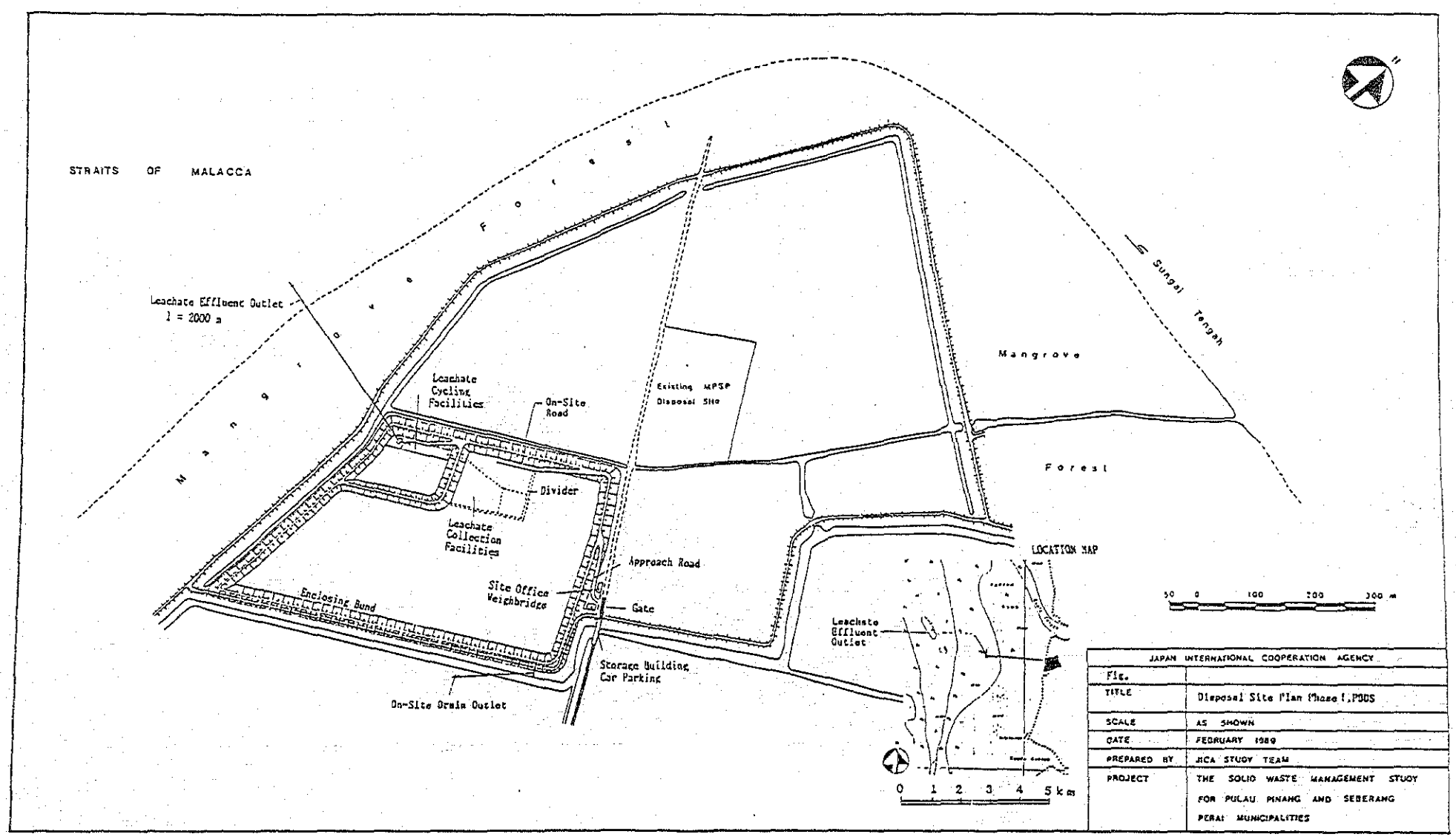


Fig. 1.3-4 First Phase Project of PBDS

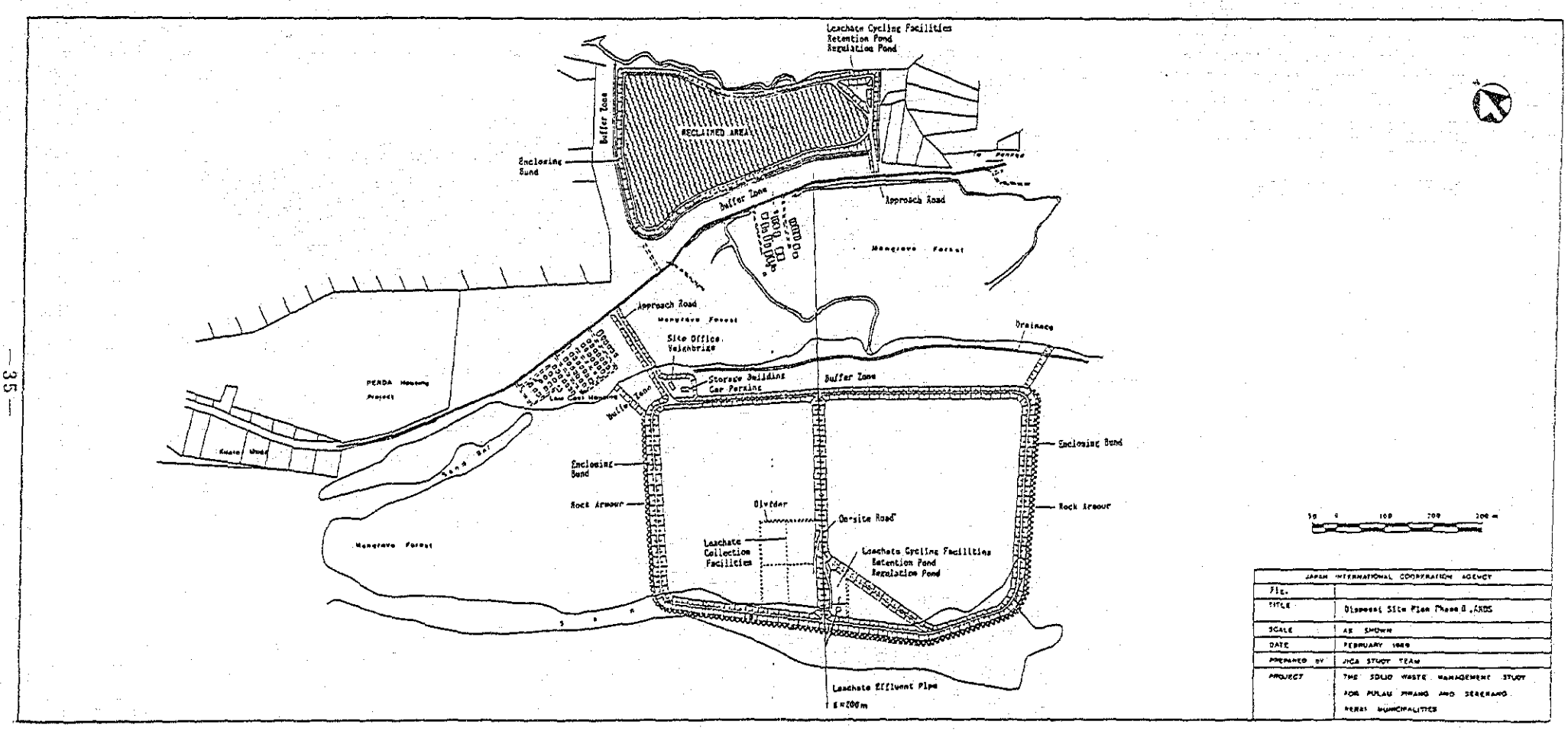


Fig. 1.3-5 Second Phase Project of KMDS

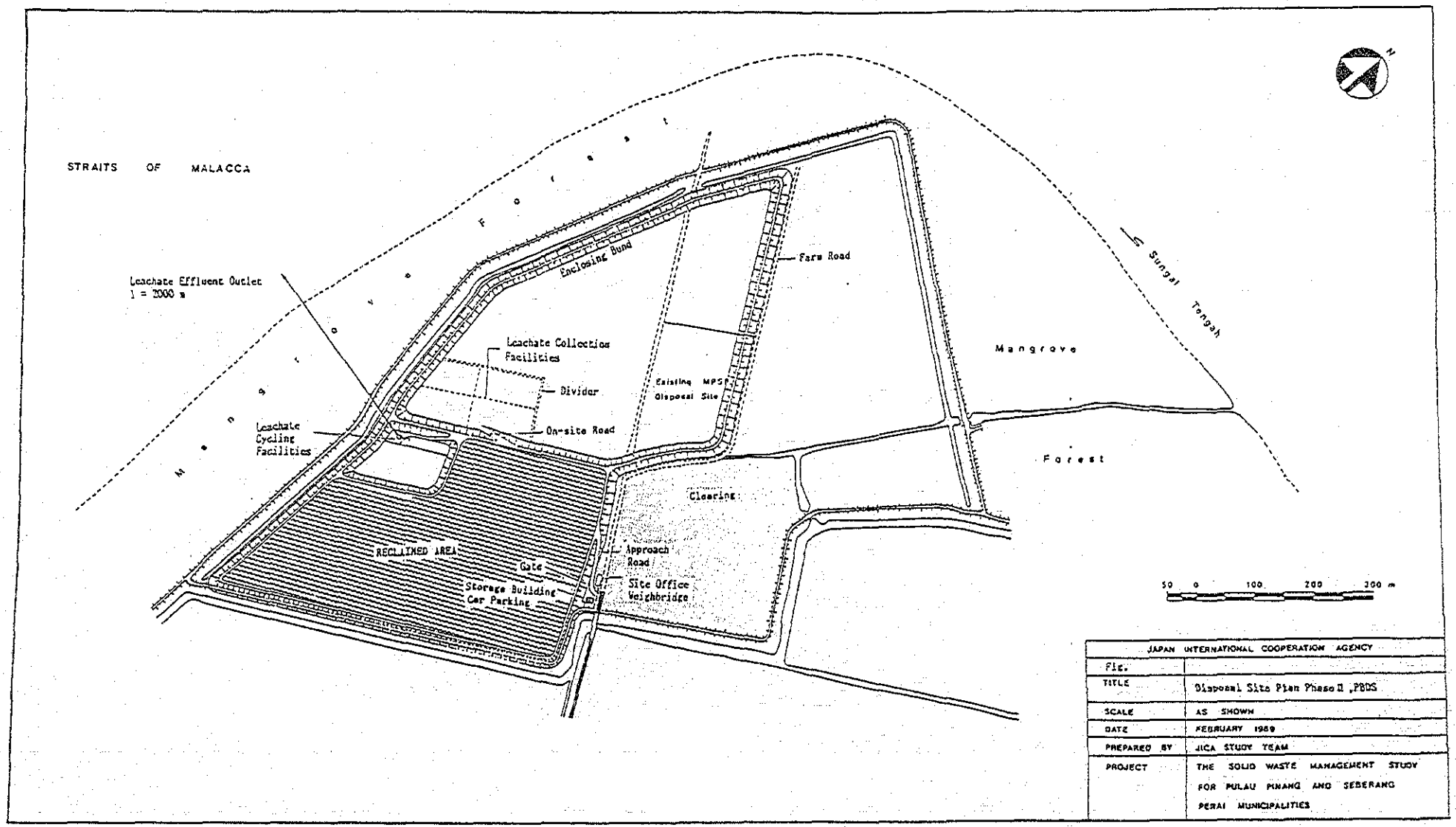


Fig. 1.3-6 Second Phase Project of PBDS

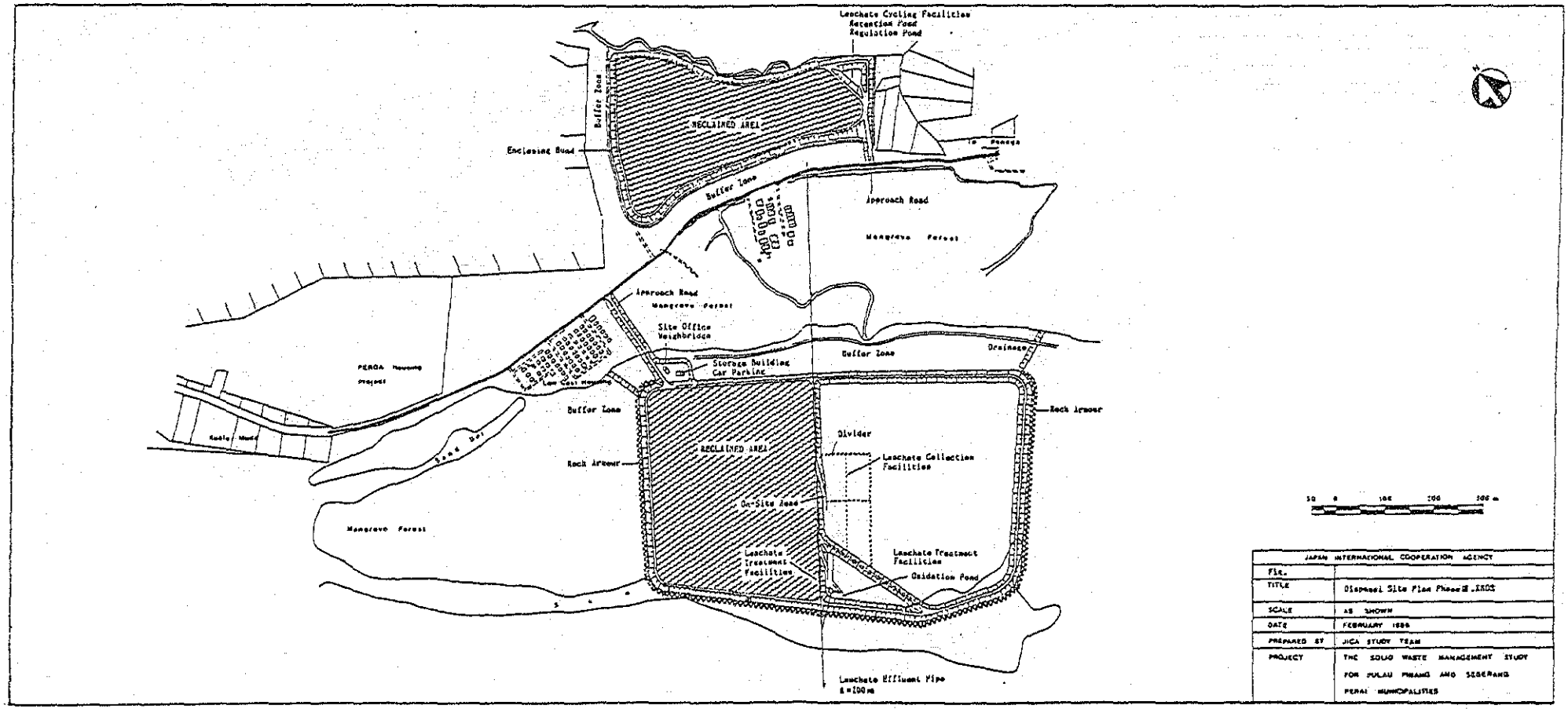


Fig. 1.3-7 Third Phase Project of KMDS

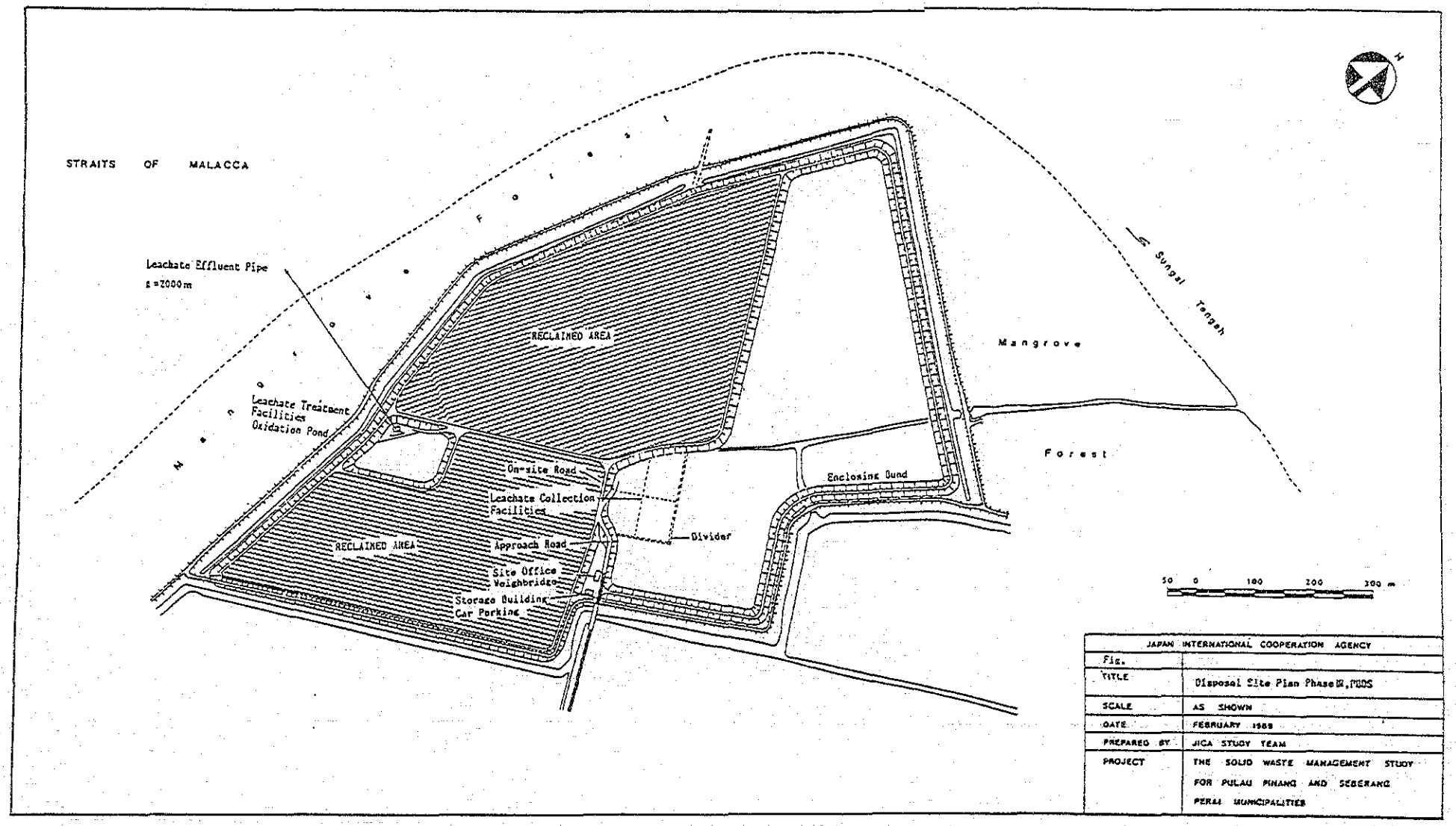


Fig. 1.3-8 Third Phase Project of PBDS

(5) Outline of the First Phase Project

Outline of the First Phase for KMDS and PBDS project is summarized and tabulated in Table 1.3-3.

