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

Action Plan for a Beautiful and Clean Malaysia ABC Bakau Street Disposal Site **BSDS** BPTS Balik Pulau Transfer Station Cost, Insurance and Freight CIF City Hall of Kuala Lumpur DBKL Drainage and Irrigation Department DID DOE Department of Environment Environmental Impact Assessment EIA ENSEARCH Environmental Management and Research Association of Malaysia EPU Economic Planning Unit Free Trade Zone Incineration Plant FTZIP Free Trade Zone Transfer Station **FTZTS** GDP Gross Domestic Product IKU Public Health Institute Japan International Cooperation Agency JICA **JKKK** Village Development and Security Committee **JMPDS** Jelutong Mole Previous Disposal Site Jelutong Mole Transfer Station JMTS **JPBD** Town and Country Planning Department **KEMAS** Community Development, Ministry of National and Development KMDS Kuala Muda Disposal Site LWL Low Water Level LA Local Authority М Million MC Municipal Council MMTS Mak Mandin Transfer Station MPPP Majlis Perbandaran Pulau Pinang MPSP Majlis Perbandaran Seberang Perai HOM 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 Pantai Acheh Disposal Site PADS **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 | | Davana Doub Countagion | |
| | : | Penang Port Commission | |
| S/R | : | Supporting Report | $\mathcal{A}_{k} = \{ (1, 1) \mid k \in \mathbb{N} \mid k \in \mathbb{N} \}$ |
| SWM | . : | Solid Waste Management | • |
| SWMIS | : | Solid Waster Management Information System | 11, 4 |
| TDC | : | Tourist Development Corporation | $(g_{ij})^{(k)} = (g_{ij})^{(k)} \cdot (f_{ij})$ |
| UDS | : | Urban Drainage System | 10 mg |
| USD | : | Urban Service Department | v [*] |
| 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

| | · · · · · · · · · · · · · · · · · · · | Standard |
|-----------------------------|---------------------------------------|----------|
| Parameter | Unit | В |
| | | |
| (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

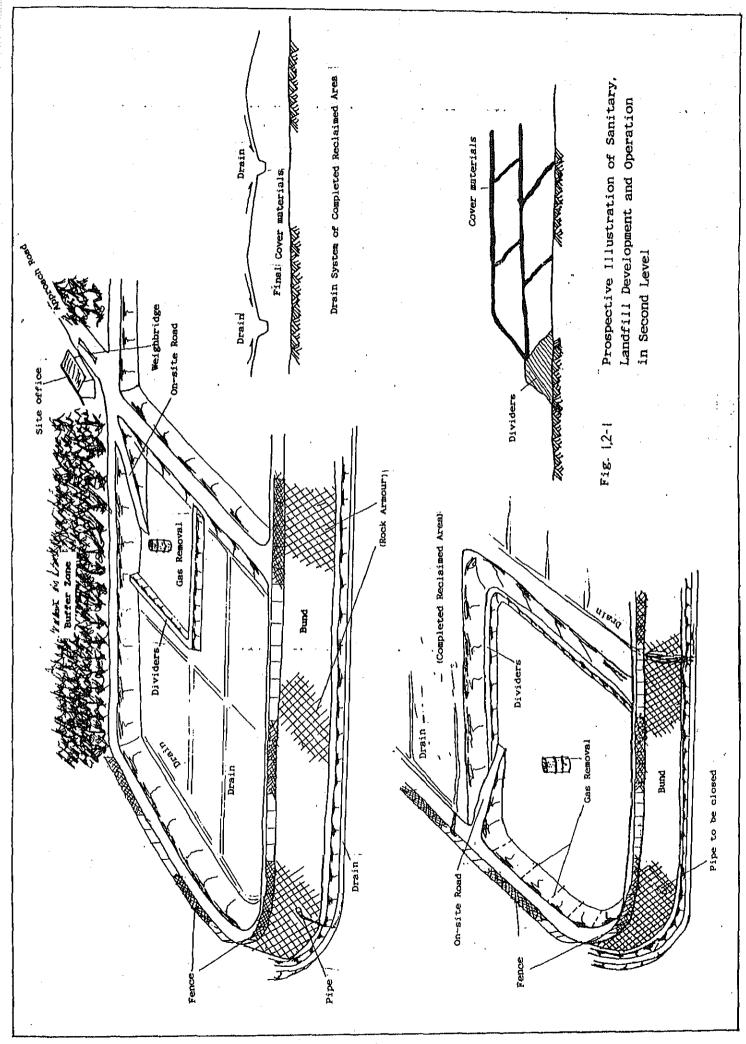
- Establishment of leachate control by the installation of leachate collection, cycling and monitoring facilities
- Establishment of semi-aerobic sanitary landfill in order to facilitate the stabilization of waste disposed through the active decomposition in semiaerobic condition
- Establishment of dust 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).

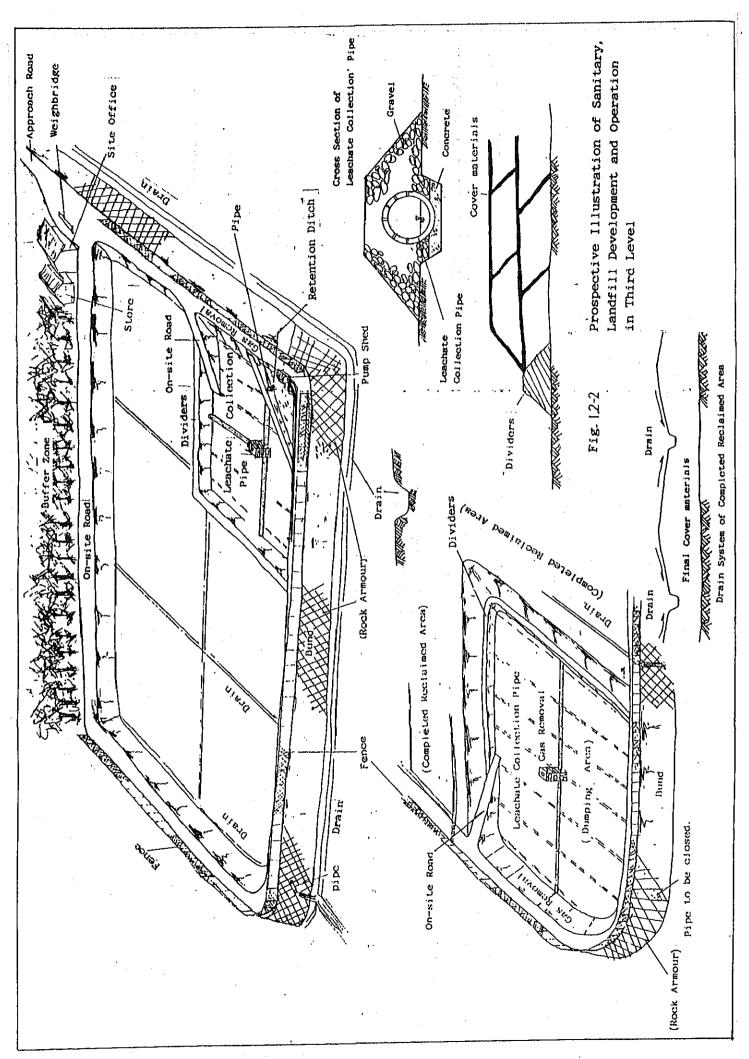
(2) Outline of Sanitary Landfill Development and Operation

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.





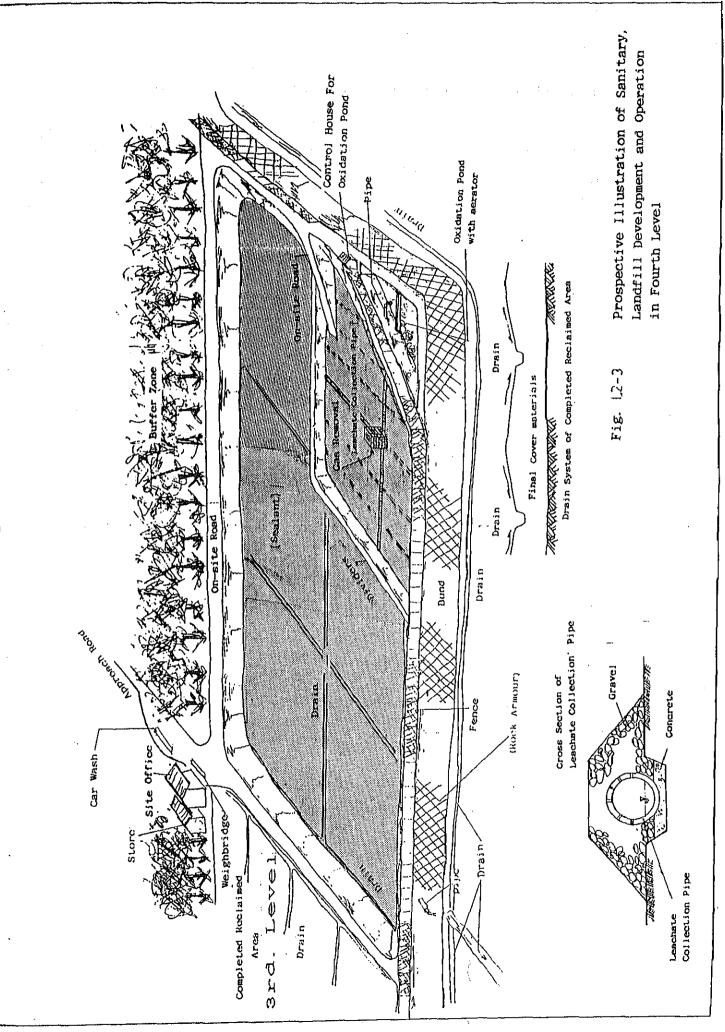


Table 1.2-1 Outline of Sanitary Landfill Development and Operation

| | Leve | el of San | itary La | indfill | |
|------------------------|-------|-----------|----------|---------|--------------|
| 1 tems | 1st | 2nd | 3rd | 4th | Remarks |
| | Level | Level | Level | Level | |
| 1. Site Development | | | | | |
| Works | | | | 1 | |
| | | | | | |
| 1.1 Main Facilities | } | · | | | |
| | | | | | |
| a. Enclosing Structure | 1 | | | | |
| i. Enclosing Bund | 1 | 0 | O | 0 | |
| ii. Divider | | | 0 | 0 | A |
| Z.i. Dividez | | | U. | ' | A means |
| | | | | j | that a bund |
| | | 10 10 10 | | | is made of |
| | | | | | construction |
| | *. | | | | demolision |
| | | | * . | | and earth |
| b. Drainage System | | ar i | | | |
| i. Surrounding Drain | | Q | О | 0 | |
| ii. On-site Drain | | | | | |
| (Surface Water) | | 0 | O | 0 | The drain |
| | | | | · | is for the |
| | | | | | site which |
| | | | | | is not used |
| | | | | . : - | for landfill |
| iii.On-site Drain | | | | | |
| (Underground | | | | | |
| Springs) | | 0 | 0 | O | If necessary |
| iv. Drain for | | | | | |
| Reclaimed Area | · | 0 | 0 | 0 | |
| | İ | | | Ŭ | |
| c. Access | | | | | ± |
| i. Approach Road | 0 | 0 | 0 | 0 | |
| ii. On-site Road | O | Ö | 0 | 1 | |
| iii.Others | Ŏ. | 0 | 0 | 0 | |
| | ~ | | | 0 | Improvement |
| | | | | | of existing |
| | | | | | road network |
| | | [| | | for |
| | | | | | accessing |
| | | | | 4 1 1 | to the site |
| | 6 | | | | |

Note: \bigcirc means the facility is necessary.

| A STATE OF THE STA | 1 | | | | |
|--|---------|-----------|----------|--------|--------------|
| | | el of San | itary La | ndfill | |
| l tems | ist | 2nd | 3rd | 4t.h | Remarks |
| | Level - | Level | Level | Level | |
| 1-2 Environment | | | | | |
| Protection | | | | | |
| Facilities | | : | | | |
| | | | | · | |
| i. Buffer Zone | | 0 | 0 | 0 | |
| ii. Litter Control | | | | | |
| Facilities | | A | О | 0 | Movable |
| iii.Gas Removal | 1 | | | | fence, etc. |
| Facilities | | A | 0 | 0 | Tonice, Cuc. |
| iv. Leachate Collection | | | | | |
| Facilities - | 1 | : . | 0 | 0 | |
| v. Leachate Cycling | | | | | |
| Facilities | : | | 0 | О | |
| vi. Seepage Control | | | U | | |
| Facilities . | | | | | |
| vii Leachate Treatment | | | | 0 | |
| Facilities | | ** | | | |
| 133117 0100 | | | | 0 | |
| | | | | | |
| 1-3 Buildings and | | | | | |
| Accessories | | | | | |
| Accessor les | | | | | |
| i. Site Office | | | | _ | |
| ii. Weigh Bridge | A | A | 0 | 0 | |
| | 0 | 0 | 0 | 0 | · |
| iii. Storage Building | | _ | 0 | · .O | |
| iv. Safety Facilities | | · O | 0 | 0 | Gate, fence |
| | | | | | lights, etc. |
| v. Fire Prevention | | | | | |
| Facilities | | • 🛦 | 0 | 0 | Watertank, |
| | | | | | extingui- |
| | | | | | sher, etc. |
| vi. Monitoring | 1 | | | | |
| Facilities | | | 0 | 0 | Monitoring |
| | | | | | well, etc. |
| vii.Car Wash | | | 0 | 0 | · |
| | | | | | |
| | ļ | | | | |
| | | . | | | |
| | | | | | |
| | | | | | |
| | | | | ı | |

| | | | · | | 3/ |
|--|---------------|-----------|----------|--------|----------------------|
| The second secon | Leve | el of San | itary ba | ndfill | |
| ltems | 1st | 2nd | 3rd | 4th | Remarks |
| | Level | Level | Level | Level | |
| 2. Equipment | | : | | | |
| i. Landfill Equipment | 0 | 0 | Ò | 0 | |
| ii Others | | | 0 | 0 | Water truck, |
| | | | | , | Inspection Vehicles, |
| | | | | | etc. |
| 3. Operation and | | | | | |
| Maintenance | | | | | |
| 3-1 Operation | | | | | |
| a. Personnel b. Cover Material | O A | 0 | 0 | 0 | ∆ means |
| | | Ĭ | Ŭ | | insufficient |
| | | | | | operation |
| c. Utility | | | | ÷ | |
| i. Fuel | 0 | 0 | 0 | 0 | |
| ii. Water | | O | 0 | 0 | |
| iii. Electricity | | liN | 0 | 0 | |
| d. Chemicals | | | | | |
| i. Insecticide | 0 | 0 | 0 | 0 | |
| ii. Monitoring | } | | 1. 1 | | |
| Chemicals | | | 0 | 0 | |
| e. Others | | 0 | 0 | 0 | Devider, |
| | : | | | | drain for |
| · . | | 4:4 | | | reclaimed area, |
| | | | | | leachate |
| : | | | | | collection |
| | | : | | | pipes, etc. |
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|--|-------------|----------|-----------|--------|---------------------------------------|
| | Leve | l of San | itary bai | ndfill | |
| 1 tems | 1st | 2nd | 3rd | 4th | Remarks |
| | Level | Level | Level | Level | |
| 3-2 Maintenance | | | | | |
| i. Main Facilities | | 0 | . 0 | 0 | |
| ii. Environment | | | | Ŭ | |
| Protection | | · | | | |
| Facilities | | 0 | 0 | 0 | |
| iii.Buildings and | | | | | |
| Accessories | 0 | · O | . 0 | 0 1 | |
| iv. Equipment | 0 | 0 | 0 | 0 | |
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Table 1.2-2

