6.5.7 Monitoring of environment and landfill stabilisation

In accordance with the Guideline, for the Post Closure Management for Pekan Nenasi, the following monitoring programme has been recommended, as shown in **Table 6.5.11**.

Table 6.5.11 Monitoring Programme

Monitoring media/parameters	Item and parameters	Frequency	Location
Leachate	• pH • BOD • COD • Nitrogen (Ammonia, Nitrate, Nitrite) • ORP • EC • TOC	4 times/year	1 point/ leachate pond
Landfill gas	• Oxygen (O_2) • Nitrogen (N_2) • Methane (CH_4) • Carbon Dioxide (CO_2) • Hydrogen Sulfide • Temperature	2 times/ year	2 points/ site
Land subsidence	Topographic height of the top of the landfill	Once a year	1 point/ landfill block
Groundwater	Groundwater benchmark parameters	Once a year	3 points/ site
Surface water	Effluent standard parameters	Once a year	2 points/ stream

The site specific recommendations are as follows.

1) Leachate

Leachate should be monitored according to the guideline.

2) Landfill gas

If the waste thickness is more than 1.5m, landfill gas monitoring will be required. The gas vent pipes should be extended when necessary.

3) Land subsidence

Since the Pekan Nenasi Landfill is still relatively shallow, the subsidence may not be detectable. Nevertheless, the surface level should be monitored in accordance with the guideline.

4) Groundwater

All the groundwater samples exhibited deteriorating water quality that is not suitable for human consumption. It is recommended that additional monitoring well be provided at the eastern direction, at about 200-300 m east of well W3.

5) Surface water

Surface water should be monitored regularly in accordance with the guideline.

6.6 PILOT PROJECT - AMPANG JAYA LANDFILL SITE (SELANGOR)

6.6.1 Outline of the site

The Ampang Jaya landfill site, at Hulu Langat, was in operations from 1992 to 1998. The site was operated by MP Ampang Jaya and on closure, the land, together with the site, was reverted to the control of MP Kajang.

The site is located at about 3 km east of Ampang Jaya, on a hilly area near the basin of the Langat River. The Hulu Langat water intake point is located about 8 km down stream of the site.

About 400 tonnes/day of waste was disposed at the site (about 1 million tonnes in total). The waste was dumped from the top of the hill and filled at the western slope, eastern slope and at the bottom of western valley. In 1998, western slope became unstable and collapsed and the accident resulted in the death of 2 landfill workers and subsequently, the site was urgently closed.

During the operations of the site, some improvement works were carried out to reform the slopes, provide soil coverings, installation of gas ventilation pipes, and the installation of a leachate treatment plant and leachate pond. For access purposes, a temporary access road was constructed. However, due to the premature closure of the site, the leachate treatment plant was not completed and the entire site has been abandoned.

During the preliminary site visit survey in mid 2003, it was observed that the slopes have been covered with grass and shrubs, and leachate was observed flowing from the slopes and flowing into the nearby stream. The covering soil and surface water drainage were not sufficient. The site is now being used as an orchard at the top of hill and at part of the bottom valley.

The landfill gas contains about 22 % of methane and hydrogen sulphide (H_2S) observed at the gas discharge pipe installed at the hilltop. The stream at the eastern side of the hill seemed clean but contains about 40 ppm of nitrate compound (T-N). In the valley, leachate is leaking continuously. The main outflow is a wetland located at the centre of the valley. The amount of leachate flow is estimated to be about $100m^3$/day.

Since the site was abandoned after the landslide, the slopes remained in precarious state and posed a dangerous risk. The temporary access road and certain low lying areas have been badly eroded due to insufficient surface water drainage and the lack of maintenance.

The summary of the remedial actions/measures to be taken and evaluation at the closure of the site are tabulated in **Table 6.6.1**.

Table 6.6.1 Closure Measures Taken in 1998 and Its Evaluation

Items	Measures taken in 1998	Evaluation
Physical stability	Reform of eastern and western slope	The slope is covered by grass and seems to be safe but drainage system should be installed
Covering soil	Covering soil at top of the hill, eastern & western slope and bottom of valley	Covering soil is not sufficient at the top of the hill, eastern and western slope and bottom of valley
Surface drainage	Almost no drainage system	Temporary access road and main waterway is badly eroded. Drainage system should be constructed comprising of main drainage and surface drainage
Leachate management	Leachate treatment facility was constructed but abandoned	Leachate treatment facility has been abandoned. Leachate is flowing out mainly from the wetland located at the centre of western valley.
Gas management	Gas discharge pipes (Diameter 100 mm) was installed	Landfill gas is still being generated. Gas collection system should be installed when the final cover has been carried out.
Monitoring facility	No monitoring facility	Monitoring should be carried out on water quality of the eastern and western streams, leachate quality, landfill gas and settlements.