Table 1.3-3 Outline of the First Phase Project for KMDS and PBDS

Items / Disposal site	KMDS	PBDS	Remarks
a. Main facilities			
i. Enclosing structure			
- Enclosing bund	○	○	
- Divider	○	○	
ii. Drainage system			
- Surrounding drain	○	○	
- On-site drain (surface water)	○	○	
- On-site drain (underground springs)	○	○	
- Drain for reclaimed area	○	○	
iii. Access			Only asphalt
- Approach road	×	○	pavement for
- On-site road	○	○	PBDS

	KMDS	PBDS	Remarks
b. Environment protection facilities			
- Buffer zone	○	○	
- Litter control facilities	○	○	
- Gas removal facilities	○	○	
- Leachate collection facilities	○	○	
- Leachate cycling facilities	○	○	
- Leachate outlet	○	○	
- Monitoring facilities	○	○	
c. Buildings and accessories			
- Site office	○	○	
- Weigh bridge	○	○	
- Garage and storage building	○	○	
- Safety facilities	○	○	
- Fire prevention facilities	○	○	
- Utilities	○	○	
d. Equipment			
i. Landfill equipment			
- Bulldozer	○	○	
- Hydraulic excavator	○	○	
ii. Others			
- Water sprinkler truck	○	○	
- Inspection vehicle	○	○	

Note : ○ ; With
× ; With out

2. Topographical Survey and Soil Investigation

2.1 Topographical Survey

(1) Survey works

The topographical survey works over the proposed KMDS and PBDS was contracted out to a local survey company. The survey covered an area of 145 hectares in KMDS and 140 hectares in PBDS.

a. Method of survey

The methods of survey adopted over each site are as follows:

For KMDS:-

i. Levelling

Sprit levelling was used for height control.

All spot levels of the site are based on the Survey Department Bench Mark BA 1316 located at culvert No. 3/12 along the Penaga to Permatang Bendahari Road.

ii. Traversing

The method of traversing used was EDM traversing. The coordinate system used is the Cassini Projection with the origin at Fort Cornwallis.

Connections were made to proven boundary marks from which the Cassini coordinates were derived. A loop traverse close was done for each network and where possible as a check another connection was done at the extreme end of the site.

iii. Tacheometry

For the purpose of spot heighting and picking up of topographic details such as houses, drains and bunds, the method of techeometry was employed.

This entails the use of a theodolite and levelling staff. Bearings and general numbers were read and from these the location and height of points were derived. All bearings are based on Cassini grid bearings.

For PBDS:-

i. Levelling

Spirit levelling was used for height control.

The datum for the spot levels for the site is the Survey Department Bench Mark BM 603 (RL1.972m) located at Bridge No. 60 along the railway line between Parit Buntar and Pinang Tunggal.

ii. Traversing

The method of traversing used was EDM traversing. The coordinate system used is the

Cassini Projection with the origin at Fort Cornwallis.

iii. Tacheometry

For the purpose of spot heighting and picking up of topographic details such as houses, drains and bunds, the method of tacheometry was employed.

(2) Results of Survey

Final plan for Kuala Muda is shown as attached maps JP/88/PG/22/KM1&2. The final plan for Pulau Burong is shown as map JP/88/PG/22/PB1&2. All maps are at 1:2000 scale.

The coordinates of each TBM as well as its elevations are shown below.

TBM KM (KMDS)	Coordinates		Elevation
	N(m)	E(m)	(m)
No. 1	16408.41	115.66	1.761
No. 2	16450.95	449.98	1.769

TBM KM (PBDS)	Coordinates		Elevation
	N(m)	E(m)	(m)
No. 1	-24546.97	9153.39	1.002
No. 2	-23653.52	8790.37	0.662

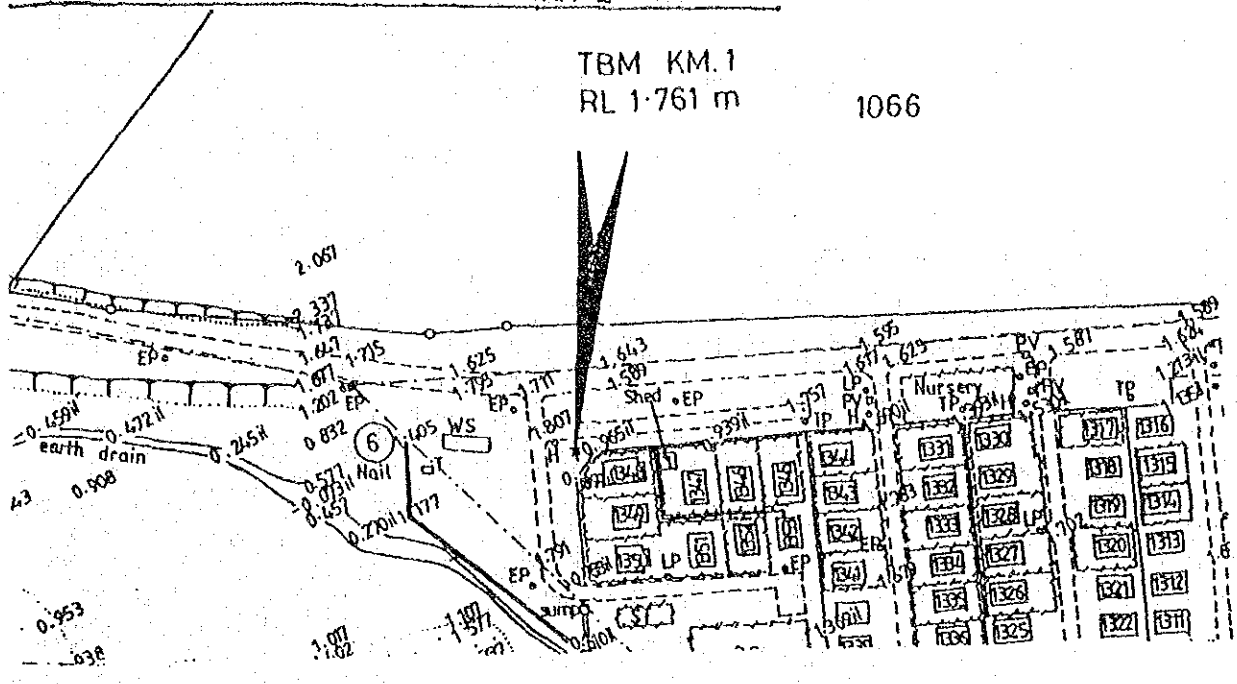
Note:-

Elevation of TBM refers to the top of the pipe in concrete.

The TBMS locations in Kuala Muda are illustrated in Fig.2.1-1 and Fig.2.1-2.TBMS in Pulau Burong are illustrated in Fig.2.1-3 and Fig.2.1-4

The traverse network at Kuala Muda and traverse stations listing program are shown in Fig.2.1-5 and Fig. 2.1-6 · The same for Pulau Burong are shown in Fig.2.1-7 and Fig.2.1-8.

LOCATION OF T.B.M,s No. KM 1



REMARKS: ⊕..... Pipe in concrete ⊕..... Peg. ⊞..... Goverment Boundary Stone

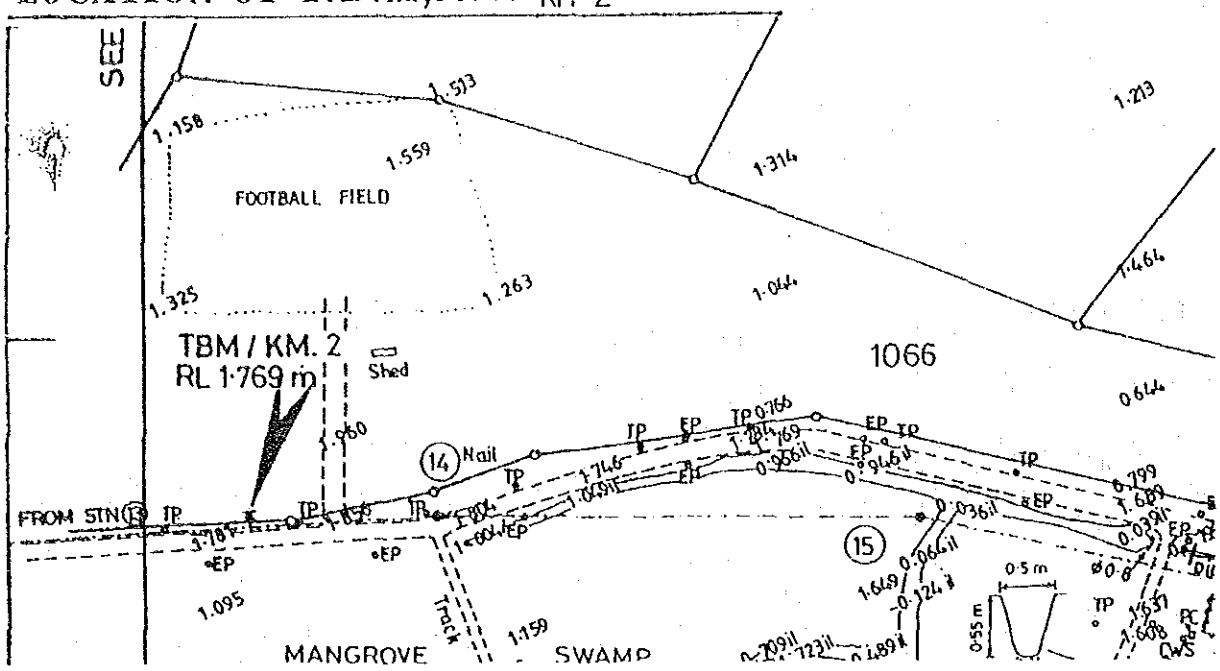
PHOTOGRAPH OF T.B.M,s

LEFT BANK RIGHT BANK

Fig.2.1-1 Location of TBM KM-1

REDUCED LEVEL OF T.B.M.	REDUCED LEVEL OF T.B.M.
H = 1.761 m	H = - m
G.H. = - m	G.H. = - m

LOCATION OF T.B.M,s No. KM 2



REMARKS: ⊕..... Pipe in concrete ⊕..... Peg. ⊞..... Government Boundary Stone

PHOTOGRAPH OF T.B.M,s

LEFT BANK RIGHT BANK

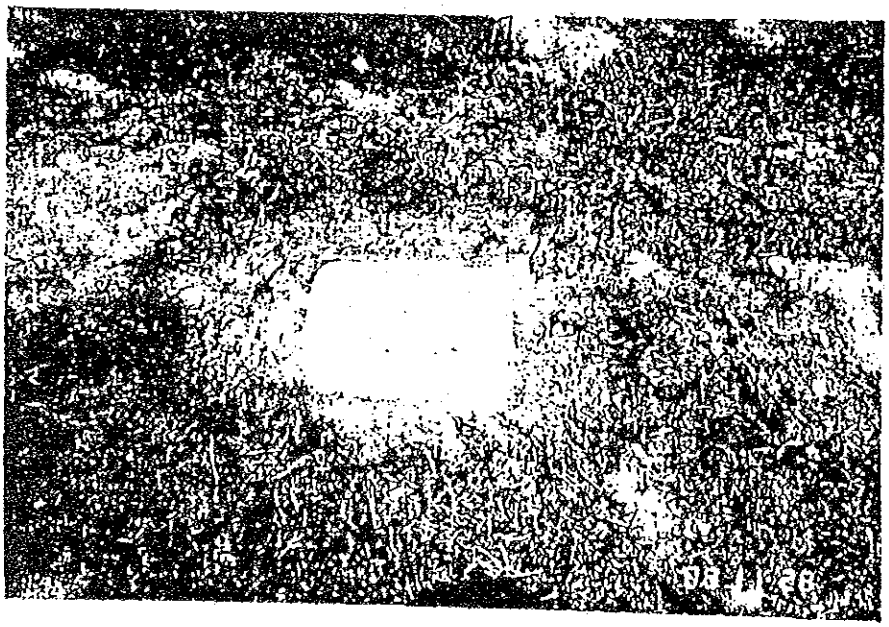
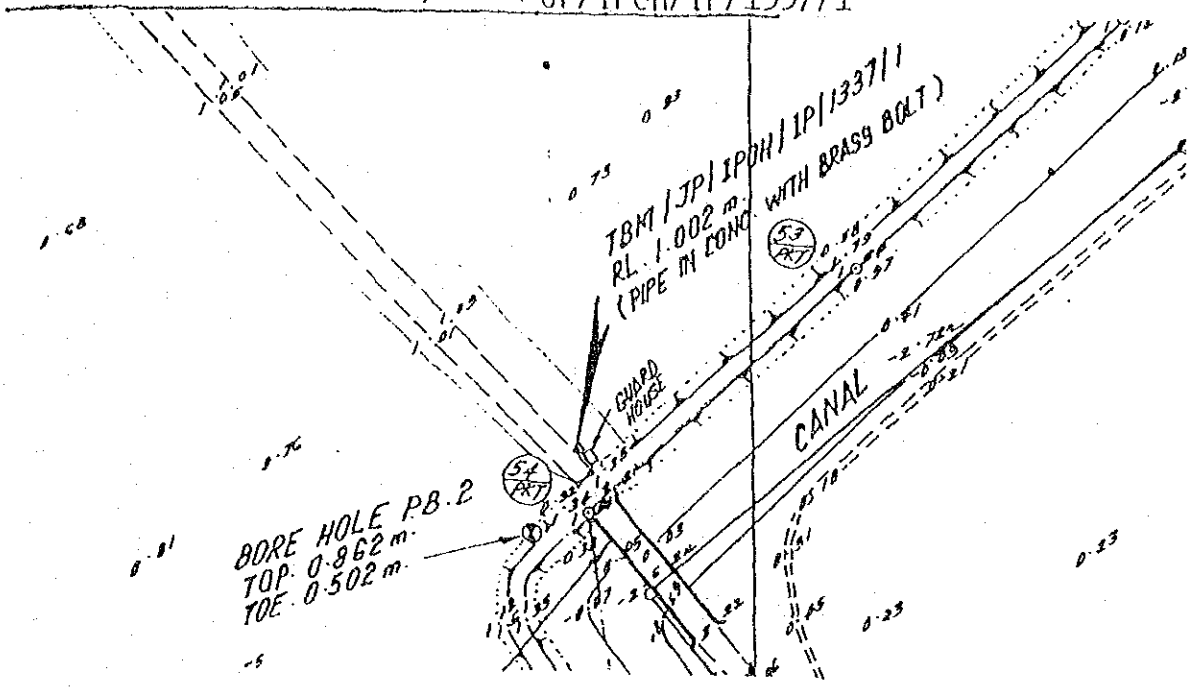