Comparison of Environmental Level to be Achieved by Each Level of Sanitary Landfill Development and Operation

| Teams First Level. Second Level. Second Level. Third Level. South Level. South Level. | Level | | revel of Santtary Landilli Development and Operation | | |
|--|---|-------------------------------------|--|--|----------------------------------|
| - Anaerobic Landill - Improved Anaerobic Sanitary Landill - Leachate generated in solid vaste landill - Improved Anaerobic Sanitary Landill - Leachate generated in solid vaste layers is solidor drain page (Leachate socimulated with manaerobic state. Generally, the quality of the solid waste, heaver, is state. Generally, the quality of the solid waste, heaver is rot improved over a still kept in an anaerobic of state. This structure facilitates the composition of sill kept in an anaerobic of state. The state of wastes, prower stabilization of a landill is not achievable. As for the reclaimed areas become of including and discharged out. - Leachate is freely discharged out. - Leachate is freely discharged out. - Rain water flows into the service of landill from carchaent areas and it increases leachate areas leachate seneration to the working area. - Rain water flows into the landill from carchaent area and it increases leachate area for leachate generation is area for leachate generation is landill from carchaent area and it increases leachate area for leachate generation is area for leachate generation is alta for larged out. - Rain water flows into the working area. - Rain water flows are for leachate generation is area for leachate generation is alta for larged out. - Rain water flows are flows into the working area. - A layled limits the area for leachate generation is alta for leachate generation is alta for leachate generation on larged to the precipitation on larged to the precipitation on large and the precipitation of the precipitation and the precipitation and the | Items | First Level | Second Level | Third Level | Fourth Level |
| Leachate generated in solid - Through gas removal facilities, but are averal later; is sallon delivery the quality of latendane is but an anaerobic strate. Generally, the quality of latendane delivery is prough drain piecs (leachate keeps landfill in an anaerobic vith the First Leval. Almost all laters from the quality of compared or a state. Doug time Photosymptosition of content of solid waste the natural inflow of air. | 1. Landfill Structure - Landfill structure | - Anaerobic Landfill | - Improved Angerobic Sanitary Landfill | - Semi-aerobic Sanitary Landfill | - Semi-aerobic Sanitary Landfill |
| button is prometry discharged the quality of lacohate is button is prometry discharged but remained within, and aleays alightly improved as compared through drain pipes (leachate state, londrally, the quality of the solid waste, however, is leachate is not improved over a still kept in an anacrobic of aliantity decomposition of the solid waste, however, is long time. Because of inactive decomposition - The rate of decomposition is structure facilitates the decomposition of a landfill is not achievable. Because of inactive decomposition - The rate of decomposition of solid wastes of wastes, prompt stabilization also slightly improved, and send that dispensed is not achievable. Because of inactive decomposition - The rate of decomposition of a landfill is not achievable. Because of inactive decomposition - The rate of decomposition of solid wastes of an analyses. The decomposition of a landfill is not achievable. Because of inactive decomposition - The rate of decomposition of an introduced and send in an analyse of lands and it increases leachate are an and it increases leachate - A divider limits the area for leachate generation to the working area. Bain water flows into the send leachate generation to the working area. Bain water flows decomposition on the precipitation on the lands and it increases leachate - A subject of the precipitation on the lands and lands an | 1-2 Achieved Condition | - Leachate generated in solid | - Through gas removal facilities, | | |
| Note the solid variety of the solid waste, however, is leadingte is not improved one state. The second state is leading the state of the solid waste is leadingte is not improved over a still kept in an anacrobic of the solid waste is leadingt in a state. - This structure facilitates the decomposition is also slightly improved. - This structure facilitates the decomposition of a landfilling and state. - This structure facilitates the decomposition is also slightly improved. - This structure facilitates the decomposition is also slightly improved. - This structure facilitates the decomposition of a landfilling and state is freely discharged out. - Leachate is freely discharged - As for the reclaimed areas of seal search of discharged out. - As mentioned above, since the same fine area for leachate generation to the vorth increases leachate - As mentioned above, since the area for leachate generation of limited, leachate generation on limited, leachate generation on limited for the precipitation of the precipitation for the precipitation for the precipitation for the precipitation fo | | | the quality of leachate is | bottom is promptly discharged | |
| state. Generally, the quality of the solid waste. however, is leachate is not improved over a still kept in an anaerobic. Because of inactive decomposition — This structure facilitates the decomposition of solid waste of wastes, prompt stabilization — The rate of decomposition of solid waste of wastes, prompt stabilization — The rate of decomposition of solid waste of wastes, prompt stabilization — The rate of decomposition is of assimation of solid waste of wastes, prompt stabilization — The rate of decomposition of solid waste of wastes, prompt stabilization — The rate of decomposition of almosting is not achievable. - Leachate is freely discharged — As for the raclaimed areas, surface water is drained and fischarged out. - Rain water flows into the drains. - Rain water flow surfounding — Same as the Second level — Same as the Same of the working area and it increases leachate — As mentioned above, since the area for leachate generation to the working area for leachate generation on limited to the precipitation on | | | slightly improved as compared | through drain pipes (leachate | |
| leachate is not improved over a still kept in an anaerobic of air. Ingerial leachate is not improved over a still kept in an anaerobic of long time. Because of inactive decomposition - The rate of decomposition is of userial sorblic condition also slightly improved. Go userial prompt stabilization also slightly improved. In a landfill is not schievable. I leachate is freely discharged - As for the reclaimed areas, out from both landfilling and discharged out. Rain water flow catchment area and it increases leachate leachate generation to the vorking stee. - As mentioned above, since the area for leachate generation to the vorking area. - As mentioned above, since the area for leachate generation on limited to the precipitation on limited to the precipitation on limited or the precipitation on limited or the precipitation on limited or the precipitation on landfill is not since the area for leachate generation on limited to the precipitation on limited or the precipitation on landfill and limited or the precipitation on leachate generation or leachate generation or leachate anount is also limited to the precipitation on landfill and limited to the precipitation on leach and landfill and limited to the precipitation on landfill and landfilll and landfill and landfill and landfill and landfill and landfil | | state. Generally, the quality of | of the solid waste, however, is | also permit the natural inflow | |
| long time. - Recause of inactive decomposition - The rate of decomposition is of vastes, prompt stabilization also slightly improved, made by the drain pupes. The quality of leachste is much improved and generation of forfersive odor is reduced fulling and discharged - As for the reclaimed areas, out from both landfilling and discharged out. - Rain vater flows into the leachate generation to the area for amount. - Rain vater flows into the leachate generation to the area for leachate area for leachate generation is individed above, since the area for leachate generation is limited to the precipitation on limited to the precipitation of solid vaste deconductor facilities the area for leachate generation to the area for leachate generation on limited to the precipitation on limited to the precipitation on limited to the precipitation of the conductor facility of the precipitation of the conductor facility of the conductor facil | | leachate is not improved over a | still kept in an anaerobic | of sir. | |
| - Because of inactive decomposition - The rate of decomposition is structure facilitates the decomposition also slightly improved, also slightly improved, and also slightly improved, and the drain pipes. The prompt stabilization of a landfill is not achievable. - Leachate is freely discharged - As for the reclaimed areas, out fits both landfilling and reclaimed areas because and it increases leachate and is diverted into surrounding and it increases leachate ending area. - Main water flows into the leachate generation to the area for amount. - Main water flows into the area for leachate generation is also limited, leachate generation on limited to the precipitation on | | long time. | state. | | |
| - Because of inactive decomposition - The rate of decomposition is decomposition of solid waste of vastes, prompt stabilization also slightly improved, made by the drain pipes. The quality of leechate is much is an echievable. - Leachate is freely discharged - As for the reclaimed areas, out from both landfilling and discharged out. - Leachate is freely discharged - As for the reclaimed areas, out from both landfilling and discharged out. - Leachate is freely discharged - As for the reclaimed areas, surface water is drained and discharged out. - As mortioned areas or and it increases leachate area for leachate generation to the and it increases leachate - As mentioned above, since the amount is also limited, leachate amount is also limited, leachate amount is also limited, leachate amount is also | | | | | |
| of a landfill is not achievable. - Leachate is freely discharged - As for the reclaimed areas, out from both landfilling and reclaimed areas because enclosing structure is not set up. - Rain water flows into the area for leachate generation to the landfill from catchment area and it increases leachate leachate generation to the area for leachate generation to the limited, leachate amount is also limited, leachate amount is also limited, leachate amount is also limited to the precipitation on | | - Because of inactive decomposition | ì | decomposition of solid waste | |
| - Leachate is freely discharged - As for the reclaimed areas, out from both landfilling and carchante is not set in the reclaimed areas become cholosing structure is not set out. - Rain water flows into the leachate generation to the area for leachate generation to the area for leachate generation to the area for leachate generation is limited, leachate amount is also limited, leachate amount is also limited to the precipitation on | | or wastes, prompt stabilization | also slightly improved. | because of semi-serobic condition | |
| - Leachate is freely discharged - As for the reclaimed areas, out from both landfilling and areas because enclosing structure is not set of land areas because enclosing structure is not set of a discharged out. - Rain water flows into the leachate generation to the area for leachate generation to the area for leachate generation is limited, leachate amount is also limited, leachate amount is also limited, leachate amount is also limited to the precipitation on | | or a randill is not achievable. | | Hade by the drain pipes, the | |
| - Leachate is freely discharged - As for the reclaimed areas, out from both landfilling and reclaimed areas because enclosing structure is not set - Rain water flow surface water from catchment area and it increases leachate area for leachate generation to the area for leachate generation is limited, leachate amount is also limited, leachate amount is also limited to the precipitation on | | | | Account of the fact of the fact of | |
| - Leachate is freely discharged - As for the reclaimed areas, out from both landfilling and reclaimed trees because enclosing structure is not set up. - Rain water flows into the landfill from catchment area and it increases leachate eneration to the amen for leachate generation to the area for leachate generation is limited, leachate amount is also limited, leachate amount is also limited to the precipitation on | | | | offensive odor is reduced | |
| - Water content of solid wastes disposed is lover than the Second level. - Leachate is freely discharged - As for the reclaimed areas, out from both landfilling and discharged out. - Rain water flows into the divider limits the area for leachate generation to the amount. - As mentioned above, since the area for leachate generation is limited, leachate amount is also limited to the precipitation on | | | | further. | |
| - Water content of solid wastes - Leachate is freely discharged - As for the reclaimed areas, 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 increases leachate - As for the reclaimed areas, - Same as the Second level - Same as the Second | | | | | |
| Second level. - Leachate is freely discharged - As for the reclaimed areas, out from both lendfilling and surface water is drained and - Same as the Second Level discharged out. - Fall mater flows into the landfill from catchment area and it increases leachate the area for leachate generation to the working area. - As mentioned above, since the area for limited, leachate amount is also limited, leachate amount is also limited. | _ | | | | |
| - Leachate is freely discharged - As for the reclaimed areas, out from both landfilling and reclaimed areas, reclaimed areas because discharged out. enclosing structure is not set enclosing structure is not set and it incresses leachate area and it incresses leachate amount. - Rain vater flows into the drains. landfill from catchment area and it incresses leachate amount is also limited, leachate amount is also limited, leachate amount is also limited to the precipitation on | states and It's | | | Second level. | |
| out from both landfilling and reclaimed areas, reclaimed areas because discharged out. enclosing structure is not set and in water from catchment area is diverted into surrounding drains. Rain water flows into the leachate generation to the amount. - As mentioned above, since the area for limited, leachate amount is also limited, leachate amount is also limited to the precipitation on | Tangotto on Cinnonnalingo | | | | |
| out from both landfilling and discharged out. enclosing structure is not set - Rain water from catchment area is diverted into surrounding drains. Rain water flows into the drains. landfill from catchment area and it incresses leachate leachate generation to the working area. - As mentioned above, since the area for lamited, leachate amount is also limited, leachate amount is also limited to the precipitation on | 1 Toochate Constant | | | | land fractor att ou areas |
| reclaimed areas because enclosing structure is not set up. Rain water flows into the landfill from catchment area and it incresses leachate amount. - A divider limits the area for leachate generation to the working area. - As mentioned above, since the area for limited, leachate generation is limited, leachate amount is also limited to the precipitation on | ליינים ביינים פסוומי מידיכון | | | are or | T3407 20000 2000 20000 |
| enclosing structure is not set up. Rain water flows into the landfill from catchment area and it increases leachate amount. | | reclaimed areas because | discharged out. | | |
| Rain water flows into the landfill from catchment area and it increases leachate amount. | | enclosing structure is not set | | | |
| Rain water flows into the landfill from catchment area and it increases leachate amount. | | can | - Rain water from catchment area | | |
| Rain water flows into the landfill from catchment area and it increases leachate amount. | | | is diverted into surrounding | | |
| T T | | | drains. | : | |
| incresses leachate | | landfill from catchment area | | · | |
| • | | and it increases leachate | | | |
| working area. - As mentioned above, since the area for leachate generation is limited, leachate amount is also limited to the precipitation on | | amount. | leachate generation to the | | |
| - As mentioned above, since the area for leachate generation is limited, leachate amount is also limited to the precipitation on | | | working area, | | |
| - As mentioned above, since the area for leachate generation is limited, leachate amount is also limited to the precipitation on | | | | | |
| area for leachate generation is limited, leachate amount is also limited to the precipitation on | | | - As mentioned above, since the | | |
| limited, leachate amount is also limited to the precipitation on | | | area for leachate generation is | | |
| limited to the precipitation on | | | limited, leachate amount is also | | |
| | | | limited to the precipitation on | | |

