

JAPAN INTERNATIONAL COOPERATION AGENCY

MINISTRY OF HOUSING AND LOCAL GOVERNMENT, MALAYSIA

**THE STUDY ON
THE SAFE CLOSURE AND REHABILITATION OF
LANDFILL SITES
IN MALAYSIA**

**FINAL REPORT
Volume 2**

Main Report



NOVEMBER 2004

**YACHIYO ENGINEERING CO., LTD.
EX CORPORATION**

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EXCHANGE RATE

US\$1.00 = RM 3.770 (September 2004)

US\$1.00 = Yen 110.88 (September 2004)



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The Final Report of “The Study on The Safe Closure and Rehabilitation of Landfill Sites in Malaysia” is composed of seven Volumes as shown below:

Volume 1	Summary
Volume 2	Main Report
Volume 3	Guideline for Safe Closure and Rehabilitation of MSW Landfill Sites
Volume 4	Pilot Projects on Safe Closure and Rehabilitation of Landfill Sites
Volume 5	Technical Guideline for Sanitary Landfill, Design and Operation (Revised Draft, 2004)
Volume 6	User Manual of LACMIS (Landfill Closure Management Information System)
Volume 7	Data Book

This Report is “**Volume 2 Main Report**”.

PREFACE

In response to a request from the Government of Malaysia, the Government of Japan decided to conduct “The Study on The Safe Closure and Rehabilitation of Landfill Sites in Malaysia ” and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA dispatched the study team headed by Mr. Hisashi YAMAUCHI of YACHIYO ENGINEERING Co., Ltd. and consisted of experts from YACHIYO ENGINEERING Co., Ltd. and EX Corporation to Malaysia, 5 times between February 2003 and November 2004. In addition, JICA set up the advisory committee headed by Yasushi MATSUFUJI, Professor at Faculty of Engineering, Fukuoka University in Japan.

The team had a series of discussions with the officials from Ministry of Housing and Local Development in Malaysia, and conducted field surveys in the study area. Upon returning to Japan, the team conducted further studies and prepared this final report.

I hope that this report will contribute to the promotion of the practice of safe closure of the landfill sites and to the enhancement of friendly relationship between Malaysia and JAPAN.

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of Malaysia for their close cooperation extended to the team.

November 2004

Etsuo KITAHARA
Vice-President
Japan International Cooperation Agency

November 2004

Mr. Etsuo KITAHARA
Vice-President
Japan International Cooperation Agency

LETTER OF TRANSMITTAL

We are pleased to submit to you the final report of the Study on The Safe Closure and Rehabilitation of Landfill Sites in Malaysia. The report includes the advise and suggestions of the authorities concerned of the Government of Japan and your Agency. Also included are comments made by the Ministry of Housing and Local Government and related authorities in Malaysia.

The report deals with the present conditions of solid waste management and landfill sites in Malaysia and presents the landfill safe closure guideline as well as action plan with the target year of 2010.

In accordance with the contract with your Agency, we Yachiyo Engineering Co., Ltd. and EX Corporation implemented this study during the period of January 24, 2003 to November 30, 2004. Based on a deep understanding of the existing conditions in Malaysia we have prepared a plan that is feasible and can be implemented.

Finally we sincerely hope that this report will be effectively used for the realization of the plan. We wish to take this opportunity to express our sincere gratitude to your Agency, the Ministry of Foreign Affaires and Ministry of the Environment. We also wish to express our deep gratitude to the Ministry of Housing and Local Government and the relating organizations in Malaysia for the close cooperation and assistance extended to us during the Study.

Very truly yours,

Hisashi YAMAUCHI

Team Leader

The Study on The Safe Closure and Rehabilitation of Landfill Sites
in Malaysia

EXECUTIVE SUMMARY

1 INTRODUCTION

1.1 Background of the Study

Approximately 170 landfill sites are operated in Malaysia where only about 10% of them are classified as sanitary landfill, in which environmental protection measures are considered for their facilities and operation. Most of the landfill sites are operated as so called open dumping sites and there are concerns that these sites are sources of environmental pollution; such includes waste scattering, offensive odour, insect infestation, surface and groundwater pollution, leachate problems, etc.

During the last 15 years about 60 landfill sites were closed without proper environmental countermeasures. Therefore, in Malaysia, environmental pollution surroundings the closed landfill sites are wide spread. Furthermore, it is reported that about 46% of the existing landfill sites will be closed within the next 5 years.

In order to prevent the environmental pollution and maintain a healthy environment and introduce the proper post-closure utilisation of landfill sites, the safe closure of existing landfill sites and rehabilitation of closed landfill sites are main issues in Malaysia that need to be urgently addressed.

Solid waste management (SWM) in Malaysia is in a transition period for privatisation, which has yet to be fully implemented. Therefore, it is strongly recommended that the Federal Government and/or States and Local Authorities should lead/control the private sector in both technical and administrative matters. Accordingly, human resource development on the management of landfill sites is also necessary.

Based on this understanding, in response to the request of the Government of Malaysia (GOM), the Japan International Cooperation Agency (JICA) conducted the Study on the Safe Closure and Rehabilitation of Landfill Sites in Malaysia.

The Study has been implemented in two phases:

- (1) Phase 1 - Basic Survey and Preparation of Pilot Projects
- (2) Phase 2 - Preparation of Guideline & Action Plan and Implementation of Pilot Projects

Phase 1 of the Study has commenced in February 2003 and completed by the end of June 2003 and Phase 2 has started from July 2003 and ended in November 2004. The entire Study period is about 22 months.

1.2 Objectives and Output of the Study

The objective of the Study is to reduce a health hazard and/or environmental pollution caused by the waste landfill sites, in the medium and long-term.

The major outputs of the Study are as follows:

(1) Development of Guidelines

- a. Guideline on the Safe closure of Landfill Sites covering institutional, financial, environment and technical issues
- b. Review of “Technical Guideline on Sanitary Landfills, Design and Operation (1990)”

(2) Developing an Action Plan for Safe Closure Implementation

(3) Implementation of Three Pilot Projects

(4) Preparation of Database of Landfill Sites

(5) Technology Transfer and Enhancing Management/Awareness on Landfill Safe Closure

2 GUIDELINE FOR SAFE CLOSURE AND REHABILITATION OF MSW LANDFILL SITES

2.1 Outline

The Guideline is divided into two sections, viz. Section I and Section II. Section I addresses the issues with regards to the general procedures for safe closure, and the legislation, institutional and financial aspects. Section II explains the technical requirements in more details.

The Guideline recommends that for all landfills, that accept municipal solid waste, including abandoned sites, where waste-filling work has been completed should be closed properly for the safe storage of the wastes and to prevent pollution to the surrounding environment. The “Safe closure plan” should be formulated to include the physical closure (PC) and the post-closure management (PCM) activities. The safe closure plan should be prepared based on the priority and the closure level of the landfill site.

The “Post-closure Land Use” is also addressed and it recommends that all future post-closure land use of closed landfill sites should be carefully considered based on the clear understanding of the landfill during its term of operation and closure as well as the impacts it has had on the surroundings. The proposed land use should not endanger the lives of the public and the users.

2.2 Purpose of the Guideline

The purpose of the landfill safe closure is as follows.

- (1) Protecting public health and the environment by proper management of landfill safe closure and post closure land use,

- (2) Prevention of environmental pollution and risks from the closed landfill sites,
- (3) Prevention of environmental pollution and risks from the uncontrolled development of closed landfill sites.

This guideline provides the recommended steps necessary to close the landfill in a safe manner, including steps to rehabilitate the closed landfills and on how to manage the closed landfill site properly. This guideline also provides the recommendations for the post closure land use of closed landfill sites.

This guideline is to be used in conjunction with the “Technical Guideline on Sanitary Landfill, Design and Operation (Revised draft, 2004)”, and should cover the entire lifespan of the landfill site.

2.3 Basic Concept of the Guideline

(1) “Safe Closure”

- 1) A landfill where waste-filling activities have been completed shall be closed properly for safe storage of the waste and prevention of pollution to the surrounding environment.
- 2) When a landfill is being closed, appropriate measures shall be taken to prevent environmental pollution caused by leachate or landfill gas resulting from the decomposition and degradation of the waste. Even long after closure of the landfill, post-closure management (including environmental monitoring) should be carried out continuously.

Parameters that indicate the stability of the landfill site and may lead the termination of the post-closure management are shown in **Table 2.3.1**.

Table 2.3.1 Parameters to Measure the Landfill Stabilization

Parameter	Target value
Leachate	Below DOE Standard A or B (depend on location of the landfill) <Mainly for BOD, COD, SS and Heavy Metals>
Landfill	Methane (CH ₄) : Below 1.0%
Subsidence rate	Below 2 cm per year

- 3) When a landfill site ceases in operation and closed, it is necessary to formulate a “safe closure plan” that which comprises of the physical closure (PC) and the post-closure management (PCM) for submission to the relevant authorities for approval. This also applies to the abandoned sites.
- 4) In order to minimize the risks of pollution and hazards caused by the landfill, *the Appropriate Technology* ranging from the basic level (C1) to the advanced level (C4) should be applied to close the site safely and to manage the closed site.

- 5) In order to determine the “safe closure” requirements, the conditions of each individual site shall be investigated based on the site-specific conditions.

(2) “Post-closure Land Use”

- 1) The type of post-closure land use of closed landfills should be carefully considered based on the clear understanding of the landfill conditions during operations, closure, and together with impacts it may have had on the surroundings.
- 2) The “Post-closure land use plan” will have to be formulated and submitted to the relevant authorities for approval.
- 3) Operation and maintenance of the landfill facilities should be continued throughout the post closure land use redevelopment. Those facilities that may have been affected by the redevelopment works, such as the gas ventilation pipes and surface drainage, must be re-installed at suitable locations in order to preserve their functions.
- 4) The stabilization period of landfill site after waste filling has completed is expected to be minimum 10 years. Therefore, post-closure land use shall be considered and can be preceded after this period. This is to minimize the effects of land subsidence and landfill gas generation on the development site.

However, for the landfill sites 5 years has past after waste filling has completed, provisional land-use might be applied under the following conditions.

1. Utilization of only surface layers of the closed landfill site and access of the people to the site shall be very limited; such as green space, parking etc.
2. Prior to the utilization, monitoring of environment and landfill stabilization shall be carried out and then the landfill condition shall be clarified.

(3) Legal Framework and Role of Stakeholder

In order to implement and manage the sustainable landfill safe closure efficiently and effectively, institutional and legal systems will have been set up in accordance with the following principles.

- 1) The registration system of landfill sites will have been established to ensure better enforcement of the required measures and long-term operation and maintenance of the closed landfills in accordance with the appropriate safe closure measures.
- 2) The State Governments will be responsible for registration of the landfills, management/monitoring of landfill safe closure and post-closure land use.

- 3) The Federal Government will set up a new funding system to subsidize the additional financial expenditure necessary to implement the safe closure of landfills.
- 4) The landfill management activities will have to be managed by the State Governments and Local Authorities complying with the relevant regulations and laws. The Federal Government will provide the necessary technical advice and assistance with the human resources development.

(4) Financial Resources and Funding

The strategic funding system will be set up at the Federal Governmental level for implementing the sustainable landfill safe closure. The general concepts for the funding system are as follows.

- 1) The setting up of a specific *Fund* for implementing the safe closure of the landfill sites.
- 2) During landfill operation, a necessary fee should be added to the tipping fee to allow for contributions towards the *Fund*.
- 3) The Federal Government will manage the *Fund* and apportion the funds accordingly upon the requests from the State Governments and by taking into account of the landfill closure priorities.

2.4 Process of Landfill Safe Closure

The processes of landfill safe closure are as follows.

- (1) The operator/owner of landfills should assess their respective sites in order to clarify the environmental pollution potential and land use potential.
- (2) Based on the assessment, the operator/owner should setup a closure level of the landfill site.
- (3) The operator/owner of landfills should prepare the “Safe Closure (SC) Plan” for submission to the State government for approval. The SC plan should be submitted one year before closure of the landfill site.
- (4) After the approval, the operator/owner of landfills will implement the physical closure works and post closure management activities. These activities should be informed to the related authorities periodically.
- (5) State government should examine the SC plan and approve if it meet the requirement. Safe closure activities (PC and PCM) carried out by the operator/owner should be managed and monitored by the State government.
- (6) The developer should prepare the “Post-closure Land Use Plan” and submit to the relevant authority in the State government for approval.

- (7) The developer can implement the post-closure land use after obtaining the approval. Implementation activities including PCM shall be informed to the related authorities periodically.

2.5 Technical requirements

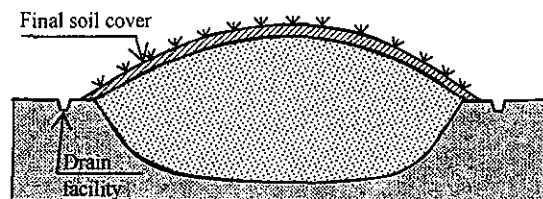
The technical requirements for safe closure of landfill sites are as follows.

- (1) Landfill sites should be closed safely and the post-closure management should be carried out properly.
- (2) Measures for safe closure of landfill sites.
 - a. To prevent wastes from littering or overflowing from the landfill site
 - b. To prevent fire or explosion that may be caused by landfill gases
 - c. To minimize offensive odours emitting from landfill site
 - d. To provide storm water run-off and drainage facilities
 - e. To minimize environmental pollution caused by leachate from landfill site
 - f. To prevent groundwater contamination
 - g. To take measures for wastes stabilization
- (3) Measures for post-closure management of landfill sites.
 - a. To implement appropriate operation and maintenance activities of landfill facilities such as providing the final cover soil
 - b. To continuously operate the landfill facilities such as the leachate treatment plant
 - c. To continue with the environmental monitoring work
 - d. To continue with the waste stabilisation monitoring
- (4) Appropriate measures and activities required to achieve safe closure should be determined based on the conditions of the site including operation level, existing facilities, surrounding environment and post closure land use.

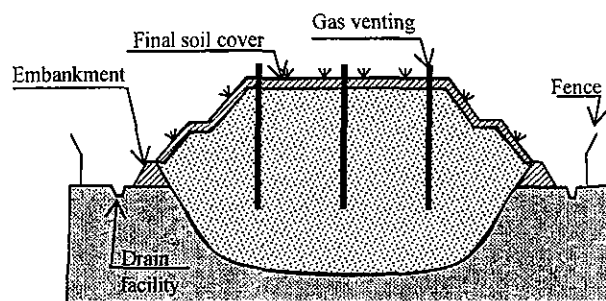
2.6 Landfill Closure Level

The closure levels are classified into 4 categories as follows, and schematic drawing of each level is shown in **Figure 2.6.1**.