Fig.2.1-2 Location of TBM KM-2

REDUCED LEVEL OF T.B.M.	REDUCED LEVEL OF T.B.M.
H = 1.769 m	H = - m
G.H. = - m	G.H. = - m

LOCATION OF T.B.M,s No. JP/IPOH/IP/1337/1



REMARKS: ⊕..... Pipe in concrete ⊕..... Peg. ⊞..... Government Boundary Stone

PHOTOGRAPH OF T.B.M,s

LEFT BANK

RIGHT BANK

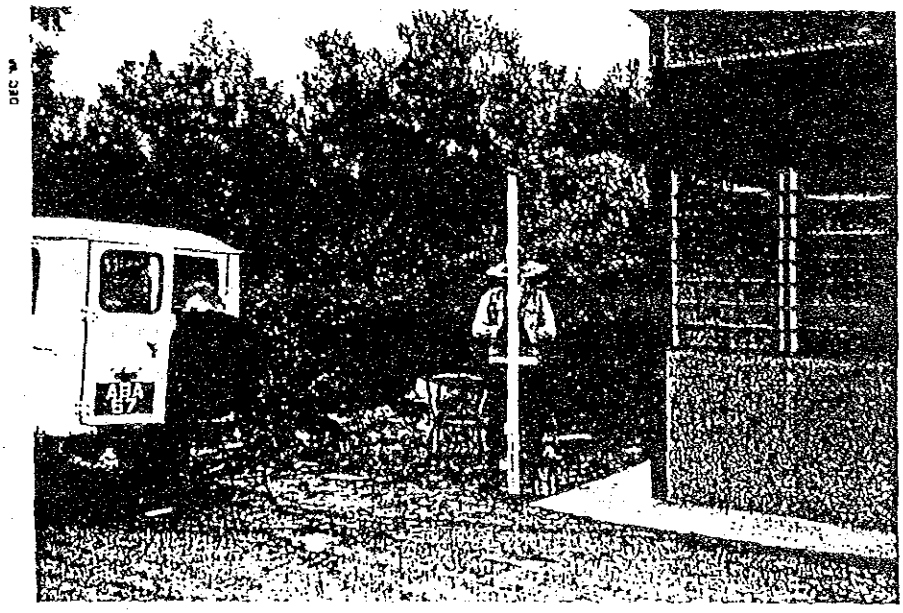
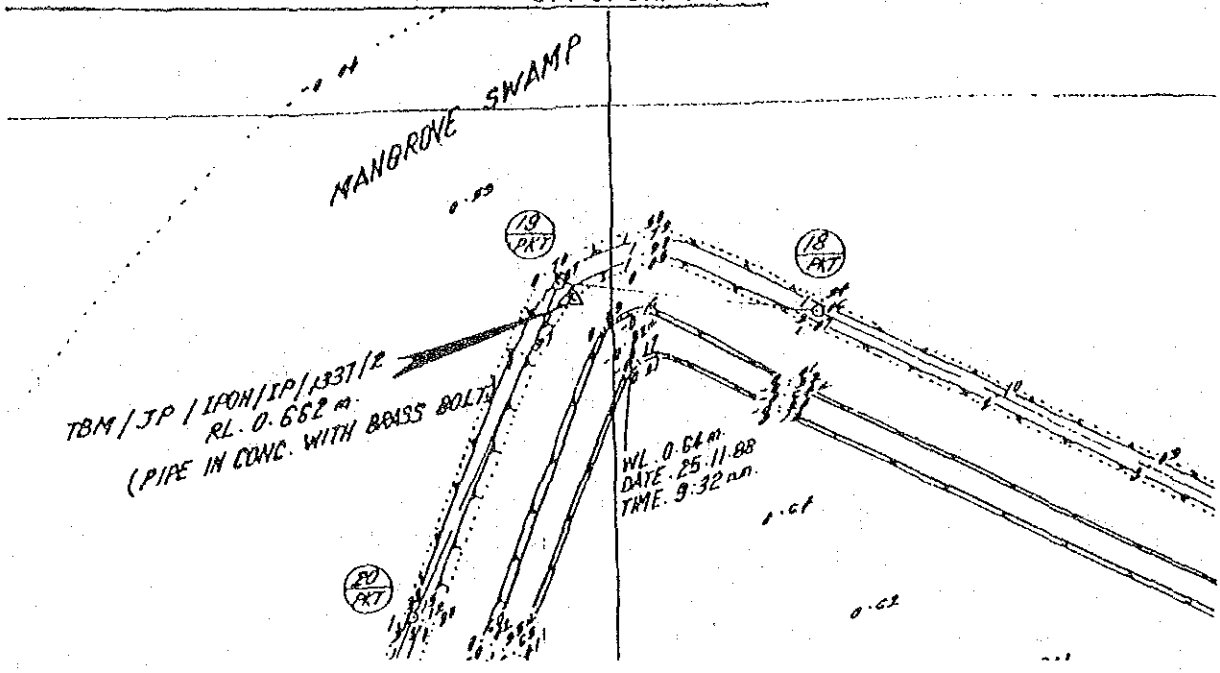


Fig.2.1-3 Location of TBM JP/IPOH/IP/1337/1

REDUCED LEVEL OF T.B.M.	REDUCED LEVEL OF T.B.M.
H = 1.002 m	H = - m
G.H. = - m	G.H. = - m

LOCATION OF T.B.M,s No. JP/IPOH/IP/1337/2



REMARKS: ⊕..... Pipe in concrete ⊕..... Peg. ⊞..... Goverment Boundary Stone

PHOTOGRAPH OF T.B.M,s

LEFT BANK RIGHT BANK

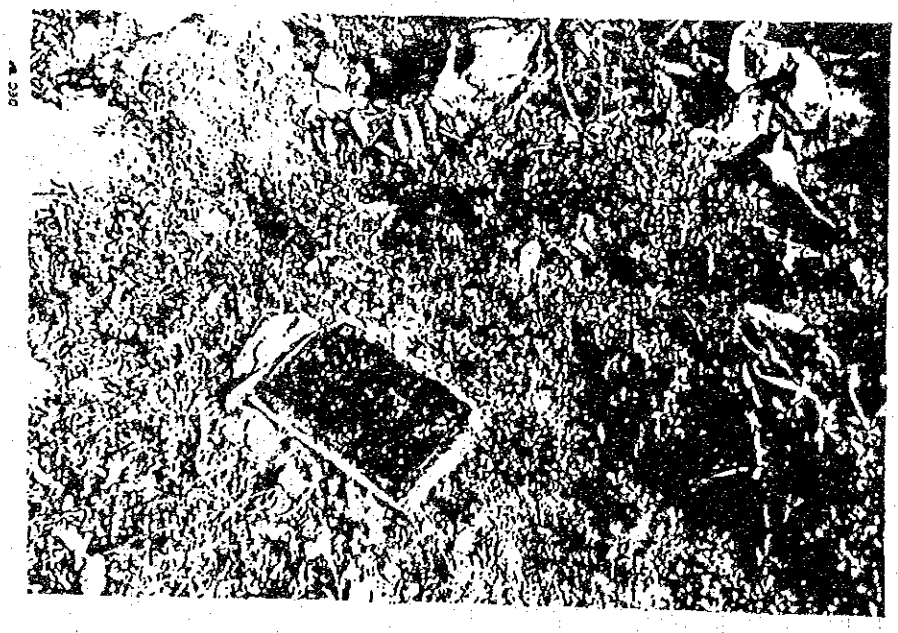


Fig.2.1-4 Location of TBM JP/IP/1337/2

REDUCED LEVEL OF T.B.M.	REDUCED LEVEL OF T.B.M.
H = 0.662 m	H = - m
G.H. = - m	G.H. = - m

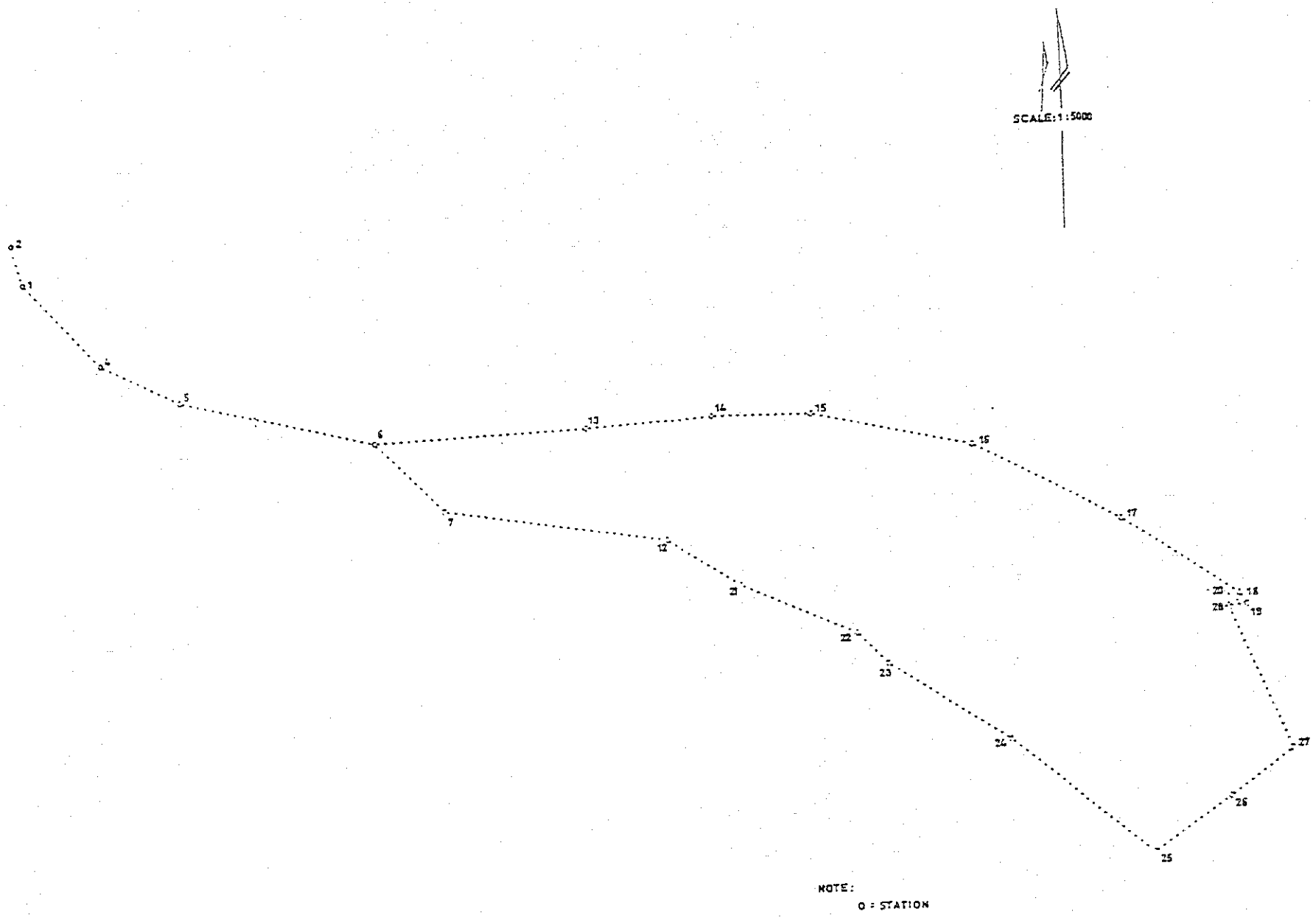


Fig.2.1.5 Network of Traverse at Kuala Muda

KUALA MUDA

TRAVERSE STATIONS LISTING PROGRAM

STATION	N	E	H
2	16699.788	- 414.107	1.836
1	16648.692	- 399.844	1.580
4	16542.828	- 300.441	2.006
5	16491.417	- 197.987	1.621
6	16428.870	56.072	1.778
7	16337.251	144.899	1.518
8	16370.897	- 189.733	1.805
12	16290.499	436.118	1.884
13	16439.716	333.691	1.655
14	16449.346	500.057	1.691
15	16448.202	631.125	1.518
16	16401.670	841.116	1.599
17	16295.874	1035.562	1.774
18	16193.490	1188.742	1.554
19	16178.694	1199.487	1.054
20	16188.399	1174.693	1.159
21	16228.821	533.759	1.803
22	16161.692	685.242	1.533
23	16119.815	752.229	1.850
24	16013.891	884.476	1.571
25	15864.436	1068.301	2.037
26	15931.631	1171.584	1.254
27	15987.910	1255.165	1.619
28	16177.101	1174.327	1.805

Fig.2.1-6 Kuala Muda Traverse Stations Listing Program

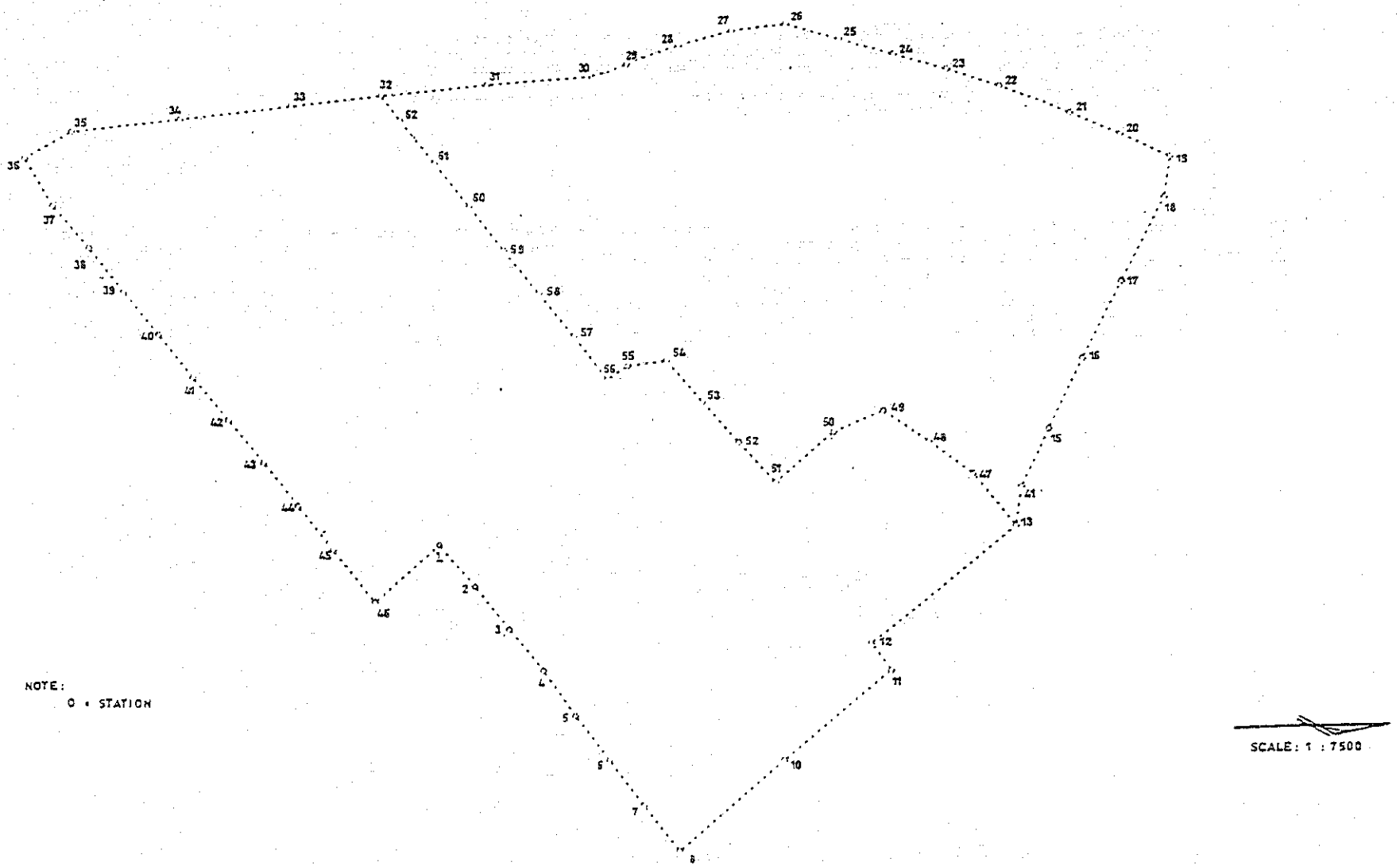


Fig.2.1-7 Network of Traverse at Pulau Burong

PULAU BURUNG

TRAVERSE STATIONS LISTING PROGRAM

STATION	N	E	H
1	-24977.015	9487.673	
2	-24910.539	9562.393	0.444
3	-24846.912	9639.564	0.434
4	-24784.486	9714.734	0.600
5	-24725.420	9796.673	0.271
6	-24660.350	9876.615	0.323
7	-24594.856	9955.495	0.413
8	-24528.171	10034.959	0.453
10	-24336.537	9876.331	0.258
11	-24142.004	9714.827	0.433
12	-24179.017	9665.902	0.396
13	-23919.172	9451.744	1.695
14	-23910.681	9383.036	1.956
15	-23860.825	9277.552	1.952
16	-23801.475	9149.301	1.912
17	-23733.610	9009.936	2.167
18	-23657.383	8858.229	2.062
19	-23648.161	8785.871	1.867
20	-23739.669	8744.152	2.154
21	-23831.778	8705.386	2.129
22	-23962.909	8655.275	1.979
23	-24058.409	8625.210	2.054
24	-24155.326	8600.476	2.128
25	-24252.962	8574.629	2.088
26	-24351.316	8549.417	1.798
27	-24450.319	8561.748	1.804
28	-24547.674	8588.813	1.912
29	-24642.735	8619.614	2.042
30	-24718.772	8644.475	1.563
31	-24899.385	8659.703	1.768
32	-25092.677	8680.711	2.008
33	-25256.407	8701.129	-
34	-25456.929	8725.375	-
35	-25654.894	8747.852	-
36	-25739.148	8795.311	-
37	-25687.885	8881.809	-
38	-25620.691	8956.145	-
39	-25555.857	9032.858	-
40	-25491.138	9109.927	-
41	-25427.352	9187.039	-
42	-25362.720	9265.568	-
43	-25298.702	9341.876	-
44	-25235.532	9418.956	-
45	-25171.032	9496.348	-
46	-25093.641	9589.814	-
1	-24977.575	9487.258	-