| P-2 Leacher Control. P-2 Leacher Control. Prolities Position to the familities | : | Level | | Level of sanitary Landfill | sanitary Landfill Development and Operation | |
|--|-----|------------------------|-----------------------------|---|--|-----------------------------------|
| - Enclosing bund and divider - In addition to the Jacilities prevents discribing bund and divider 10x Second Level, there are leachete. - Macunt of leachete is high and - Amount of leachete is limited - Retention and regulating ponds. - Macunt of leachete is high and - Amount of leachete is limited - Retention and regulating ponds. - Amount of leachete is high and - Amount of leachete is limited - Retention and regulating ponds other levels. Resides that, However, the quality of leachete is limited in Second Level. However, the quality of leachete is limited in Second Level. - Retention and regulating ponds however, the quality of leachete is limited in Second Level. - Retention of leachete is limited in Second Level. - Retention of leachete is limited in Second Level. - Retention of leachete is limited in Second Level. - Retention of Leachete is limited in Second Level. - Retention of Leachete is limited in Second Level. - Retention of Leachete is limited in Second Level. - Retention of Leachete is limited in Second Level. - Retention of Leachete is limited in Second Level. - Retention of Leachete is limited in Second Level. - Retention of Leachete is limited in Second Level. - Retention of Leachete is limited in Second Level. - Retention to distribute in Leachete explication of the Wastess disposed. - Leachete cycling Second Level. - Leachete cycling Second | | | First Level | Second Level | Third Level | Fourth Level |
| - Mone - Faciosaing bund and divider - In addition to the revewent direct discharge of 10° Second Level, there are leachate. - None - | | | | | | |
| - Mone - Mount of leachate is high and - Marount of leachate is high and because of bund and divider. - Mount of leachate is high and - Marount of leachate is limited as long period of time. - Mount of leachate is high and - Marount of leachate is limited as any work as oxidation pond. - Mount of leachate is high and because of bund and divider. - Marount of leachate is limited as any work as oxidation pond. - Marount of leachate is limited as any work as oxidation pond. - Marount of leachate is limited as in Second Level. - Marount of leachate is limited as a long period of time. - Leachate cycling facilitates - Leachate cycling facilitates - Marount of leachate is limited as in Second level. - Marount of leachate is limited as in Second level. - Marount of leachate is limited as in Second level. - Marount of leachate is limited as in Second level. - Marount of leachate is limited as in Second level. - Marount of leachate is limited as in Second level. - Marount of leachate is limited as limited as in Second level. - Marount of leachate is limited as limited as in Second level. - Marount of leachate is limited as limited. - Marount of leachate is discharged only during heavy rain, it is therefore, diluted. - Marount of leachate is discharged only during heavy rain, it is therefore, diluted. - Marount of leachate as discharged only during heavy rain, it is therefore, diluted. | . : | 2-2 Leachate Control | None | | - In addition to the facilities | |
| leachate cycling and wonitoring | | Facilites | | prevents direct discharge of | for Second Level, there are | effluent which is constantly |
| - Leachate is discharged only during heavy rain from regulating pond. - Moone - Moont of leachate is high and - Moont of leachate is limited - Maount of leachate is high and - Maount of leachate is limited as in Second Level. Besides that, they were, the quality of leachate is limited as in Second Level is not improvement on the quality after a long improvement on the quality after a long leachate of semi-serobic languages of time. - Inequality of Leachate is limited as languages of time. - Inequality of Leachate is languaged in the vastes of semi-serobic languages. - Leachate cycling facilities self-profit on the vastes disposed. - Since leachate is discharged only during heavy rain, it is therefore, diluted. - Since leachate is discharged only during heavy rain, it is therefore, diluted. | | | | leachate. | leachate cycling and monitoring | treated and discharged from |
| - None - Mount of leachate is high and hecause of bund and divide. - Amount of leachate is high and hecause of bund and divider. - Amount of leachate is high and hecause of bund and divider. - Amount of leachate is high and hecause of bund and divider. - Amount of leachate is high and hecause of bund and divider. - Amount of leachate is limited as in Second level. - However, the quality of leachate is limited as insproved atter a long improved atter a long improved of time. - Leachate discharged is therefore, discharged only during heavy rain, it is therefore, diluted. - Since leachate a discharged only during heavy rain, it is therefore, diluted. | | | | | facilities. | oxidation pond. |
| - Leachste is discharged only during heavy rain from - Mone - Mount of leachate is high and hount of leachate is limited - Amount of leachate is high and hount of leachate is limited - Amount of leachate is high and hount of leachate is limited - Amount of leachate is limited as hereaster than may work as oxidation pond. - Amount of leachate is limited as hereaster is limited as in Second level. - However, the quality of leachate is limited as improved much faster than Second a long period of time. - In quality of leachate is limited as improved much faster than Second level faster | | | | | | |
| - None - Maount of leachate is high and haount of leachate is limited - Maount of leachate is high and haount of leachate is limited - Maount of leachate is high and haount of leachate is limited - Maount of leachate is limited as limited - In quality is leachate is limited - In quality of leachate is limited - In quality of leachate is limited - In an improved after a long - In quality of leachate is limited - In quality of leachate is | | | | | - Leachate is discharged only | |
| - None - Amount of leachate is high and - Amount of leachate is limited any work as oxidation pends. - Amount of leachate is high and - Amount of leachate is limited and york as oxidation pends. - Amount of leachate is high and - Amount of leachate is limited as any work as oxidation pends. - Amount of leachate is high and - Amount of leachate is limited as it's quality is worse than any because of bund and divider, there shall be negligible is proveed the quality of leachate is is proved and face a long improved much faster than Second level because of sami-percola a long period of time. - Leachate cycling facilitates sall period of time. - Leachate cycling facilitates sall period of time. - Leachate is discharged only diring heavy rain, it is therefore, diluted. - Since leachate is discharged only diring heavy rain, it is therefore, diluted. | | | | | during heavy rain from | |
| - None - Amount of leachate is high and - Amount of leachate is light and there is high and because of bund and divider. - Amount of leachate is high and because of bund and divider. - Amount of leachate is light and because of bund and divider. - Amount of leachate is light and because of bund and divider. - Amount of leachate is light and because of leachate is limited as in Second Level. - Amount of leachate is light and because of leachate is limited as in Second Level. - In equality of leachate is limited as in Second Level because of semi-serois condition. - Leachate cycling facilitates sell purification of the wastes disposed. - Since leachate is discharged only during heavy rain, it is therefore, diluted. | | | | | regulating pond. | |
| - None - Amount of leachate is high and - Amount of leachate is limited - Amount of leachate is high and - Amount of leachate is limited as in Second Level The quality of leachate is limited is not fine as long period of time The quality of leachate is limited as improved much faster than Second level Leachate cycling facilitates - Leachate cycling facilitates - Since leachate is discharged only during heavy rain, it is therefore, diluted Since leachate is discharged only during heavy rain, it is therefore, diluted. | | | | | Leachate discharged is therefore, | |
| - None - Amount of leachate is high and - Amount of leachate is limited it's quality is vorse than any because of bund and divider. other levels. Resides that, However, the quality of leachate is limited in Second Level. However, the quality of leachate is limited in Second Level. is not improved after a long improved autoh faster than Second level is not improved after a long improved autoh faster than Second level in Second Level is not improved after a long improved autoh faster than Second level in Second level is not improved after a long improved autoh faster than Second level is not improved after a long leachate is second level in Seco | | 2-3 Leachate Treatment | | | diluted. | |
| - None - None - Maount of leachate is high and because of leachate is limited there shall be negligible there shall be negligible is not improved after a long period of time. a long period of time. - Maount of leachate is limited to have the deality of leachate is limited there shall be negligible is not improved after a long improved auch faster than Second level to leachate is limited as long period of time. - Inequality of leachate is limited as improved auch faster than Second level to leachate is limited as long period of time. - Inequality of leachate is limited as improved auch faster than Second level leachate is limited as limited. - Inequality of leachate is limited as limited a | | Facilities | | | | |
| - Amount of leachate is high and - Amount of leachate is limited - Amount of leachate is high and because of bund and divider. other levels. Besides that, the quality of leachate is limited as there shall be negligible is not improved after a long period of time. a long period of time. Leachate cycling facilitates shall purification of the wastes disposed. - Since leachate is discharged only during heavy rain, it is therefore, diluted. | | | None | - None | | |
| - Amount of leachate is high and because of bund and divider. other levels. Besides that, however, the quality of leachate is limited in Second Level. However, the quality of leachate is is not improved much faster than Second level because of semi-serobic langing period of time. a long period of time. - Leachate cycling facilitates self purification of the wastes disposed. - Since leachate is discharged only during heavy rain, it is therefore, diuted. | | | | | may work as oxidation pond. | - Leachate is treated in an |
| - Amount of leachate is high and - Amount of leachate is limited - Amount of leachate is high and because of bund and divider. it's quality is verse than any because of bund and divider. other levels. Besides that, is not improved after a long improved much faster than Second improvement on the quality after period of time. a long period of time. - Leachate cycling facilitates self purification of the wastes disposed. - Since leachate is discharged only during heavy rain, it is therefore, diluted. | | | | | | oxidation pond with aerator |
| - Amount of leachate is high and - Amount of leachate is limited it's quality is worse than any because of bund and divider. other levels. Besides that, However, the quality of leachate is inprovement on the quality after is not improved after a long improved much faster than Second level improvement on the quality after period of time. a long period of time. Leachate cycling facilitates self purification of the wastes disposed. Leachate cycling facilitates self purification of the wastes disposed. Since leachate is discharged only during heavy rain, it is therefore, diluted. | | | | | | so as to satisfy the DOE |
| - Amount of leachate is high and because of bund and divider. other levels. Besides that, however, the quality of leachate is limited of there shall be negligible improvement on the quality after a long period of time. a long period of time. Leachate cycling facilitates self purification of the wastes disposed. - Since leachate is discharged only during heavy rain, it is therefore, diluted. | | | | | | offlight Standard B |
| it's quality is worse than any because of bund and divider, other levels. Besides that, however, the quality of leachate is there shall be negligible is not improved after a long improved much faster than Second laprovement on the quality after period of time. a long period of time. - Leachate cycling facilitates self purification of the wastes disposed. - Leachate cycling facilitates self purification of the wastes disposed. - Since leachate is discharged only during heavy rain, it is therefore, diluted. | | 2-4 Leachate Duality | decinat of leachate is high | - decipt of leachaste is limited | - Amount of leachate is limited as | |
| However, the quality of leachate is is not improved after a long 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. | | | it's quelity is nortes than | hereine of hind and divider | in Second Level | |
| is not improved after a long 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. | | | other levels Besides that | However, the quality of leachate | | |
| 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. | | | there shall be negligible | is not improved after a long | | |
| 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. | | | | 2011-10-10-10-10-10-10-10-10-10-10-10-10- | | - The quality of leachate to be |
| landfill condition. - Leachate cycling facilitates self purification of the wastes disposed. - Since leachate is discharged only during heavy rain, it is therefore, diluted. | | | 7 7 7 | | TENDER PROPERTY OF THE PROPERT | discharged satisfies the DOF |
| Leachate cycling facilitates self purification of the wastes disposed. Since leachate is discharged only during heavy rain, it is therefore, diluted. | | | מ זמוע לבידמת מז נדייים: | | landfill condition | effluent Standard B: i.e. |
| Leachate cycling facilitates self purification of the wastes disposed. Since leachate is discharged only during heavy rain, it is therefore, diluted. | | | | | *************************************** | BOD less than 50mg/l, COD less |
| Leachate cycling racilitates self purification of the wastes disposed. Since leachate is discharged only during heavy rain, it is therefore, diluted. | | | | | 4 | DOD TESS CHAIL SUBSTITUTE OF TESS |
| | , | | | | | than luumg/1, etc. |
| | | : | | | self purification of the wastes | |
| | | | | | disposed. | |
| | | : | | | | |
| therefore, diluted, | | | - | | | |
| | | | | | therefore, diluted, | |
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| :[| Ţ <u>-</u> - | t o | n T | ·. | | | |
|---|---------------------------|---|---|--|--|--|--|
| 3./. | Fourth [Age] | | seepage. There is very little underground water contamination. | | - Effluent from landfill site satisfies the DOE Standard B. | - Same as Second Level. | - Same as Third Level. |
| and of anothern I madell I December and Consideration | Pevelopaent and Overstion | ndent on the | | The quality of leachate is better than Second Level. However, possibility of under- ground water contamination still exists. | 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. | - Same as Second Level. - Due to semi-aerobic landfill structure, it is better than Second Level. | - In addition to the condition achieved at Second Level, dust problem is improved by water sprinkler. |
| [[] or for a longer | Second Level | ndent on the | - The amount of leachate is less than First Level. However, the impacts are still high in the case of permeable bottom soil. | | 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. | - Vector control is achieved and it is much improved compared to First Level. It is much better than First Level. | No occurance of fire It is improved in all aspects. |
| | Ritat (eve) | 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. | | - Because of free discharge of leachte from a landfill site, the impacts on to surrounding vater area is very high. | - Great generation of flies, insects and rodents. - Great cros gathering. - Odors are constantly generated. - Occational fires occur due to | spontaneous ignition Litter of wastes and dust Deterioration of landscape Noise Existence of scavengers. |
| l cons | Ttess | cs by Leachate | | | b. Impacts on Surface | 3. Others 3-1 Vector control 3-2 Odors and Gas Production | 3-3 Others |
| | | | | | - 18 | 1 | . - |

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 | | the state of the s | | Remarks |
|--------------------------------|--|--|------|----------------------|
| Area of Site | | | 29.1 | |
| Disposal | Phase I 1992-1996 | | 664 | including cover soil |
| Volume - (1000m ³) | Phase I 1997-2005 Phase III 2002-2005 | | 823 | including cover soil |
| | n for Phase I(| ha) 17.9 | 16.7 | |
| Level of Land | B £ill | 3 | 3 | |
| Construction | | | · . | 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.

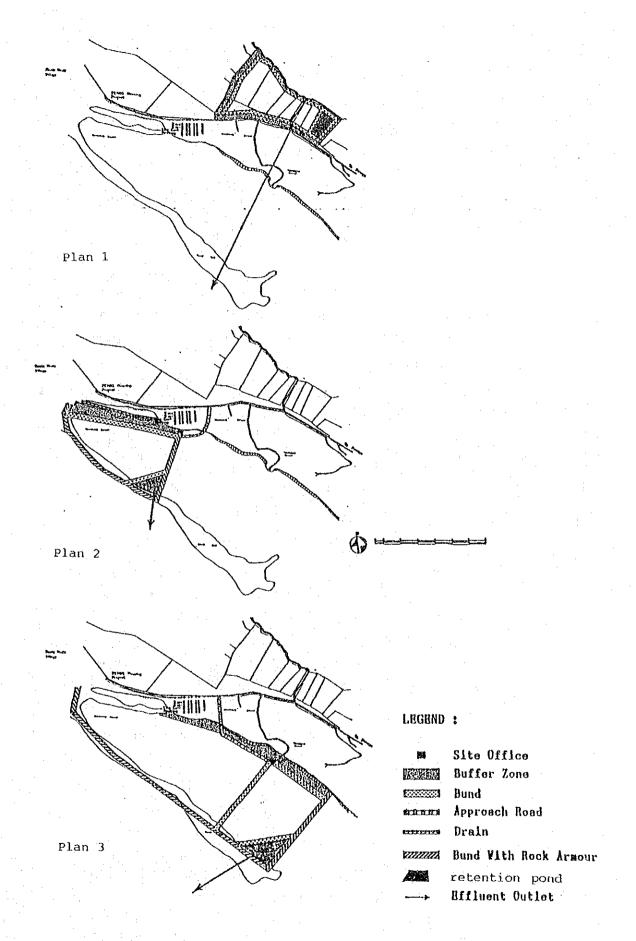


Fig.1.3-1 Concept Plan for First Phase Project of KMDS

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 Sungaí Tengah.

Plan 2

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

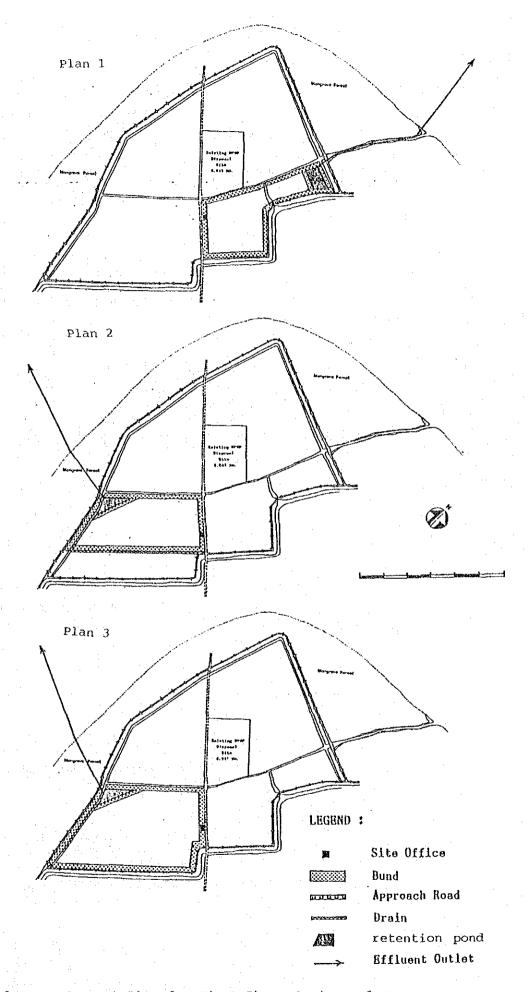


Fig. 1.3-2 Concept Plan for First Phase Project of PBDS

- 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 KMOS First Phase Project

| Item | Plan 1 | Plan 2 | Plan 3 |
|---|-------------------------------|-------------------------------|--|
| (1) Possibility of | - It is necessary to acquire | - In order to construct 200 | - In order to construct 200 |
| Land Acquisition | the private owned land | meter length of approach | meter of approach road, |
| • | within the site. | road, it is necessary to | acquisition of new land is |
| the first of the con- | | acquire new land. | necessery. |
| | | | |
| | | | 1 |
| 2 Possibility of | - Since the site is | - Since the site is in close | - Since the site is |
| Gotting Neigh- | relatively far from | proximity to low cost | relatively far from |
| bouring Consen- | residential area, it is | housing and PERDA housing | residential area, it is |
| eus | rather easy to obtain | development project, it | rather easy to obtain |
| a de la companya de | neighbourhood consensus. | may be difficult to acquire | neighbourhood consensus. |
| | | neighbourhood consensus. | · |
| | • | · | |
| 5.50 | | | |
| | , | | |
| | | | en de la companya de |
| ③ Compatibility | - No special plan | - PERDA is developing a | - No special plan |
| with Regional | - * | housing complex in the | |
| Development Plan | | opposite side of the road | |
| | | to Kuala Muda. | |
| | | 1 | |
| | | | |
| | | | |
| | | | |
| 1 | | | |
| | | | |
| Reconomic Feasi- | - Rough estimate of site | - Rough estimate of site | - Rough estimate of site |
| bility | development cost is 2.3 | development cost is 4.1 | development cost is 6.2 |
| | million ringgit. | million ringgit. | million ringgit. |
| | | | |
| | | 1 | |
| | • | | |
| | | | |
| | | | |
| | | : : | |
| | <u> </u> | | |
| ® Environmental | - Since discharge of leachate | - Due to extremely poor | - Due to extremely poor |
| Acceptability | into Sungai Muda is not | ground condition, sanitary | ground condition, sanitary |
| | accepted environmentally, | landfill operation in the | landfill operation in the |
| | leachate outlet is in the | lagoon may be quite | lagoon may be quite |
| | sea, out of the natural | difficult. | difficult. |
| | bund. | - Buffer zone is necessary | - Buffer zone is necessary |
| | - Buffer zone is necessary | in the northern part of the | the northern part of the |
| | in the western and southern | site. | site. |
| | part of the site. | - Leachate outlet is in the | - Leachate outlet is in the |
| | | sea, out of the natural | sea, out of the natural |
| | | bund. | bund. |
| | | - Special measure is required | - Special measure is require |
| | | for the prevention of | for the prevention of |
| er er a | | environmental hezard to the | environmental hazard to the |
| | | low cost housing. | low cost housing. |
| | 1 | I | I |
| | <u></u> | <u> </u> | <u>L</u> |