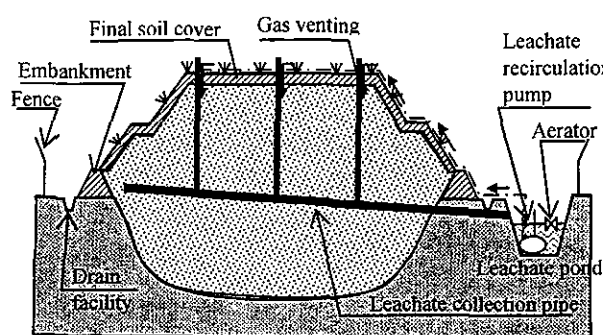
- Level C1: Minimal closure level
- Level C2: Low closure level
- Level C3: Middle closure level
- Level C4: High closure level



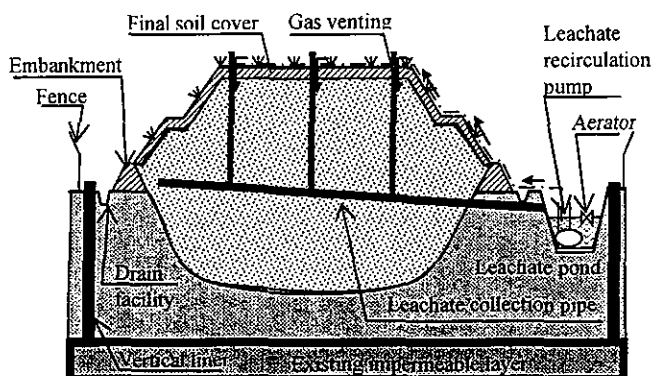
Landfill safe closure level: C1



Landfill safe closure level: C2



Landfill safe closure level: C3



Landfill safe closure level: C4

Note: For C3 & C4, aerobic area of existing landfill site will be expanded by safe closure measures.

Figure 2.6.1 Landfill Safe Closure Level

The measures necessary to be taken for each of the closure levels are tabulated in **Table 2.6.1**.

Table 2.6.1 Closure Levels and Required Measures/Facilities

Measures	Safe closure Level			
	C1	C2	C3	C4
Final cover soil	++	+++	+++	+++
Storm-water drainage	+	++	+++	+++
Safely storage	+	++	+++	+++
Gas vent		++	+++	+++
Leachate		+	+++	+++
Groundwater			++	+++
Early stabilization		+	+++	+++
Post closure measures		+	+++	+++
Monitoring	+	++	+++	+++
Landfill system			Semi-aerobic System	

Notes: 1. The methodology of closure level set-up is described at the Appendix, Chapter 5, Volume 2.

(Refer to article 3.1 of chapter 3.)

2. +: minimum equipped/ operated, ++: fair, +++: Fully equipped/ operated

3 ACTION PLAN ON SAFE CLOSURE OF LANDFILL SITES

3.1 Objective of Action Plan

(1) Outline

The Action Plan aims to set the proceedings and schedule to implement the safe closure for all the priority sites and to establish the required institutional mechanism and financial support by the year 2010. The major “Action” activities are as follows:

- Action 1: To authorise the safe closure guideline
- Action 2: To implement the physical closure and post closure management including the social considerations
- Action 3: To establish the landfill registration system
- Action 4: To arrange the Federal and State Organisation (Committee)
- Action 5: To establish a funding system for safe closure
- Action 6: To develop human resources for capacity building

(2) Target Year and Target Sites

- a. Target year : 2010
- b. Target sites : 72 landfill sites in Groups A, B and C

The breakdown of the number of sites in their respective groups is shown in

Table 3.1.1 Target Sites for Action Plan

Item	Target sites				Group D	Total
	Group A	Group B	Group C	Total		
Closed site	7	9	17	33	22	55
Operating site	13	18	8	39	17	56
Total	20	27	25	72	39	111

Note It is noted that, among 111 landfill sites which will be closed up to 2010, 72 landfills identified as the priority sites in terms of their environmental risk potential and land use potential will be considered for the action plan.

3.2 Action 1: To Authorise the Safe Closure Guideline

In order to achieve a safe closure of the landfill, it is important that the various measures for safe closure have been considered even at the initial stages, from planning through to design and construction, and eventually throughout the operations. The safe closure guideline provides the recommended steps necessary to close the landfill in a safe manner, including steps to rehabilitate the closed landfills and on how to manage the closed landfill site properly. This guideline also provides the recommendations for the post closure land use of closed landfill sites. Thus it is important that the safe closure guideline is authorised by the relevant Governmental authorities and adopted as the official guideline for all future landfill safe closure requirements.

3.3 Action 2: To Implement the Physical Closure and Post Closure Management Including the Social Considerations

The Study has identified a total of 72 sites that require safe closure by the year 2010, and have been categorised into Groups A, B and C. The proposed implementation schedule should only commence from the year 2005, after the finalisation of the guideline and the necessary mechanisms.

The implementation schedule for the landfill safe closure is shown in **Table 3.3.1**. The table shows the annual breakdown of the number of sites, the closure levels and priority groups, which are to be closed from 2005 to 2010. The estimated CAPEX and OPEX have also been summarised in the table.

The social aspects/issues on scavengers and/or nearby households should be taken into consideration for each of the pre-closure, closing and post-closure stages of the landfill sites.

3.4 Action 3: To Establish the Landfill Registration System

The landfill registration system should be carried out by and managed by the State Government under the guidance of the Federal Government. The Local Authorities should be responsible for providing the updated information to the State, together with reporting of any infringements or irregularities that may occur. The introduction of the landfill registration system will be the first step towards preventing illegal waste dumping.

In addition, the registration system should be used to check and monitor the post-closure utilisation of the sites and to prevent any over exploitation of the site for purposes not suitable for the area.

3.5 Action 4: To Arrange the Federal and State Organisations

Since all land matters are under the control of the State Government, it is appropriate that the related authorities of the State Government should be responsible for implementing and maintaining the Landfill Registration System. It is understood that, even after the proposed privatisation of landfill sites, no specific agency will be responsible for the closed landfill sites or illegal dumping grounds, as the State Government should continue to be responsible for such sites.

It is proposed that the Landfill Sites Management Committee (LSMC) should be set up at the State Government level, as the main player in the management/monitoring of the safe closure of landfill sites.

It is also recommended that the Technical Committee for Management of Landfill (TCMLS) should be set up at the Federal level and to provide technical support to the State Government.

Table 3.3.1 Implementation Schedule for Landfill Safe Closure

(Unit of CAPEX & OPEX RM)

1. CAPEX (Capital expenditure)	2005				2006				2007				2008				2009				2010				Total	
	C1	C2	C3	C4	Total	C1	C2	C3	C4	Total	C1	C2	C3	C4	Total	C1	C2	C3	C4	Total	C1	C2	C3	C4		Total
A Closed Sites																										
a) Group A			4	3	7																					
b) Group B							1		4	9																
c) Group C											1	12	4		17											
A Sub-total sites number					7					9					17											33
A Sub-total CAPEX					16,750,000					19,541,000					36,200,000						0					0
A Area of sites (ha)					28.3					40.0					195.8						0					0
B Operating Sites																										
a) Group A			7	1	8					1					1						1					0
b) Group B			4	1	5					3					3						2					2
c) Group C			2		2					2			3		3						1					0
B Sub-total sites number					15					6					7						3					2
B Sub-total CAPEX					52,913,000					16,154,000					20,692,000						14,409,000					9,167,000
B Area of sites (ha)					171.4					56.1					49.9						56.5					19.7
Total Sites Number					22					15					24						3					2
Total CAPEX					69,663,000					35,695,000					56,892,000						14,409,000					9,167,000
Total Area (ha)					199.7					96.1					245.7						56.5					19.7
2. OPEX (Operational expenditure)																										
A Closed Sites																										
a) Group A																										
b) Group B																										
c) Group C																										
A Sub-total sites number										7					16						33					33
A Sub-total OPEX										1,278,000					2,904,000						6,478,000					6,478,000
A Area of sites (ha)										28.31					68.29						264.11					264.11
B Operating Sites																										
a) Group A																										
b) Group B																										
c) Group C																										
B Sub-total sites number					0					15					21						28					37
B Sub-total OPEX					-					5,277,000					7,044,000						8,671,000					11,868,000
Total Sites Number					0					22					37						61					70
Total OPEX					-					6,555,000					9,948,000						15,149,000					16,346,000
																										66,535,000

3.6 Action 5: To Establish a Funding System for Safe Closure

To secure availability of the fund, the Study recommends creation of the national fund for landfill closure in Malaysia. The fund mainly consists of:

- Additional allocation of national budget specifically used for landfill closure,
- Additional tipping fees collected from those who bring waste into the landfills including public and private SW haulers.

The schedule for the additional tipping fee collection is proposed as shown in **Table 3.6.1**.

Table 3.6.1 Schedule of Additional Fee Collection

2005-2006	2007-2009	2010-
Additional fee collection will be carried out in Kuala Lumpur	Additional fee collection will be gradually extended to other urbanised areas	Additional fee collection will be extended for the whole of the Peninsular Malaysia.

- The shortage of the fund for implementing the action plan during 2005-2010 will be covered by additional allocation from the national budget.
- From 2010 onward, the fund for safe closure will be mostly covered by additional fee collection.

Table 3.6.2 below estimates the amount of the fund that could be raised from the additional fee collection and additional National budget allocation required for safe closure of the landfill sites in accordance with the action plan.

Table 3.6.2 Estimated Amount of Fund with the Required Fund for Safe Closure of Landfill Sites during 2005-2010 (72 sites)

(Unit: RM)

Item	2005	2006	2007	2008	2009	2010
National budget required	55,750,000	55,750,000	29,610,000	29,610,000	NIL	NIL
Collection of tipping fees	3,602,000	3,795,000	12,199,000	24,988,000	39,348,000	40,760,000
Required fund for closure	69,663,000	42,250,000	66,840,000	29,558,000	39,659,000	27,513,000
Balance	-10,311,000	17,295,000	-25,031,000	25,040,000	-311,000	13,247,000

Figure 3.6.1 shows the estimated trend of CAPEX and OPEX in accordance with the action plan for safe closure of landfill sites (72 numbers).

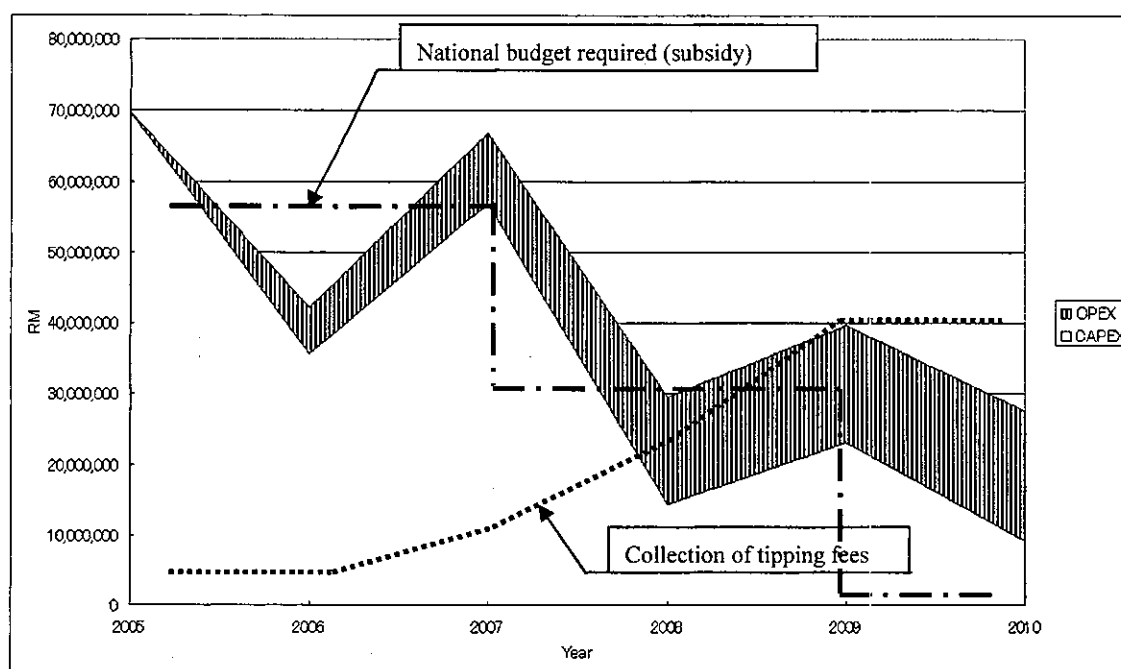


Figure 3.2.1 Trend of CAPEX and OPEX for Action Plan (2005 - 2010)

3.7 Action 6: To Develop Human Resource for Capacity Building

In order for the proper implementation of safe closure of landfill sites, it is necessary to identify the responsible organisations, operators and managers who will handle the management and/or carry out the actual safe closure works. However, due to the lack of suitably trained managers or operators in this field in Malaysia at present, the Federal Government must ensure that proper training and technical assistance must be provided.

The proposed contents of the training course are shown in **Table 3.7.1**.

Table 3.7.1 Proposed content of training courses for safe closure of landfill sites

	Training courses	State officials	LAs	Operator/ owner
1	Administration, management and finance	+++	+	+
2	Guideline	+++	+++	+++
3	Laws and enforcement	+++	++	+
4	Registration of landfill sites	+++	+	+
5	Inventory survey/priority and closure level set-up	+++	++	+
6	Physical closure and post-closure management	++	++	+++
7	Environmental risk and monitoring	++	+	+++
8	Re-development of closed landfill site	++	+	+++

Note: (+: Recommended, ++: Should Attend, +++: Compulsory)

3.8 Implementation Schedule

The implementation schedule for the Action Plan is shown in **Table 3.8.1**.

Table 3.8.1 Implementation Schedule of Action Plan

	Item	2004	2005	2006	2007	2008	2009	2010
	JICA Study on landfill safe closure	+	+	+	+			
I	Landfill safe closure implementation		+	+	+	+	+	+
	- Closed sites (High Priority: 7 sites)		+	+	+	+		
	- Closed sites (Medium Priority: 9 sites)			+	+	+	+	
	- Closed sites (Medium-Low Priority: 17 sites)				+	+	+	+
	- Operation sites (High-Med-Low Priority: 39 sites)			+	+	+	+	+
II	Guideline for landfill safe closure	+	+	+	+			
III	Landfill registration (set-up committee in State Gov.)	+	+	+	+			
IV	Landfill sites list	+	+	+	+			
V	Funding system set-up	+	+	+	+			
VI	Human resource development	+	+	+	+	+	+	+

4 PILOT PROJECTS

4.1 Purpose

The three Pilot Projects (PP) as shown below have been implemented in order to examine the standards for the Safe Closure Guideline and demonstrate the method and effect of the safe closure and rehabilitation.

- Ampang Jajar landfill site (Pulau Pinang State)
- Pekan Nenasi landfill site (Pahang State)
- Ampang Jaya closed landfill site (Selangor State).

4.2 Outline of the Pilot Projects

An outline of the pilot projects is shown in **Table 4.2.1**.