Fig.2.1-8 Pulau Burong Traverse Stations Listing Program

contd 2

PULAU BURUNG

TRAVERSE STATIONS LISTING PROGRAM

STATION	N	E	H
13	-23919.172	9451.744	
47	-23998.388	9359.303	1.488
48	-24079.445	9301.219	1.488
49	-24163.106	9245.658	1.301
50	-24252.888	9283.819	1.627
51	-24358.642	9376.808	1.147
52	-24427.775	9304.359	1.560
53	-24495.227	9230.475	1.542
54	-24562.563	9155.237	1.842
55	-24633.327	9164.473	1.555
56	-24672.345	9189.198	1.262
57	-24736.544	9112.083	1.447
58	-24800.627	9034.796	1.633
59	-24864.800	8957.849	1.763
60	-24928.493	8880.514	1.693
61	-24992.799	8802.582	1.873
62	-25057.193	8725.643	1.918
32	-25092.374	8680.829	

2.2 Soil Investigation

(1) Soil investigation works

The soil investigation works were carried out by a local soil investigation company. The purpose of the investigation is to obtain subsoil information at the sites for foundation design.

The scope of works included the following.

i. Boring of 2 deep bone holes at each site. Their locations are shown in **Table 2.2-1** and **2.2-2**.

ii. Standard Penetration Test (SPT) and obtain disturbed and undistrubed samples for usual examination and laboratory testing at the sites.

iii. Perform various laboratory tests on the collected sumples to determine and evaluate the enggineering parameters of the subsoil.

iv. Measurement of the groundwater table.

The location coordinates and elevations of the KMDS and and PBDS boreholes are as described below.

Table 2.2-1 Location of Boreholes in Kuala Muda

Kuala Muda (KM)	Coordinates		Elevation
	N(m)	E(m)	(m)
No. 1	16276.38	255.24	0.35
No. 2	15711.88	280.17	0.51

Table 2.2-2 Location of Boreholes in Pulau Burong

Pulau Burong (PB)	Coordinates		Elevation
	N(m)	E(m)	(m)
No. 1	-23989.90	8653.16	0.62
No. 2	-24567.70	9138.29	0.86

(2) Results of soil investigation

The following observations and results were gathered from the investigations carried out over KMDS and PBDS.

a. Visual observation

i. KMDS

Visual observation of the soil samples from Borehole No. KM-1 obtained in the Kuala Muda area has that marine silty clay with some fine to medium sand extends to a depth of 18 meters below ground level. Medium to coarse sand layer was seen between the 1.5 meters and 2.1 meters depth from the surface. The N-value was 7 blows at a depth of 18 meters.

The soil at Borehole No. KM-2 on the sandbank consists of 3 meters of fine to medium sand followed by silty clay with a little fine sand to a depth of 9 meters below ground level. this was underlain by fine to coarse clayey sand with a little shell fragments to t depth of 13.5 meters followed by silty with a little

fine sand. The N-value was 3 blows at the depth of 18 meters.

ii. PBDS

The soil at Borehole No. PB-1 near the shoreline of the Pulau Burong area consists of 4 meters of soft wilty clay or clayey silt followed by clayey fine sand with some shell fragments to a depth of 9 meters below ground level. This was underlain by soft silty clay with fine sand partly to a depth of 20 meters. The N-value was 4 blows at the depth of 18 meters.

The soil at Boreholde No. PB-2 on the inland consists of soft silty clay to a depth of 10.5 meters below ground level. This was followed by silty clay with trace of fine snad. The N-value was 2 blows at the depth of 15 meters.

b. Compilation of test results

The following figures and tables were extracted from the soil investigation report submitted by the contractor.

Fig. 2.2-1 :	Kuala Muda Soil Profile
Table 2.2-3:	Borehole KM-1 log (KMDS)
Table 2.2-4:	Borehole KM-2 log (KMDS)
Table 2.2-5:	Falling Head Permeability Test of Undistrubed Sample from KM-1
Table 2.2-6:	Falling Head Permeability Test of Undistrubed Sample from KM-2
Table 2.2-7:	Summary of Laboratory Test Results
Fig. 2.2-2 :	Pulau Burong Soil Profile

KUALA MUDA SITE

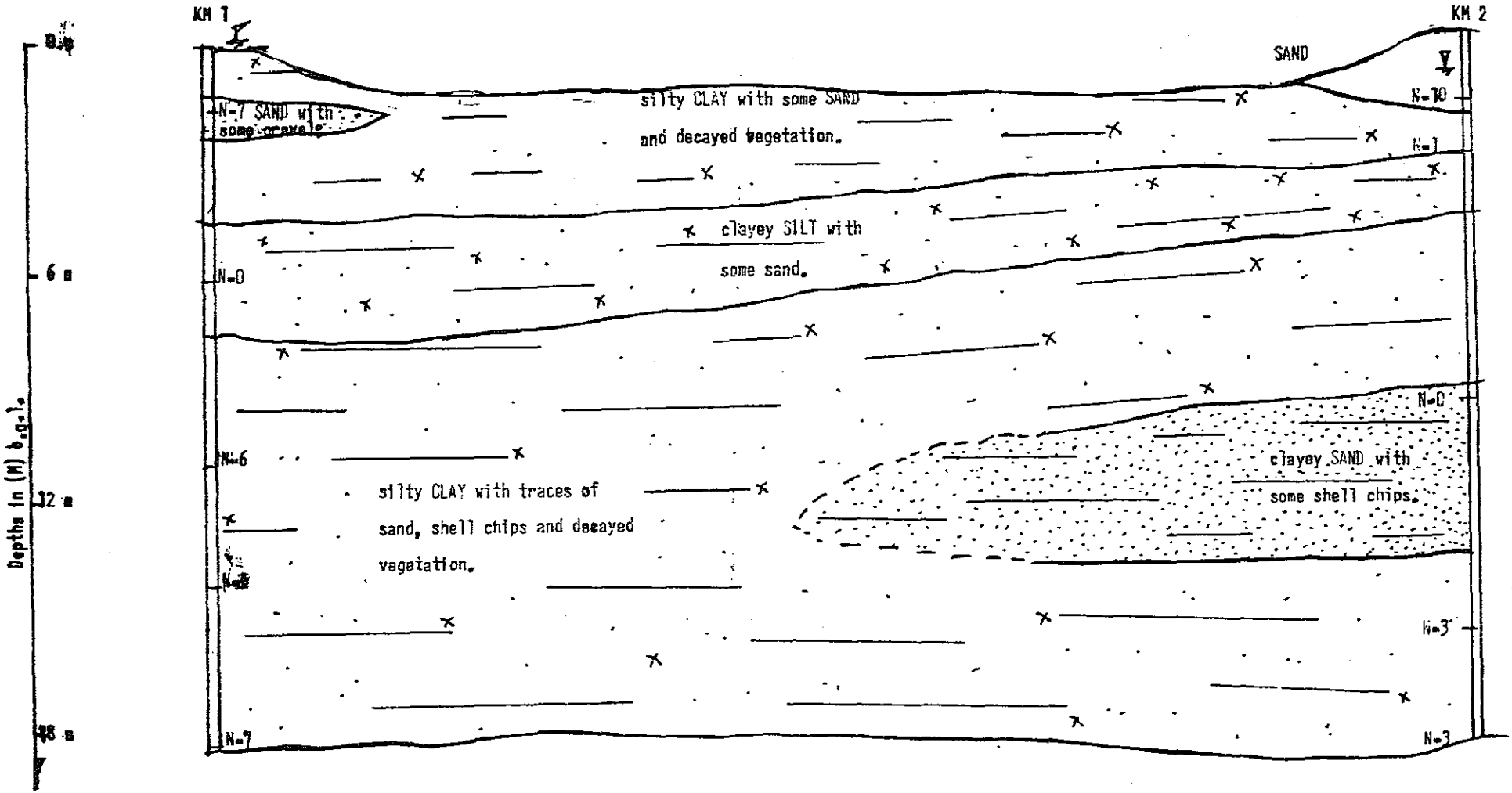


Fig.2.2-1 : Kuala Muda Soil Profile

Scale: Horizontal : 1cm = 6m
Verticle : 1cm = 2m

No.

/88

Type of boring: Percussion
Type of rig: KBI. 200
Dia of boring: 156 mm
Casing details:

BOREHOLE No. KM - 1
Sheet 1 of 3

Feature: Soil Investigation Works for The Solid Waste Management Study For Pulau Pinang And Seberang Prai Municipalities.
Location:
Ground level:

Date & (Time)	Depth of boring & (casing)	Ground Water	Samples & Tests: Depth	Sample	Test	Strata: Legend	Depth	Reduced Level	Thickness	Description
			m				m	m	m	
20-11-88 (11:00)			0.00 to							Very Soft Dark grey silty CLAY with some fine to medium sand and traces of decaying vegetation.
				D1						
			1.50 to		N=7		1.50		1.50	
				D2						Loose Dark grey medium to coarse SAND with traces of fine gravel.
			1.95				2.10		0.60	
				D3						Very Soft Dark grey silty CLAY with traces of fine to medium sand.
			3.00 to							
				UD1						
			3.50							
			4.53 to				4.50		2.40	
				UD2						Very Soft Dark grey clayey SILT with some fine sand.
			4.93							
				D4						
			6.00 to		N=0 (Weight of Hammer)		6.00		1.50	
				D5						Very Soft to Soft Dark grey clayey SILT with some fine sand.
			6.45							
			7.50 to				7.50		1.50	Soft to firm Dark grey silty CLAY with traces of fine sand and some shell fragments.
				UD3						
							18.00			

- Small disturbed sample
- Large disturbed sample
- Undisturbed sample
- Standard penetration test
- Water sample
- Drill core sample
- Vane test
- Field permeability test
- Moisture content (%)

Remarks

Table 2.2-3 Borehole KM-1 log (KMDS)

Contractor: Geotechnique (M)
Date started: 20-11-88
Date finished: 21-11-88

Scale: 1 div. = 10cm
Logged by:
Checked by:
Date:
Fig. No.

BOREHOLE No. K? - 1
Sheet 2 of 3

Type of boring ..... Percussion .....
Type of rig ..... HSL 200 .....
Dia of boring ..... 156 mm .....
Casing details .....

Feature ..... Soil Investigation Works For The Solid .....
Location Waste Management Study For Pulau Pinang .....
And Seberang Prai Municipalities. .....
Ground level:

Date & (Time)	Depth of boring & (casing)	Ground Water	Samples & Tests: Depth	Sample	Test	Strata: Legend	Depth	Reduced Level	Thickness	Description
			m				m	m	m	
20-11-88				D6						Soft to Firm Dark grey silty CLAY with traces of fine sand and some shell fragments.
			9.00 to 9.50	UD4						
			10.50 to 10.95	D7	N=6		10.50		3.00	
			12.00 to 12.50	UD5						Firm Dark grey silty CLAY with traces of fine sand.
				D8						
			13.50 to 13.95		N=5					
			15.00 to 15.50	UD6						
							16.00			

Small disturbed sample
Large disturbed sample
Undisturbed sample
Standard penetration test
Water sample
Drill core sample
Vane test
Field permeability test
m Moisture content (%)

Remarks

Contractor Geotechnique (M)
Date started 20-11-88
Date finished 21-11-88

Scale: 1 div. : 10cm
Logged by .....
Checked by: .....
Date: .....
Fig. No.

BOREHOLE No. KK - 1
Sheet 1 of 1

Type of boring ... Percussion
Type of rig ... KSI 200
Dia of boring ... 156 mm
Casing details ...

Feature ... Soil Investigation Works For The Solid
Location ... Waste Management Study For Pulau Pinang
And Seberang Prai Municipalities
Ground level:

Date & (Time)	Depth of boring & (casing)	Ground Water	Samples & Tests: Depth	Sample	Test	Strata: Legend	Depth	Reduced Level	Thickness	Description
			m				m	m	m	
			16.83 to 16.93	UD7						Firm Dark grey silty CLAY with traces of fine sand.
			18.00 to 18.45	D11	N-7					
(19:00)		6.50m					18.15		7.85	
20-11-88 (09:10)	Full	0.00m								- End Of Borehole -

Small disturbed sample
Large disturbed sample
Undisturbed sample
Standard penetration test
Water sample
Drill core sample
Vane test
Field permeability test
Moisture content (%)

Remarks

Contractor Geotechnique (M)
Date started 20-11-88
Date finished 21-11-88

Scale: 1 div. : 10cm

Logged by .....
Checked by: .....
Date: .....

Fig. No.

BOREHOLE No. KM - 2

Sheet 1 of 3

Type of boring ..... Percussion .....
Type of rig ..... 851.200 .....
Dia of boring ..... 156 mm .....
Casing details .....

Feature : Soil Investigation Works For The Solid
Location : Waste Management Study For Pulau Pinang
And Seberang Prai Municipalities.
Ground level:

Date & (Time)	Depth of boring & (casing)	Ground Water	Samples & Tests: Depth	Sample	Test	Strata: Legend	Depth	Reduced Level	Thickness	Description
			m				m	m	m	
24-11-88 (08:00)			0.00 to							
				D1						Loose to Medium Dense White brown fine to medium SAND.
			1.50 to		N=10					
				D2						
			1.95							
				D3						
			3.00 to		N=1		3.00		3.00	
				D4						Very Soft Dark grey clayey SILT with some fine sand.
			3.45							
				D5						
			4.50 to				4.50		1.50	
				UD1						Very Soft Dark grey silty CLAY with some fine sand and traces of shell fragments.
			5.00							
			6.03 to							
				UD2						
			6.43							
				D6						
			7.50 to							
				UD3						
							8.00			

- Small disturbed sample
- Large disturbed sample
- Undisturbed sample
- Standard penetration test
- Water sample
- Drill core sample
- Vane test
- Field permeability test
- m Moisture content (%)

Remarks

Table 2.2-4 Borehole KM-2 log (KMDS)

Contractor Geotechniques (M)
Date started 24-11-88
Date finished 24-11-88

Scale: 1 div. : 10cm

Logged by .....
Checked by: .....
Date: .....

Fig. No.

BOREHOLE No. KK - 2
Sheet 2 of 3

Type of boring ... Percussion
Type of rig ... MSI 200
Dia of boring ... 146 mm
Casing details :

Feature : Soil Investigation Works for the Solid Waste Management Study For Pulau Pinang And Seberang Perai Municipalities
Location :
Ground level:

Date & (Time)	Depth of boring & (casing)	Ground Water	Samples & Tests: Depth (m)	Sample	Test	Strata: Legend	Depth (m)	Reduced Level (m)	Thickness (m)	Description
										Very Soft Dark grey silty CLAY with some fine sand and traces of shell fragments.
			9.00 to 9.45	D7	N=0 (Weight of Hammer)		9.00		4.50	
				D8						
			10.50 to 11.00	UD4						
										Very Loose Dark grey clayey fine to coarse SAND with some shell fragments.
			12.00 to 12.45	D9	N=0 (Weight of Hammer)					
			13.50 to 14.00	UD5			13.50		4.50	
				D10						Soft Dark grey silty CLAY with some fine sand and traces of decaying vegetation.
			15.00 to 15.45	D11	N=3					
							16.00			

- Small disturbed sample
- Large disturbed sample
- Undisturbed sample
- Standard penetration test
- Water sample
- Drill core sample
- Vane test
- Field permeability test
- m Moisture content (%)

Remarks

Contractor Geotechnique (M)...
Date started 21-11-88
Date finished 24-11-88

Scale: 1 div. : 10cm

Logged by .....
Checked by: .....
Date: .....