- 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 operation, 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 PBUS First Phase Project

| | | | · | · · · · · · · · · · · · · · · · · · · |
|-----|--------------------|--|--|--|
| L | Item | Plan 1 | Plan 2 | Plan 3 |
| 0 | Possibility of | - Nothing special - | - Nothing special | - Nothing special |
| | Land Acquisition | | · | |
| ļ | : | | | |
| | | | | |
| | | :. | | |
|] | | | | |
| (2) | Possibility of | - Nothing special | - Nothing special | - Nothing special |
| | Getting Neigh- | | : | |
| | bouring Consen- | | : | • |
| ĺ | ธบธ | | · | |
| | | • | | |
| | | | · | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| Ŕ | Compatibility | - Since only the BFR is used | - Since only the BFR is used | - If the exchange of the |
| " | with Regional | as landfill site in the | as landfill site in the | completed landfill with the |
| | Development Plan | plan, the completed | plan, the completed | existing form in Pulan |
| | DOTO TOPACHE 1 Zan | landfill will be 7.5 meters | | Burong is realized, it is |
| | | higher than the surrounding | | |
| | | area. | area. | sites up to the same level, |
| 1 | | a. ea. | atea, | - After completion of the |
| ŀ | | | | landfill, reclaimed land |
|] | j | all markets and the control of the c | | will be higher than the sea |
| 1 | | | | level. Thus, the tidal gate |
| ŀ | | | | becomes redundant. |
| 1 | Economic Feasi- | - Rough estimate of site | - Rough estimate of site | - Rough estimate of site |
| | bility | development is 2.7 million | development is 3.0 million | development is 2.7 million |
| İ | billity | | | • |
| 1 | | ringgit. | ringgit. | ringgit. - Since landfill height is |
| 1 | | - Due to higher mount of | - Due to higher mount of | the same as bund height, |
| | · | enclosing bund, operation cost is relatively high. | enclosing bund, operation cost is relatively high. | operational cost is |
| | | cost is lelacively wigh. | Cost is relatively high. | - |
| | | | | relatively low. |
| ĺ | | | . : | |
| | | | | |
| 6 | Environmental | - Effluent from leachate | - Leachate outlet is set up | - Leachate outlet is set up |
| Ψ | | | Ť | · |
| | Acceptability | outlet into Sungai Tengah | in the sea, out of the | in the sea, out of the |
| | | may affect the fishery | mangrove forest. | mangrove forest. |
| | | lives. | <u></u> | |
| | | · · · · · · · · · · · · · · · · · · · | | |
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| l | | | } | } |

- 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 : KMDS: 3.3 million ringgit

(including equipment) PBDS: 3.6 million ringgit

Unit disposal Cost : 6.7\$/ton

(excluding depreciation)

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) Unit disposal Cost (excluding depreciation) : KMDS: 4.3 million ringgit PBDS: 1.5 million ringgit

6.88/ton

Phase 3 C.

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

Fourth Level Level of Sanitary Landfill

2001 Construction Completion Year : January, 2002 Operation

Final Year of Landfill

(including depreciation)

Commencement Year of Landfill:

Operation December, 2005

KMDS: 311 tons/day (2005) Design Disposal Amount

PBDS: 368 tons/day (2005)

KMDS: 0.70 million m3 Design Landfill Volume

> 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 KMDS: 7.9 million ringgit (including equipment)

PBDS: 9.5 million ringgit

Unit disposal Cost 11.7 \$/ton

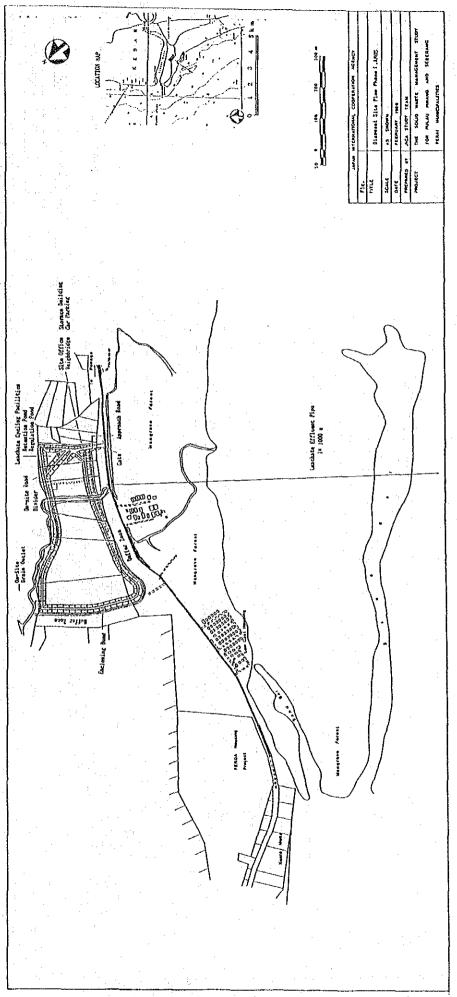
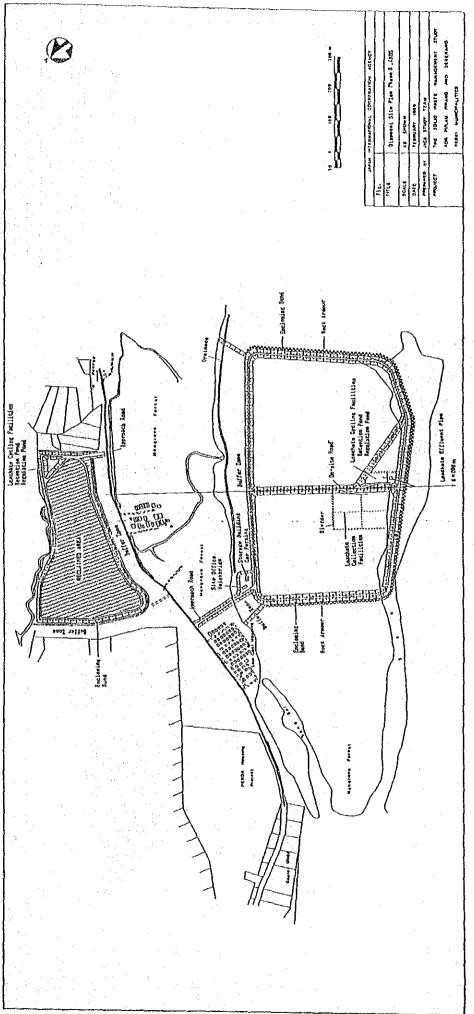


Fig. 1.3-3 First Phase Project of KMDS

Fig. 1.3-4 First Phase Project of PBDS



g. 1.3-5 Second Phase Project of KMDS

ig. 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

| Item | s Disposal site | KMDS | PBDS | Remarks |
|--------|-----------------------|----------|------|--------------|
| a. Mai | n facilities | | | |
| i. | Enclosing structure | • | | |
| | - Enclosing bund | | | |
| | - Divider | · . O | | |
| | | | | |
| ii. | Drainage system | | | |
| | - Surrounding drain | | 0 | |
| | - On-site drain | 0 | | |
| | (surface water) | | | |
| | - On-site drain | Ö | 0 | |
| | (underground springs) | | | |
| | | | | |
| | - Drain for reclaimed | . 0 | Ö | |
| | area | | | |
| | | | • | |
| iii. | Access | | | Only asphalt |
| | - Approach road | × × | Ó | pavement for |
| | - On-site road | \circ | Ō | PBDS |
| | | - : . | · · | |

| | ٠. | | |
|--|---|-------------|---|
| | | | ر المراكز المراكز المراكز المراكز المراكز المراكز المراكز المراكز المراكز المراكز المراكز المراكز المراكز المرا |
| | KMDS | PBDS | Remarks |
| b. Environment protection | | | ه پیده دیده کنید چین کی کی کی |
| facilities | | | |
| | | | · |
| - Buffer zone | O | O | |
| - Litter control | O T | O | : |
| facilities | | | |
| - Gas removal facilities | 0 | O | |
| - Leachate collection | 0 | Ô | |
| facilities | | | 1 |
| - Leachate cycling | 0 | | |
| facilities | | | |
| - Leachate outlet | Ö | O | |
| - Monitoring facilities | | О | |
| a puilding and accepting | | | |
| c. Buildings and accessoriesSite office | | | |
| - Weigh bridge | 0 | 0 | |
| - Garage and storage buildin | - 0 | 0 | |
| - Safety facilities | 9 () | 0 | |
| - Fire prevention facilities | | | |
| - Utilities | O. | 0 | |
| | | | |
| d. Equipment | • | | |
| | | • | |
| i. Landfill equipment | | | |
| - Bulldozer | O _x | | ٠ |
| - Hydraulic excavator | O . | 0 | |
| ii. Others | | | |
| - Water sprinkler truck | 6 | | |
| - Inspection vehicle | Ö . | 0 | |
| | Note : | O ; Wi | |
| | .,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,, | A MT | -1 1 |

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) | Coord | Elevation | |
|------------------|----------|-----------|-------|
| | N(m) | E(m) | (m) |
| No. 1 | 16408.41 | 115.66 | 1.761 |
| No. 2 | 16450.95 | 449,98 | 1.769 |

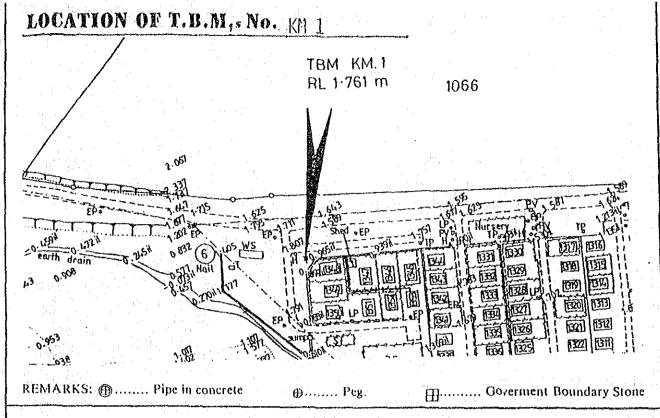
| TBM KM | Coord | Elevation | | |
|--------|-----------|-----------|-------|--|
| (PBDS) | N(m) | E(m) | (m) | |
| No. 1 | -24546.97 | 9153.39 | 1.002 | |
| No. 2 | -23653.52 | 8790.37 | 0.662 | |

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.



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PHOTOGRAPH OF T.B.M,.

RIGHT BANK

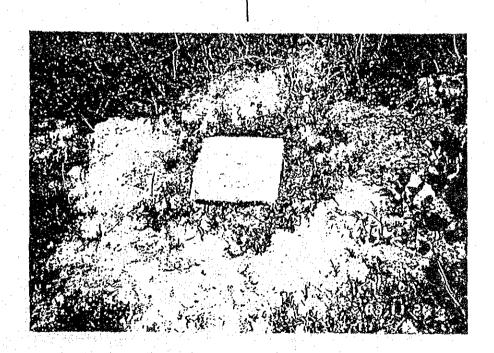
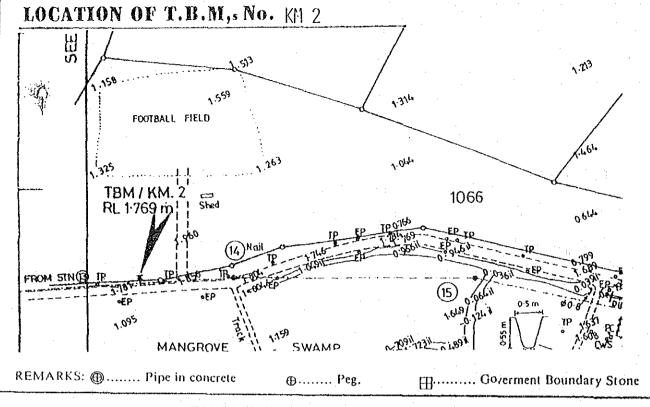


Fig. 2.1-1 Location of TBM KM-1

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



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RIGHT BANK

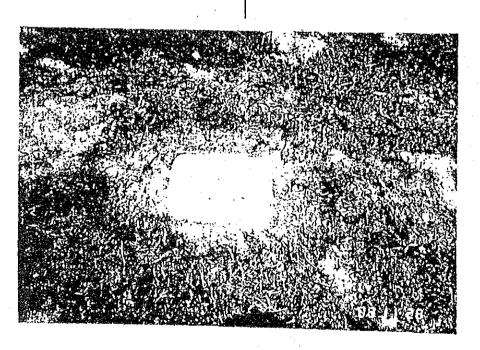
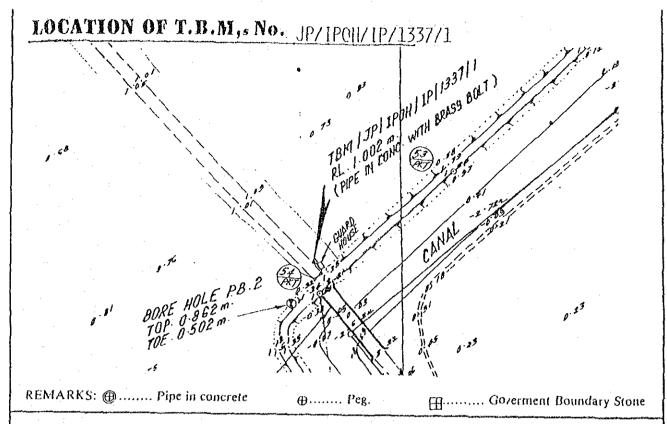


Fig.2.1-2 Location of TBM KM-2

| REDUCI | ED LEVEL | OF T.B.M. | REDUCED | LEVEL OF | T.B.M. |
|---------|----------|-----------|---------|----------|--------|
|)i = | = 1.769 | m | II = | | |
| G.II. = | = · | m | G.H. = | | 123 |
| | | | | _ | m · |

-46--



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PHOTOGRAPH OF T.B.M,

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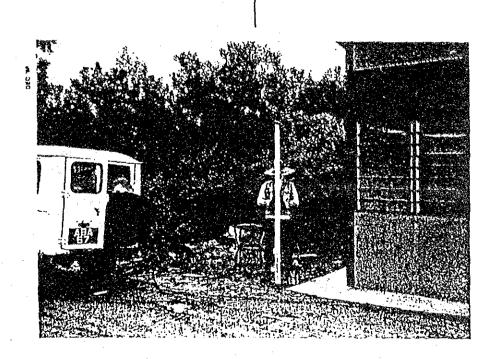
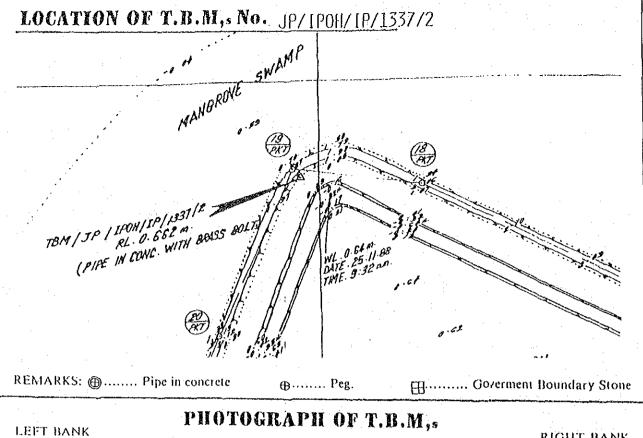