Table 4.2.1 Brief Description of the Pilot Projects

Item	Pilot Projects		
	Ampang Jajar Landfill	Pekan Nenasi Landfill	Ampang Jaya Closed Landfill
Status of landfill	Closed (2003)	In Operations	Closed (1998)
Key points in safe closure consideration	Safety closure of landfill that has been operated under improved conditions	Model for rehabilitation of landfill located on wetlands	Safety closure of landfill previously operated as an open dump site and poorly located
Targeted safe closure levels	Landscaping and safety closure to Level C3	Safety closure to Level C3	Safety closure to Level C2

Brief description of the pilot projects	Improvement of the slopes and installation of storm water drains, leachate collection pipes and gas vents	Upgrading to semi-aerobic landfill with leachate collection pipes, recirculation system and gas vents	Provision of leachate collection pipes and gas vents. Installation of surface storm water drainage system
Major works carried out	<ul style="list-style-type: none"> • Topographic and geological survey • Re-forming 250m stretch of slopes from 3.2m to 7m high • Applying 8,000m² cover soil (150mm thick) • Plant 11,400m² turfing & 240 trees • Installing 275m of 450mm dia. leachate collection pipes • Installing 600m of 150mm dia. Leachate/gas pipes • Installing 900m of pre-cast surface/stormwater drains 	<ul style="list-style-type: none"> • Topographic and geological survey • Install 84m of 450mm dia leachate collection pipe • Install 330m of 225mm dia branch pipes • Excavation of 100m x 10m x 2m(deep) leachate collection pond • Installation of one 7.5kw surface aerator c/w control systems • Installation of one 5kw recirculation pump c/w piping and control panel 	<ul style="list-style-type: none"> • Topographic and geological survey • Construct 1km, 7m wide access road • Install 1km stormwater drains alongside access road • Install 126m of 450mm dia HDPE leachate collection pipe • Install 500m of 100mm dia leachate / gas collection pipes • Install 500m stormwater drains • Excavation of wetland area for leachate pond
Environmental monitoring	Before and after PP <ul style="list-style-type: none"> • Surface & groundwater • Leachate • Landfill gas 	Before and after PP <ul style="list-style-type: none"> • Surface & groundwater • Leachate • Landfill gas 	Before and after PP <ul style="list-style-type: none"> • Surface & groundwater • Leachate • Landfill gas

Evaluation of the Pilot Project is summarized in **Table 4.2.2**.

Table 4.2.2 Evaluation of Pilot Projects

Item	A*	B*	C*	Comment
1. Malaysian technical capability				
(1) Detailed design	O			Detailed design was prepared by Local consultants appropriately based on the instruction of the JICA Study Team.
(2) Construction	O			Contractors implemented the construction works well.
2. Construction Implementation				
(1) Construction period	O	O		Ampang Jaya PP completed on time, but Ampang Jajar and Pekan Nenasi PP faced some delays due to rainy season
(2) Budget maintenance	O			All PPs completed within the budgets.
(3) Equipment and materials		O		All the equipment and materials for the works procured in Malaysia.
(4) Workmanship		O		Contractors implemented the construction works as it was designed.
3. Applicability of Guidelines				
(1) Ampang Jajar PP	O			Re-formation of slope and application of C3 level (leachate collection, drainage system, gas vents, etc)
(2) Pekan Nenasi PP	O			Application of C3 level (semi-aerobic landfill system including leachate re-circulation system).

(3) Ampang Jaya PP		O		Installation of leachate collection and drainage system.
4. Deepening understanding of safe closure				
(1) MHLG		O		Arrangement of C/P personnel for each pilot site for supervise works. Implementation of training workshops
(2) Local Authorities	O		O	Active participation of Las in Ampang Jajar and Pekan Nenasi PP. Inadequate participation in the case of Ampang Jaya PP.
(3) Site operators	O			Understanding and Cooperation of landfill operators during implementation. Adjacent cell was developed by LA's initiative in Pekan Nenasi.
(4) Public	O			Based on the public hearing to Ampang Jajar residents (about 200 attendees), PP was totally accepted by the public.
(5) 1 st Training Workshop	O			Topic: Evaluation of landfill sites and planning of pilot projects. Attendees: Federal/state government and local authorities.
(6) 2 nd Training Workshop	O			Topic. Detail design, construction work and monitoring of PP. Attendees. federal/state government, LAs, and concessionaires
5. Environmental improvement				
(1) Ampang Jajar	O			Surface water & Leachate improved. Landscaping improved.
(2) Pekan Nenasi		O		Leachete improved. Continuous monitoring is required
(3) Ampang Jaya		O	O	Leachate can be controlled. Leachate treatment is urgently required.

Note * Key. A = Excellent, B = Satisfactory, C = Inadequate

5 FORMULATION OF LANDFILL DATABASE

Landfill inventory survey composed of two survey exercises were carried out, one was the actual site visit and inspection survey and the other was the desk-top questionnaire survey whereby proforma questionnaires were sent to the Local Authorities for them to provide as much information and details about their respective landfills.

From the results of the surveys and information collated in the inventory list, the database of landfills in Malaysia for 147 landfill sites was created. This leads to the formation of the Landfill Closure Management Information System (LACMIS).

The LACMIS database is based upon the Geographical Information System (GIS) that comprises of a series of spatial data and non-spatial attribute data. The Spatial Data include geographical information on the Administration boundaries, the landfill site location, the location of water intake points, hydrological map and the transportation network. The non-spatial attribute data include information on the administrative database, the environmental database, the land utilisation database and the rating database.

Figure 5.1.1 shows the example page of the LACMIS visual display with the map of the Peninsular Malaysia, indicating the locations of the major cities/town, roads, rivers, and the locations of the landfill sites.

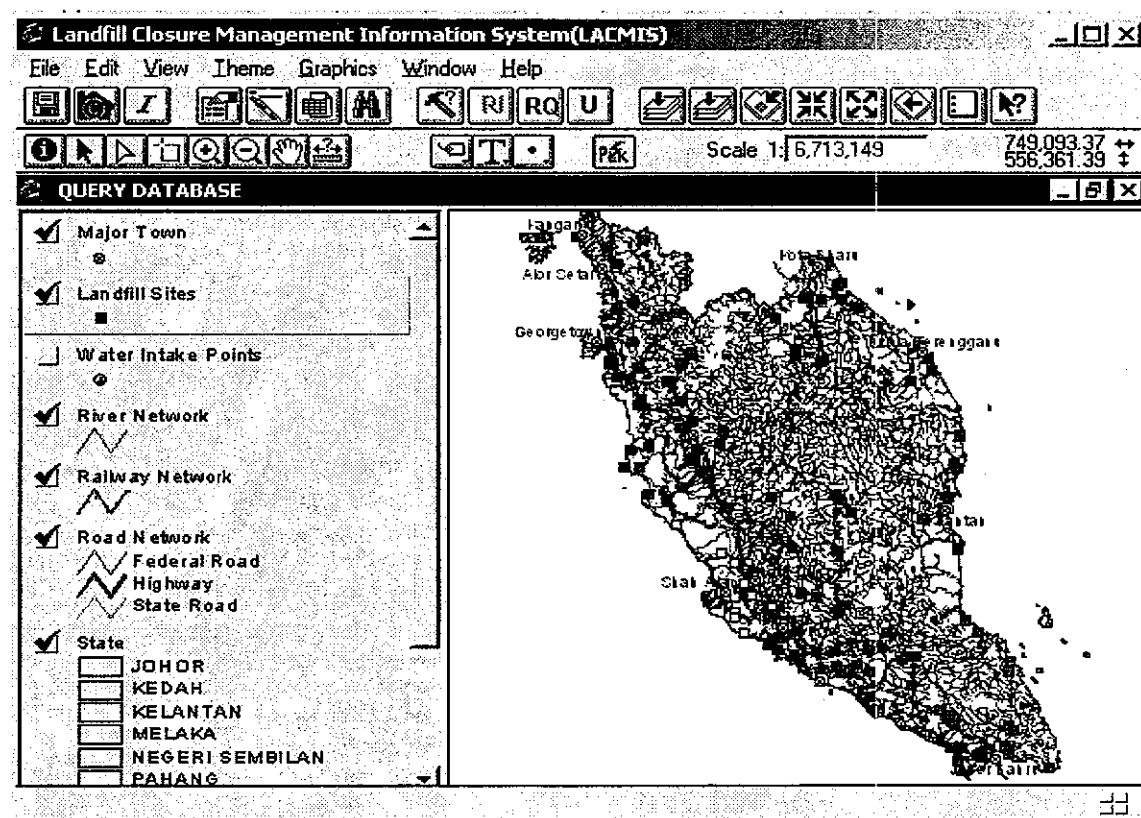


Figure 5.1.1 Example of LACMIS Visual Display

6 REVIEW OF TECHNICAL GUIDELINE ON SANITARY LANDFILL

The "Technical Guideline on Sanitary Landfill, Design and Operation (draft)" was prepared by the JICA expert in October 1990. In order to meet the present conditions of solid waste management activities in Malaysia, the technical guideline (draft) were reviewed considering the following key items, and "Revised draft, 2004" has been prepared by the study.

- Recommendation for Semi-aerobic landfill system
- Sanitary landfill levels
- Function of the landfill
- Necessity of the cover soil
- Environmental monitoring
- Countermeasures for heavy rainfalls
- Sectional land filling

- Design requirements for leachate control system
- Treatment method of leachate
- Occupational health and safety
- Landfill operation and maintenance control
- Rehabilitation of existing landfill site
- Cost for landfill construction and operation
- Explanation of intermediate treatment
- Updating of data
- Revision of the contents

TABLE OF CONTENTS

EXECUTIVE SUMMARY

ABBREVIATIONS

DEFINITION OF TERMS

CHAPTER 1 INTRODUCTION	1-1
1.1 Background of the Study	1-1
1.2 Objective and Output of the Study	1-1
1.3 Study Implementation Process	1-2
1.4 Study Team Members	1-4
CHAPTER 2 OUTLINE OF SOLID WASTE MANAGEMENT IN MALAYSIA	2-1
2.1 Review of Existing Legislation	2-1
2.1.1 Local Government Act, 1976 (LGA)	2-1
2.1.2 Street, Drainage and Building Act, 1974 (SDBA)	2-2
2.1.3 Environmental Quality Act, 1974 (EQA)	2-3
2.2 Institutional Structure for SWM	2-4
2.2.1 Introduction	2-4
2.2.2 Federal Government Agencies	2-5
2.2.3 State Government and Local Authorities	2-8
2.2.4 National Councils	2-9
2.2.5 Non-Government Stakeholders	2-9
2.2.6 Research Institutions and Universities	2-10
2.2.7 Non-Government Groups	2-10
2.3 Priority Plans on SWM and Privatisation	2-10
2.3.1 Priority Plans on SWM	2-10
2.3.2 Privatisation of SWM	2-12
2.4 Meteorological and Geological Profile of Malaysia	2-16
2.5 Waste Amount And Composition	2-18
2.5.1 Waste Amount Generated	2-19
2.5.2 Waste Composition and Characteristics	2-19
CHAPTER 3 ISSUES OF SAFE CLOSURE OF LANDFILL SITES.....	3-1
3.1 Landfill Sites In Malaysia	3-1
3.1.1 Findings and Issues of Landfill Sites in Malaysia	3-1
3.1.2 Photographs of landfill sites in Malaysia	3-6
3.1.3 Post-closure Land Use Practices and Issues	3-9
3.2 Number of Landfill Sites in Malaysia	3-12
3.3 Environmental Issues of Landfill Sites	3-14
3.3.1 Surface Water	3-14
3.3.2 Groundwater	3-14
3.3.3 Sanitary Condition (Vector and Odour)	3-16
3.3.4 Land Subsidence and Landfill Gas	3-16
3.3.5 Landslide/Collapse and Fire	3-16
3.3.6 Effects to Natural Drainage System	3-17
3.3.7 Necessity for Monitoring	3-17
3.3.8 Environmental Liabilities – Necessity for Good Record Keeping -	3-17
3.4 Risks of Redevelopment of the Closed Landfill Sites	3-18
3.4.1 Risk of Landslide or Collapse	3-18
3.4.2 Problems of Subsidence	3-19
3.4.3 Risk of Groundwater Pollution	3-19
3.4.4 Risk of Gas Explosion or Fire	3-20

3.4.5	Damages to the Plant life on the Site and Surroundings	3-21
3.4.6	Appropriate Measures against the Pollution and Hazards	3-21
3.4.7	Unintentional Chemical Reaction.....	3-21
3.4.8	Change of Surface Covers	3-22
3.5	Legislation, Institutional and Financial Issues	3-22
3.5.1	Legislation Issues	3-22
3.5.2	Institutional and Financial Issues	3-23
CHAPTER 4 Guideline for Safe closure and Rehabilitation of MSW Landfill Sites		4-1
4.1	Introduction	4-1
4.2	Part I General	4-3
4.3	Part II Technical Requirements.....	4-11
CHAPTER 5 Action plan on safe closure of landfill sites.....		5-1
5.1	Objectives of Action Plan	5-1
5.1.1	Target Year and Target Sites	5-2
5.1.2	Basic Policies and Strategies	5-5
5.2	Action 1: To Authorise the Safe Closure Guideline.....	5-5
5.3	Action 2: To Implement the Physical Closure and Post Closure Management Including the Social Considerations	5-6
5.3.1	Physical Closure	5-7
5.3.2	Post Closure Management.....	5-10
5.3.3	Social Considerations	5-12
5.4	Action 3: To Establish the Landfill Registration System.....	5-15
5.5	Action 4: To Arrange the Federal and State Organisations.....	5-17
5.5.1	Landfill Sites Management Committee (LSMC)	5-17
5.5.2	Technical Committee for Management of Landfill Site (TCMLS).....	5-18
5.5.3	Role of Major Stakeholders for Landfill Safe Closure	5-18
5.6	Action 5: To Establish a Funding System for Safe Closure.....	5-20
5.7	Action 6: To Develop Human Resource for Capacity Building	5-25
5.8	Action Plan Schedule	5-26
5.8.1	Implementation Schedule	5-26
5.9	Action Plan Evaluation	5-28
APPENDIX - Classification and Prioritisation of Landfill Sites		5-32
CHAPTER 6 Pilot Project.....		6-1
6.1	Introduction	6-1
6.2	Selection of Pilot Projects Sites	6-3
6.2.1	Categorisation of Candidate Sites.....	6-5
6.3	Pilot Projects Implementation Process.....	6-5
6.3.1	Implementation Flowchart.....	6-5
6.3.2	Cost Estimation	6-6
6.3.3	Survey of Existing Natural Condition	6-6
6.3.4	Pilot Project Design	6-7
6.3.5	Pilot Project Implementation	6-8
6.3.6	Monitoring Programme for the Pilot Projects	6-8
6.4	Pilot Project - Ampang Jajar Landfill Site (Pulau Pinang)	6-9
6.4.1	Outline of the site	6-9
6.4.2	Total safe closure plan.....	6-10
6.4.3	Proposed land use plan	6-11
6.4.4	Ampang Jajar Pilot Project Implementation.....	6-11
6.4.5	Environmental Monitoring – Ampang Jajar PP.....	6-21
6.4.6	Considerations	6-25
6.4.7	Continuous Operations & Maintenance and Monitoring.....	6-29