Fig. No.

BOREHOLE No. KH - 2
Sheet 3 of 3

Type of boring ..... Percussion .....
Type of rig ..... HSI 200 .....
Dia of boring ..... 156 mm .....
Casing details .....

Feature . Soil Investigation Works For the Solid
Location Waste Management Study For Pulau Pinang
And Seberang Prai Municipalities.....
Ground level:

Date & (Time)	Depth of boring & (casing)	Ground Water	Samples & Tests: Depth	Sample	Test	Strata: Legend	Depth	Reduced Level	Thickness	Description
			m				m	m	m	
			16.53 to 16.93	U06						Soft Dark grey silty CLAY with some fine sand and traces of decaying vegetation.
				U12						
			18.00 to 18.45	U13	N=3		18.45		4.95	
(16:00)		1.00m ▲								- End Of Borehole -

Small disturbed sample
Large disturbed sample
Undisturbed sample
Standard penetration test
Water sample
Drill core sample
Vane test
Field permeability test
m Moisture content (%)

Remarks ▲ Water Sample collected at 18.45 m.

Contractor Geotechnique (K)
Date started . 24-11-88
Date finished 24-11-88

Scale: 1 div. : 10cm
Logged by .....
Checked by: .....
Date: .....
Fig. No.

Table 2.2-5 Falling Head Permeability Test of Undistrubed Sample from KM-1

Project : Soil Investigation Works For The Solid Waste Management Study For Pulau Pinang And Seberang Prai Municipalities.

Sample No. & Depth : KM-2/UD2 (6.00 - 6.45m) Sample Condition : Undisturbed

Weight of Empty Mould	(gm)	:	2014
Weight of Mould + Wet Soil	(gm)	:	3,604
Ø of Mould	(cm)	:	10.20
Initial Moisture Content	(%)	:	59.7
Final Moisture Content	(%)	:	65.8
Length of Sample (L)	(cm)	:	11.9
Ø of Standpipe	(cm)	:	1.40
Sectional Area of Standpipe = $\frac{\pi D^2}{4}$ (a)	(cm^2)	:	1.54
Volume of Mould	(cm^3)	:	972.38
Cross Sectional Area of Sample (A)	(cm^2)	:	81.71
Wet Density	(Mg/m^3)	:	1.63
Dry Density	(Mg/m^3)	:	1.02

Date	Time on clock	Time Elapsed	Height (cm)	
3/12/88	12:10		96.9	Saturation
	12:17		96.0	Saturation
	12:45		95.3	Saturation
4/12/88	(t1) 10:54		73.9	Saturation h1
		77,460 seconds		
5/12/88	8:25		59.0	
	9:35		58.4	
	10:19		58.1	
		18,000 seconds		
	11:25		57.7	
	12:25		56.8	
	(t2) 1:25		56.2	h2

$$K = \frac{2.3026\ aL}{A(t2 - t1)} \log_{10} \frac{h1}{h2}$$

$K_{29^0} = 6.40 \times 10^{-7}$ cm/sec.

$K_{20} = K_{29^0} \frac{nT}{n20} = 5.40 \times 10^{-7}$ cm/sec.

$t2 - t1 = 95,460$ seconds
A = 81.71
h1 = 73.9
h2 = 56.2
a = 1.54

Remarks : Initial K = 7.4×10^{-7} cm/sec.

Table 2.2-6 Falling Head Permeability Test of Undistrubed Sample from KM-2

Project : Soil Investigation Works For The Solid Waste Management Study For Pulau Pinang And Seberang Prai Municipalicities

Sample No. & Depth : KM-1/U02 (4.50 - 4.95m) Sample Condition : Undisturbed

Weight of Empty Mould	(gm)	:	1952
Weight of Mould + Wet Soil	(gm)	:	3667
Ø of Mould	(cm)	:	10.20
Initial Moisture Content	(%)	:	38.9
Final Moisture Content	(%)	:	41.9
Length of Sample (L)	(cm)	:	11.90
Ø of Standpipe	(cm)	:	1.27
Sectional Area of Standpipe = $\frac{\pi D^2}{4}$ (a)	(cm^2)	:	1.267
Volume of Mould	(cm^3)	:	972.38
Cross Sectional Area of Sample (A)	(cm^2)	:	81.71
Wet Density	(Mg/m^3)	:	1.76
Dry Density	(Mg/m^3)	:	1.27

Date	Time on Clock	Time Elapsed	Height (cm)
3/12/88	11:10:37		81.5 Saturation
	11:14:13		81.0 Saturation
	12:10		75.0 Saturation
	12:44		72.0 Saturation
4/12/88	10:53		19.8 Saturation
	Refilling		
	t1 10:55		96.0 h1
5/12/88	8:24		45.8
	9:34		43.8
	10:18	95,340 seconds	42.4
	10:52		41.7
	11:24		40.8
	12:24		39.6
	(t2) 1:24		37.7 h2

Sample No. & Depth : KM-1/UD2 (4.50 - 4.95m)

$$K = \frac{2.3026\ aL}{A(t2 - t1)} \log_{10} \frac{h1}{h2}$$

$K_{29^0} = 1.81 \times 10^{-6}$ cm/sec.

$K_{20} = K_{29^0} \frac{nT}{n20} = 1.50 \times 10^{-6}$ cm/sec.

Remarks : Initial K = 3.06×10^{-6} cm/sec.

t2 - t1 = 95,340 seconds
A = 81.71
h1 = 96.0
h2 = 37.7
a = 1.267

SUMMARY OF LABORATORY TEST RESULTS

Soil Investigation Works For The Solid Waste Management Study for Pulau Pinang And Seberang Prai Municipalities - MJ/032/88

GEOTECHNIQUE (M) SDN. BHD.

BOREHOLE No.	SAMPLE No.	DEPTH (M) FROM	DEPTH (M) TO	NATURAL MOISTURE CONTENT %	BULK DENSITY Mg/m³	DRY DENSITY Mg/m³	SPECIFIC GRAVITY	ATTERBERG LIMITS % LIQUID LIMIT	ATTERBERG LIMITS % PLASTIC LIMIT	ATTERBERG LIMITS % PLASTIC INDEX	UNCONFINED COMPRESSION STRENGTH kN/m²	TRIAXIAL COMPRESSION TEST APPARENT COHESION kN/m²	TRIAXIAL COMPRESSION TEST ANGLE OF SHEARING RESISTANCE φ	VOID RATIO e	COEFFICIENT OF PERMEABILITY K CM/SEC.	CON SOLIDATION TEST PRE-COMPRESSION LOAD kN/m²	CON SOLIDATION TEST COMPRESSION INDEX Cc	COMPACTION TEST OPTIMUM MOISTURE CONTENT %	COMPACTION TEST MAXIMUM DRY DENSITY Mg/m³	PARTICLE SIZE DISTRIBUTION % GRAVEL > 2 mm.	PARTICLE SIZE DISTRIBUTION % SAND 0.06 - 2 mm.	PARTICLE SIZE DISTRIBUTION % SILT/CLAY < 0.06 mm.
KM-1	D2	1.50	1.96				2.68													25	72	3
	UD1	3.00	3.50	63.3			2.61	42	23	19										1	2	50/47
	UD2	4.53	4.93				2.67	26	20	6	22.3					In Appendix				1	41	43/15
	D5	6.00	6.45	75.5																		
	UD3	7.50	8.00				2.51	71	34	37	35.8									2	4	43/51
	D7	10.50	10.95	73.6			2.57															
	UD5	12.00	12.50				2.38	93	46	47						In Appendix				0	1	41/58
	D9	13.50	13.95	79.1																		
	UD6	15.00	15.50	36.9				63	27	36												
	UD7	16.50	16.95	56.7	1.68	1.07	2.57	75	33	42		35.0	6.7							1	2	35/62
	D11	18.00	18.45	54.3			2.55	65	30	35										1	2	43/54

Table 2.2-7 Summary of Laboratory Test Results for KMDS

SUMMARY OF LABORATORY TEST RESULTS

Soil Investigation Works For The Solid Waste Management Study For Pulau Pinang And Seberang Prai Municipalities - MJ/032/88

GEOTECHNIQUE (M) SDN. BHD.

BOREHOLE No.	SAMPLE No.	DEPTH (M) FROM	DEPTH (M) TO	NATURAL MOISTURE CONTENT %	BULK DENSITY Mg/m^3	DRY DENSITY Mg/m^3	SPECIFIC GRAVITY	ATTERBERG LIMITS % LIQUID LIMIT	ATTERBERG LIMITS % PLASTIC LIMIT	ATTERBERG LIMITS % PLASTIC INDEX	UNCONFINED COMPRESSION STRENGTH kN/m^2	TRIAXIAL COMPRESSION TEST APPARENT COHESION kN/m^2	TRIAXIAL COMPRESSION TEST ANGLE OF SHEARING RESISTANCE ϕ	VOID RATIO e	COEFFICIENT OF PERMEABILITY K CM/SEC.	CONSOLIDATION TEST PRE-COMPRESSION LOAD kN/m^2	CONSOLIDATION TEST COMPRESSION INDEX Cc.	COMPACTION TEST OPTIMUM MOISTURE CONTENT %	COMPACTION TEST MAXIMUM DRY DENSITY Mg/m^3	PARTICLE SIZE DISTRIBUTION % GRAVEL > 2 mm.	PARTICLE SIZE DISTRIBUTION % SAND 0.06 - 2 mm.	PARTICLE SIZE DISTRIBUTION % SILT/CLAY < 0.06 mm.
KK-2	D2	1.50	1.95				2.45													1	97	2
	D4	3.00	3.45	98.0				64	35	29												
	UD1	4.50	5.00	78.0			2.52	36	20	16										0	25	52/23
	UD2	6.03	6.43	79.2	1.53	0.85	2.64	49	24	25		7.5	1.8							1	4	63/32
	UD3	7.50	8.00				2.48	74	35	39	15.4					In Appendix						
	UD4	10.50	11.00				2.56				20.0									19	56	12/13
	D9	12.00	12.45	43.6			2.60													17	51	20/17
	UD5	13.50	14.00	66.0	1.52	0.92	2.44	80	36	44		15.0	5.8			In Appendix				?	?	43/50
	D11	15.00	15.45	94.5				83	42	41												
	D13	18.00	18.45	92.8			2.41	72	40	32										1	19	40/40

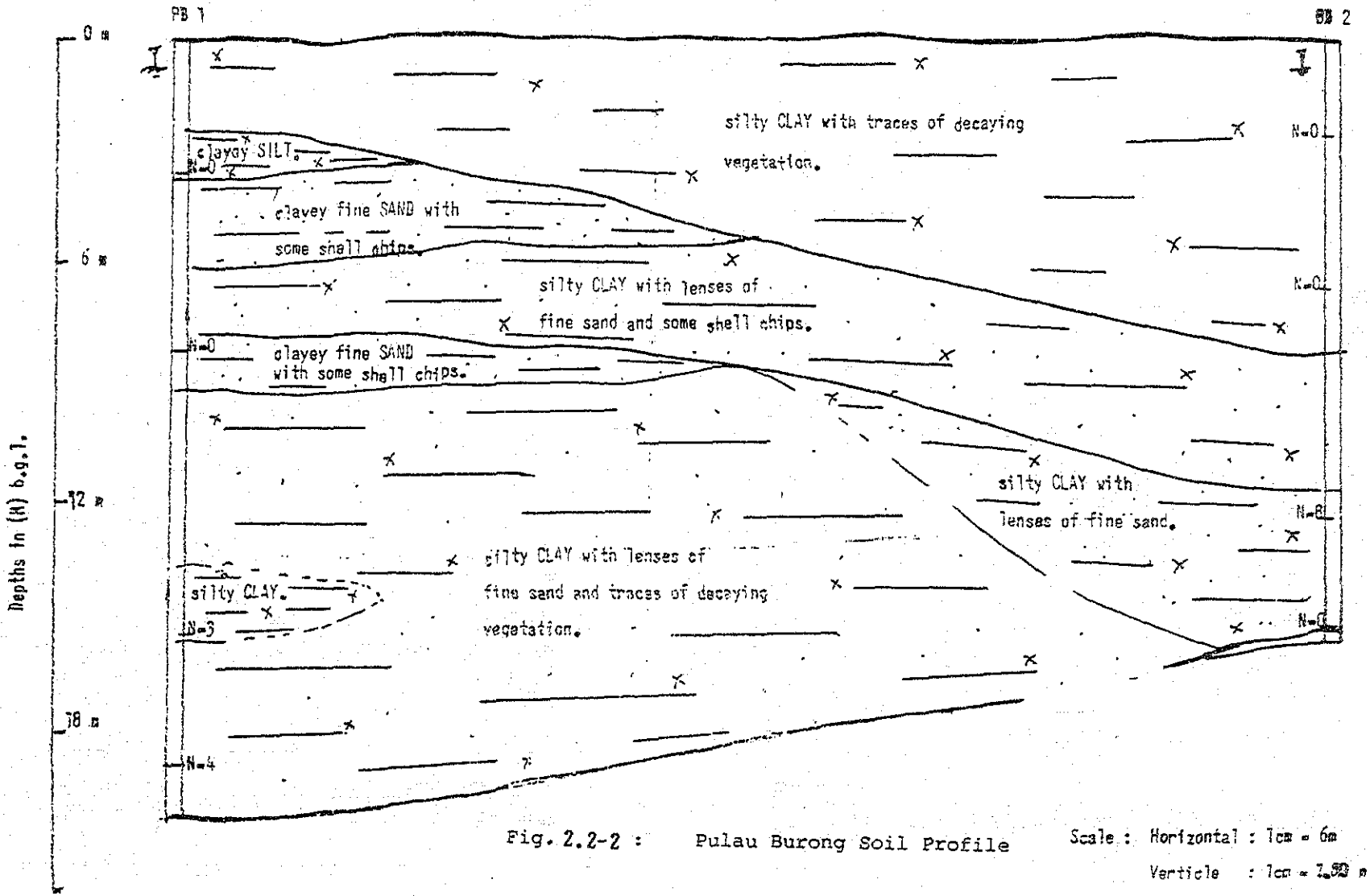


Fig. 2.2-2 : Pulau Burong Soil Profile

Scale : Horizontal : 1cm = 6m

Verticle : 1cm = 7.50 m

BOREHOLE No. PB-1
Sheet 1 of 1

Type of boring ..... Percussion
Type of rig ..... HSI 200
Dia of boring ..... 146 mm
Casing details .....

Feature ..... Soil Investigation Works For The Solid Waste Management Study For Pulau Pinang And Seberang Prai Municipalities.....
Location .....
Ground level:

Date & (Time)	Depth of boring & (casing)	Ground Water	Samples & Tests: Depth	Sample	Test	Strata: Legend	Depth	Reduced Level	Thickness	Description
			m				m	m	m	
17-11-88 (13:10)			0.00 to							
				D1						Very Soft to Soft Dark grey silty CLAY with traces of decaying vegetation.
			1.50				1.50		1.50	
				UD1						Very Soft Dark grey clayey SILT.
			2.00							
			3.00 to		N=0 (Weight of Hammer)					
				D2						
			3.45				3.45		1.95	
				D3						Very Loose Dark grey clayey fine SAND with some shell fragments.
			4.50 to		N=0 (Weight of Hammer)					
				D4						
			4.95							
			6.03 to		2/6 x 10		6.00		2.55	
				UD2						Very Soft Dark grey silty CLAY with lenses of fine sand and a trace of shell fragments.
			6.43							
			7.50 to		N=0 (Weight of Hammer)		7.50		1.50	
				D5						Very Loose Dark grey clayey fine SAND with some shell fragments.
			7.95							
							8.00			

- Small disturbed sample
- Large disturbed sample
- Undisturbed sample
- Standard penetration test
- Water sample
- Drill core sample
- Vane test
- Field permeability test
- m Moisture content (%)

Remarks

Table 2.2-8 Borehole PB-1 log (PBDS)

Contractor 17-11-88
Date started 18-11-88
Date finished .....

Scale: 1 div. : 10cm

Logged by .....
Checked by: .....
Date: .....

Fig. No.

BOREHOLE No. PB-1

Sheet 2 of 3

Type of boring ..... Percussion
Type of rig ..... HSI 200
Dia of boring ..... 156 mm
Casing details .....

Feature / Location: Soil Investigation Works For The Solid Waste Management Study For Pulau Pinang And Sberang Prai Municipalities.