Fig.2.1-3 Location of TBM JP/IPON/IP/1337/1

| REDUC | CED | LEVE | LOF | r.B.n | 1. | R | | CED | | т.в.м. | |
|-----------|-----|-------|---------|-------|----|---|-------|---------------|---|--------|---|
| N | =] | L.002 | | m : | | | 11 | === | _ | | |
| G.H. | === | _ | <u></u> | m | | - ^ | G.II. | == | | | : |
| | | | | | | — <i>о</i> , починаном, 7 | | - | | | |



RIGHT BANK

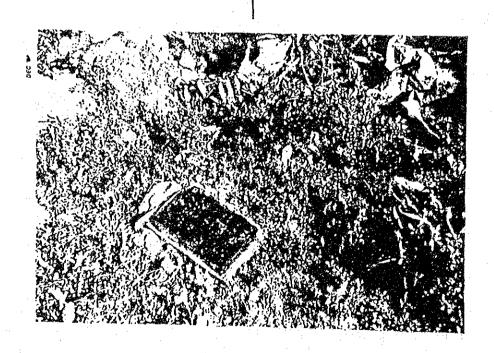
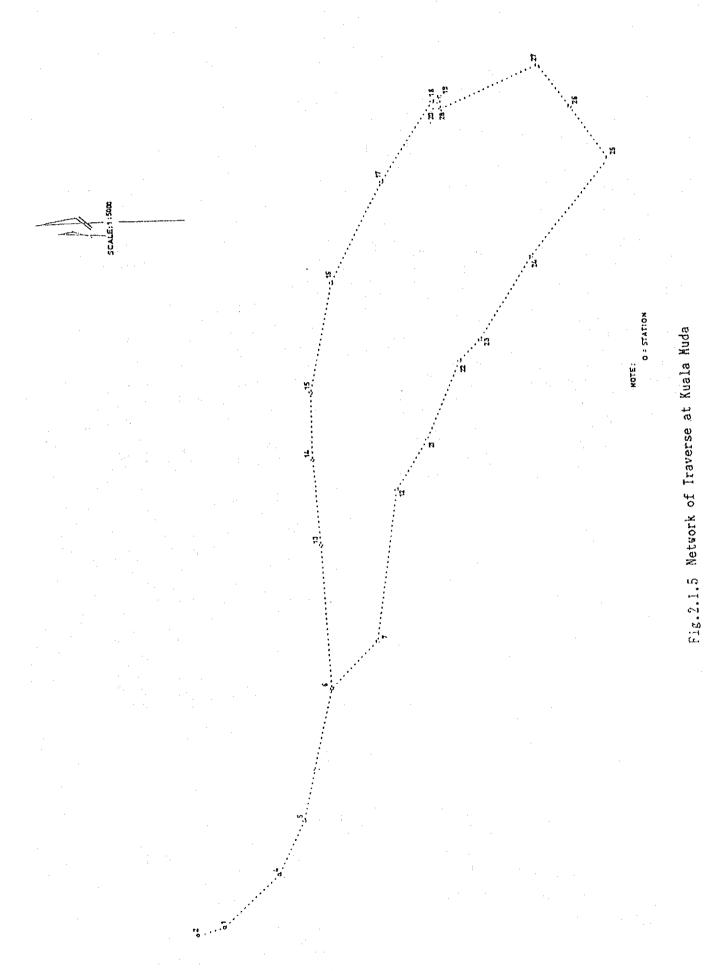


Fig.2.1-4 Location of TBM JP/IP/13372

| REDU | CEP | LEVE | L OF | T.B.M. | REDUCED LEVEL OF T.B.M. |
|------|-----|-------|-----------|----------------|-------------------------|
| X | = (| 0.662 | | . _m | II = |
| G.H. | - | | * = = = · | m | G.N. = |



4.0

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 | |
| 25 | 15864.436 | 1068.301 | 1.571 |
| 26 | 15931.631 | 1171.584 | 2.037 |
| 27 | 15987.910 | 1255.165 | 1.254 |
| 28 | 16177.101 | 1174.327 | 1.619 |
| | | しんじろ・ひんじ | 1.000 |

Fig. 2.1-6 Kuala Muda Traverse Stations Listing Program

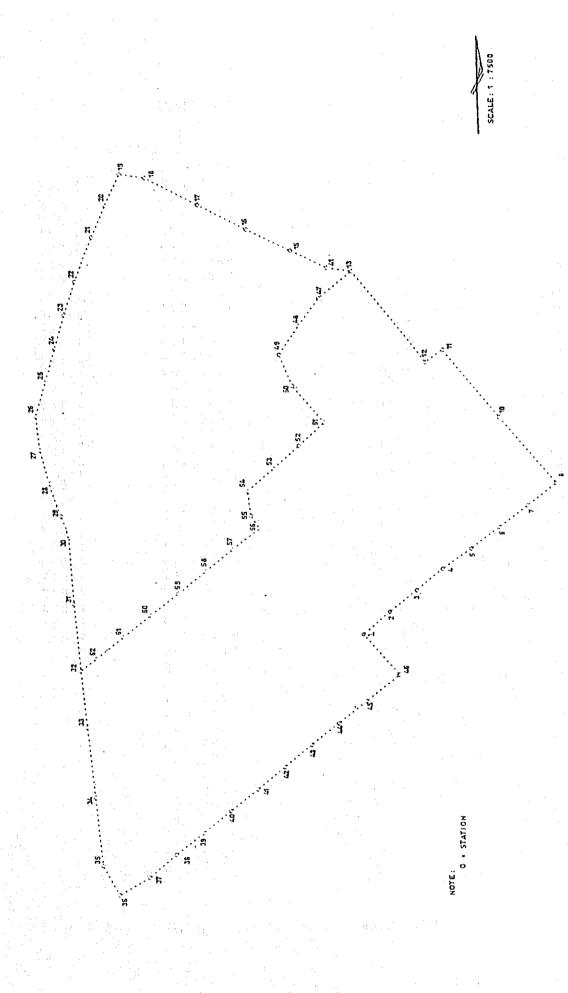


Fig. 2.1-7 Network of Traverse at Pulau Burong

PULAU BURUNG

TRAVERSE STATIONS LISTING PROGRAM

| | and the second s | e e e | |
|--|--|-----------|---|
| STATION | N | E | H |
| 1 | -24977,015 | 9487,673 | |
| $\hat{2}$ | -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 | |
| 7 | -24594.856 | 9955.495 | 0.323 |
| 8 | -24528.171 | 10034.959 | 0.413 |
| 10 | -24336,537 | 9876.331 | 0.453 |
| 11 | -24142.004 | 9714.827 | 0.258 |
| 1 2 | -24179.017 | | 0.433 |
| 13 | -23919.172 | 9665,902 | 0.396 |
| 14 | | 9451.744 | 1.695 |
| 15 | -23910.681 | 9383,036 | 1.956 |
| 16 | -23860.825 | 9277.552 | 1.952 |
| 17 | -23801.475 | 9149.301 | 1.912 |
| | -23733.610 | 9009.936 | 2.167 |
| 18 19 | -23657,383 | 8858.229 | 2.062 |
| | -23648.161 | 8785.871 | 1.867 |
| 20 21 | -23739.669 | 8744.152 | 2.154 |
| 22 | -23831.778 | 8705.386 | 2.129 |
| 23 | -23962.909 | 8655.275 | 1.979 |
| | -24058.409 | 8625.210 | 2,054 |
| 2 4 2 5 | -24155.326 | 8600.476 | 2.128 |
| | -24252.962 | 8574.629 | 2.088 |
| 26 27 | -24351.316 | 8549.417 | 1.798 |
| 28 | -24450.319 | 8561.748 | 1.804 |
| 29 | -24547.674 | 8588.813 | 1.912 |
| 30 | -24642.735 | 8619.614 | 2.042 |
| 31 | -24718.772 | 8644.475 | 1.563 |
| | -24899.385 | 8659.703 | 1.768 |
| 32 | -25092.677 | 8680.711 | 2.008 |
| 33 | -25256.407 | 8701.129 | •• |
| 34 | -25456.929 | 8725.375 | bes |
| 35 | -25654.894 | 8747.852 | , |
| 36 | -25739.148 | 8795,311 | <u></u> |
| 37 | -25687.885 | 8881,809 | _ |
| 38 | -25620.691 | 8956.145 | · · · · |
| 39 | -25555.857 | 9032.858 | -7 |
| 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 | |
| the second secon | | | a a - • • • • • • • • • • • • • • • • • |

Fig. 2.1-8 Pulau Burong Traverse Stations Listing Program

contd 2

PULAU BURUNG

TRAVERSE STATIONS LISTING PROGRAM

| STATION | N | E | Н |
|---------|------------|----------|-------|
| 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 |
| 5 1 | -24358,642 | 9376.808 | 1.147 |
| 52 | -24427.775 | 9304.359 | 1.560 |
| 5 3 | -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 E | | levation | |
|--------------------|---------------|--------|----------|--|
| | 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 | Coordin | Elevation | |
|--------------|-----------|-----------|------|
| (PD) | 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

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

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

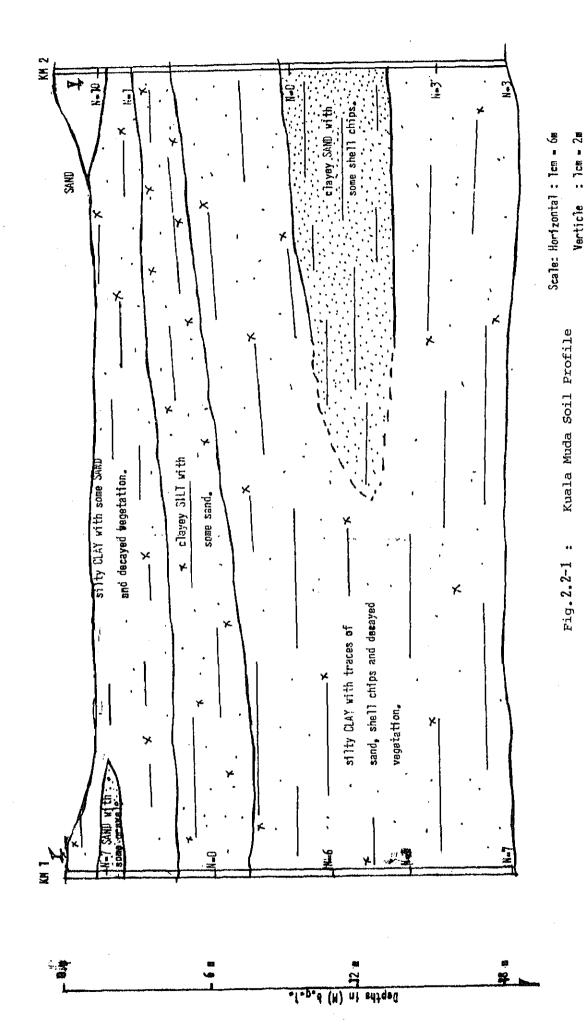
Table 2.2-10: Falling Head Permeability Test of

Undistrubed Sample from PB-1

Table 2.2-11: Falling Head Permeability Test of

Undistrubed Sample from PB-2

Table 2.2-12: Summary of Laboratory Test Results



No.

/88

BOREHOLE No. Mr - 1 Sheet 1 of 3

Type of boring Percussion

Type of rig ... A31, 200.

Dia of boring ... 156, pg.

Casing details ...

Feature Soil Investigation Works for The Soild Location Maste Hanagement Study For Pulau Pinang And Seberang Prat Hunicipalities.

Ground level:

| Date J | Depth of boring & | Ground | | ryples & Test | : | Strela | | | | | | | |
|-----------------|---|-------------|---|--|---------------|--|----------|------------------|-----------|-----------------|-----------------------|--|--|
| (fame) | (casing) | Walter | Depth | Sample | Test | Lagend | Depth | Reduced Level | Thickness | (| Description | | |
| - <u>11-8</u> 8 | | | 0.00 to | T | | | m | Fn | m | | | | |
| 1:00) | | | 0,00 (0 | } | | * . | F | | | | | | |
| | | | • * • | | | X. | | ., | | Yery S | ioft | | |
| | | | | D) 6 | | <u> </u> | r F |] | | Dark o | rey silty CLAY with | | |
| 1 | | | | | | | Ē. | : | | | ine to medium sand | | |
| | | | | | | ··· _K | - | · | | | | | |
| | | | ĺ | | | [| <u></u> | [| | | aces of decaying | | |
| | | | 1,50 to | | N-7 | , 1 | - 1.50 | | 1,50 | vegela | ition. | | |
| | | | 3 or | 02 | | | <u>-</u> | | | Loose Namb d | prey medium to coarse | | |
| | | | 1.95 | | A | 0 | 2,10 | | 0,60 | SAND V | ith traces of fine | | |
| l | | | | | | κ . | - 2,10 | | 0.00 | grave | | | |
| | | | | D3 ® | | | - - | } |] | | | | |
| | | | | | | <u> </u> | E | | | | | | |
| | | | 3.00 to | | | ж. | _ | | | Yery S | ioft | | |
| | j | |) to 10 | | ÷ | | | | | Dark o | gray silty CLAY with | | |
| İ | | : | 3 50 | UDI | | <u>-</u> - | - | | | traces | s of fine to medium | | |
| | | | 3,50 | i | | | | | | sand. | | | |
| İ | | | | | • | X | | | | • | | | |
| | | : | | | | | - - | | | | · | | |
| | | | | | | | | | | | | | |
| | | | 4,53 to | | | <u> </u> | 4.50 | | 2.40 | | | | |
| İ | | | | UD 2 | | * * X | - | | | | | | |
| ļ | | | 4.93 | | | , 7 ¢, ¥ | - | | | Yery S | Soft | | |
| | | | | A | | ** x x X | - | | | Dark (| grey alayay SILT | | |
| | | | | 04 | • | <u> </u> | ~ | | | with: | some fine sand, | | |
| ŀ | j | | | | | * * * X | - | | | | • | | |
| 1 | | | 4 | | | 1 .xx. | ~ ~ | | , | | | | |
| | | | 6.00 to | ⊚ (v. | N=0 | *** *** | 6.00 | | 1.50 | | | | |
| ĺ | Í | | | 05 113 | ight of | I | | | | | | | |
| | | | 6,45 | | A | - \(\frac{1}{2} \times \frac{1}{2} \) | - | | | Vary : | Soft to Soft | | |
| ł | | | | | | [X × X | - - | ! | | Dark | gray clayay SILI | | |
| | . 1 | | | | | - × × × | - | | | w/th | some fine sand. | | |
| | | | | | | <u> </u> | - | } | | | • | | |
|] | | | 7.50 to | | | X X X | 7.50 | | 1.50 | Saf t | to firm | | |
|] | | | | m | | Κ, | <u> </u> | ļ | | | gray silly CLAY with | | |
|] | | | | נטע 🏻 | | ^* .± | E | ĺ | | trace | s of fine mand and | | |
| | | | * ************************************* | | *********** |]Si.l | 18,00 | t | · | АОЛВ. | shell fragments | | |
| | ell disturb | | | marks | | 1 | | | L | | Scale: 1 div. : 10e | | |
| Un | disturbed | sample . | | | ' n n | . 9 | | _ | | _ | | | |
| W | indard pe | | fe#t | Table | e 2.2~ | o E | oreho | ie KM- | l log (K | (NDS) | Logged by | | |
|) Dri | il core sar ne teet | | <u> </u> | ntractor . | an tache | laus (N) | | · · · · · · | | | Checked by: | | |
|) Fle | ld permee | bility test | Da | ntractor !! le slarted te finishec | ,20-11- | 1 HY 7 . 3 (") BB | | | | | | | |
| * 4 * | 1-1.,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,, | | l De | te finished | 1 K Jer I Jer | 0 | 1 | | | | Fig. No. | | |

BOREHOLE No. K? - 1
Sheet ? of 3
Feature Soll Investigation works for the Solld
Location waste Kanagement Study for Fulsu Pinang
And Seberang Frail Auntolpalities.