6.5	Pilot Project - Pekan Nenasi Landfill Site (Pahang)	6-32
6.5.1	Outline of the Site	6-32
6.5.2	Development plan and closure plan	6-33
6.5.3	Pekan Nenasi Pilot Project Implementation	6-34
6.5.4	Environmental Monitoring – Pekan Nenasi PP	6-41
6.5.5	Considerations	6-45
6.5.6	Continuous Operations & Maintenance and Monitoring	6-49
6.5.7	Monitoring of environment and landfill stabilisation	6-51
6.6	Pilot Project - Ampang Jaya Closed Landfill Site (Selangor)	6-52
6.6.1	Outline of the site	6-52
6.6.2	Safe closure plan	6-53
6.6.3	Ampang Jaya Pilot Project Implementation	6-54
6.6.4	Environmental Monitoring – Ampang Jaya PP	6-61
6.6.5	Considerations	6-65
6.6.6	Continuous Operations & Maintenance and Monitoring	6-68
6.7	Pilot Project Evaluation	6-71
6.7.1	Technical Evaluation	6-71
6.7.2	Environmental Evaluation	6-80
6.7.3	Summary and conclusions	6-94
6.8	The evaluation of the improvement of Ampang Jajar landfill site	6-95
6.8.1	Background	6-95
6.8.2	Methodology	6-95
6.8.3	Result of the survey	6-96
CHAPTER 7	FORMULATION OF LANDFILL DATABASE	7-1
7.1	Landfill Inventory in Malaysia	7-1
7.1.1	Outline of the Survey	7-1
7.1.2	Results of the Survey	7-7
7.1.3	Formulation of the Landfill Database	7-11
7.1.4	Management of the Landfill Database	7-13
7.2	Landfill Closure Management Information System (LACMIS)	7-15
7.2.1	Introduction	7-15
7.2.2	Scope of GIS development	7-15
7.2.3	Methodology for development of GIS	7-15
7.2.4	GIS System and analysis	7-17
7.3	Add/Delete Theme	7-29
CHAPTER 8	REVIEW OF TECHNICAL GUIDELINE ON SANITARY LANDFILL	8-1
8.1	Background	8-1
8.1.1	Technical Guideline on Sanitary Landfill (draft), 1990	8-1
8.1.2	Purpose of the Review	8-1
8.2	Items to be Reviewed	8-2
8.2.1	Recommendation for Semi-aerobic Landfill System	8-2
8.2.2	Sanitary Landfill Levels	8-2
8.2.3	Function of the Landfill	8-3
8.2.4	Necessity of the Cover Soil	8-3
8.2.5	Environmental Monitoring	8-3
8.2.6	Countermeasures for Heavy Rainfalls	8-3
8.2.7	Sectional Land filling	8-3
8.2.8	Design Requirements for Leachate Control Systems	8-4
8.2.9	Treatment Method of Leachate	8-4
8.2.10	Occupational Health and Safety	8-4
8.2.11	Landfill Operation and Maintenance Control	8-4
8.2.12	Rehabilitation of Existing Landfill Site	8-5
8.2.13	Cost for Landfill Construction and Operation	8-5
8.2.14	Explanation of Intermediate Treatment	8-5

8.2.15	Updating of Data	8-5
8.2.16	Revision of the Contents.....	8-5

LIST OF TABLES

Table 2.1.1	List of Legislation Relevant to Solid Waste Management in Peninsular Malaysia.....	2-2
Table 2.2.1	Agencies Relevant to Solid Waste Management.....	2-5
Table 2.3.1	Performance Standards for Waste Collection (Example).....	2-13
Table 2.3.2	Landfill Sites Operated by the Alam Flora.....	2-14
Table 2.3.3	Operation Body of Several Landfill Sites.....	2-15
Table 2.4.1	5 Years Total Rainfall and Total Solar Evaporation.....	2-16
Table 2.5.1	Estimated Solid Waste Generated in Malaysia.....	2-19
Table 2.5.2	Waste Composition in Kuala Lumpur.....	2-20
Table 3.1.1	Existing Landfill Sites in Malaysia.....	3-2
Table 3.1.2	Closed Landfill Sites in Malaysia.....	3-3
Table 3.1.3	Existing Landfill Sites in Peninsular Malaysia.....	3-3
Table 3.1.4	Hazard Experiences Caused by the Landfill Sites in Several Countries ...	3-10
Table 3.2.1	Number of Landfill Site visited by Study Team (2003).....	3-13
Table 3.2.2	Landfill Site List Not Recorded in MHLG List (as of 2003)	3-13
Table 3.3.1	National Guidelines for Drinking Water Quality	3-14
Table 4.2.1	Parameters to Measure the Landfill Stabilization.....	4-6
Table 4.3.1	Grouping of Landfill Sites for Safe Closure Priority.....	4-12
Table 4.3.2	Closure Levels and Required Measures/Facilities.....	4-13
Table 4.3.3	Relationship between Landfill Closure Priority and Safe Closure Level ..	4-13
Table 4.3.4	Survey Items for Evaluation of the Site.....	4-14
Table 4.3.5	Summary of Maintenance Items	4-17
Table 4.3.6	Summary of Monitoring Items	4-18
Table 4.3.7	Safety Control Items	4-20
Table 4.3.8	Environmental Control Items	4-20
Table 5.2.1	Implementation Schedule of Action Plan	5-2
Table 5.2.2	Target Sites for Action Plan	5-2
Table 5.2.3 (i)	List of Closed Landfill Sites for the Action Plan (2005-2010).....	5-3
Table 5.2.3 (ii)	List of Operating Landfill Sites for the Action Plan (2005-2010).....	5-4
Table 5.3.1	Implementation Schedule for Landfill Safe Closure	5-8
Table 5.3.2	Cost of Safe Closure up to 2010	5-10
Table 5.3.3	Summary of Maintenance Items	5-11
Table 5.3.4	Summary of Monitoring Items	5-11
Table 5.4.1	Flowchart of Landfill Registration and Management System.....	5-16
Table 5.6.1	Duties and Responsibilities of Key Stakeholders.....	5-21
Table 5.6.2	Schedule of Additional Fee Collection.....	5-23
Table 5.6.3	Estimated Amount of Fund with the Required Fund for Safe Closure of Landfill Sites during 2005 to 2010 (72 sites)	5-24
Table 5.7.1	Proposed content of training courses for safe closure of landfill sites	5-25
Table 5.8.1	Implementation Schedule for Action Plan.....	5-27
Table 5.9.1	The Cost of Implementing the Action Plan	5-28
Table 5.9.2	The Cost of Implementing the Strategic Plan.....	5-28
Table 5.9.3	Gross Monthly Household Income Distribution in 1999.....	5-29
Table 5.9.4	Percentage of the Cost for Safe Closure of Landfill to the Gross Monthly Household Income (RM0.70/month for household).....	5-29
Table 5.9.5	Variation of Market Land Price between Types of Land Use Potential	5-31
Table 6.1.1	Brief Description of the Pilot Projects.....	6-2
Table 6.2.1	Descriptions of Candidate Sites for the Pilot Projects.....	6-4
Table 6.3.1	Analytical Parameters.....	6-8
Table 6.3.2	Sampling Schedule	6-9
Table 6.4.1	Ampang Jajar Landfill Operations and Site Characteristics.....	6-10
Table 6.4.2	Summary of the Total Safe Closure Plan for Ampang Jajar Landfill Site.....	6-10

Table 6.4.3	Proposed Land Use Plan for Ampang Jajar Landfill Site	6-11
Table 6.4.4	Ampang Jajar PP Description	6-14
Table 6.4.5	Sample Number at Ampang Jajar Pilot Project Site	6-21
Table 6.4.6	Summary of Results - Physical Parameters	6-24
Table 6.4.7	Summary of Results - Landfill Gases	6-25
Table 6.4.8	Groundwater Levels at Ampang Jajar PP Site	6-26
Table 6.4.9	Leachate and Water Quality	6-28
Table 6.4.10	Monitoring Value Exceeding Effluent Standard B	6-29
Table 6.4.11	Summary of Maintenance Items	6-30
Table 6.4.12	Monitoring Programme	6-31
Table 6.5.1	Pekan Nenasi Landfill Operations and Site Characteristics	6-33
Table 6.5.2	Conceptual Development Plan for the Western Part of Pekan Nenasi Landfill Site	6-33
Table 6.5.3	Pekan Nenasi PP Description	6-36
Table 6.5.4	Sample Number at Pekan Nenasi Pilot Project Site	6-41
Table 6.5.5	Summary of Results - Physical Parameters	6-44
Table 6.5.6	Summary of results - landfill gases	6-45
Table 6.5.7	Groundwater Levels at Pekan Nenasi PP Site	6-46
Table 6.5.8	Leachate and Water Quality	6-48
Table 6.5.9	Monitoring Value Exceeding Effluent Standard B	6-48
Table 6.5.10	Summary of Maintenance Items	6-50
Table 6.5.11	Monitoring Programme	6-51
Table 6.6.1	Closure Measures Taken in 1998 and Its Evaluation	6-53
Table 6.6.2	Ampang Jaya Closed Landfill Operations and Site Characteristics	6-53
Table 6.6.3	Closure Plan for the Ampang Jaya Closed Landfill Site	6-54
Table 6.6.4	Ampang Jaya PP Description	6-56
Table 6.6.5	Sample Number at Ampang Jaya Pilot Project Site	6-61
Table 6.6.6	Summary of Results - Physical Parameters	6-64
Table 6.6.7	Summary of Results - Landfill Gases	6-65
Table 6.6.8	Groundwater Levels at Ampang Jaya PP Site	6-66
Table 6.6.9	Leachate and Water Quality	6-67
Table 6.6.10	Monitoring Value Exceeding Effluent Standard A	6-68
Table 6.6.11	Summary of Maintenance Items	6-69
Table 6.6.12	Monitoring Programme	6-70
Table 6.7.1	Evaluation of Pilot Projects	6-72
Table 6.7.2	Summary of Environmental Evaluation	6-94
Table 6.8.1	The Numbers of Attendees and Questionnaires Submission	6-96
Table 6.8.2	Willingness to Pay for the Project	6-97
Table 6.8.3	Attendees Showed the Support for the Project	6-97
Table 6.8.4	Amount to be Paid for the Project	6-98
Table 6.8.5	Answers Selected from RM2.00 to RM20.00	6-99
Table 7.1.1	Overview of Site Visiting (actual field survey)	7-2
Table 7.1.2	List of Landfill Sites Covered by the JICA Study	7-3
Table 7.1.3	Management and Land Ownership of the Landfill Sites	7-8
Table 7.1.4	Classification of Landfill Sites	7-8
Table 7.1.5	Location of Landfill Sites to Water Intake Points	7-10
Table 7.1.6	Land Use of Closed Landfill Sites	7-10
Table 7.1.7	Level and Potential for Post Closure Land Use of the Landfill Sites	7-11
Table 7.1.8	Site "Attribute" Data Items (Table Format)	7-12
Table 8.2.1	Comparison of the Contents of Original Guideline and the Reviewed Guideline	8-6

LIST OF FIGURES

Figure 1.3.1	Study Implementation Schedule.....	1-4
Figure 2.2.1	Organization Chart of Ministry of Housing and Local Government.....	2-6
Figure 2.2.2	Organization Chart of Department of Local Government.....	2-7
Figure 3.1.1	Comparison of the Landfill Level in Peninsular Malaysia.....	3-4
Figure 3.1.2	Location and Level of Landfill Sites in Peninsular Malaysia	3-5
Figure 4.1.1	Schematic Diagrams of Landfill Closure Levels.....	4-2
Figure 5.2.1	Schematic Flow of Action Plan.....	5-1
Figure 5.3.1	Process of Landfill Safe Closure	5-6
Figure 5.3.2	Process of Physical Closure	5-9
Figure 5.5.1	Organisation Structure of the LSMD	5-17
Figure 5.5.2	Roles of the Stakeholders for the Landfill Safe Closure Process	5-19
Figure 5.6.1	Basic Mechanism of the Reserve Fund	5-21
Figure 5.6.2	Trend of CAPEX and OPEX for Landfill Closure Action Plan (2005 - 2010).....	5-24
Figure 6.2.1	Site Selection Procedure for the Pilot Projects.....	6-3
Figure 6.3.1	Implementation Flow	6-5
Figure 6.4.1	Project Implementation Schedule for Ampang Jajar PP	6-13
Figure 6.4.2	Layout Plan (Ampang Jajar Pilot Project).....	6-16
Figure 6.4.3	Typical Sections (Ampang Jajar Pilot Project)	6-17
Figure 6.4.4	Map of Sampling Location for Monitoring, Ampang Jajar.....	6-22
Figure 6.4.5	Map of Geological Setting, Ampang Jajar (reproduced from geological map published by Geological Survey Malaysia, 1985).....	6-23
Figure 6.4.6	Groundwater Level Contour Map - Ampang Jajar PP	6-27
Figure 6.5.1	Project Implementation Schedule for Pekan Nenasi PP.....	6-35
Figure 6.5.2	Layout Plan (Pekan Nenasi Pilot Project)	6-37
Figure 6.5.3	Typical Sections (Pekan Nenasi Pilot Project)	6-38
Figure 6.5.4	Sampling Location for Monitoring, Pekan Nenasi.....	6-42
Figure 6.5.5	Map of Geological Setting Pekan Nenasi (reproduced from geological map published by Geological Survey Malaysia, 1985)	6-43
Figure 6.5.6	Groundwater Level Contour Map - Pekan Nenasi PP.....	6-47
Figure 6.6.1	Project Implementation Schedule for Ampang Jaya Pilot Project	6-55
Figure 6.6.2	Layout Plan (Ampang Jaya Pilot Project)	6-57
Figure 6.6.3	Typical Sections (Ampang Jaya Pilot Project).....	6-58
Figure 6.6.4	Map of Sampling Location for Monitoring, Ampang Jaya	6-62
Figure 6.6.5	Map of Geological Setting, Ampang Jaya (reproduced from geological map published by Geological Survey Malaysia, 1985)	6-63
Figure 6.6.6	Groundwater Level Contour Map - Ampang Jaya PP.....	6-66
Figure 6.7.1	Ampang Jajar Leachate (L1) Monitoring Results	6-81
Figure 6.7.2	Ampang Jajar Surface Water (SW2) Monitoring Results	6-82
Figure 6.7.3	Ampang Jajar Leachate (L1) and Surface Water (SW2) Monitoring : Boron and Iron Data	6-83
Figure 6.7.4	Ampang Jajar Groundwater (W3) Monitoring Results	6-84
Figure 6.7.5	Ampang Jajar Landfill Gas Monitoring Results.....	6-85
Figure 6.7.6	Pekan Nenasi Leachate (L1) Monitoring Results.....	6-86
Figure 6.7.7	Pekan Nenasi Surface Water (SW2) Monitoring Results.....	6-87
Figure 6.7.8	Pekan Nenasi Groundwater (W2) Monitoring Results.....	6-88
Figure 6.7.9	Ampang Jaya Leachate (L1) Monitoring Results.....	6-89
Figure 6.7.10	Ampang Jaya Leachate (L2) Monitoring Results.....	6-90
Figure 6.7.11	Ampang Jaya Surface Water (SW2) Monitoring Results.....	6-91
Figure 6.7.12	Ampang Jaya Surface Water (SW2) Monitoring : Boron, Iron and Manganese Data.....	6-92
Figure 6.7.13	Ampang Jaya Groundwater (W2) Monitoring Results.....	6-93