Ground level:

Date & (Time)	Depth of boring & (casing)	Ground Water	Samples & Tests: Depth	Sample	Test	Strata: Legend	Depth	Reduced Level	Thickness	Description
			m				m	m	m	
17-11-88 (15:15)				D6						Very Loose Dark grey clayey fine SAND with some shell fragments.
			9.00 to 9.45	D7	N=1		9.00		1.50	
				D8						Very Soft Dark grey silty CLAY with lenses of fine sand and traces of decaying vegetation.
			10.53 to 10.95	UD3						
			12.00 to 12.50	UD4						
			13.53 to 13.93	UD5			13.53		4.53	
				D10						Soft Brown mottled with light grey silty CLAY.
			15.00 to 15.45	D11	N=3					
18:00 (09:10)		8.10m 7.90m					15.45		1.92	Soft to Firm Dark grey silty CLAY with traces of decaying vegetation.
							16.00			

- Small disturbed sample
- Large disturbed sample
- Undisturbed sample
- Standard penetration test
- Water sample
- Drill core sample
- Vane test
- Field permeability test
- m Moisture content (%)

Remarks

Contractor Geotechnique (M)
Date started 17-11-88
Date finished 18-11-88

Scale:

Logged by .....
Checked by: .....
Date: .....

Fig. No.

BOREHOLE No. PB-1
Sheet 3 of 3

Type of boring ..... Percussion
Type of rig ..... HSI 200
Dia of boring ..... 156 mm
Casing details .....

Feature Soil Investigation Works For The Solid Waste Management Study For Pulau Pinang And Seberang Prai Municipalities.
Location .....
Ground level:

Date & (Time)	Depth of boring & (casing)	Ground Water	Samples & Tests: Depth	Sample	Test	Strata: Legend	Depth	Reduced Level	Thickness	Description
			m				m	m	m	
18-11-88				D12						
(18:00)		8.10m	16.50 to							
(09:10)		7.90m		UD6						
			17.00							
										Soft to Firm Dark grey silty CLAY with traces of decaying vegetation.
			18.00 to		N=4					
				D13						
			18.45							
			19.50 to							
				UD7						
			20.00				20.00		4.55	
(11:10)		0.75m ▲								- END OF BOREHOLE -

● Small disturbed sample
● Large disturbed sample
Undisturbed sample
Standard penetration test
▲ Water sample
Drill core sample
× Vane test
Field permeability test
m Moisture content (%)

Remarks ▲ Water Sample collected at 20.00 m.

Scale: 1 div. : 10cm

Logged by .....
Checked by: .....
Date: .....

Contractor Geotechnique (M)
Date started 17-11-88
Date finished 18-11-88

Fig. No.

BOREHOLE No. PB-2
Sheet 1 of 2

Type of boring ..... Percussion .....
Type of rig ..... KSL 20I .....
Dia of boring ..... 156 mm .....
Casing details .....

Feature Soil Investigation Works For The Solid
Location Waste Management Study For Pulau Pinang
And Seberang Prai Municipalities....
Ground level:

Date & (Time)	Depth of boring & (casing)	Ground Water	Samples & Tests: Depth (m)	Sample	Test	Strata: Legend	Depth (m)	Reduced Level (m)	Thickness (m)	Description
16-11-88 08:00			0.00 to	D1						
			1.00 to	D2	N=0 (Weight of Hammer)					
			1.45							
			1.50 to	UD1						
			2.00							
			3.00 to	UD2						Very Soft to Soft Dark grey silty CLAY with traces of decaying vegetation.
			3.50							
			4.50 to	UD3						
			5.00							
				D3						
			6.00 to	D4	N=0 (Weight of Hammer)					
			6.45							
			7.50 to	UD4						
			8.00				8.00			

- Small disturbed sample
- Large disturbed sample
- Undisturbed sample
- Standard penetration test
- Water sample
- Drill core sample
- Vane test
- Field permeability test
- m Moisture content (%)

Remarks

Table 2.2-9 Borehole PB-2 log (PBDS)

Contractor Geotechnique (M)
Date started 16-11-88
Date finished 17-11-88

Scale: 1 div. : 10cm
Logged by .....
Checked by: .....
Date: .....
Fig. No

BOREHOLE No. PB-2
Sheet 2 of 2

Type of boring ..... Percussion .....
Type of rig ..... HSJ 200 .....
Dia of boring ..... 150 mm .....
Casing details .....

Feature ..... Soil Investigation Works for The Solid .....
Location Waste Management Study For Pulau Pinang .....
And Seberang Prai Municipalities .....
Ground level:

Date & (time)	Depth of boring & (casing)	Ground Water	Samples & Tests: Depth	Sample	Test	Strata: Legend	Depth	Reduced Level	Thickness	Description
			m				m	m	m	
16-11-88 (11:30)			9.00 to 9.50	UD5						Soft to Firm Dark grey silty CLAY with lenses of fine sand.
			10.50 to 11.00	UD6			10.50		2.50	Soft to Firm Dark grey silty CLAY with lenses of fine sand.
			11.50 to 12.00	D5	N=8		11.50		1.00	Firm to Stiff White grey, red brown mottled with silty CLAY and lenses of fine sand.
			12.45	D6						
			13.50 to 14.00	UD7			13.50		2.00	Top: Firm to Stiff White grey, red brown mottled with silty CLAY and lenses of fine sand. Bottom: Very Soft to Soft Dark grey silty CLAY with traces of fine sand.
			15.00 to 15.45	D7	N=2		15.45		1.95	
(17:00) 17-11-88 (09:10) (17:00)	7.60m 7.00m Extracted 0.90m									- End Of Borehole -

- Small disturbed sample
- Large disturbed sample
- Undisturbed sample
- Standard penetration test
- Water sample
- Drill core sample
- Vane test
- Field permeability test
- m Moisture content (%)

Remarks ▲ Water Sample collected at 15.45 m.

Contractor Geotechnique (M)
Date started 16-11-88
Date finished 17-11-88

Scale: 1 div. : 10cm

Logged by .....
Checked by: .....
Date: .....

Fig. No.

Table 2.2-10 Falling Head Permeability Test of Undistrubed Sample from PB-1

Project : Soil Investigation Works For The Solid Waste Management Study For Pulau Pinang And Seberang Prai Municipalities.

Sample No. & Depth : PB-1/U02 (6.00 - 6.45m) Sample Condition : Undisturbed

Weight of Empty	(gm)	:	1952
Weight of Mould + Wet Soil	(gm)	:	3547
ϕ of Mould	(cm)	:	10.20
Initial Moisture Content	(%)	:	62.0
Final Moisture Content	(%)	:	63.4
Length of Sample (L)	(cm)	:	11.90
ϕ of Standpipe	(cm)	:	1.27
Section Area of Standpipe = $\frac{\pi D^2}{4}$ (a)	(cm^2)	:	1.267
Volume of Mould	(cm^3)	:	972.38
Cross Sectional Area of Sample (A)	(cm^2)	:	81.71
Wet Density	(Mg/m^3)	:	1.64
Dry Density	(Mg/m^3)	:	1.01

Date	Time on clock	Time Elapsed	Height (cm)	
25/11/88			Saturation	
26/11/88			Saturation	
27/11/88			Saturation	
28/11/88	(t1) 08:54	-	94.6	h1
	09:54	1 hr	93.0	
	10:54	1 hr	91.4	
	11:54	1 hr	90.3	
	12:54	1 hr	89.4	
29/11/88	(t2) 08:54	24 hrs	64.4	h2

$$K = \frac{2.3026\ aL}{A(t2 - t1)} \log_{10} \frac{h1}{h2}$$

$K_{29^0} = 8.20 \times 10^{-7}$ cm/sec.

$K_{20} = K_{29^0} \frac{nT}{n20} = 6.70 \times 10^{-7}$ cm/sec.

t2 - t1 = 86,400 seconds
A = 81.71
h1 = 94.6
h2 = 64.4
a = 1.267

Remarks : Initial K = 2.16×10^{-6} cm/sec. (estimated)

Table 2.2-11 Falling Head Permeability Test of Undistrubed Sample from PB-2

Project : Soil Investigation Works For The Solid Waste Management Study For Pulau Pinang And Seberang Prai Municipalities

Sample No. & Depth : PB-2/U03 (4.50 - 5.00m) Sample Condition : Undisturbed

Weight of Empty Mould	(gm)	:	740
Weight of Mould + Wet Soil	(gm)	:	7750
ϕ of Mould	(cm)	:	5.08
Length of Sample (L)	(cm)	:	11.99
Initial Moisture Content	(%)	:	106.8
Final Moisture Content	(%)	:	113.1
ϕ of Standpipe	(cm)	:	1.40
Sectional Area of Standpipe - $\frac{\pi D^2}{4}$ (a)	(cm^2)	:	1.54
Volume of Mould	(cm^3)	:	241.193
Cross Sectional Area of Sample (A)	(cm^2)	:	20.27
Wet Density	(Mg/m^3)	:	1.43
Dry Density	(Mg/m^3)	:	0.69

Date	Time on Clock	Time Elapsed	Height (cm)	
26/11/88			Saturation	
27/11/88			Saturation	
28/11/88	(t1) 8:51	-	83.2	h1
	09:51	1 hr	83.0	
	10:51	1 hr	82.9	
	11:51	1 hr	82.8	
	12:32	1 hr	82.7	
29/11/88	(t2) 08:51	24 hrs	78.7	h2

$$K = \frac{2.3026\ aL}{A(t2 - t1)} \log 10 \frac{h1}{h2}$$

$K_{29^\circ} = 5.80 \times 10^{-7}$ cm/sec.

$K_{20} = K_{29^\circ} \frac{\eta}{\eta 20} = 4.70 \times 10^{-7}$ cm/sec.

t2 - t1 = 86,400 seconds
A = 20.27
h1 = 83.2
h2 = 78.7
a = 1.54

SUMMARY OF LABORATORY TEST RESULTS

Soil Investigation Works For The Solid Waste Management Study For Pulau Pinang And Seberang Prai Municipalities - MJ/032/88

GEOTECHNIQUE (M) SDN. BHD.

BOREHOLE No.	SAMPLE No.	DEPTH (M) FROM	DEPTH (M) TO	NATURAL MOISTURE CONTENT %	BULK DENSITY Mg/m³	DRY DENSITY Mg/m³	SPECIFIC GRAVITY	ATTERBERG LIMITS % LIQUID LIMIT	ATTERBERG LIMITS % PLASTIC LIMIT	ATTERBERG LIMITS % PLASTIC INDEX	UNCONFINED COMPRESSION STRENGTH kN/m²	TRIAXIAL COMPRESSION TEST APPARENT COHESION kN/m²	TRIAXIAL COMPRESSION TEST ANGLE OF SHEARING RESISTANCE φ	VOID RATIO e	COEFFICIENT OF PERMEABILITY K CM/SEC.	CON SOLIDATION TEST PRE-COMPRESSION LOAD kN/m²	CON SOLIDATION TEST COMPRESSION INDEX Cc	COMPACTION TEST OPTIMUM MOISTURE CONTENT %	COMPACTION TEST MAXIMUM DRY DENSITY Mg/m³	PARTICLE SIZE DISTRIBUTION % GRAVEL > 2 mm.	PARTICLE SIZE DISTRIBUTION % SAND 0.06 - 2 mm.	PARTICLE SIZE DISTRIBUTION % SILT/CLAY < 0.06 mm.
PB-1	UD1	1.50	2.00				2.39	42	22	20	4.3									1	11	68/20
	D2	3.00	3.45	78.9																		
	D4	4.50	4.05				2.47													2	43	31/24
	UD2	6.03	6.43	62.0	1.63	1.01	2.49	37	19	18	22.5	7.0	0.2		In Appendix					1	26	47/26
	D5	7.50	7.95				2.53													5	48	29/18
	D7	9.00	9.45	61.4				40	19	21												
	UD4	12.00	12.50	68.6			2.61	76	28	48												
	UD5	13.50	13.95	38.3				66	23	43												
	D11	15.00	15.45	36.4																		
	UD6	16.50	17.00	48.0	1.72	1.16	2.56	80	32	48		17.0	4.2		In Appendix					1	2	21/76
	D13	18.00	18.45	69.2																		
	UD7	19.50	20.00	70.3			2.32	70	39	31												

Table 2.2-12 Summary of Laboratory Test Results for PBDS

SUMMARY OF LABORATORY TEST RESULTS

Soil Investigation Works For The Solid Waste Management Study For Pulau Pinang And Seberang Prai Municipalities - MJ/032/88

GEOTECHNIQUE (M) SDN. BHD.

BOREHOLE No.	SAMPLE No.	DEPTH (M)		NATURAL MOISTURE CONTENT %	BULK DENSITY Mg/m³	DRY DENSITY Mg/m³	SPECIFIC GRAVITY	ATTERBERG LIMITS %			UNCONFINED COMPRESSION STRENGTH kN/m²	TRIAXIAL COMPRESSION TEST		VOID RATIO e	COEFFICIENT OF PERMEABILITY K CM/SEC.	CONSOLIDATION TEST		COMPACTION TEST		PARTICLE SIZE DISTRIBUTION %		
		FROM	TO					LIQUID LIMIT	PLASTIC LIMIT	PLASTIC INDEX		APPARENT COHESION kN/m²	ANGLE OF SHEARING RESISTANCE φ			PRE-COMPRESSION LOAD kN/m²	COMPRESSION INDEX Cc.	OPTIMUM MOISTURE CONTENT %	MAXIMUM DRY DENSITY Mg/m³	GRAVEL > 2 mm.	SAND 0.06 - 2 mm.	SILT/CLAY < 0.06 mm.
PB-2	D2	1.00	1.45	99.4																		
	UD1	1.50	2.00				2.51	41	21	20	11.5					In Appendix				1	9	66/24
	UD2	3.00	3.50	102.5	1.41	0.70	2.41	63	30	33		3.0	1.3							1	3	57/39
	UD3	4.50	5.00	106.8			2.32	60	33	27										0	1	52/47
	D4	6.00	6.45	98.9																		
	UD4	7.50	8.00	81.2																		
	UD6	10.50	11.00	87.0			2.45	68	33	35										1	5	46/48
	D6	12.00	12.45	33.6																		
	UD7	13.50	14.00	74.3	1.54	0.88	2.42	73	36	37		24.0	1.8			In Appendix				0	1	39/60
	D7	15.00	15.45	60.4			2.44	56	27	29										1	3	44/52
	UD5	9.00	9.50				2.41	45	22	23	15.4									1	10	53/36

3 Preliminary Design of KMDS and PBDS

3.1 Planning Conditions

3.1.1 Basic Principals

The final disposal site composes the ultimate termination point of accumulated waste, resulting in a land reclamation site by means of landfill. Accordingly, upon consideration of the necessary functions of a final disposal site, the basic principals for the execution of the preliminary designs regarding Phase I of the project have been conceived of and are arranged in the following.

(1) An adequate landfill volume exists
Within the areas selected as final disposal sites, the guarantee of landfill volume in Phase III (2005) and the smooth derivation from the landfill design of Phase I are considered.

(2) The design appropriately pertains to the topography, geology and surrounding environment.

(3) The wastes disposed of at the site are to be harmless and stablized quickly.

(4) During and after completion of the filling, the area does not became a pollution outbreak source.

(5) During and after completion of the filling, safety from disaster is guaranteed.

(6) The completed site will be of a configuration harmonious with the surrounding environment.

(7) Throughout and after completion of the filling, the operation and maintenance expenses will be kept low.

3.1.2 Designed Landfill Volume

(1) Conditions for Estimation

a. Landfill periods: 1992 - 1996 (Phase I)
1997 - 2001 (Phase II)
2002 - 2005 (Phase III)

b. Unit weight of wastes disposed: 0.8 ton/m3
(after compaction)

c. Covering materials ; 30% of the waste volume performed everyday

(2) Desinged Landfill Volume

The designed landfill volumes for the Kuala Muda and Pulau Burong disposal sites within Phase I, II and III are listed below.

Table 3.1-1 Designed Landfill Volume

Item	Unit	KMDS Phase I	KMDS II	KMDS III	PBDS I	PBDS II	PBDS III	Remarks
Disposal Amount	t/day	210	264	311	250	312	368	Phase I 1996 Phase II 2001 Phase III 2005
Cumulative Disposal Amount Total	1000t	345	442	429	409	523	506	
Cumulative Disposal Volume	1000m3	431	552	536	511	653	634	o.8ton/m^3
Cumulative Covering Material	1000m3	129	166	161	153	196	190	30% of the above volume
Designed Landfill Volume	1000m3	560	718	697	664	850	823	

3.1.3 Topography and Geology

In MPSP two disposal sites are proposed to be each located on the west coast of the Malay Peninsula flatland. Below are summarized the topography and geology of each site.

(1) Topography

a. KMDS

At this location, there are really two sites existing. The inland site is at the northern tip of Penang State, along the Muda River sandwiched in by the national road. The lagoon site is within the lagoon which is located near the mouth of the Muda River.

i. Inland site

There are the national road at the north of the site and the low-cost housing project under construction by PERDA at the east. Actually, the site is vacant and low flatland, and is partly used as a sportsfield.

ii. Lagoon site

The marsh within the lagoon, at high tide is lost into the sea, and at low tide is dried up. Approaching the shore, the young mangrove are growing.