The brief description of the closed landfill operations and site characteristics are summarised in **Table 6.6.2**.

Table 6.6.2 Ampang Jaya Closed Landfill Operations and Site Characteristics

Operational Characteristics	Location Characteristics
⇒ Started operations in 1992 and closed in 1998 after an accident at the site ⇒ About 400 tonnes/day of waste was disposed at the landfill (about 1.0 million tons in total) ⇒ Waste was by dumped into the valley from the top and filled the western and eastern slopes and the bottom of the western valley	⇒ Located east of MP Ampang Jaya on a hilly area in the basin of Sungai Langat ⇒ The Hulu Langat water intake point is located about 8km downstream of the site

6.6.2 Safe closure plan

During the closure of the site, minor mitigating measures were carried out in order to close the site urgently. No great attention was made towards the safe closure of the site and hence now, the leachate and landfill gas are still being released in great quantities. Therefore, more additional measures should be carried out for the proper safe closure.

The proposed safe closure plan is shown in **Table 6.6.3**.

Table 6.6.3 Closure Plan for the Ampang Jaya Closed Landfill Site

Items	Proposed Action
1. Hydrogeological information	Hilly area and granite
2. Final site topographic plan	The gradient of the slopes should be checked and steeper part l should be moderated to the 1:2 gradient.
3. Final cover design	Barrier layer should be laid about 0.6 m thick Topsoil layer should be laid about 0.15 m thick
4. Covering soil material	Low permeability soil and good topsoil
5. Final landscape and site plan	Orchard or vacant land
6. On site facility	Gas discharge ventilation pipes
7. Surface water management plan	Installation of main drainage and surface drainage system; Monitoring the surface water quality
8. Ground water management plan	Installation of monitoring wells
9. Leachate management plan	Installation of leachate collection system and leachate treatment system
10. Landfill gas management plan	Installation of gas collection piping system and gas discharge pipe
11. Monitoring	Monitoring of water quality down stream. (East and west streams) Groundwater monitoring well Gas and waste layer monitoring well Leachate pond and gas discharge pipe will be used for sampling.

6.6.3 Ampang Jaya Pilot Project Implementation

Subsequent to the PP tender and evaluation exercise, the Ampang Jaya Pilot Project was eventually awarded to the successful contracting company, JDC (Malaysia) Corporation Sdn. Bhd, and the Design and Build Contract was signed on August 13th, 2003.

Following the commencement of the project, as part of the deliverables, the contractor prepared and submitted the project implementation schedule as shown in **Figure 6.6.1**.

The detailed design was completed and approved by the Study Team within three weeks from the project commencement date. Samples of the design drawings are shown in **Figure 6.6.2** and **Figure 6.6.3**. The final As-built drawings are provided in Volume 4, Chapter 8. The photographic records of the progress of the work and the main facilities are shown in **Plate 6.6.1** and **Plate 6.6.2** respectively.

The brief description and Bill-of-Quantities (BQ) of the Pilot Project is summarised in **Table 6.6.4**.