Figure 6.7.14	Ampang Jaya Landfill Gas Monitoring Results	6-94
Figure 6.8.1 (1)	Distribution of Answers of Q2 for “Q2-20”	6-98
Figure 6.8.1 (2)	Distribution of Answers of Q2 for “Q20-2”	6-99
Figure 6.8.2 (1)	Distribution of Amount to Pay for “Q2-20”	6-100
Figure 6.8.2 (2)	Distribution of Amount to Pay for “Q20-2”	6-100
Figure 6.8.3	Distribution of Cost sharing for “Q2-20” and “Q20-2”	6-101
Figure 7.1.1	Number and Status of Landfill Sites in Peninsular Malaysia.....	7-7
Figure 7.1.2	Distribution of Landfill Sites Visited by the JICA Study Team (64 Landfills) in Malaysia.....	7-9
Figure 7.1.3	Formation of Landfill Database	7-11
Figure 7.1.4	Roles of the Stakeholders for Management of the LACMIS	7-14
Figure 7.2.1	GIS Methodology Flowchart.....	7-16
Figure 7.2.2	Spatial Database – Transportation Network.....	7-17
Figure 7.2.3	Spatial Database – Administration Map.....	7-18
Figure 7.2.4	Spatial Database – Landfill Site Location	7-18
Figure 7.2.5	Spatial Database – Hydrological Maps	7-19
Figure 7.2.6	Basic Information Database	7-20
Figure 7.2.7	Environmental Impact Database	7-20
Figure 7.2.8	Land Utilisation Database	7-21
Figure 7.2.9	Rating Database.....	7-21
Figure 7.2.10	Relational Database Linkage between Two Set of Data	7-22
Figure 7.2.11	Linkage between Spatial and Non-spatial Databases.....	7-23
Figure 7.2.12	Linkage between Spatial and Non-spatial Databases.....	7-23
Figure 7.2.13	Query Dialog Box of Landfill Sites	7-24
Figure 7.2.14	The Results of the Query Highlighted in the Non-spatial Database.....	7-24
Figure 7.2.15	The Results of the Query Highlighted in the Spatial Database	7-25
Figure 7.2.16	Continuation of Query Made Based on the Conditions by Using the Select from Set Function	7-25
Figure 7.2.17	Results of Query Highlighted in the Non-spatial Database.....	7-26
Figure 7.2.18	The Results of the Query Highlighted in the Spatial Database	7-26
Figure 7.2.19	Map Created in LACMIS Application	7-27
Figure 7.2.20	Table Summary Created in LACMIS.....	7-27
Figure 7.2.21	Inputing New Point in LACMIS	7-28
Figure 7.2.22	Data that been Keyed in to LACMIS	7-28

LIST OF PLATES

Plate 3.1.1	Photographs of Landfill Sites in Malaysia.....	3-6
Plate 3.1.2	Redevelopment of Closed Landfill Sites in Malaysia.....	3-9
Plate 6.4.1	Ampang Jajar Pilot Project 1	6-18
Plate 6.4.2	Ampang Jajar Pilot Project 2	6-19
Plate 6.4.3	Ampang Jajar Pilot Project 3	6-20
Plate 6.5.1	Pekan Nenasi Pilot Project 1.....	6-39
Plate 6.5.2	Pekan Nenasi Pilot Project 2.....	6-40
Plate 6.6.1	Ampang Jaya Pilot Project 1.....	6-59
Plate 6.6.2	Ampang Jaya Pilot Project 2.....	6-60

ABBREVIATIONS

Note: Abbreviations used in this Report

BOD	Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
DOE	Department of Environment, Malaysia
DANCED	Danish Cooperation for Environment and Development
EIA	Environmental Impact Assessment
EMP	Eight Malaysian Plan 2001 – 2005
EPU	Economic Planning Unit
EQA	Environmental Quality Act
FTKL	Federal Territory of Kuala Lumpur
GIS	Geographical Information System
GPS	Global Positioning System
HA (ha)	Hectare (=10,000 m ² = 2.4711 acres)
IEE	Initial Environmental Evaluation
JICA	Japan International Cooperation Agency
MD	Majlis Daerah (District Council)
MHLG	Ministry of Housing & Local Government, Malaysia
MOH	Ministry of Health, Malaysia
MP	Majlis Perbandaran (Town Council)
NREB	Natural Resources and Environment Board
NSP	National Strategic Plan for Solid Waste Management 2003
OPP3	Third Outline Perspective Plan for 2001 - 2010
PJ	Petaling Jaya, Selangor
PPM (ppm)	Parts Per Million
SWM	Solid Waste Management
Ton	Metric Ton (Tonne)
TWG	Technical Working Group
UPM	University Putra Malaysia
WHO	World Health Organisation

DEFINITION OF TERMS

Landfill site: The site where municipal wastes are disposed off by land filling. Such sites may be provided with various landfill facilities. In accordance with the “Technical Guideline on Sanitary Landfill, Design and Operation (Revised draft, 2004)”, the landfill sites can be categorised into 4 types; i.e. from Level 1 (L1) to Level 4 (L4). Open Dumpsite is categorised as Level Zero (L0.)

Closed landfill site: The landfill site where the waste filling activities have been completed.

Abandoned site: The landfill site where the owners/operators could not be identified. “Illegal dump site” will be included in this category.

Safe closure (SC): “Safe closure” consists of the activities of “Physical closure (PC)” and “Post-closure management (PCM)”.

Physical closure (PC): The action by which the necessary measures for safe closure has been applied to the entire landfill area.

Closure levels (C1, C2, C3, C4): There are 4 closure levels, i.e. from C1 to C4. These closure levels indicate the countermeasures necessary to control the environmental pollution and hazards from the landfill sites. Each landfill site should be assigned with a targeted closure level at the initial stages of the safe closure process.

Post-closure management (PCM): The management activities necessary to operate, maintain and monitor the landfill facilities such as the leachate treatment, landfill gas treatment, cover soil etc. The activities also include the environmental monitoring, landfill stabilization monitoring and management of information/ records of the closed landfills.

Post-closure land use: The re-utilization of closed landfill sites for purposes other than for waste filling. The PCM activities should be continued through out the post-closure land use.

CHAPTER 1 INTRODUCTION

1.1 BACKGROUND OF THE STUDY

Approximately 170 landfill sites are operated in Malaysia where only about 10% of them are classified as sanitary landfill, in which environmental protection measures are considered for their facilities and operation. Most of the landfill sites are operated as so called open dumping sites and there are concerns that these sites are sources of environmental pollution; such includes waste scattering, offensive odour, insect infestation, surface and groundwater pollution, leachate problems, etc.

During the last 15 years about 60 landfill sites were closed without proper environmental countermeasures. Therefore, in Malaysia, environmental pollution surroundings the closed landfill sites are wide spread. Furthermore, it is reported that about 46% of the existing landfill sites will be closed within the next 5 years.

In order to prevent the environmental pollution and maintain a healthy environment and introduce the proper post-closure utilisation of landfill sites, the safe closure of existing landfill sites and rehabilitation of closed landfill sites are main issues in Malaysia that need to be urgently addressed.

Solid waste management (SWM) in Malaysia is in a transition period for privatisation, which has yet to be fully implemented. Therefore, it is strongly recommended that the Federal Government and/or States and Local Authorities should lead/control the private sector in both technical and administrative matters. Accordingly, human resource development on the management of landfill sites is also necessary.

Based on this understanding, in response to the request of the Government of Malaysia (GOM), the Japan International Cooperation Agency (JICA) conducted the Study on Safe closure and Rehabilitation of Landfill Sites in Malaysia.

1.2 OBJECTIVE AND OUTPUT OF THE STUDY

The objective of the Study is to reduce a health hazard and/or environmental pollution caused by the waste landfill sites, in the medium and long-term.

The major outputs of the Study are as follows:

- (1) Development of Guidelines
 - a. Guideline on the Safe closure of Landfill Sites covering institutional, financial, environment and technical issues
 - b. Review of “Technical Guideline on the Design, Construction and Operation of Sanitary Landfills, Design and Operation (1990)”

- (2) Developing an Action Plan for Safe closure implementation
 - a. Determination of priority and safe closure levels for 147 landfill sites listed in the Landfill Inventory based on evaluation of environmental risks and value of land use for each site
 - b. Preparation of Action Plan for safe closure of 72 landfills by the year 2010 covering technical requirements and associated costs
 - c. Institutional modifications recommendations to effectively implement safe closure of the landfills
 - d. Developing a landfill registration system
- (3) Pilot Projects Implementation
 - a. Ampang Jaya Landfill Site
 - b. Pekan Nenasi Landfill Site
 - c. Ampang Jajar Landfill Site
- (4) Preparation of Database
 - a. Field reconnaissance and data collection to supplement and update existing information
 - b. Preparation of Landfill Inventory
 - c. Preparation of data maintenance system for inputting and analysing data related to landfills
- (5) Technology Transfer and Enhancing Awareness on Safe closure
 - a. Implementation, monitoring and evaluation of the 3 Pilot Projects to study effective technical measures, related costs and serve as models for GOM officials
 - b. Seminars and workshops to discuss technical issues related to safe closure and enhance awareness on this subject
 - c. Implementation of field visits together with GOM officials to develop mutual understanding of issues associated with sanitary landfill design, construction, operation and safe closure
 - d. Training of GOM officials on maintenance of data base and analysis

1.3 STUDY IMPLEMENTATION PROCESS

The Study has been implemented in two phases:

- (1) Phase 1 - Basic Survey and Preparation of Pilot Projects
- (2) Phase 2 - Preparation of Guideline & Action Plan and Implementation of Pilot Projects

Phase 1 of the Study has commenced in February 2003 and completed by the end of June 2003 and Phase 2 has started from July 2003 and ended in November 2004. The entire Study period is about 22 months and the schedule for implementation of each study task is shown in **Figure 1.3.1**.

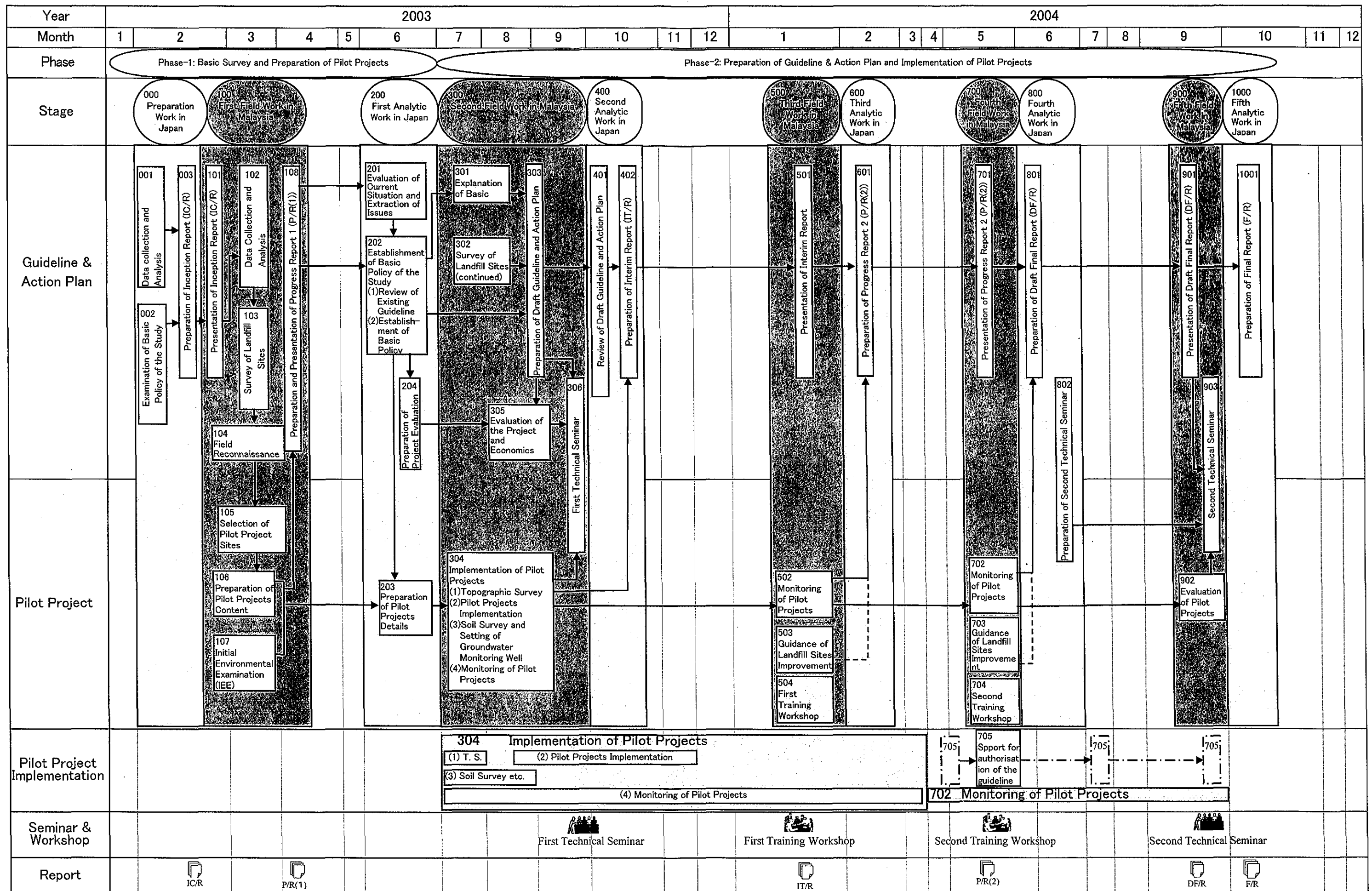


Figure 1.3.1 Study Implementation Schedule

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CHAPTER 2 OUTLINE OF SOLID WASTE MANAGEMENT IN MALAYSIA

2.1 REVIEW OF EXISTING LEGISLATION

With the exception of the Environmental Quality Act (EQA), there is at present, no Federal Legislation that deals with any aspect of Solid Waste Management (SWM). Consistent with the current constitutional position whereby State Governments appear to have jurisdiction over SWM, management of solid waste is covered by several State laws. The legislation in Malaysia directly or indirectly related to SWM, land matters, Local Government and the environment are shown in **Table 2.1.1**.

2.1.1 Local Government Act, 1976 (LGA)

In essence municipal administration is about providing essential services to the public. Such services include sanitation, solid waste management and public cleansing. In return for such services citizens pay rates to fund the activities of the authorities. The provision of such services and the collection of rates are governed by various laws. The principal legislation is the Local Government Act, 1976 (LGA), and applies throughout the Peninsular Malaysia. It provides for the formation of Local Authorities and governs their administration, operations, areas of control and regulation and financing. It also allows detailed regulations to be enacted by the Local Authorities to regulate specific matters such as to establish, maintain and compel the use of services set up for solid waste removal and public cleansing. Many Local Authorities have made such regulations, which are reflected in **Table 2.1.1**.