The sea side of the lagoon compared with the inland side, has a more profound water depth.

b. Pulau Burong

At the southern tip of Penang State, as a flat marsh at the mouth of the Tengah River, the present disposal site (PBDS), is located on the island side of the narrow canal. The inner side of the bund constructed by the DID is already used as farmland. The proposed disposal site (PBDS) is located in the Byram Forest Reserve separated by the canal of the oil palm plantation on the peninsula side adjacent to the above-mentioned present site.

(2) Geology

a. KMDS

i. Inland site

The surface soil is silty sand, however the basement layer is made up of marine clay from the main stream of the mouth the Muda River.

ii. Lagoon site

A natural bund results from 3m of sandy soil, the lower portion from marine clay mixed with loose sand layer.

The inland lacks the sand layer and has only what lies below the natural bund. The marsh enclosed by the natural bund also results from marine clay. The marine clay permeability coefficient is 10^{-6} - 10^{-7} cm/sec.

b. PBDS

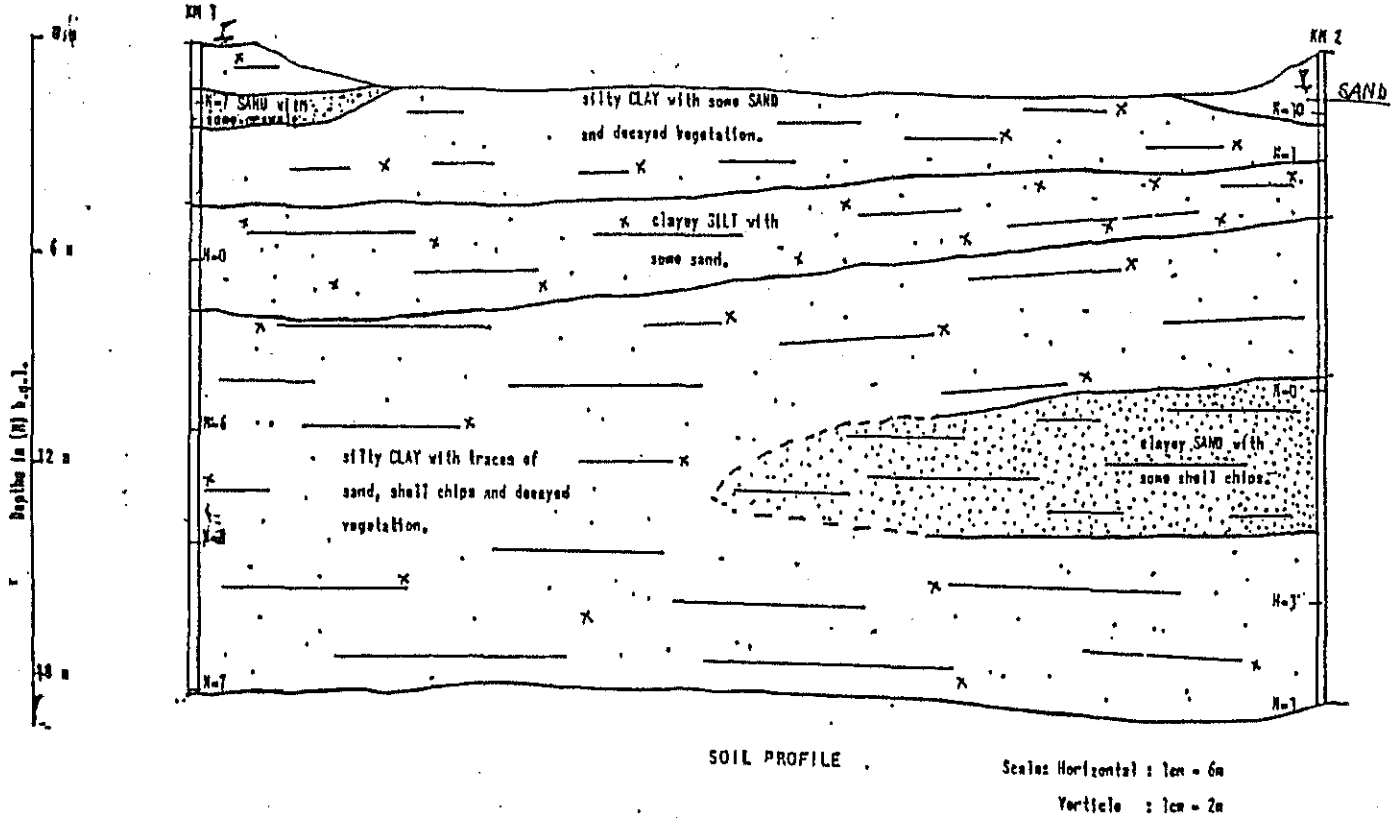
i. The accumulated marine clay in the site has a permeability coefficient of 10^{-6} - 10^{-7} cm/sec.

ii. Characteristics of Marine Clay

Laboratory testing on selected soil samples has been performed to evaluate the engineering parameters of the subsoil encountered. Based on soil testing, the characteristics of marine clay are summarized as follows.

Table 3.1-2 Characteristics of Marine Clay

Items	Unit	KMDS	PBDS
Natural Moisture Content	%	60 - 80	60 - 90
Bulk Density	ton/m^3	1.5 - 1.6	1.55 - 1.7
Specific gravity		2.4 - 2.7	2.4 - 2.7
Atterberg limit			
- Plastic limit	%	25 - 40	20 - 37
- Liquid limit	%	47 - 90	40 - 70
Permeability coefficient	cm/sec	10^{-6} - 10^{-7}	10^{-6} - 10^{-7}



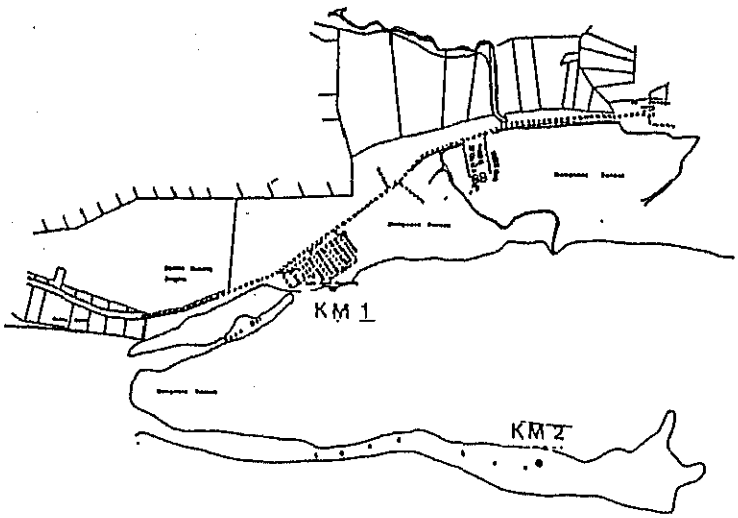


Fig. 3.1-1 KMDS Geological Profile

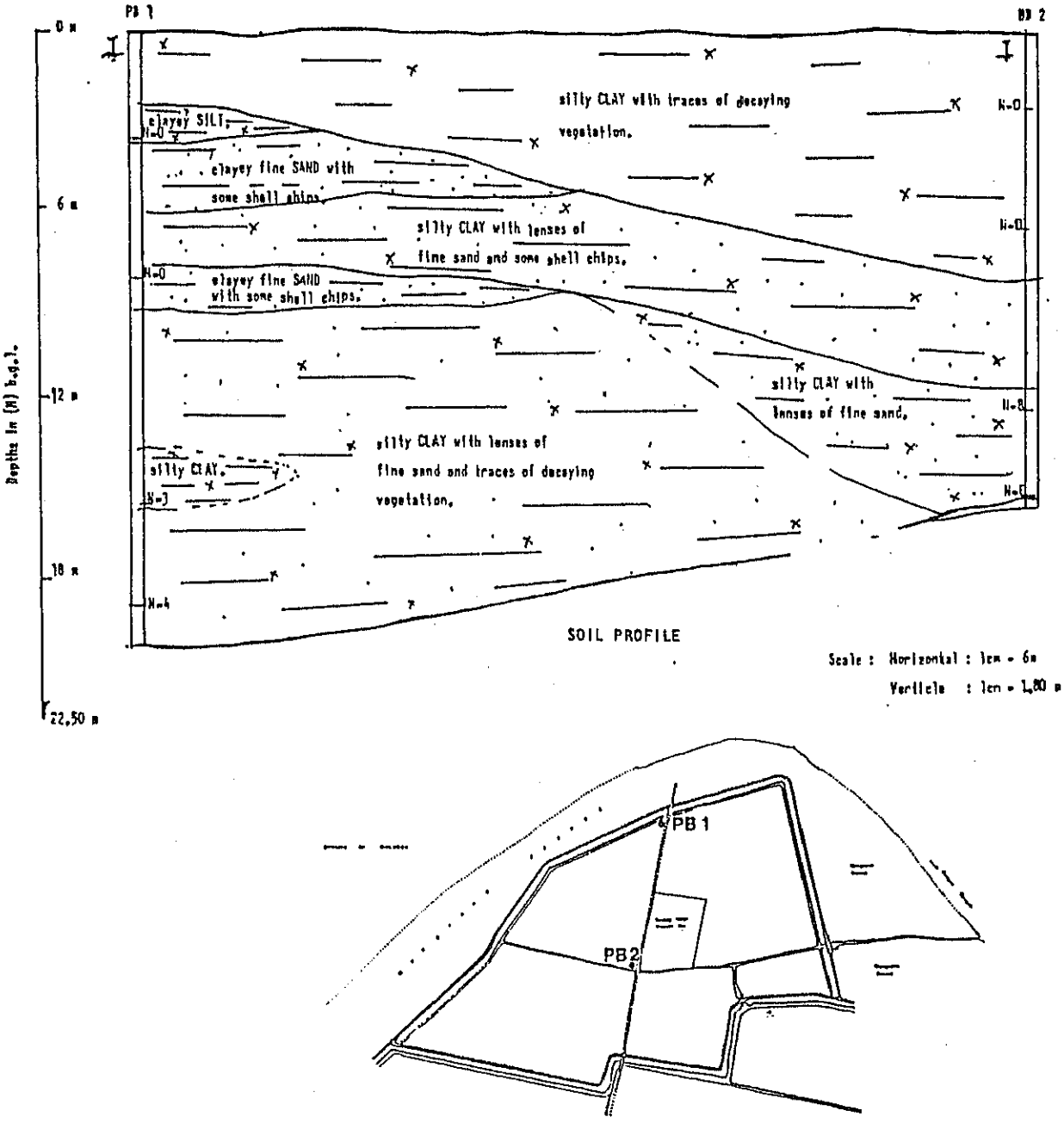


Fig. 3.1-2 PBDS Geological Profile

3.2 Facility Design

3.2.1 Facility Lay-out

(1) Design principals

The design principals for the facility lay-out are as follows.

a. The design is to smoothen the execution and transitions in the work from Phase I through to Phase III.

b. Regarding the surrounding land use conditions, the consideration is that each facility cast no bad effects on the local area.

c. The on-site roads/or landfill flow are to be uncomplicated and harmonious.

d. The administration facilities are to be erected near the entrance to the disposal site for full supervision of the waste collection vehicles.

e. Each type of facility is to not be decentralized but placed near administration facilities, making maintenance operation easy.

f. The leachate cycling facilities are to be placed as far away as possible from residential areas.

(2) Types of facilities

a. Main Facilities

i. Enclosing structure .... Enclosing bund/divider

ii. Drainage system ..... Surrounding drain/on-site drain (surface)/on-site drain (underground)/drain for reclaimed area.

iii. Access ..... Approach road/on-site road/improvement of existing road.

b. Environmental protection facilities

i. Buffer zone

ii. Litter control facilities

iii. Gas removal facilities

iv. Leachate collection facilities

v. Leachate cycling facilities

vi. Leachate effluence facilities

vii. Monitoring facilities

c. Building and accessories

i. Site office

ii. Weighbridge

iii. Storage building

iv. Safety facilities ..... Gates/fences/street lights

v. Fire prevention facilities .... Water tank, extinguisher,

vi. Other ..... Parking lot/greenery/car wash, etc.

(3) Lay-out design

The lay-out of the main facilities is as follows.

a. KMDS

i. Approach road

An approach road is planned in order to regulate the site. The sight distance at the intersection of the existing road is to be adequate.

ii. Buffer zone

The buffer zone is established along the existing road and the PERDA reclaimed land side.

iii. Surrounding drain

A bund of 5m height is designed to be placed inside the buffer zone along the land in use for an assured 10ha landfill site.

iv. Retention pond

This is to be placed at a distance from the residential area, along the shore, and where effluence is easy.

b. PBDS

i. Approach road

As the existing road is dirt, this is to be asphalt-paved. The sight distance at the intersection of the existing road is to be adequate.

ii. Enclosing bund

A bund of 5m height is designed to be placed inside the drainage and existing roads for an assured 12ha landfill site.

iii. Retention pond

Leachate cycling facilities are to be installed on the profitable oceanside. That the use of these facilities in Phase II is easy and that in Phase III they will be used as an oxidation pond is principally regarded.