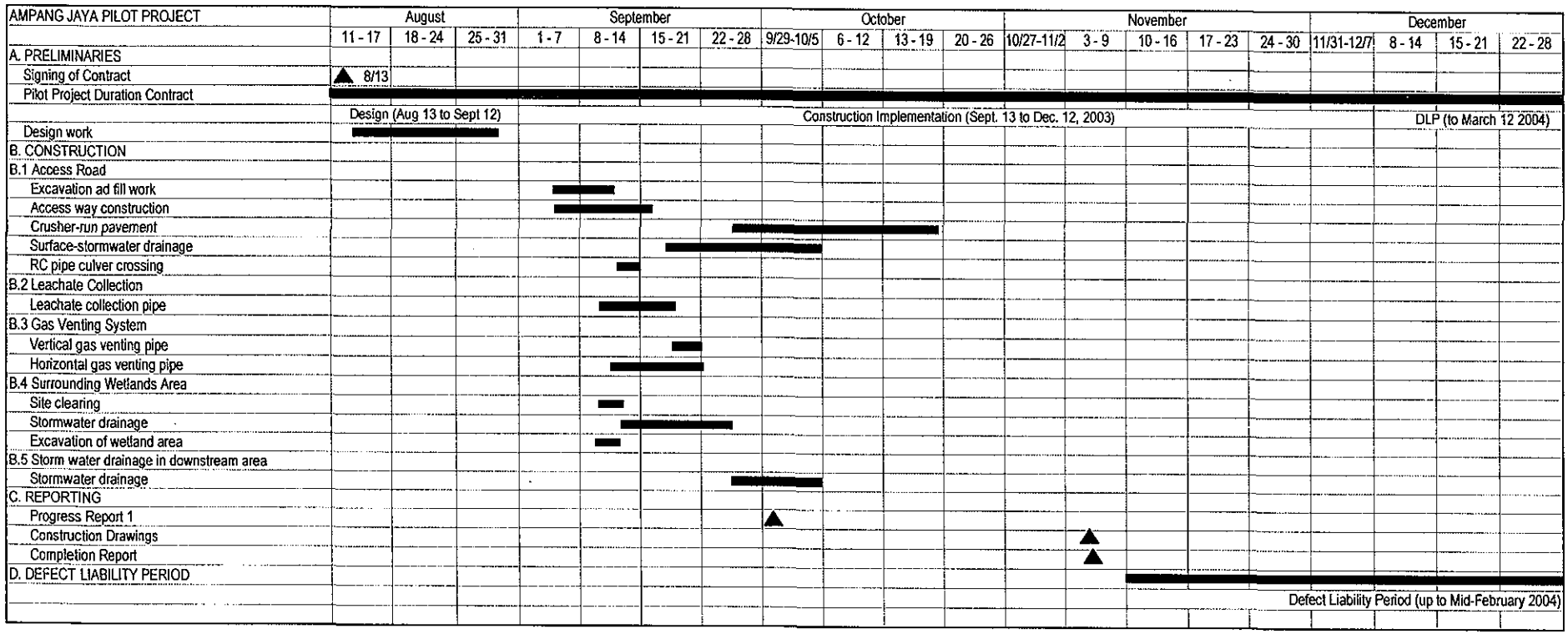
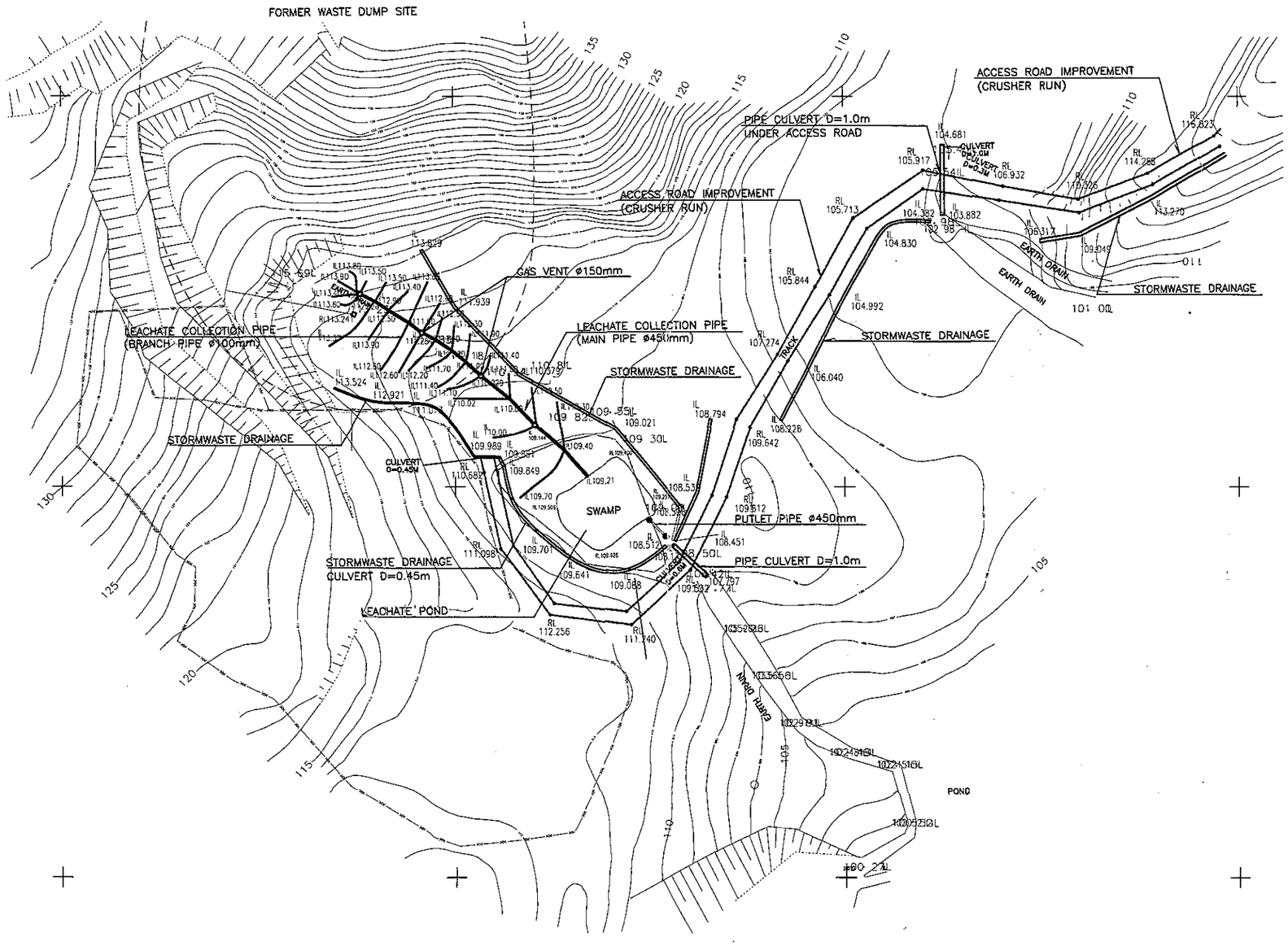
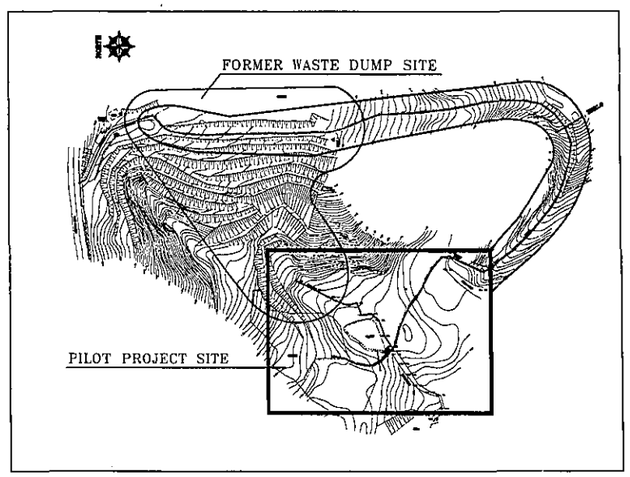