The LGA provides for the control of activities or nuisance within any Local Authority area. Local Authorities may:

- a) Maintain public health through the carrying out of sanitary services such as the removal of night soil, slops, rubbish and all kinds of refuse and effluents;
- b) Prevent littering or depositing of any waste or filth;
- c) Prevent any waste from being allowed to flow into or discharge of any liquid or solid into drains or watercourses;
- d) Prohibit, abate, remove or prevent the occurrence of any nuisance;
- e) Collect rates (either consolidated or separate) from any holding within the Local Authority area, including where deemed necessary a sewerage improvement rate and a drainage rate; and

- f) Generally do all things necessary for, or conducive to, safety, health and convenience of the public.

Most major Local Authorities have enacted By-laws relating to the collection and disposal of refuse and wastes, including anti-litter provision. The major By-law related to SWM is the Refuse Collection, Removal and Disposal By-law. Other relevant By-laws are indicated in **Table 2.1.1**.

Table 2.1.1 List of Legislation Relevant to Solid Waste Management in Peninsular Malaysia

1. Street, Drainage and Building Act, 1974
2. The National Land Code, 1965
3. Environmental Quality Act, 1974
4. Town & Country Planning Act, 1976
5. Local Government Act, 1976
6. Federal Territory (Planning) Act, 1982
7. Land Acquisition Act, 1960
<u>RULES</u>
8. Planning Control (General) Rules
9. Uniform Building By-laws
10. Earthworks By-laws
11. Public Cleansing By-laws
12. Anti Litter By-laws
13. Refuse Collection, Removal and Disposal By-laws
14. Environmental Quality (Licensing) Regulation 1977
15. Environmental Quality (Sewage and Industrial Effluents) Regulations 1979
16. Environmental Quality (Prescribed Activities) (Environmental Impact Assessment) Order 1987
17. Environmental Quality (Scheduled Wastes) Regulation 1989
18. Environmental Quality (Prescribed Premises) (Scheduled Wastes Treatment and Disposal Facilities) Regulations 1989

2.1.2 Street, Drainage and Building Act, 1974 (SDBA)

The carrying out of any works for streets, buildings or drains is controlled under the Street, Drainage and Building Act, 1974 (SDBA). The SDBA provides power to Local Authorities to effect control on the deposition of any refuse, wastes or unwanted material onto any street, building or drains. The deposition of any thing or article on to streets such as to cause an obstruction is prohibited. In fact frontages of

streets have an obligation to keep the adjoining street clean (section 44). The construction of any building on ground that has been used as a landfill is prohibited (section 76). Building and Earthworks By-laws have been made by most Local Authorities or State authorities to control the carrying out of works. These By-laws contain provisions to control the effects of construction, and disposal of wastes arising from such activities.

Drainage in municipal areas is the responsibility of the Local Authorities under the SDBA (and LGA). The SDBA imposes an obligation on the Local Authority to construct and maintain drains. The Local Authority has powers under this Act to levy fees or charges to enable it to defray expenses in executing its functions. It also has powers to determine the location, design, flow and other detailed characteristics of drainage in any area within its jurisdiction.

Whilst the SDBA provides adequate powers for the design and layout of drainage it does not however provide for controls over the quality of discharge into such drains. The quality of discharge is controlled under the Environmental Quality Act, 1974 (EQA). The EQA controls largely point sources of discharge originating from premises such as factories and plants. Local Authorities have limited powers (under the LGA) in terms of controlling discharge of effluents and noxious substances into any drain within the local authorities area.

2.1.3 Environmental Quality Act, 1974 (EQA)

The EQA, a Federal law, is the principal legislation pertaining to environmental protection. Various sections of the EQA provide controls over air, water, soil and noise pollution. Section 21 provides powers for the Minister (of Science, Technology and Environment) to specify the acceptable conditions for emission or discharge of waste, pollutants or noise into any area of the environment while Section 15 provides powers for the Minister to make regulation for various purposes. Pursuant to these provisions, several regulations have been enacted. The Environmental Quality (Licensing) Regulations 1977 provides for licensing of prescribed premises or any premises that emit or discharge wastes or noise (greater than the prescribed volumes, intensity or quality) into the environment. The Environmental Quality (Sewage and Industrial Effluents) Regulations 1979 regulate effluent discharges from domestic, industrial and other point sources of pollution (such as leachate from sanitary landfills). The Environmental Quality (Scheduled Waste) Regulations 1989 imposes controls on “Scheduled Wastes”, which are generally classified as toxic and hazardous and include mainly wastes from industry but also some wastes from domestic sources (such as batteries). There are several other relevant regulations including the Environmental Quality (Clean Air) Regulations 1978, which applies to

emissions from industrial premises and will apply to emissions from incinerators. In addition the DOE has issued a Guideline for the disposal of solid waste on land namely the “Recommended Code of Practice for the Disposal of Solid Waste on Land”.

Section 34 (A) of the EQA provides for environmental impact assessment of prescribed activities. The Environmental Quality (Prescribed Activities) (Environmental Impact Assessment) Order 1987 prescribed various activities, for which an assessment of the environmental impacts be undertaken and report submitted to the Director General of Environmental for approval. Activities related to waste treatment and disposal of toxic and hazardous wastes and municipal solid waste are regulated by this Order. Construction of incineration, composting and recovery/recycling plants and all landfills require an EIA to be undertaken.

Amendments introduced in 1996 make provision for encouraging recycling of products. Section 30A enables the Minister to prescribe any substance as hazardous and require the substance “to be reduced, recycled, recovered or regulated’ in a manner to be prescribed by the Minister. Furthermore, any product may be required to contain a minimum content of recycled substances. Section 30B allows the Minister to specify guidelines and procedures on deposit and rebate schemes for the disposal of products that are considered to be “environmentally unfriendly or causing an adverse constraint on the environment’ so that the products may be recycled or disposed off in a sound manner. These provisions are far reaching and would enable the DOE and the nation to step into an era where products are designed with environmental friendly disposal in mind. These provisions have not been implemented as yet.

2.2 INSTITUTIONAL STRUCTURE FOR SWM

2.2.1 Introduction

The present management of solid waste may appropriately be divided according to the major players involved at various levels and their degree of involvement. The major players are the Federal, State and Local Authorities and the private/commercial operators.

The agencies relevant to solid waste management are provided in **Table 2.2.1**.

Table 2.2.1 Agencies Relevant to Solid Waste Management

a) Key Federal Agencies	
Federal Agency	Ministry
Economic Planning Unit (Social & Privatisation Divisions)	The Prime Minister's Department
Department of Local Government Department of Town & Country Planning	Ministry of Housing & Local Government
Department of Environment	Ministry of Natural Resources and Environment
Engineering Services Division	Ministry of Health
Treasury – Various Divisions	Ministry of Finance
b) State & Local Government	
Municipal or City Council	
District Councils (for areas outside the town administrative boundaries)	

Local Authorities are the lowest level of government within the structure of the government system in the country. Except for the Federal Territories and Putrajaya, Local Authorities are subservient to the State Government.

At the operating level there would be numerous stakeholders. This would include the concessionaires or privatised main service providers (Alam Flora Sdn Bhd, Southern Waste Management Sdn Bhd and Environment Idaman Sdn Bhd), subcontractors, transport operators, disposal and or landfill site operators, recycling vendors, equipment and chemical manufacturers, R&D institutions, industry association etc. The critical role played by all these organisations in maintaining the SWM machinery should not be underestimated.

2.2.2 Federal Government Agencies

(1) Ministry of Housing and Local Government (MHLG)

Local Government is a State matter in the Constitution. However, despite the constitutional position, the Federal Government has taken upon itself the responsibility to ensure that effective Local Government services are provided to the general public. This responsibility is channelled through the MHLG (see **Figure 2.2.1**). Within the MHLG, the Department of Local Government handles all related matters pertaining to this issue. The MHLG is responsible for the development of national policies related to Local Government. It plays a coordinating role pertaining to the development, financing and operations of Local Authorities. All Local Authority applications for Federal Government financial and development assistance are channelled through the Ministry for consideration before it is forwarded to the

central agencies for approval. Issues such as privatisation of SWM services would be matters directly under the purview of this Ministry.

The Department of Local Government (see **Figure 2.2.2**) has been particularly active in developing uniform standards, by-laws and guidelines for use by Local Authorities. The Action Plan for a Beautiful and Clean Malaysia (the ABC Plan) was a document that was prepared by the Ministry with the assistance of the Japan International Cooperation Agency (JICA). The Ministry is also the Secretariat for the National Council for Local Government, which is the supreme body for the coordination of all policies and laws related to Local Authorities. Any move to change existing laws or introduce new laws related to Local Government is required to be submitted for consideration by this Council.

The Town and Country Planning Department, under the MHLG, is another important agency, which can play a crucial role in SWM. The Department is responsible for the implementation of the Town and Country Planning Act 1976 (TCPA) and it advises State Governments with regards to land use and physical planning. The Department is responsible for the preparation of detailed plans for urban development and the allocation of land for various purposes. Such detailed plans include the identification and allocation of sites for the treatment and disposal of solid wastes.

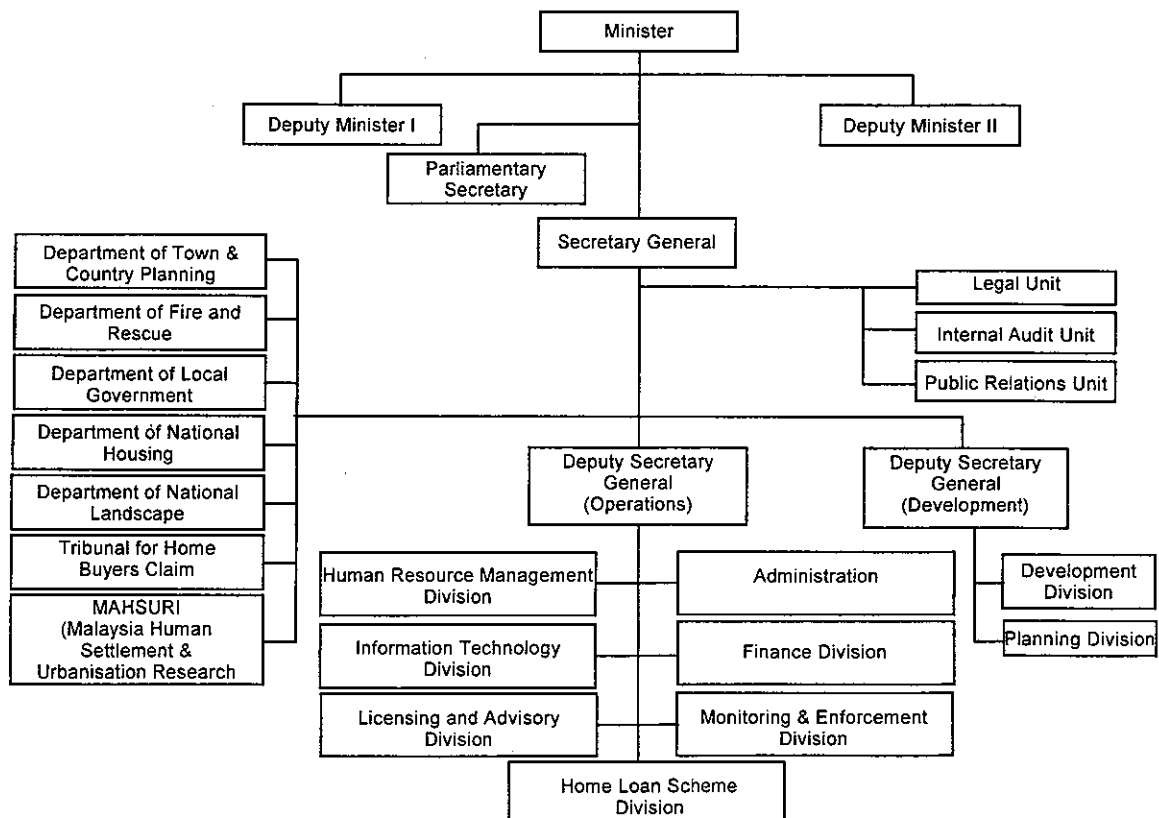


Figure 2.2.1 Organization Chart of Ministry of Housing and Local Government

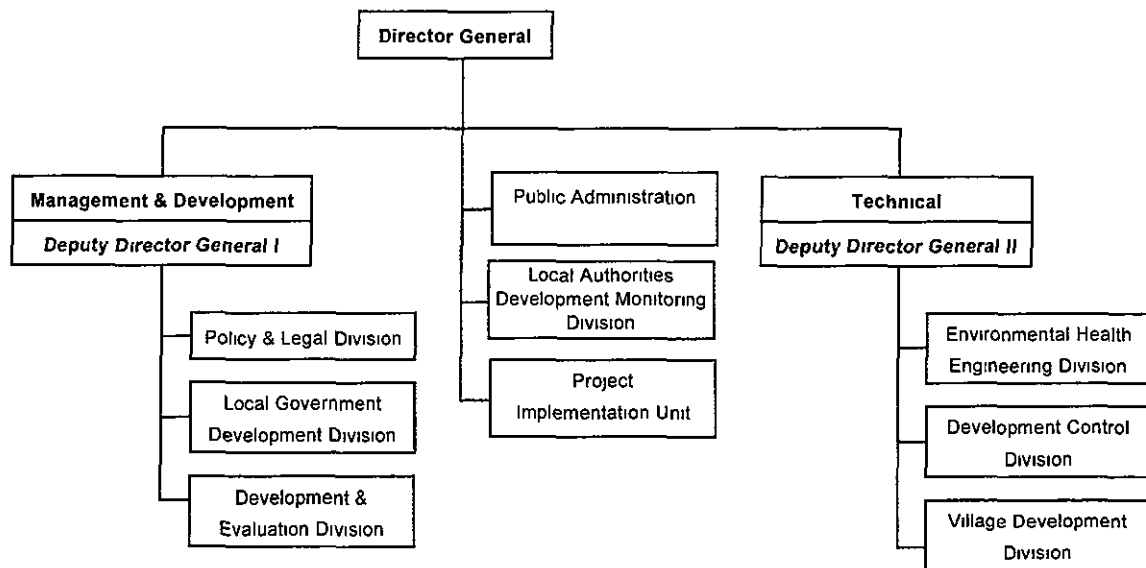


Figure 2.2.2 Organization Chart of Department of Local Government

(2) Economic Planning Unit, Prime Minister's Department

The EPU is one of the central agencies of the Government for planning. Specifically it is charged with charting the economic development of the nation. National development plans are produced by the EPU every five years and this will include matters pertaining to SWM. Financial allocations for development projects are largely determined in accordance with the five year plans. The EPU is also responsible for privatisation programmes. The appointment of the concessionaires for the management of solid wastes was undertaken by the EPU. Major capital investment in solid waste management facilities such as incinerators or sanitary landfills, particularly where it involves federal funding, would generally require the approval of the EPU.