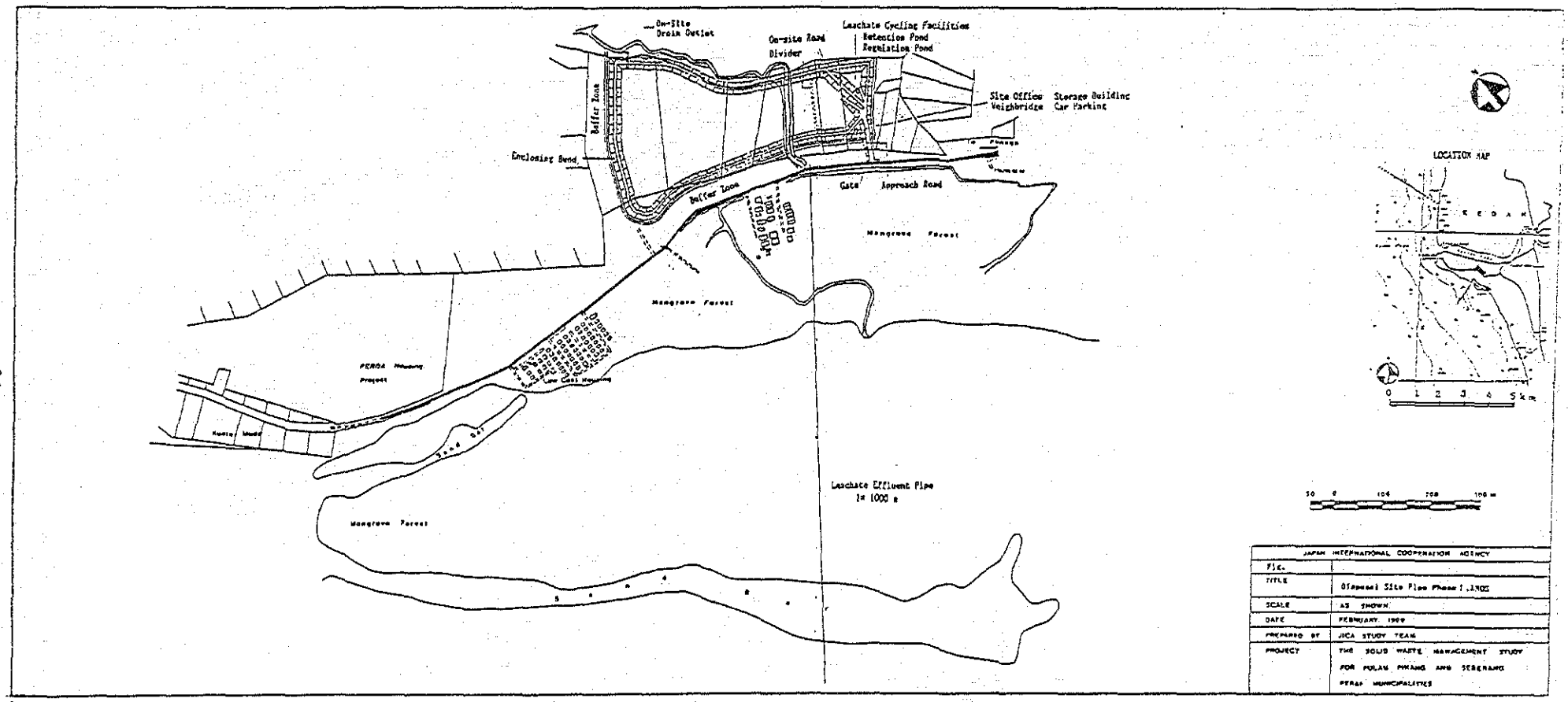


Fig. 3.2-1 Disposal Site Plan Phase I, KMDS

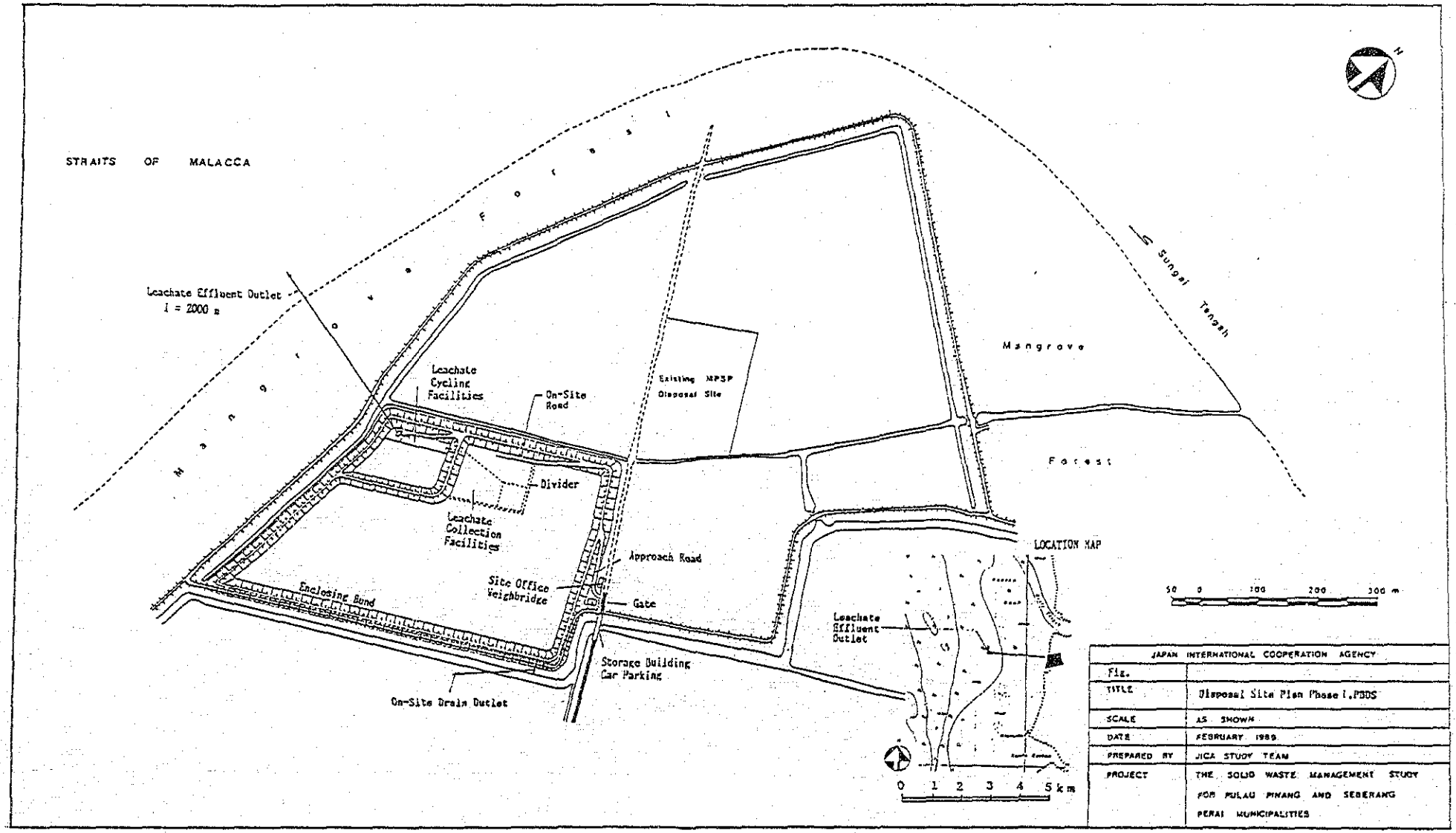


Fig. 3.2-2 Disposal Site Plan Phase I, PBDS

3.2.2 Main Facilities

At the final disposal site, as basic facilities for landfill disposal, the principal goals for the main facilities are the guarantee of landfill volume and the reduction of leachate.

(1) Enclosing structures

a. Enclosing bund

Because the disposal site is located on flat land in order to carry out sanitary landfill, enclosing the landfill site will be a bund for the prevention of rain water invasion and the guarantee of the designed landfill volume.

Earth construction is applied to the bund structure based on,

i. topography (marsh),
ii. ground (soft ground),
iii. construction characteristics, and
iv. economic characteristics.

The landfill height and bund height are calculated based on the results from the study on the

i. designed landfill volume
(The target year for the master plan is 2005)
ii. site area ; KMDS (inland) 17.9ha, (lagoon) 60ha and PBDS (including Pulau Burong) 62.2ha
iii. facilities site (bund, facilities for inspection and administration, buffer zone etc.),
iv. bund foundation soil,
v. settlement,
vi. covering materials, and
vii. tide and waves.

The results show the landfill height at 6.1m and the bund height at 5m. The bund top functioning as the on-site road and the disposal site administration road is of a 5m width and a gravel pavement.

As for the bund, a typical cross section shown in Fig. 3.2-3, follows a land sliding analysis and the settlement study, based on geological investigation data.

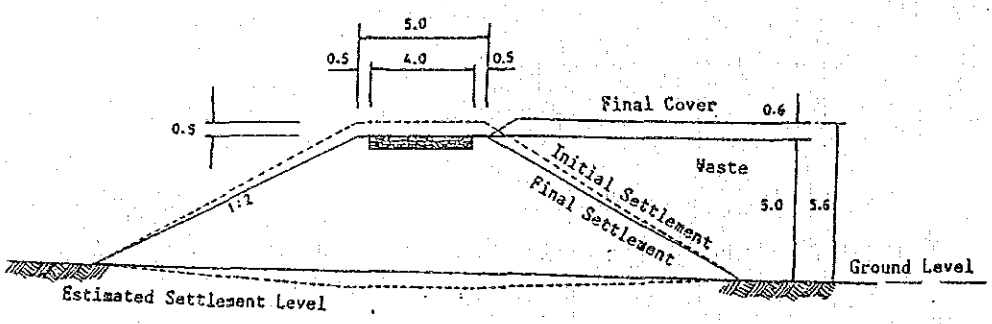


Fig. 3.2-3 Typical Cross Section of Enclosing Bund

Within the preliminary designs, by the typical cross section of enclosing bund required in the master plan, the designed landfill volume up until 1996 of Phase I is assured. The Phase I necessary landfill site is for KMDS, 10ha and for PBDS, 11ha.

The soil parameter employing the land sliding analysis is shown in the following table.

Table 3.2-1 Soil Parameter Table

Earth Layer	Unit Weight r (t/m^3)	Cohesion c (t/m^2)	Angle of Internal Friction ϕ (Degree)
Foundation	1.5	1.5	0
Bund	1.6	2.0	30
Waste Layer	1.0	1.5	30

And, the groundwater level is the same as that of the earth's surface.

b. Divider

Generally, the divider inside the enclosing bund is established based on the following goals.

i. Landfill Work ..... By limiting the area for landfilling, efficient equipment and landfill operation are assured.

ii. Waste conditions ..... The types of waste are separated for landfill purposes.

iii. Leachate Measure ..... The rainwater and spring water from non-landfill areas are eliminated thus allowing for smaller scale leachate cycling facilities.

iv. Facility Construction ..... Leachate collection facilities are prepared in a step-by-step procedure.

Since waste to be disposed of is not reduced in volume due to non-intermediate treatment facilities such as incinerators, the landfill volume is huge. The major purpose of a divider is explained in iii. reduction of leachate quantity.

For maintenance operation of the divider,

- Bund deformation ..... Differential settlement
- Bund water isolation .... Impermeable soil

have been considered, with the bund height at 1.5m.

The site soil permeability coefficient of 10^{-6} - 10^{-7} cm/sec is suitable for the the divider construction. However, as this is a marsh, the construction is carried out using imported soil.

The 1996 yearly landfill area is calculated at 2.5ha for KMDS and 3.0ha for PBDS, after considering the bund height and final covering materials. Consequently, in order to find the average leachate volume, for the KMDS in rainy season the area of a divider is determined at 1.5ha, in dry season at 1.0ha, for the PBDS in rainy season at 1.0ha and in dry season at 2.0ha.

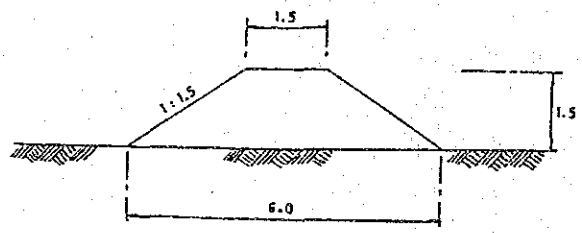


Fig. 3.2-4 Typical Cross Section of Divider

(2) Drainage System

a. General

When waste comes in contact with rainwater, following waste decomposition, there is elution of many produced contaminants and /or suspension resulting in the formation of leachate.

Because leachate contaminates the surrounding area, the target for a drainage system is the reduction of leachate volume. The principal purposes for the systems are listed below.

i. Elimination of rainwater from the water inflow from outside theandfill site.

ii. Eimination of inflowing spring water from side surfaces/or underground.

iii. Elimination of rainwater from the non-landfill site partitioned-off by the divider within the enclosing bund.

iv. Elimination of rainwater from the completed landfill site.

As a disaster prevention measure, the drainage discharges outside the disposal site.

b. Design Conditions

The conditions for the design of economical systems for the effectiveness of the above purposes are as follows.

i. The drainage system design is based on the "Urban Drainage Design Standards and Procedures for Peninsular Malaysia"

ii. Dischange Design ;

Table 3.2-2 Discharge Design

Drain	Return Period (year)	Daily Rain-fall (mm/day)	Rainfall Intensity (mm/hr)	Runoff Coeff-icient	Discharge (m3/sec/ha)	Remarks
Surrounding Drain	2 to 5 yrs.	100 125	65 80	0.35 0.35	0.064 0.078	Rainfall duration is one hour
On-site Drain*	0.5	60	30	1.0	0.167	Rainfall duration is 30min.
Drain for Reclaimed Area	0.5	60	30	0.9	0.150	- ditto -

*The on-site drain for underground water will be constructed if necessary.

c. Drain

i. Surrounding drain

1) KMDS

The drain will be installed outside of the enclosing bund, joining the existing drain.

2) PBDS

The drain will be installed between the existing road and the enclosing bund, joining the existing drain.

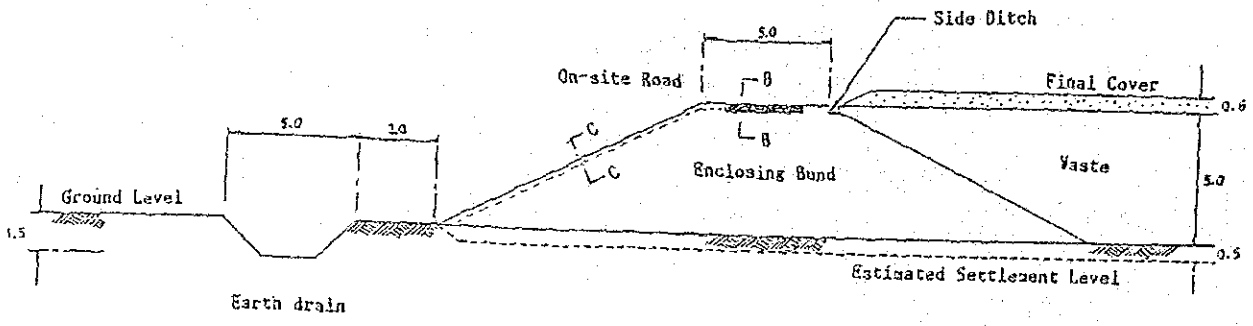


Fig. 3.2-5 Typical Cross Section of Surrounding Drain

ii.On-site drain (surface)

1) Since the ground is composed of marine clay, unlined drains are installed.
2) The drainage from the inside of the landfill area to the outside the bund is discharged naturally following the tidal fluctuations. (cf. Fig. 3.2-6)

iii. Drain for reclaimed area

1) This drain is established after the completion of final covering of material.
2) The lining of the unlined drain is marine clay.
3) The slope of the drain is less than 2%.
4) Rainwater is discharged outside the enclosing bund.

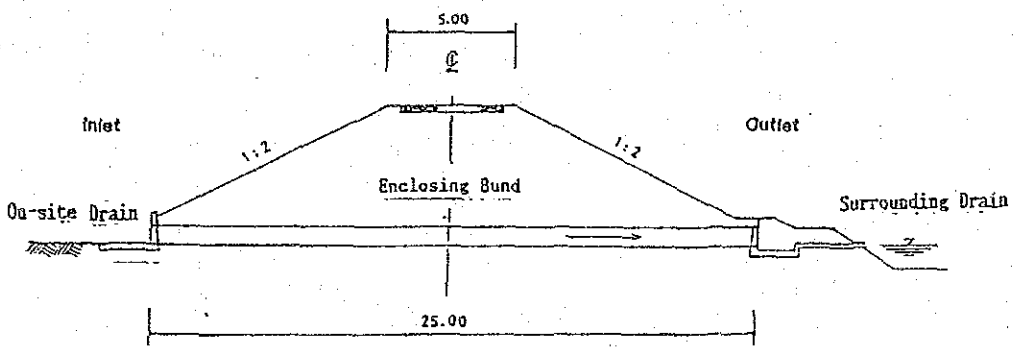


Fig. 3.2-6 Drain Outlet Profile

(3) Access

a. Approach road

This road is to harmonize the entrance of the collection vehicle from the public road to the disposal site.

i. KMDS

1) An approach road from the public road into the disposal site will be established.
2) The road will be wide encough for two-way traffic with a carriageway of 6m.
3) The road will be asphalt-paved.

ii. PBDS

1) The existing 6m dirt road will be paved with asphalt.
2) An approach road into the disposal site will be established.
3) The road will be wide enough for two-way traffic with carriageway of 6m.
4) The road will be asphalt-paved.

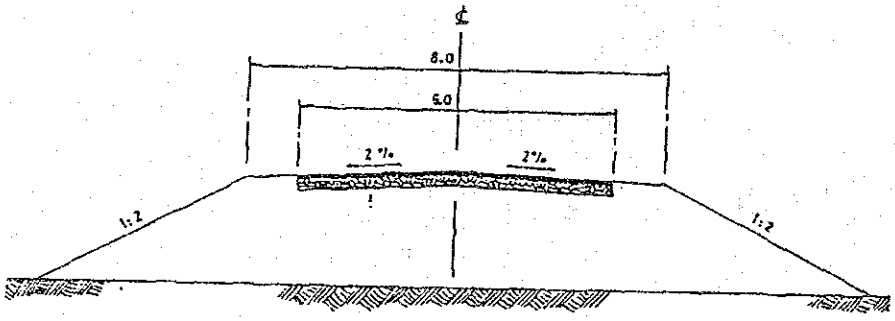


Fig. 3.2-7 Typical Cross Section of Approach Road

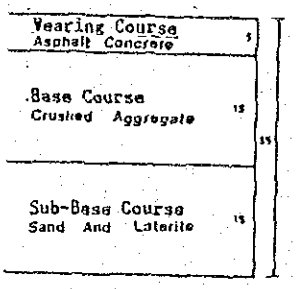


Fig. 3.2-8 Detail of Pavement for Approach Road

b. On-site road

The on-site road includes the road on the top of the bund and the road which joins the bund and working face. The road on the top of the bund also represents the inspection and administration road of the disposal site.

i. The road width is to be 5m.

ii. 4m of the road is paved with gravel at a thickness of 30cm.

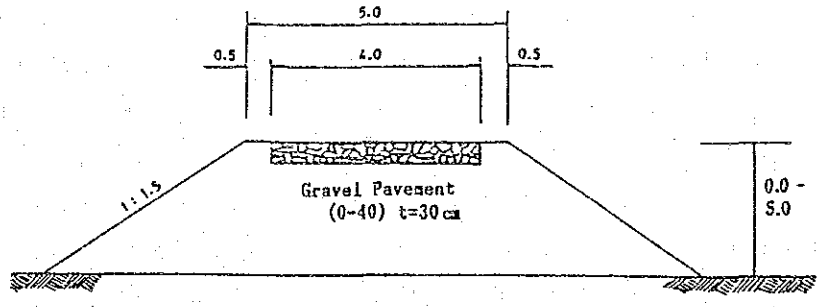


Fig. 3.2-9 Typical Cross Section of On-site Road

c. Improvement of the existing pavement

The existing dirt road to the PDBS will be paved with asphalt.

i. Pavement width ... 6m.

ii. Pavement structure .. same as the approach road