Figure 6.6.1 Project Implementation Schedule for Ampang Jaya Pilot Project

Table 6.6.4 Ampang Jaya PP Description

No.	Item/Description	Quantity
1	Access way through the site Improvement of existing access road which extends to the valley bed, descending from an elevation of 187.980 at the site entrance (Station 1) to an elevation of 105.800 at the pipe culvert crossing. Road section to be improved extends to a length of 1,032m.	
	Excavation and fill work *Cut and fill works to form subgrade.*	4,500m^3
	Access way construction (w = 7.0m) *Level the subgrade.*	7,350m^2
	Crusher-run pavement (t = 200mm) *Supply, level and compact crusher run of thickness 200mm.*	3,675m^2
	Surface storm water plastered drains (width 450 to 600mm) at the higher road elevation section *Install plaster drain along the inner access road edge to a length of approximately 400m.*	400m
	Surface storm water drainage (w = 600 to 900mm) installed at the lower road section as it descends into the valley *Supply and install precast RC drains off size 600 x 600mm and 900 x 900mm to a length of about 500m along the inner edge of the access road.*	500m
	Pipe culvert at crossings (dia. = 1m) *Supply and installation of concrete pipe culvert of diameter 1.05m, spun pipe, Class H below the road to channel the water in the existing earth drain below the road.*	45m
2	Leachate collection	
	Main leachate collection pipes (dia. = 450mm) *Supply and install perforated spun concrete pipe, Class H, of nominal diameter 450mm, including placing of gravel around the pipe, with partial excavation and preparation of pipe bed with crusher run of 200mm and over wooden sleeper/wedge with a length of about 130m. RC pipe is installed in 5 sections with inclinations of 1:26, 1:13, 1:4, 1:8 and 1:4 in ascending order. Elevations are RL 110 at the swamp and increasing to RL 125 at the foot of the waste slope.*	126m
3	Gas venting system and branch leachate pipes	
	Vertical gas venting pipe (dia. = 150mm) *Supply and install vertical gas ventilation perforated pipe, HDPE, of diameter150mm and heights of approximately 1.5m. Pipes are installed at four locations at the upper portions of the pipe at the pits were pipe inclination changes.*	4 units
	Horizontal leachate and gas venting pipe (dia. = 100mm) *Supply and install horizontal gas ventilation perforated HDPE pipe, of diameter 100mm, in trenches of size 500m x 350m, surrounded by gravel of size 25mm. Pipes installed in pairs at 7 points of intersection with the main leachate pipe and at varying lengths, with the total length of 500m. The ends of the pipes bend to the vertical position to serve as gas vents as well.*	500m
4	Surrounding wetland areas	
	Site clearing *Clearing the site, trees and shrubs in order to implement the construction of the storm water drainage and leachate retention pond.*	6,000m^3
	Storm water drainage (w = 600) *Supply and install RC pre-cast drains of 600 x 600mm surrounding the swamp (pond) and channelled to the earth drain in order to limit divert rain water from the pond.*	300m
	Excavation of wetland area *Deepening the swamp area to receive the collected leachate for retention before discharge into the water channel.*	1,500m^3
5	Storm water drainage in the downstream area	
	Storm water drainage (w = 1,000 mm) *Supply and install three RC pipes under the access road to channel storm water from the storm water drainage system and leachate from the retention pond to the earth drain.*	200m





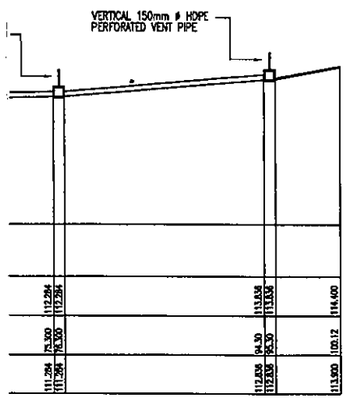
KEY PALN

NORTH

SCALE

0 20 40 60 80 100m

Figure 6.6.2 Layout Plan (Ampang Jaya Pilot Project)



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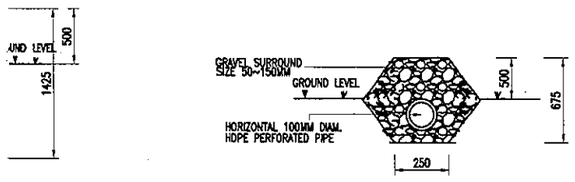

RROUND **TYPICAL SECTION OF GRAVEL SURROUND FOR 100mm Ø LEACHATE PIPE**

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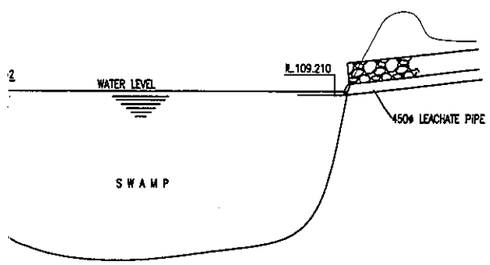

CROSS SECTION AT SWAMP AREA

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re 6.6.3 Typical Sections (Ampang Jaya Pilot Project)