(3) Ministry of Finance

The Ministry of Finance is also a central agency. It is the approving agency for all budgetary and financial allocations to government agencies. Annual allocations are approved by this Ministry. Allocations of grants or loans to Local Authorities would require the approval of this Ministry.

(4) Ministry of Natural Resources and Environment – Department of Environment (DOE)

The DOE is charged with the responsibility for the prevention, control and regulation of environmental pollution. It is the main implementing agency for the EQA. In relation to wastes management, the DOE's emphasis is on the control and regulation of scheduled wastes, while control the management of non-scheduled solid wastes rests with the Local Authorities. The DOE however has power to impose controls on SWM facilities particularly where it involves incinerators or landfills, through the EIA provisions. The DOE has issued the Guidelines on the Code of Practice for the Disposal of Solid Waste on Land. This Code and the other existing regulations provide advice to the Local Authorities on the development, siting and operation of landfills and incinerators.

(5) Ministry of Health – Engineering Services Division

The Ministry of Health (MOH) is responsible for public health in the country. Its role in SWM however is, at this juncture, confined to ensuring that solid wastes are disposed off in a hygienic way in areas where no Local Authority has jurisdiction. Such areas are largely rural areas.

2.2.3 State Government and Local Authorities

City Councils (Majlis Bandaraya) are established for those large urban areas which have been conferred city status (generally an area having a very large population). Municipal Councils (Majlis Perbandaran) are established for areas with more than (100,000) population. District Councils (Majlis Daerah) are administered by District Officers who are also in charge of the overall administration of the district. These districts may be largely rural in nature with very small urban conurbations. All these councils are created by the State Governments in consultation with the Minister for Housing and Local Government and are established by virtue of the provisions of the LGA. SWM and public cleansing traditionally have been Local Government services. Local Authorities are responsible to State Government. Local Authorities operate as a City Council, Municipal Council or District Council administering a pre-defined local administrative area. The powers of local authorities are vested in the *Local Government Act 1976 (LGA)* and the *Street, Drainage and Building Act, 1974 (SDBA)*. In addition, local authorities have also been vested with powers to implement the *Town and Country Planning Act 1976 (TCPA)*.

The functions of the Local Authorities can be categorised in terms of their activities. These activities include the following:

- a) Determination of policy or broad guidelines for action
- b) Planning and budgeting for the five-year socio-economic development programmes and annual programmes within the policy framework (directed and approved by the State Government in respect of the Municipalities and Local Authorities) given the financial and administrative constraints.
- c) Control or regulation of new development and activities that could create a public nuisance or be injurious to health.
- d) Provision of services which can be broken down into sub activities such as programme planning, development and operation.
- e) Monitoring of the social and physical environment, including aspects of environmental quality and health.
- f) Financial management including determining tariff and assessment rates.

2.2.4 National Councils

The National Councils are national level sectorial councils which report directly to the Federal Ministerial Cabinet and advise the Federal and State Governments on sectorial policies and guidelines. Presently, the Councils that have relevance for solid waste management include:

- a) National Land Council
- b) National Council for Local Government; and
- c) Environmental Quality Council (advises the Minister of Science, Technology & the Environment)

2.2.5 Non-Government Stakeholders

There are several groups in the private sector that are stakeholders in solid waste management. They include the following:

(1) Solid Waste Concessionaires

These are the companies that were awarded the concession based on a regional basis.

- Alam Flora Sdn Bhd
- Southern Waste Management Sdn Bhd
- Environment Idaman Sdn Bhd

(2) Solid Waste Contractors

These are the companies that were given contracts for solid waste collection services in the concessions areas in the Local Authority areas where solid waste services have not been taken over.

(3) Solid Waste Recyclers

These are the companies that utilize recyclables in their manufacturing process. The main recyclables used are paper, plastic, glass and aluminium cans.

2.2.6 Research Institutions and Universities

The stakeholders from research institutions and universities provide an important link by carrying out studies related to solid waste. They also provide technical expertise to assist the government in assessing waste management technologies. Some of these organisations provide facilities for analytical purposes e.g. for waste composition and characterisation.

2.2.7 Non-Government Groups

The non-government stakeholders who have a direct or indirect role in solid waste management include environmental organisations, social and residents associations, manufacturer's associations, consumer associations, the construction industry, property developers and professional associations.

2.3 PRIORITY PLANS ON SWM AND PRIVATISATION

2.3.1 Priority Plans on SWM

Priority plans showing the government development policy related to the solid waste management in Malaysia are the "*Eighth Malaysian Plan (EMP), 2001-2005*" and the "*National Strategic Plan for Solid Waste Management (NSP), 2003*". In this section, these plans are briefly reviewed.

(1) Eighth Malaysian Plan 2001-2005 (EMP)

The first Malaysian development plan was issued in 1965 covering the period from 1966 to 1970. Currently, it is in a middle of the eighth plan which covers the period from 2001-2005. The EMP is placed as the first phase in implementation of the Third Outline Perspective Plan for 2001-2010 (OPP3) which will chart the development of the nation in the first decade of the 21st century.

The EMP does not specifically mention about the SWM sector, however, it is described with relationship to the privatisation of the SWM.

The strategies for privatisation as stated in the EMP are as follows:

- Emphasising projects which will stimulate economic growth;
- Further strengthening and streamlining the implementation process to ensure the effectiveness of the privatisation program;
- Ensuring that privatised projects are commercially viable and contribute to the social well-being;
- Strengthening the regulatory authorities to protect consumer interests and to foster the health development of the privatised sector;
- Enhancing Bumiputra participation through vendor schemes and provision of better access to capital
- Promoting wider public participation in privatised entities through public listing.

(2) National Strategic Plan for Solid Waste Management (NSP)

National Strategic Plan for Solid Waste Management (NSP) has been prepared by the Local Government Department of the Ministry of Housing and Local Government in 2003. The status of the NSP is still confidential; therefore, details are not yet ready for release to the public.

However, it should be noted that one of the main issues for the safe closure of landfill sites are “who will be responsible for this matter (institutional set up)” and “who will pay for the measures (fund resources)”. From this point of view, adjustment with the NSP is considered to be substantial for the preparation of landfill safe closure guideline.

The objectives of the NSP are:

- To provide a strategic framework related to the overall management of solid waste in Malaysia including the scope of privatisation and implementation strategies, taking into account of current obstacles or shortfalls faced in implementing the privatisation policy; and
- To recommend an effective management plan, which identifies the roles of each of the stakeholders, and actions that are required to be taken to meet the objectives of the national development policy.

2.3.2 Privatisation of SWM

(1) Privatisation Practice on SWM

Privatisation of SWM sector in Malaysia is still in a transition period. In order to introduce the full privatisation in Malaysia, the NSP was prepared.

In October 1994, the Government invited private firms to bid for the privatisation of the national solid waste management system. In December 1995, the Government issued letters of intent to four consortia, which gave them the exclusive right to negotiate with the government over the possible structure of regulation, and over tariff structures and levels.¹ The first takeover started in January 1997 with interim agreements for three-year period between the local authorities and the concessionaires.²

At this stage, whole Malaysia has been divided into four regions as follows, and four consortia were selected for each region.

- Central region: Selengor, Pahang, Terengganu and Kelantan States, and FTKL
- Northern region: Kedah, Penang, Perak and Perlis States
- Southern region: Johor, Melaka and Negeri Sembilan States
- East Malaysia: Sabah and Sarawak state and FT Labuan

However, as to date, concessionaire took over the SWM works from Local Authorities only in the Central region (by Alam Flora Sdn Bhd), under an interim agreement, and is partially introduced in the Southern region (by Southern Waste Management Sdn Bhd). In the Northern region and the East Malaysia, concessionaire arrangements have yet to be negotiated.

The EMP summarises the current condition of the privatisation of SWM sector as follows;

“The privatisation of the solid waste disposal services was divided into four regions covering the central and eastern region; the Northern region; the Southern region; Sabah, Sarawak, and the Federal Territory of Labuan. Although the privatisation of solid waste disposal was not fully implemented, the concessionaires for the central and eastern regions as well as the southern region took over the services, on an interim basis, from several Local Authorities in the respective States.

As a result of the takeover, there was a general improvement in the level of services of the solid waste collection. To ensure optimum efficiency in the waste collection

¹ National Economic Research Associates, 1997

system, the concessionaires reorganised and optimised their collection routes, resulting in an increase in the number of collection per trip. For the Central region, the number of collections per trip increased to an average of 1,100 during the interim period, from about 700 before the interim period. In terms of improving the storage system, the concessionaires also introduced and provided standardised waste bins with wheels in certain areas. To further improve service level to the public, the concessionaires also purchased additional equipment and vehicles as well as invested in improvement works to the existing landfills.”³

For example, the “Performance Standards” regarding waste collection agreed between MD Pekan and Alam Flora Sdn Bhd is divided in three component parts; i.e. collection, cleansing and grass cutting. Extracts of the performance agreement are shown in **Table 2.3.1**.

Table 2.3.1 Performance Standards for Waste Collection (Example)

1. Collection		
	Type of Solid Waste	Frequency of Collection Service
	Household solid waste from Residential Kerbside	3 times per week
	Household solid waste from Residential Highrise, such as flats and condominiums	3 times per week
	Commercial solid waste from shophouses	Daily (except Sunday)
	Institutional solid waste from schools, higher learning institutions and government departments	6 times per week (working days only)
	Commercial solid waste from markets	Daily
	Hawker stalls (gerai) along the roadside	As and when required
2 Cleansing		
	a. Drain	Open cement drains, slab covered cement drains, cement drains covered by fixed concrete slabs, monsoon drains, scupper drain, sump, culvert, out-let
	b. Roads and Public Places	Main road, protocol road, footways and paths, road, footway and oaths within residential areas
	c. Public Places	
	d. Cleansing after storm, etc	
	e. Collection from Litter Bins	
	f. Market Grounds	Pekan Sari and Pasar Tani
3. Grass Cutting		
	Service	Frequency
	Cutting and maintaining grass on the kerbsides of the roads, road divides and (applicable areas) in commercial and industrial areas except for the roads, road dividers and areas maintained by Jabatan Kerja Raya.	Once in three weeks
	Cutting and maintaining grass in public places.	Once in three weeks

Source. MD Pekan

² Privatisation of Waster, Sanitation & Environment-related Services in Malaysia, JICA, 1999

³ EMP 2001-2005, P.188

(2) Contracted-out Landfill Site Operation

In Malaysia, at present there are no privately owned landfill sites and all the landfill sites are either owned by the State Government or by the Local Authorities. However, in recent years, several landfill sites in the Peninsular Malaysia have now being operated by the State or LA appointed private companies.

Under the interim agreements, Alam Flora Sdn Bhd took over the operations of 20 landfill sites (1 in Kuala Lumpur, 5 in Selangor and 14 in Pahang) from the Local Authorities. In Pahang, all the landfill sites are operated by Alam Flora.

The Southern Waste Management Sdn Bhd has took over and manage 20 landfill sites (10 in Johor, 8 in Negeri Sembilan and 2 in Malaka) from LAs.

The list of landfill sites operated by the Alam Flora is shown in **Table 2.3.2**.

Table 2.3.2 Landfill Sites Operated by the Alam Flora

No	States	Landfill nos. operated ^{*)}	Landfill nos. by Alam Flora	Local Authority	Landfill site operated by Alam Flora
1	KL	1	1 (100%)	DBKL	Taman Beringin
2	Selangor	14	5 (36%)	MP Selayang	Kundang
3				MD K. Langat	Sg. Sedu
4				MD Sepang	Ampar Tenang
5				MD K. Selangor	Kg. Kubang Badak
6				MD S. Bernam	Sg. Besar
7	Pahang	14	14 (100%)	MP Kuantan	Jln Jerangau – Jabor
8				MD Pekan	Jln Pekan – Nenası
9				MD Rompin	Kg. Ferı
10				MP Temerloh	Ulu Tualang
11				MD Jerantut	Kg. Mat Kilau
12				MD Maran	Maran
13				MD Maran	Jengka
14				MD Maran	Jengka
15				MD Bera	Chuat
16				MD Bentong	Chamang
17				MD Bentong	Chamang
18				MD Raub	Cheroh
19				MD Raub	Cheroh
20				MD Lipis	Lipis

Note. ^{*)} Data source of landfill numbers operated is MHLG in 2002

Source: Alam Flora Sdn Bhd, 2003

Table 2.3.3 shows the list of landfill sites visited by the JICA Study Team in March 2003 through the landfill inventory survey exercise. The operator of each landfill site; i.e. the Local Authority or the private companies, are tabulated in the table.

Among the 39 landfill sites visited, 21 sites (approx. 55%) are operated by the Local Authorities and 18 sites (approx. 45%) are by private companies. It can be seen from the table that majority of the States in the Peninsular Malaysia have subcontracted

the operations to the private company, with the exception of Terengganu and Kelantan (in the Central region). It should also be noted that all the landfill sites visited in Negeri Sembilan, Melaka (in Southern region) and Pahang (in Central region) are operated by the LA appointed private companies.

Table 2.3.3 Operation Body of Several Landfill Sites

No	State	Local Authority	Name of Landfill Site	Operation Body	JICA Inventory No.
1	Selangor	MP Klang	Telok Kapas	L.A.	SL-02
2		MP Kajang	Sungai Kembong	L.A.	SL-03
3		MP Selayang	Kundang	Private	SL-04
4		DB Kuala Lumpur	Taman Beringin	Private	SL-05
5	N.Sembilan	MP Nilai	Pajam	Private	NS-01
6		MP Seremban	Sikamat	Private	NS-03
7		MP Port Dickson	Bukit Palung	Private	NS-05
8		MP Port Dickson	Sua Betong	Private	NS-07
9	Melaka	MD Alor Gajah	Air Molek	Private	ML-01
10		MB Melaka	Krubong	Private	ML-03
11	Johor	MP Muar	Bakri	L.A.	JH-02
12		MP JB Tengah	Ulu Tiram	Private	JH-03
13		MD Kota Tinggi	Batu Empat	Private	JH-07
14		MD Kota Tinggi	Sungai Rengit	Private	JH-08
15		MD Mersing	Jemaluang	L.A.	JH-10
16		MD Mersing	Endau	L.A.	JH-11
17		MD Mersing	Sri Pantai	L.A.	JH-12
18	Pahang	MD Rompin	Kampung Feri	Private	PH-01
19		MD Pekan	Keledang	Private	PH-02
20		MP Kuantan	Jabor Jerangau	Private	PH-06
21	Terengganu	MP Kemaman	Gelugor	L.A.	TR-03
22		MP Kemaman	Mak Cili Paya	L.A.	TR-04
23		MP K. Terengganu	Kubang Ikan	L.A.	TR-07
24	Kelantan	MP Kota Baru	Tebing Tinggi	L.A.	KL-02
25		MD K. Krai Selatan	Bukit Tembeling	L.A.	KL-04
26	Perak	MD Kinta Selatan	Sg. Siput Selatan	L.A.	PR-01
27		MB Ipoh	Bercham	Private	PR-04
28		MB Taiping	Jebong	L.A.	PR-06
29		MD Tapah	Pekan Getah	L.A.	PR-08
30		MD Tapah	Bidor	L.A.	PR-09
31	Penang	MP Pulau Pinang	Jeti Jelutong	L.A.	PP-01
32		MP Seberang Perai	Ampang Jajar	L.A.	PP-02
33		MP Seberang Perai	Pulau Burong	Private	PP-03
34	Kedah	MP Kulim Kedah	Padang Cina	L.A.	KD-01
35		MD Baling	Pulai	L.A.	KD-02
36		MP Sungai Petani	Semeling	L.A.	KD-04
37		MP Kota Setar	Bukit Tok Bertandok	Private	KD-06
38		MD Kubang Pasu	Paya Kemunting	L.A.	KD-07
39	Perlis	MP Kangar	Kuala Perlis	Private/ L.A.	PL-01

2.4 METEOROLOGICAL AND GEOLOGICAL PROFILE OF MALAYSIA

When considering solid waste management operation, meteorological and geological conditions have significant importance. Meteorological condition such as temperature and rainfall directly affects the organic decomposition as well as leachate at landfill site. Geological condition, especially hydrogeological condition, also directly affects the penetration and transport of pollutant from the landfill sites in the groundwater aquifer. The meteorological condition of Malaysia is characterised as hot and humid tropical climate. Dairy average room temperature is between 21°C to 32° C. There are monsoon period dominated by the wind from the Southwest (end of May to September) and than dominated by the wind from the Northeast (November to March), as well as two transitional periods between the two monsoons. Generally, the period from April to July is considered to be the rainy season, and from October to January is considered to be the dry season.