|)ala | Depth of | Ground | | Samplas & Test | | | | | \$116 | it a |
|--------------|----------------------------|-------------|----------------|-------------------------------|---------|--|--------------|---------------|-----------|----------------------|
| 8. (1988) | borng & (casing) | Wale/ | Depth | Sample | fest | Legend | Depth | Reduced Level | Thickness | Description |
| | | | m | | | | m | m | w | |
| 11-8 | | | | | | Α, | | | | |
| | . | | | D6 | : . | × | <u>-</u> | | | Soft to Firm |
| - 1 | | | | | · | × | - - | | | Dark grey silly CLAY |
| | | | 9.00 | | | | | | | with traces of fine |
| | | | 7,00 | . . | | × - | ` | | | · · |
| | | | | UD4 | | | <u>.</u> | | | sand and some shell |
| ĺ | | : | 9.50 | | | ' | | | | fragments. |
| | | | | | | X | | | | |
| | | | | | | | | | | |
| | 1 | | | | | <u> </u> | | : ' | .] | |
| | | | 10,50 | | N=6 | | 10,50 | | 3,00 | |
| | | | | D7 | | * | - | , | | |
| | | | 10.95 | | * | × - | | | | |
| | | | | | | _x | - | | | |
| | | | | } | | - ₁ - | - - | | | |
| | ļ | | 1 | | | | _ | | | |
| | . | | 12,00 t | | | ×:- | - | | | |
| | | | 72,00 | | | т. | | · | | |
| | | | 12,50 | UD5 | | | - | | | |
| | 1 | | 12,70 | | | | - - | | | Fire |
| 1 | | | | | • | | <u>.</u> | | | Dark grey silty CLAY |
| | | | | 90 | | <u>x</u> :- | | | | with traces of fine |
| | . [| | | | | x | ÷ | | | |
| | | | 13,50 t | 0 | N-5 | | - | | | sand, |
| | 1 | | 15 AE | | 1 | | - | | | |
| İ | | | 13 .9 5 | | * | - 77. | · | | . | |
| | | | | | | <u>x</u> – | - | | | |
| | | | | | : | | - | | | |
| | | | | | : | | | | | |
| | | | 15.00 t | | | | - - | | | |
| | } | | | VD6 | | _ × | - - | 1. | | · |
| | | | 15,50 | 8 | | Х | - | | | |
| | | : | • | | | ж . | | | | |
| | | | | | | <u> </u> | - | | | |
| | | | | | | | -16;00 | اا | | |
| Lan | ali disturbi Pe disturb | ed sample | | Remarks | | | | ٠. | | Scale: 1 d1v. : 10e |
| Und | lsturbed s | elqma | 1 | | | | | | | |
| Wat | er sample | | 160 | . | | | | | | Logged by |
| Van | DOTE SAM | * 1 | r | Contractor G | ooleehn | que (H) | 1 | | | Checked by: Date: |
| Flak | s permeat ture cont | ollity test | | Date started Date finished | 20-11-8 | 8 | | | | |

Sheet) of) Feature Soil Investigation works for the Soild Location Waste Management Study for Fulau Pinang Type of boring ... fercussion Type of rig KSI 200 Dia of boring 154.4m And Babarang frat Kuntstnatities. Casing details Ground level: Dopth of Date Ground Semples & Tests Strata A (Turne) a gninod, (casing) Water Depth Sample heducad Danta Tryck/1656 Description Lavel m 16.33 to Firm UD7 Dark grey silly CLAY 16.93 with traces of fine sand. 18,00 to K-7 011 (10:00) 6.50a 0.00a 18.45 18,15 7.05 20-11-83 Full (09:10) - End Of Borehole -Small disturbed sample Scale: 1 div. : 10ea Remarks Leige disturbed sample Undisturbed sample Standard penetration test Logged by Water sample Checked by: Orlif core sample Contractor Geotechnique (A) Date:.... Vane test Date started 20+))-BB Field permeability test Flg. No. Date finished 21-11-86 Moisture content (%)

-- 61

BOREHOLE No. KK - 1

BOREHOLE No. NE - ? Sheet 1 of 3 Feature Soll Investigation works for the Solid Type of boring Percussion: Location Waste Hanagement Study for Fulau Pinang And Seberang Prat Municipatities. Dia of boring 156 es Casing details Ground level: Strete Samples & fasts Date Depth of Rediced (firms) (casing) Depth Sample Deplh 1hickness Leasod Description U.W To (08:00) 91 Loose to Medium Dense li - 10 1.50 to White brown fine to 02 medium SAND 1.95 D3 ® -3.00 3,00 3,00 to 11-1 *** .**. **.* D4 😂 3.45 Yary Soft Dark grey clavey SILI D5 **®** with some fine sand. 4,50 lo 1,50 UDI 5,00 Vary Soft X 6,03 to . Dark grey silty CLAY UD2 with some fine sand 6.43 and traces of shell fragments. D6 7,50 to UD3 8.00 Small disturbed sample Remarks Scale: 1 div. : 10cm Large disturbed sample Undisturbed sample Table 2.2-4 Borehole KM-2 log (KMDS) Standard penetration test Logged by . . . Water sample

Confractor Gentachniqua (N)
Dele started 24-11-88
Date finished 24-11-88

-62

Drill core sample

Fleid permeability test Moisture content (%)

Vene test

Checked by:

Date:

Fig. No.

BOREHOLE No. KK - 2
Sheet 2 of 3
Feature Soff Investigation conks for the Soffd
Location Saste Management Study for Pulsy Pinang
And Seberang Real Municipalities...

Ground level:

| Dale 8 | Depth of boring & | Ground | | Samples & Test | š | | | | Strat | 14 | The second secon |
|-----------------|---|----------------|----------|--------------------------------------|----------|----------------|---------------------|------------------|---------------------------------------|--------------------|--|
| (Ime) | (casing) | Water | Dornh | Sample | lest | (egend | Depth | Reduced Level | Thickness | 9. | teriplion |
| | | | m | | | | - th | m | m | | |
| | | | ÷ | | | , k | | | | with so | ft ey silty CLAY me fine sand ces of shell |
| | | | 9.00 to | | {{=0 | <u>, x</u> | 9.00 | : | 4,50 | fragmen | ls, |
| 3 7 | | | 9.45 | D7 (ke Ha | nner) | | | | | · : | |
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| | | | 10.50 to |) | | | - - - - | | | | |
| | | | 11,00 | UD4 | | · · · · | | | | | |
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| | | | 12,00 to | | fi≖0 | | <u>-</u> | | | to coar | se SAND with |
| | | | 12,45 | D9 (Ha | ight of | | [. - | | | | |
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| | | | 13,50 to |) | | | 13.50 | | 4.50 | | |
| | | | 14.00 | UD5 | | | - - - | | | Soft | |
| | | | | D10 | | Y | | | | with so | ey silty CLAY one fine sand |
| | | | 15,00 t | | N-3 | * | - - - - | | | and (ravegela | nces of decaying tion. |
| | | | 15.45 | וום | A | X | | | | | |
| | | | | | | ., ¥ m. n.π | 16,00 | | | | |
| La Un | nali dialuri nge disturi disturbed | sample | ło | Remarks | | | · | | · · · · · · · · · · · · · · · · · · · | | Scale: 1 div. : 10c |
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|) fie | id permei sisture cor | | | Contractor Date started Date linishe | 31:11 | -88 -00 | | | | | Fig. No. |

BOREHOLE No.KH - 2

Sheet) of)

| Type of boring | Parcussian |
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Feature Soil Invastigation Verts For the Soild Location Vasta Jianagement Study For Pulau Pinang And Seberang Prat Hunicipalities.

Ground level:

| Date | Depth of | Ground | Se | mples & Test | k | . | | | Ste | 414 |
|---------------|------------------------|---------------------|-----------------|-----------------------------|---------------------------------------|--------------|-----------|------------------|------------|------------------------|
| 8 (Ime) | boxing & (casing) | Water | Depth | Sample . | last | Legend | Depth | Reduced Level | Thickreass | Description |
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| | | | 18,45 | U13 | | <u> </u> | 18,45 | | 4.95 | |
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| Sme | ili diaturb | ed sample | , I A | marks | | <u> </u> | | | | |
| Und | Islurbed (| ed sample sample | '] ~ | | A Yale | er Sampla | collect | ed at 16 | .45 m. | Scale: 1 div. : 10cs |
| Wate | ei sample | | esi . | • | | | | | | Logged by |
| Vers | corè san e lest | | Co | nirector .6 | no tachni | qua (K) | 7 | | | Date: |
| Fleic Moi: |) permeat Hure cont | ollity test | Da | te started . te finished | 24-11-8 | ø | | | | |

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

Project : Soil Investigation Works for The Salid Waste Management Study For Pulau Pinan; and Seterang Prot Municipalities.

| Sample No. 1 Depth: KIL7/UTZ (6.00 - | 6.45n) | •••• | | Sample Condition : Undisturbed |
|--|-------------------------------------|------|--------|--------------------------------|
| Reight of Empty Mould | (āw) | : | 2014 | |
| Meight of Mould + Met Spil | (g#) | : | 3,604 | |
| A of Mould | (cm) | : | 10.20 | |
| Initial Moisture Content | (4) | : | 59.7 | |
| Final Moisture Content | (1) | : | 65.8 | |
| Length of Sample (L) | (cn) | : | 11.9 | |
| Ø of Standrine | (cn) | : | 1.40 | |
| Sectional Area of Standpipe = $\frac{10^2}{4}$ (a) | (c 7 ²) | : | 1,54 | |
| Yolune of Hould | (cn ³) | : | 972.38 | |
| Cross Sectional Free of Sample (A) | (ce ²) | ٠: | 81.71 | |
| Wet Density | (Rg/m²) | : | 1.63 | |
| Dry Density | $(\mathrm{id}_{\mathcal{G}}/\pi^3)$ | : | 1.02 | |

| Date | Time on clock | Time Elepsed | H | sight (cm) | |
|---------|---------------|----------------|------|------------|----|
| 3/12/88 | 12:10 | | 96.9 | Saturation | |
| | 12:17 | | 96.0 | Saturation | |
| | 12:45 | | 95.3 | Saturation | |
| 4/12/88 | (11) 10:54 | | 73.9 | Saturation | hi |
| 5/12/88 | B:25 | 77,460 seconds | 59.0 | | |
| | 9:35 | | 58.4 | | |
| | 10:19 | 14 | 58.1 | | |
| | 11:25 | 18,000 seconds | 57.7 | | |
| | 12:25 | | 56.8 | | |
| | (12) 1:25 | | 56.2 | | հ2 |

$$\frac{2.3076 \text{ aL}}{A(\$2-\$1)} = \frac{10910}{h2} = \frac{h1}{h2}$$

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Remarks: Initial K - 7.4 x 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 Pulcu Pineng And Seherang Prai Municipalicities

| Sam'le 40. 1 Depth : XX-1/402 (4.50 | _ 4.95m) | •••• | Sample Condition : Undisturbed |
|---|---------------------|----------|--------------------------------|
| Height of Empty Hould | (gm) | : | 1952 |
| Reight of Mould + Met Soil | (gm) | : | 3667 |
| g of Hould | (cn) | : | 10.20 |
| Initial Moisture Content | · (%) | . : | 38.9 |
| Final Moisture Content | (%) | : | 41.9 |
| Length of Sample (L) | (c n) | : | 11_90 |
| Ø of Standpipe | (cm) | : | 1.27 |
| Sectional Area of Standpipe $= \frac{110^2}{4}$ (a) | (cm ²) | : | 1.267 |
| Volume of Kould | (cm ³) | : | 972.38 |
| Cross Sectional Area of Sample (A) | (cm ²) | | 81,71 |
| Wet Density | $(H_{\rm S}/\pi^3)$ | <u>:</u> | 1.76 |
| Dry Density | $(11g/m^3)$ | • | 1,27 |

| Date | Time on Clock | Time Elapsed | Height (cm) |
|---------|---------------|----------------|-----------------|
| 3/12/08 | 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 | Í | 96.0 h1 |
| 5/12/88 | Ř: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 |
| | (12) 1:24 | | 37.7 h2 |

t2 - t1 - 95,340 seconds A - 81.71

h2

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

| K | • | 2.3026 | al | | hl |
|-----|---|----------------|----------------|-------|----|
| | | ************** | | 1og10 | |
| 2.4 | | v(45 ~ | } î | · | h2 |

K₂₀₀ = 1.81 x 10⁻⁶ cm/sec.

$$K_{20} - K_{290} \frac{nT}{n^{20}} - 1.50 \times 10^{-6} \text{ cz/sec.}$$

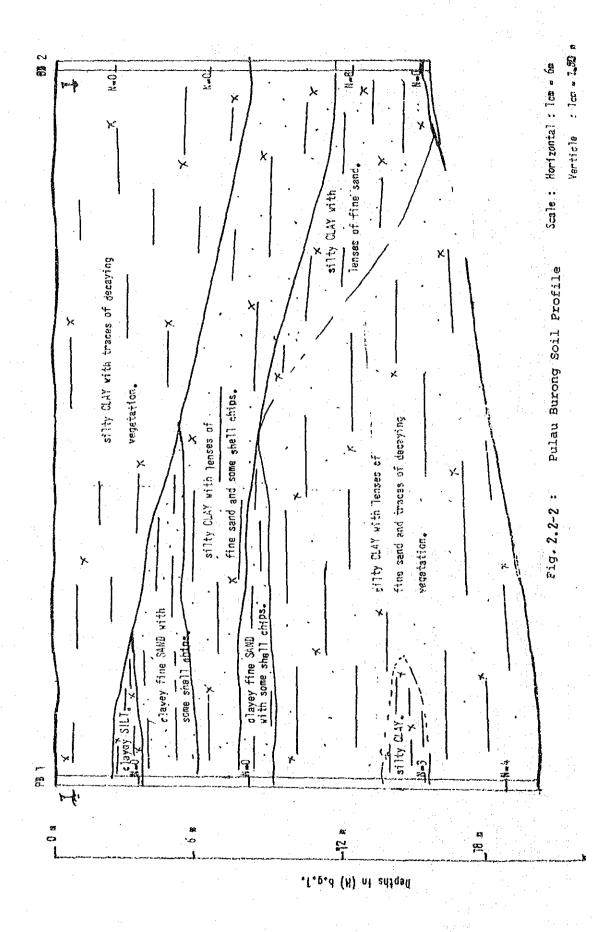
Remarks: Initial K - 3.06 x 10⁻⁶ cm/sec.

| | SCHOOL SE | , | 0.06 2 s SILTACIA >0.05 500 | ۲, | 20/43 | 43/15 | y-12 bes. 25 | 13/51 | | 41/58 | | | 35/62 | 43/54 | |
|---|----------------------|-------------|--|----------|-------|----------|--------------|-------|-------|-------------|-------|-------|-------|-------|--|
| <u> </u> | RTICLE | | GNA8 | 72 | C1 | 2.7 | | 74 | | 4- - | | | ., | 61 | |
| S | PA Dis | | CRAYEL | 25 | \ | T | · | 2 | | C (| | | 7 | - | |
| | PACTION TEST | K K L | MAXIMU PRY DENS MAXIMU | | | | | | | <u>- ; </u> | | · | | | |
| <u>ш</u> | COMP | 30 | ОРТИМИР МОІЗТИР СОИТЕИТ | | | | | - | | | | | | | |
| | ATTON ST | NO | COMPRESSI INDEX Cc | | | Appendix | | | | Appendix | | | | | |
| E D | SOLID | רם יסא | LOAD LM | | | In A | | | : | In A | | | | | |
| U U | | IX K | COELLICIENT | | | | ! | | | | | | | | |
| | | • C | - VOID RATIC | | | | | | | | | | | | |
| | XIAL ESSION ST | 9 | ANCLE O | | | | | | | | : | | 6.7 | | |
| | TRIA COMPK TE | N L | FX\ [®] 7 COHEZION VSSVER | | | | | | | | | | 35.0 | | |
| | 3 | | UNCONFIN STRENGTH STRENGTH | | | 22.3 | | 35,8 | | | | | | | |
| ъ | ည္က | DEX | PLASTIC 141 | | 19 | ٠, | <u> </u> | 32 | | 1.77 | | 36 | 24 | E | |
| LABORATORY TEST RESULTS d Waste Management Study for Pulau Pinang And ATTERBERG TRIAMAL SOLIDATION COMPACTION PARTICLE ME | ATTERBEI LIMITS | TIM | ILI SITZAJI | | 23 | 58 | | 35 | | 9# | | 27 | 8 | 30 | |
| RESUI | ¥ 1 | TIM | FIGNID FB | | 25 | 92 | | F | | 63 | | 69 | 75 | 65 | |
| TEST tudy for | λĽ | C8AY | SPECIFIC | 2,68 | 2,61 | 2.61 | | 2.51 | 2.57 | 2,38 | | | 2.57 | 2,55 | |
| TORY gement S | | | DRY DE | | | | | | | | | | 1,07 | | |
| ABORA Iste Hana | A | | BULK DI | | | | | | | | | | 1.68 | | |
| OF LA Solid Wa | JAU | | NATURAL I | | 63.3 | | 75.5 | | 73.6 | | 79.1 | 36.9 | 56.7 | 54.3 | |
| MARY For The | DEPTH | | ٤ | 寄 | 3.50 | 4.93 | 6,45 | 8.00 | 10.95 | 12.50 | 13.95 | 15.50 | 16.95 | 18,45 | |
| SUM! | DE | (¥) | FROM | 1,50 | 3,00 | 4.53 | 6,00 | 7.50 | 10,50 | 12,00 | 13.50 | 15,00 | 16.50 | 18,00 | |
| stigatio Prai Mun | | : но: | SAMPL | 20 | 1GN | 200 | 5 | Egn | LO . | 300 | 66 | nne. | , Lan | Ē | |
| oil Inve berang | ~ | re h | PORTHO | 7. 1. | | | | | | | | | | | |