East Malaysia, i.e. Sabah and Sarawak, has an annual rainfall as high as 5000mm, while Peninsular Malaysia has approximately 2500mm. **Table 2.4.1** shows the past 5 years monthly total rainfall and total solar evaporation data from three meteorological stations, i.e. Bayan Lepas (Pulau Penang), Kuantan (Pahang) and Subang (Selangor).

Table 2.4.1 5 Years Total Rainfall and Total Solar Evaporation

Year	Months	Station : Bayan Lepas		Station : Kuantan		Station : Subang	
		Total Rainfall	Total Solar Evaporation	Total Rainfall	Total Solar Evaporation	Total Rainfall	Total Solar Evaporation
		(mm)	(mm)	(mm)	(mm)	(mm)	(mm)
1998	Jan	84.8	145.1	326.0	103.0	196.0	133.9
	Feb	71.2	144.2	1.2	134.8	162.9	147.1
	Mar	79.6	156.0	53.1	141.4	179.2	164.0
	Apr	75.7	144.1	11.0	167.0	185.7	148.9
	May	355.4	125.3	59.2	141.6	309.9	159.7
	Jun	271.3	103.5	147.0	117.3	122.6	137.0
	Jul	295.2	101.2	201.4	126.3	204.0	131.1
	Aug	304.8	96.3	364.1	107.8	348.9	110.0
	Sep	251.8	97.2	47.7	128.5	147.6	131.4
	Oct	547.0	82.4	343.0	126.4	124.8	144.0
	Nov	516.9	82.3	308.9	96.4	199.2	129.4
	Dec	178.9	93.4	1107.9	76.5	238.2	86.4
	TOTAL	3032.6	1371	2970.5	1467	2419	1622.9
1999	Jan	155.5	121.1	689.8	72.0	174.2	97.1
	Feb	330.8	239.2	190.6	114.2	213.6	118.1
	Mar	119.0	106.8	296.6	124.2	389.7	112.0
	Apr	328.7	102.2	302.0	109.8	71.2	140.6
	May	173.3	106.9	284.6	124.8	315.2	102.4
	Jun	246.9	93.4	158.6	106.9	24.8	123.4
	Jul	214.8	104.5	102.9	131.4	118.9	136.0

	Aug	506.6	85.5	228.5	127.4	99.7	114.4
	Sep	472.5	86.6	175.5	111.4	299.9	104.2
	Oct	453.6	76.9	181.8	95.0	376.4	96.0
	Nov	171.9	85.4	268.9	86.1	405.6	114.9
	Dec	213.5	102.3	362.4	79.8	234.4	95.5
	TOTAL	3387.1	1310.8	3242.2	1283	2723.6	1354.6
2000	Jan	178.4	109.1	398.6	95.8	330.3	112.2
	Feb	193.9	106.1	371.4	87.5	111.9	107.9
	Mar	256.3	91.4	208.5	122.0	225.0	143.6
	Apr	121.5	95.4	250.5	120.5	348.8	117.0
	May	350.4	88.3	127.0	124.8	192.4	130.0
	Jun	208.5	85.2	212.0	107.4	102.7	102.4
	Jul	106.6	84.2	124.0	120.1	147.7	138.6
	Aug	209.9	95.8	211.8	132.8	226.7	113.3
	Sep	308.9	94.7	110.6	106.7	239.0	95.6
	Oct	556.3	84.0	386.2	124.6	236.3	142.6
	Nov	108.2	86.2	201.0	88.4	354.7	84.2
	Dec	54.3	101.9	265.8	86.5	296.0	114.2
	TOTAL	2653.2	1122.3	2867.4	1317.1	2811.5	1401.6
2001	Jan	75.8	90.2	451.6	97.0	378.3	80.1
	Feb	18.4	109.0	102.0	103.6	112.3	92.3
	Mar	184.4	110.4	347.2	109.1	253.3	127.5
	Apr	293.3	97.6	94.1	117.3	467.3	111.3
	May	251.4	97.9	156.2	124.2	105.9	100.1
	Jun	148.6	94.1	221.5	115.1	175.1	125.6
	Jul	227.2	104.4	98.5	141.2	185.7	125.2
	Aug	282.2	95.7	235.6	129.1	111.3	132.8
	Sep	247.4	98.7	67.5	127.7	215.3	129.7
	Oct	350.3	87.0	274.9	114.0	277.9	118.6
	Nov	202.3	91.0	219.2	75.5	221.8	113.2
	Dec	53.4	118.6	1471.1	65.9	147.3	120.1
	TOTAL	2334.7	1194.6	3739.4	1319.7	2651.5	1376.5
2002	Jan	12.8	143.4	61.2	99.0	117.7	129.1
	Feb	38.8	138.9	10.0	126.0	138.2	144.7
	Mar	77.2	155.1	158.3	158.1	141.1	160.8
	Apr	255.4	127.0	118.4	135.0	438.7	140.0
	May	77.0	117.6	346.6	119.9	84.9	143.4
	Jun	120.0	104.0	144.4	113.1	131.2	117.4
	Jul	144.6	106.1	147.4	138.9	67.1	135.0
	Aug	134.8	99.4	344.5	129.3	202.0	132.8
	Sep	371.2	94.3	169.9	127.1	358.6	127.9
	Oct	206.4	117.9	173.4	142.7	288.0	121.7
	Nov	198.6	101.2	218.3	115.3	428.1	140.3
	Dec	239.4	119.3	644.4	104	298.9	125.0
	TOTAL	1876.2	1424.2	2536.8	1508.4	2694.5	1618.1

Source: Perkhidmatan Kajicuaca Malaysia, Records of Meteorological Data

1. Station : Bayan Lepas (P.Pinang), Lat. : 05 ° 18' N, Long. : 100 ° 16' E, Ht. Above MSL : 2.8 m
2. Station : Kuantan (Pahang), Lat. : 03 ° 47' N, Long. : 103 ° 13' E, Ht. Above MSL : 15.3 m
3. Station : Subang (Selangor), Lat. : 03 ° 07' N, Long. : 101 ° 33' E, Ht. Above MSL : 16.5 m

The Peninsular Malaysia can be further divided into three areas. The East coast has the highest rainfall from November to January, and dry season from June to July. The Central and West coast, except South-Western part, has biannual rainy and dry seasons. From October to November and from April to May are the rainy seasons.

The South-Western part of the peninsula, under the influence of the Sumatra Island, has less defined rainy seasons. Other consideration in terms of rainfall is the frequent local downpour which causes flooding, mudflow and landslide. Therefore drainage system of the site should take into account the intensive but transient rain load.

As for the geology of the Peninsular Malaysia, all the system ranging from Cambrian to Quaternary is represented. The pre-Triassic rocks are mainly marine while younger rocks are non-marine. Igneous rocks predominantly of granitic composition out crop almost half of the total surface area. These rocks commonly form the high mountain ranges aligned approximately North-South. The most dominant structural features in the peninsula are the large North-South to Northwest-Southwest trending faults. The region can be conventionally divided into three belts, 1) the Eastern belt, 2) the Central belt and 3) Western belt. Generally, the boundaries of the belt separate the predominantly granitic terrain of the East and West from the relatively less granitic area in the Central part of the peninsula. This division is also related to the tin mining area in East and West, and gold mining in Central belt.

From 1970s to mid. 1980s, Malaysia was the world largest producer of tin, accounting approximately 40% of the free world supply. All of the tin production was in the Peninsular Malaysia. Tin has been mined both from alluvial and lode deposits. Alluvial mining is the dominant production method. Such alluvial mining sites are distributed widely in Western and Eastern costal area. The area around Ipoh and Kuala Lumpur are well known for the rich deposit of tin and there are numerous alluvial mining ponds, many of which is used as dump site of the solid waste. Such mining sites are, in general, sandy alluvial and hence groundwater could be at high risk of pollution from the landfill operation.

The geology of the Borneo Island (East Malaysia, i.e. Sabah and Sarawak) is significantly different from that of the Peninsular Malaysia. In stratigraphy, the tertiary is most important and well developed in Borneo Island but in the peninsula, the tertiary is poorly represented. In pultonism, granitic intrusive occupy the large surface area of the Peninsular Malaysia but in Borneo Island pultonics occupy only a few percent of the total surface area.⁴

2.5 WASTE AMOUNT AND COMPOSITION

The amount of waste and composition in Malaysia shall be discussed briefly in order to understand the basis of solid waste management.

⁴ B.K.Tan, T.T.Kho, "Review of the development in the geology and mineral resources of Malaysia and Singapore Third regional conference on geology and mineral resources of Southeast Asia, Bangkok, Thailand"

2.5.1 Waste Amount Generated

There are a number of published statistics describing the waste generation rate and the quantity in Malaysia. **Table 2.5.1** shows the latest data published by the Ministry of Housing and Local Government in 2002.

The densely populated area such as the Federal Territory of Kuala Lumpur (FTKL), Selangor and Johor generated larger amount of solid waste. Especially in FTKL, the unit generation rate of waste is about 1.87 kg/capita/day that is more than double that of the other States.

The amount of waste generated in Malaysia in the recent year is estimated to be about 19,800 ton/day or about 7,227,000 ton/year. Taking into account the waste collection ratio of 90% in FTKL and 70% in other states,⁵ and waste recycling ratio of only 2%.⁶ The amount of waste disposed of at various landfill sites distributed across Malaysia is estimated to be about 13,500 ton/day or about 4,914,000 ton/year.

Table 2.5.1 Estimated Solid Waste Generated in Malaysia

No	States	Estimated Population (2002)	Unit Generation Rate (kg/cap/day)	Waste generation amount (ton/day)	Waste generation amount (ton/year)
1	Johor	2,366,934	0.88	2,083	760,260
2	Melaka	636,007	0.88	560	204,290
3	N. Sembilan	935,683	0.88	823	300,540
4	Selangor	3,493,602	0.88	3,074	1,122,140
5	Pahang	1,183,004	0.88	1,041	379,980
6	Terengganu	1,091,007	0.88	960	350,430
7	Kelantan	1,278,368	0.88	1,125	410,610
8	Perak	1,887,527	0.88	1,661	606,270
9	Kedah	1,636,095	0.88	1,441	525,790
10	P. Pinang	1,344,243	0.88	1,183	431,770
11	Perlis	241,644	0.88	213	77,620
12	Sarawak	2,007,528	0.70	1,405	512,920
13	Sabah	2,115,546	0.70	1,481	540,520
14	FTKL	1,470,875	1.87	2,751	1,003,950
Total		21,688,063	0.91	19,801	7,227,090

Note: Data for Peninsular Malaysia is taken from publications by Ministry of Housing and Local Government, Malaysia, 2002 Data for Sarawak and Sabah is taken from "NREB and DANCED, 2001"

2.5.2 Waste Composition and Characteristics

The waste composition and characteristics from Kuala Lumpur as analysed by NREB and DANCED in 2001 is tabulated in **Table 2.5.2**.

⁵ NREB and DANCED, 2001

⁶ Malaysia, 1992

The ratio of organic waste ranges from 62% (for high income residents) to 72% (for low income residents) and about 95% of residential waste is combustible. The average bulk density of residential waste is about 287.5 kg/m³ and the average moisture content is about 56.2%.

Table 2.5.2 Waste Composition in Kuala Lumpur

Item	Residential waste (%)			Commercial waste (%)	Institutional waste (%)
	High income	Middle income	Low income		
<i>Combustible</i>					
Food waste & organic	62.0	70.8	71.6	79.0	58.7
Mix paper	8.0	5.1	5.8	5.1	7.9
Mix plastic	9.3	11.3	13.3	9.1	16.1
Textile	2.2	1.3	2.4	0.8	0.8
Rubber & leather	0.8	0.6	0.5	0.8	0.1
Wood	0.5	0.4	0.5	1.9	0.2
Other combustible	0.0	0.0	0.0	0.0	0.0
Yard waste	11.8	4.7	1.0	0.2	9.7
Fine	0.6	0.7	0.5	0.1	0.5
Sub-total	95.0	94.7	95.5	97.1	94.0
<i>Incombustible</i>					
Glass	1.6	1.2	2.1	1.2	1.1
Ferrous	2.8	2.4	1.9	1.6	4.8
Aluminium	0.1	0.1	0.1	0.1	0.1
Nonferrous	0.0	0.0	0.0	0.0	0.0
Other incombustible	0.0	0.0	0.0	0.0	0.0
Other bulky waste	0.6	1.7	0.5	0.0	0.0
Sub-total	5.0	5.3	4.5	2.9	6.0
Total	100.0	100.0	100.0	100.0	100.0
Bulk density (kg/m ³)	273.1	310.7	278.8	372.1	277.1
Moisture content (%)	52.9	62.7	52.6	66.2	59.9

Source: NREB and DANCED, 2001

The waste composition as reported in most literatures published in Malaysia, including figures by the World Bank in 1999, shows the ratio of organic waste is less than 50%. Statistics gathered by the Government indicated the average amount of organic wastes for high income areas like Petaling Jaya and Kuala Lumpur is around 48.32%. This is followed by paper (23.56%), plastic and rubber (9.37%), metal (5.93%), wood (4.82%), glass and ceramics (4.03%) and textile (3.97%).⁷

For the purpose of this study, the preference is to use data recorded by the Local Authorities. It is apparent that the ratios of organic waste in local towns are higher than that of major cities. However, data for the bulk density of solid waste is limited and therefore it has been decided the Study will employ the figures as tabulated in **Table 2.5.2**.

⁷ Project Formulation Study for Promotion of Solid Waste Recycling in Malaysia by JICA, 2002