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|--|--|-------------------|---|------|------|-------|------------|-----------|-------|-------|-----------|----------|-------|------------|--|
| T | PARTICLE SIZE DISTRIBUTION S | TEST. | 0.06 − 2 g | 60 | | 52 | ij | | 55 | 77. | e i | | 10 | | |
| Z | PAR | • | CKAVEL | : 4 | | 0 | 1 — | | 19 | ç. | ¢ . | | · | | |
| GEOTECHNIQUE (M) SDN. BHD. | CTION | VT1 | MAXIMUI PRY DENS | | | | | | | | | | | | |
| 5 | COMPACTION TEST | % 37 | OPTIMUR MOISTUR CONTENT | | | | | | | | | | | | |
| | SOLIDATION TEST | ΝО | C¢ INDEX COMB <i>E</i> E22I | | | | | sthnerdp. | | | λης endix | | | | |
| | SOLID TE | ζ ^Β , | COMPRESSI | | | | | क्षं ग | | | ın Δρ | | | | |
| S C | | LX K | COEFFICIENT | | | | | | | | | | | | |
| | | : - C | VOID RATIO | : | | ď | | | | | | | | | |
| | TRIAXIAL COMPRESSION TEST | Ø 3 | YESISTANCE SHEARING WIGLE OI | | · | | 1 8 | | | | 5.8 | | | | |
| | COMPR | i 1 | К ∦\¶7 СОНЕ21О 1 УБЬУ КЕИ. | · | | | 7.5 | | | | 15.0 | | | | |
| | i | KK\≢, ON ED | COMPRESSI COMPRESSI STRENGTH | | | | | 15,4 | 20.0 | | | | | | |
| -pe | U . | хэс | PLASTIC INE | | 62 | 16 | 52 | 39 | | | 7/1 | 4 | 32 | | |
| TS A guent | ATTERBERG LIMITS % | TIN | PLASTIC UA | | 35 | 20 | 54 | 35 | | | 36 | 14.2 | Üħ | | |
| RESUL | A | TIP | riónid fil | | 79 | 35 | óħ | 74 | | | 22 | 89 | 72 | | |
| TEST Study Fo | YII | SEAVI | SPECIFIC C | 2,45 | | 2,52 | 2.64 | 2.48 | 2.56 | 2,60 | 44.5 | , | 7.41 | | |
| 10RY agement | | YTISN | PRY DE | | | | 0.85 | | | | 0,92 | | | | |
| BORA aste Kan | | TISME | вогк рг | | | : | 1.53 | | | | 1.52 | | | | |
| Y OF LABORATORY TEST RESULTS The Solid Haste Manayement Study For Pulau Pinang And #1/037/88 | URE | | NATURAL N | | 0.89 | 78.0 | 79.2 | | | 43.6 | 0.39 | 94.5 | 92.8 | | |
| IARY of For the | . H1 | | ٤ | 1.95 | 3.45 | 5.00 | 6,43 | 8,00 | 11.00 | 12,45 | 14,00 | 15.45 | 10,45 | | |
| SUMMARY on Borks For In | HLAHG | Œ | FROM | 1.35 | 3.8 | 4.50 | 6.03 | 7.50 | 10.50 | 12,00 | 13.50 | 15,00 | 18,00 | <u>.</u> | |
| SUMMARY Soil Investigation Works For Soherang Prai Ministralities | | E No. | ZAMPL | 20 | 40 | Æ | 200 | £an | 加加 | 60 | £00 | 2 | g3 | | |
| Soil Inv | 3 | TE N | РОЯ ЕНО | KK-2 | | | 39 — | | | | | | | | |

-69-



BOREHOLE No. P8-1 Sheet 1 of 3 Type of boring Percussion Type of rig HSI 200 Feature Soll Investigation Works for the Solid Location Haste Kanagesent Study For Fulau Finang Dia of boring 166 mm And Seberary Prat Huntelpalities.... Casing details Ground level: Depth of Ground Date boring & (casing) Water finel Depth Fleduced Sample Legand Dopth Thickness Detciption t,evel m U.UI 10 7-11-8 (13:10) Yery Soft to Soft Ж Dark grey silly CLAY 01 with traces of decaying vegetation. 1,50 1.50 1.50 X X UD 1 2.00 Yary Soft ×х <u>አ አ አ</u> Dark grey slayey ×Χ K K X SILI. 74 * * * 3.00 to , N=0 Weight of xxx Nammer) xx 3.45 א א א 1.95 3.45 b3 **8** Yery Loose Dark ore; clayey fine 4.50 to: 11.0 (Weight of liammer) Still will some sholl D4 fragments. 4.95 6,00 2.35 6.03 to UD2 Yery Soft 6.43 Dark gray silty CLAY with lenses of fine mand and a trace of. shall fragments. 1,50 7,50 to N-0 Jo Halak) Very Loose D5 | Hanner) Dark grey clayey fine 7.95 SARD with some shell 0.00 frageents. Small disturbed sample Scale: 1 div. : 10en Remarks Large disturbed sample Undisturbed sample Table 2.2-8 Borehole PB-1 log (PBDS) Standard penetration test Logged by Water sample Checked by:.... Drill core sample

Fig. No.

Contractor . 17-11-88

Dale staned . R-11-88

Date (Inlahed

Vano lest

Field permeability test

Molsture content (%)

BOREHOLE No. PB-1 Sheet 2 of 3. Feature Soil Investigation Works for The Solid Type of boring Percussion Location Wasta Planagement Study for Pulau Pinang And Sherang Prai Hunicipalities, Dis of boring 156 mm Ground level: \$11.11 Date Samples & Yests Depth of boring & (casing) floducad Level (farrer) Thickness Denth Sample Dapth Description Very Loose D6 🍑 Dark grey clayey fine S'HO with some shell fragments, 1,50 9.00 to N-7 9.00 07 🕏 9.45 n8 😝 10,53 to. Very Soft UD3 Dark grey silty CLAY 10.95 with lenses of fine sand and traces of decaying vegetation. 12,00 to UD4 12.50 13.53 to 4,53 UD 5 13,93 Soft D10 Brown notiled with light gray silty CLAY. Χ 15,00 to N-3 D11 8.10m 7.90m 15.45 1,92 Soft to Firm Dark grey silly CLAY with traces of decaying vegetation. 16.00 Small disturbed sample Remarks Large disturbed sample Scale: Undiaturbed sample Standard penatration test Logged by Water sample Checked by: Drill core sample Contractor Septechnique (H) Date started 17-11-88 Date: Vane test Field permeability test Oate finished . 18-11-88 Moisture content (%) Fig. No.

-72-

BOREHOLE No. P8-1 Sheet 3 of 3 Percussion Type of boring, Feature . Soil Investigation Works For The Soild MST 200 Type of rig Location Maste Management Study For Pulau Pinang Dia of boring 156 mg And Sebenang Prat Municipalities. Ground level: Depth of Strata boring & (casing) (firme) Reduced Depth Semple Thickness Lagend Depth Description U) 10-11-88 D12® (18:00) 8,10m 7,90m 16.50 to 109.10 UD6 17.00 Soft to Firm Dark grey silty CLAY 18,00 to 11-4 with traces of D1) decaying vegetation. 18,45 19,50 to (ID7 20.00 20,00 4.55 प्रातः गर्भ U,75a - END OF BOREHOLE -Small disturbed sample

Scala: 1 div. : 10am Remarks A Water Sample collected at 20.00 m. Large disturbed sample -Undisturbed sample Standard penatration test Logged by Water sample Chacked by:..... Drill core sample Contractor 6so technique (R)
Date started . [7-]]-89 Vana test Field permeability test Fig. No. Date (Intered 18-1)-88...... Moleture content (%)

BOBEHOLE No Bana

| • | | | | • | • | | | | | Sheet 1 | of 2 | |
|------------------|---|----------------|--------------------|--|-------------------|-------------------|---------------|---|----------------------|---------------------------------------|---|---|
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BOREHOLE No. PB-2 Sheet 2 of 2

Type of boring Percussian

Type of rig WS1 200

Dia of boring 150 mm

Casing details

Feature Soll Investigation works for The Solld Location Maste Hanagement Study for Pylay Pinang And Seberang Frat Kunicipalities.

Ground level:

| Casing | | · | | · · · · · · · · · · · · · · · · · · · | ****** | | G | round le | avei: | |
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| 11:389 | i | | |]:] | | * . | Ī. | | | |
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| | | | 9 00 to | | | 7 | | | | Dark gray silty CLAY |
| 1 | | 1. | , | UD5 | | - X | - | | | with lenses of fine |
| | | | 9.50 | | | | | | | sand. |
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| .] | | | | | | - - - | | | | |
| | | | | | | · · · · | | | | * i |
| | | | 10.50 to | | | , * | 10.50 | | 2,50 | |
| Ì | : | | | UD6 | .* | <u> </u> | - | | | Soft to Fire |
| | | · | 11.00 | 18 | | ĸ- | <u> </u> | | | Dark grey silty CLAY with lenses of fine |
| l | | | | | | X | n . | | | sand, |
| | | | 11.50 to | | - | X_ | 11.50 | | 1,00 | |
| | | | | D5 ® | | x . | }- | | | Firm to Stiff |
| | | | 12,00 |)) | H-8 | * | | | | |
| | | | | b6 [●] | "-" | -:- | - | | | White grey, rdd brown |
| | | | 12.45 | 100 | 4 | K | E | | | nottled with silty |
| | | | | 1 | • | × | - | 1 | | CLAY and lenses of |
| | | | | | • | | - | 1 | | fine sand, |
| | | | | 1 1 | | 三文 | _ | | | |
| | | , | | | | X | L | | | |
| | | | 13.50 to | | | * | 13,50 | | 2,00 | |
| | | | | UD7 | | -x | F | • | | Top: Firm to Stiff |
| | | ; | 14.00 | 24 | | × | E | | | White gray, red brown |
| | | | | | | X::- | - | | | acttled with silty |
| , | | | • | | | x | <u> </u> | | | CLAY and tenses of fine sand. |
| | | } | | | | | E | | | Bottom: Very Soft to Soft |
| | | | 15.00 to | 1 1 | N=2 | | - | | | Dark grey silty CLAY with |
| •. | | | | . 07, | | | | | | traces of fine sand. |
| 17:00 | | 7.60a | 15.45 | .ger, . | | | 5.45 | | 1.95 | |
| -11-8 09:10 | 8 | 7.60m 7.00m | 1 | | | | Ē | | 1 | - End Of Borehole - |
| 17:00 | Extracti | 0.90 | | | | | - | | | |
| | .l | · | | | | | <i>F</i> | .J | | |
| | nall distur | | | lemarks | A W | ater Samp | ole coll | ected at | 15.45 = | Scala: 1 div. : 10er |
| Y U | ndisturbed tandard p | sample | - | | | : | - | | | Logged by |
| Å ₩ | aler samp | le . | 1001 | | | | | | 1. | Chacked by: |
| [] D | rilli core es | imple | | | حرب ا | 741 | | ****** | - | Date: |
| | ene test | | [· C | ontractor . | and the citi | idná tul | | | | £2415 |

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. 1 Depth : PS-1/U92 (6.00 | - 6,45n) | •••• | **** | Sample Condition : Undisturbed |
|--|----------------------|------|--------|--------------------------------|
| lies oht of Empty | (gn) | : | 1952 | |
| Weight of Mould + Wet Soil | (gn) | : | 3547 | |
| Ø of Hou)d | (cm) | : | 10,20 | |
| Initial Moisture Content | (₁ %) | ; | 62.0 | |
| Final Moisture Content | (;) | : | 63.4 | |
| Length of Sample (L) | (cn) | : | 11,90 | |
| Ø of Standpipa | (cn) | : | 1.27 | |
| Section Area of Standpipe = $\frac{\text{MD}^2}{\text{(a)}}$ | (cn ²) | : | 1,267 | |
| Volume of Mould | (cm ³) | : | 972.38 | |
| Cross Sectional Area of Sample (A) | (cm ²) | : | 81.71 | |
| Wet Density | (Hg/n ³) | : | 1.64 | |
| Dry Density | (N_g/n^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 | (+1) 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 | (12) 08:54 | 24 hrs | 64 . 4 h2 |

Remarks: Initial K = 2.16×10^{-6} cm/sec. (estimated) -7.6

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

Project: Soil Investigation Works for The Solid Waste Hanagement Study For Pulau Pinang And Seberang Prai Hunicipalities

| Sample No. 1 Depth : PB-2/U03 (4. | 50 - 5 00m) | | | Sample Condition: Undisturbed |
|--|----------------------|-----|--------|-------------------------------|
| Weight of Empty Hould | (gm) | : , | 740f | |
| Weight of Mould + Wet Soil | (gn) | ; | 7750 | |
| ø of Hould | (cm) | | 5.08 | |
| Longth of Sample (L) | (cn) | ; | 11,90 | |
| Initial Hoisture Content | (;) | : | 106.8 | |
| Final Hoisture Content | (2) | : | 113,1 | |
| Ø of Standpipe | (c n) | ÷ | 1,40 | |
| Sectional Area of Standpipe - $\frac{\pi v^2}{4}$ (a |) (ca ²) | : . | 1,54 | |
| Volume of Mould | (cm ³) | : | 241.19 | 3 |
| Cross Sectional Area of Sample (A) | (cm ²) | : | 20.27 | |
| Het Density | (Hg/n3) | : . | 1.43 | |
| Dry Censity | (n_g/n^3) | : | 0.69 | |

| Date | Time on Clock | Time Elzpsed | Reight (cm) | · |
|----------|---------------|--------------|-------------|---|
| 26/11/88 | | | Saturation | |
| 27/11/88 | | | Saturation | |
| 28/11/88 | (t1) 8:51 | <u>-</u> | 83.2 h1 | |
| | 09:51 | 1 hr | 83.0 | |
| • | 10:51 | 1 hr | 82.9 | ٠ |
| | 11:51 | 1 hr | 82.8 | |
| | 12:32 | 1 hr | 82.7 | |
| 29/11/88 | (12) 08:51 | 24 hrs | 78.7 62 | |
| | | | | |

| | DIN S | STLYCLAY | 68/70 | | 31/24 | 47/26 | 29/18 | | | | | 21/76 | | |
|---|---------------------------------|---|-------|------|-------|----------|-------|------|-------|-------|-------|----------------|-------|-------|
| Ö | PARTICLE SIZE DISTRIBUTION S | 30.00 J 1800. | 7 | | 5 | 2,6 | S | | | | | . 61 | | |
| Ž | PART | S J ww C K Y AE F | 1- | | 651 | r- | 2 | | | | | 1 - | | |
| | HOE I | махімия рву реціпу ручана | | | | | | | : | | | | | |
| GEOTECHNIQUE (M) | COMPACTION TEST | CONTENT & OPTIMUM | | | | : | | | | | | | • | |
| Z | SOLIDATION TEST | COMPRESSION CC | | | | | | | | | | | | |
| TEC. | SOLID | LOAD KK/#2 COMPRESSION PRE- | | | | Appendix | | | | | | ληρendix | | |
| 0.5 | | COEFFICENT OF TERMEABILITY K | | | | In Ap | | | | | | In A | | |
| | | 9 OITAR GIOV | : | | | | | | | | | | | |
| | SSION ST | KEZIZIYMCE Q ZHEYKINC YMCFE OL | | | | 2,0 | | | | | | 4.2 | | |
| | TRIAXIAL COMPRESSION TEST | KK/¶ COHEZION FK/¶ FK/¶ | | | | 7.0 | | | | | | 17.0 | | |
| | 2 | ZLEENCLH KK\ COMERESZION ONCONFINED | 4.3 | | | 22.5 | | | | | | | : | |
| 70 | o . | PLASTIC INDEX | 20 | | | 18 | | 23 | 148 | 3 | | 84 | | 31 |
| TS inang And | ATTERBERG LIMITS % | PLASTTC LIMIT | 22 | | | 19 | | 19 | 28 | 23 | | 32 | | 33 |
| RESUI Pulan P | A) | רוסטום רואוז | 24 | | | 33 | | Çţ | 3/6 | 99 | | 80 | | 70 |
| TEST tudy For | Ш | SPECIFIC GRAV | 2.39 | | 2,47 | 2.49 | 2,53 | | 2.61 | | | 2.56 | | 2**35 |
| JORY genent S | | DRY DENSITY | | | | 8 | | | | - | | 1.16 | | |
| BORA' | | BULK DENSIT | | | | 1.63 | | | | | | 1.72 | | |
| OF LABORATORY TEST RESULTS Solid Waste Management Study For Pulau Pinan | URE | NATURAL MOIST | | 78.9 | | 62.0 | | 61.4 | 68.6 | 38.3 | 36.4 | 7.8.1 1.8.1 | 69.2 | 70.3 |
| SUMMARY Norks For The | TH | 5 | 2,00 | 3,45 | 4.05 | 6.43 | 7.95 | 9.45 | 12,50 | 13.95 | 15.45 | 17,00 | 18,45 | 30°E |
| SUMN Norks | DEPTH | FROM (#) | 1.50 | 3.00 | 4.50 | 6,03 | 7.50 | 00.6 | 12,00 | 13.50 | 15,00 | 16.50 | 18,00 | 19,50 |
| stigatio | | SAMPLE No. | Ē | 20 | 25 | 290 | 35 | 5 | †G9 | W05 | E E | 900 | ef 3 | 200 |
| Soil Investigation Works for The Solid Maste Management Study for Pulau Pinange | 2008-2008-2 | ₽O &EHOLE N | Fig. | | | | | | | | | | | |

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| Soil Investigation Works For The Solid Waste Management Study For Pulau Pinang Asherson Prai Americalities - AJ/032/88 | sstigation Prai Men | SUMB on Works | SUMMARY Works For The | OF LA Solid Ha | BORA ste liana | TORY Igement 3 | LABORATORY TEST RESULTS 6 Waste Management Study For Pulau Finar 72/88 | RESUL Pulau | TrS Inang And | 7 73 | , | | | | 0 | S E | 2 | | GEOTECHNIQUE (M) SDN. BHD. | Š | T C | oi. |
|--|------------------------|------------------|--------------------------|-------------------|-------------------|---|--|----------------|-----------------------|-------------|------------------------------------|---|------------------------------------|------------|----------------------------|------------------------|-----------|--------------------|--------------------------------|------------------|---------------------------------|----------------------|
| 0 | 1 | DE | рерти | URE | | | λιι | A. | ATTERBERG LIMITS % | ی | 2 | , , | TRIAXIAL COMPRESSION TEST | | | SOLIDATION TEST | NOTT I | COMPACTION TEST | ¥51TO. Si | PAR | PARTICLE MIZE DISTRIBUTION S | N X |
| re n | .ом з | (H) | () | | TISNE | | VAS | 111 | TIV | EX | KK\B ON ED | Ĺ | | ə (| J K | у <mark>в</mark> ОМ | NO | 3 | A.I. | | -80 | |
| o∦a%o∉ | 14MA2 | FROM | OT. | NATURAL I | BULK DI | 30 УЯО ^{\$} в\ _ұ Ж | SPECIFIC (| רוסחום רוא | PLASTIC LIN | PLASTIC INI | UNCONFINI COMPRESSI STRENGTH | АРРАЯЕН' СОНЕSІОР КК/я ² | ANGLE OI SHEARING RESISTANCE | VOID RATIC | COEFFICIENT PERMEABILIT | LOAD KKY | COMPRESSI | CONTENT | рку рейзі Рку рейзі Кұрв | > 3 mm CRANEL | 3VVD | MLIXIAN MM 80.0 > |
| PB-2 | 05 | 8 | 4. | 7.66 | • | | | | | | | | | | | | | : . | | | | |
| | EG. | 1.50 | 2,00 | | | | 2.51 | 1.7 | 72 | 02 | 11.5 | · | | | | In App | Appendix | | | - | c. | 72/99 |
| | 200 | 3.00 | 3,50 | 102.5 | 14. | 0.70 | 2.41 | 63 | 8 | 33 | | 3.0 | .3 | | | | | | | - - | 6 | 57/39 |
| | Egg. | 4.50 | 5.00 | 106.8 | | | 2.32 | 99 | 33 | ĹZ | | | | | | | | | 1 | C | \- | 52,47 |
| | Ď | 6,00 | 6.45 | 98.9 | | | | | | | | | | | - | | | | | | , | |
| | †an | 7.50 | 8,00 | 81.2 | | | | | | | | | | | | | | | | | | |
| | 30n | 10.50 | 11.00 | 87.0 | | | 2,45 | 89 | 33 | 35 | | | | | | | , | | | , | 5 | 84/97 |
| | 90 | 12,00 | 12,45 | 33.6 | | | | | | | | | | | | : | | | | · | | |
| | Lon | 13.50 | 14,00 | 74.3 | 1,54 | 0,88 | 2,42 | 73 | 36 | 37 | | 24.0 | 80 | | | In App | Appendīx | | | C | - | 09/62 |
| . — | 20 | 15,00 | 15,45 | 4.09 | | · | 2,44 | 56 | 27 | 62 | | | | | | | | | | · | ۳, | 25/44 |
| | 500 | 9,00 | 9.50 | | | | 2,41 | 45 | 72 | 23 | 15.4 | | | ı. | | | | | | - | 5 | 53/36 |
| | | | | | | | | | | | | | | | | | | | | | | |

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- 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 | 3 | | PBDS | | Remarks |
|-------------------|--------|-------|------|-----|-----|------|-----|---|
| | Pha | ise I | II. | III | I | II | III | |
| Disposal Amount | t/day | 210 | 264 | 311 | 250 | 312 | 368 | Phase I 1996 |
| | | | | | * . | | | Phase II 2001 |
| | | | | | | | | Phase III 2005 |
| Cumulative Dispos | al | - | | - | | | | |
| Amount Total | 1000t | 345 | 442 | 429 | 409 | 523 | 506 | The state of the state of |
| Cumulative Dispos | al | | 1 | | | 1. | | |
| Volume | 1000m3 | 431 | 552 | 536 | 511 | 653 | 634 | o.8ton/m ³ |
| Cumulative Coveri | ng | | | | | | | 30% of the |
| Material | 1000m3 | 129 | 166 | 161 | 153 | 196 | 190 | above volume |
| Designed Landfill | | | | | | | | |
| Volume | 1000m3 | 560 | 718 | 697 | 664 | 850 | 823 | |
| | | | | | 4 | 4 4 | . 4 | $(x_{i})_{i=1}^{n} = (x_{i})_{i=1}^{n}$ |

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.

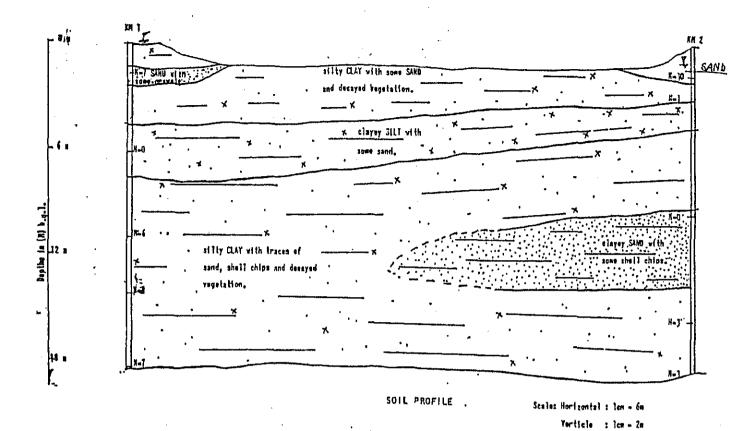
b. PBDS

- 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 | . 8 | 60 - 80 | 60 - 90 |
| Bulk Density | ton/m ³ | 1.5 - 1.6 | 1.55 ~ 1.7 |
| Specific gravity Atterberg limit | | 2.4 - 2.7 | 2.4 - 2.7 |
| - Plastic limit | B | 25 - 40 | 20 - 37 |
| - Liquid limit | 8 | 47 - 90 | 40 - 70 |
| Permeability | | 4.00 | |
| coefficient | cm/sec | $10^{-6} - 10^{-7}$ | $10^{-6} - 10^{-7}$ |



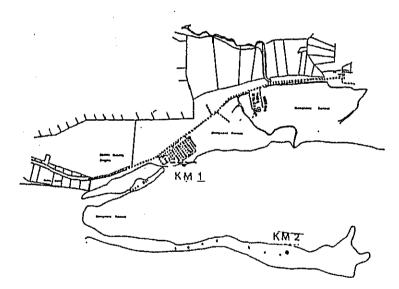


Fig. 3.1-1 KMDS Geological Profile

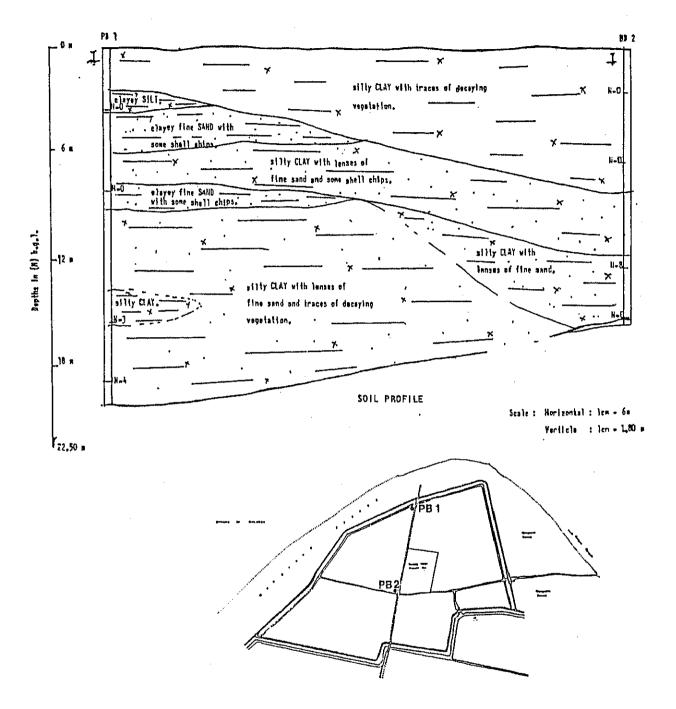


Fig. 3.1-2 PBDS Geological Profile

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
 - Enclosing structure ... Enclosing bund/divider
 - ii. Drainage system Surrounding drain/on-site drain (surface)/on-site drain (under-ground)/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 facilitiesvii. Monitoring facilities
 - 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.

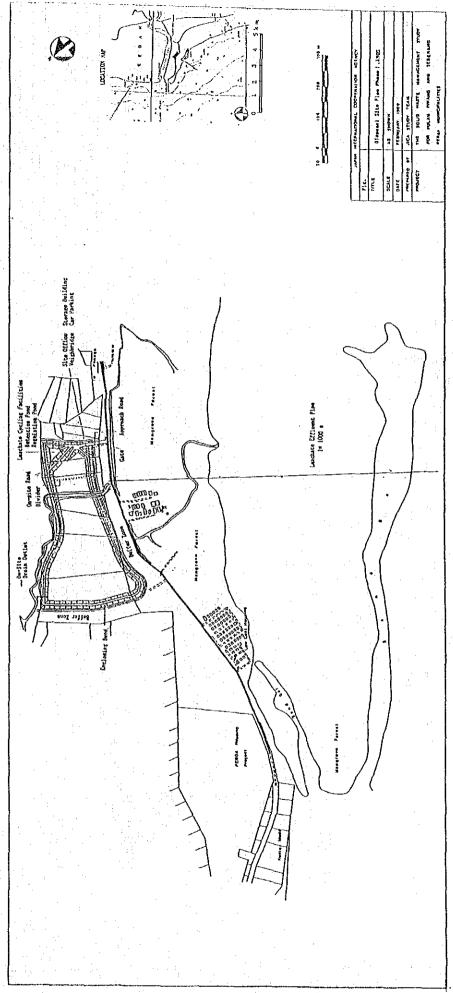


Fig. 3.2-1 Disposal Site Plan Phase I, KMDS

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.

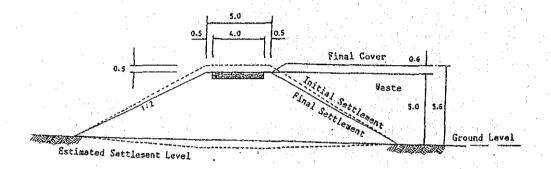


Fig. 3.2-3 Typical Cross Section of Enclosing Bund

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 | Cohesion | Angle of Internal Friction |
|-------------|-----------------------|-----------------------|----------------------------------|
| | r (t/m ³) | c (t/m ²) | ø (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.

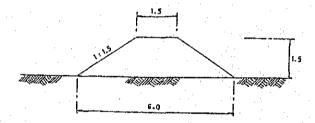


Fig. 3.2-4 Typical Cross Section of Divider

(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.

- 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 🕽

| Drain | Return Period (year) | Daily Rain- fall (mm/day) | Rainfall Intensity (mm/hr) | Runoff Coeff- icient | Dischard (m3/sec | ge /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

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.

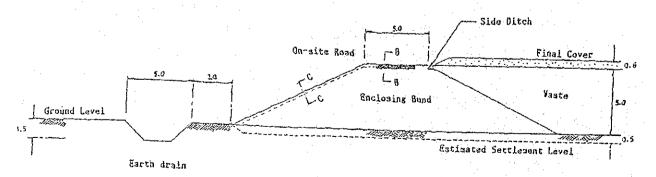


Fig. 3.2-5 Typical Cross Section of Surrounding Drain

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.

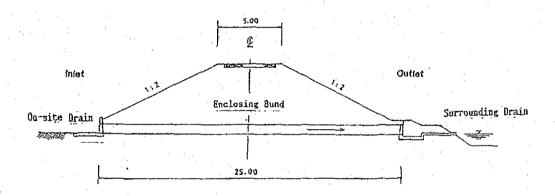


Fig. 3.2-6 Drain Outlet Profile

(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.

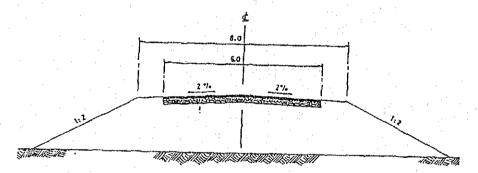


Fig. 3.2-7 Typical Cross Section of Approach Road

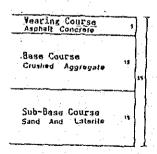


Fig. 3.2-8 Detail of Pavement for Approach Road

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.

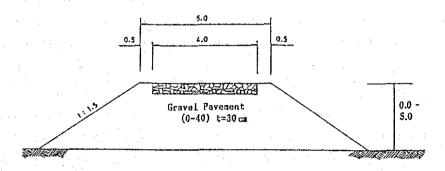


Fig. 3.2-9 Typical Cross Section of On-site Road

- 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