Plate 6.6.1 Ampang Jaya Pilot Project 1

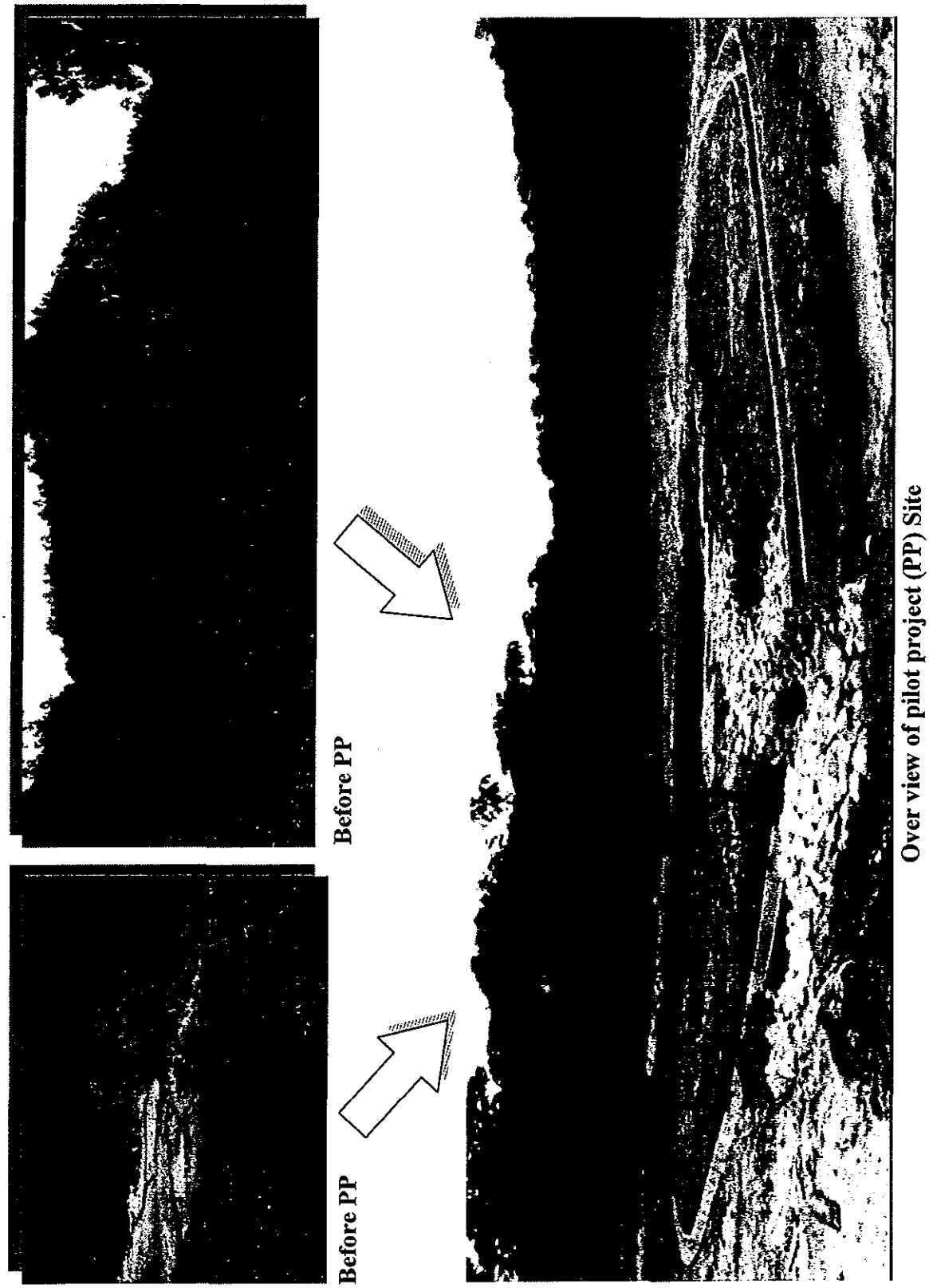
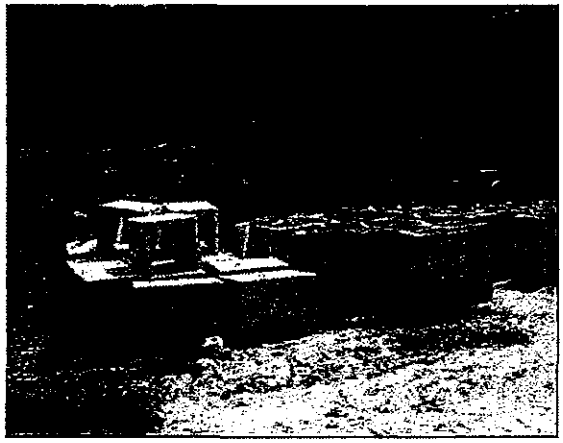


Plate 6.6.2 Ampang Jaya Pilot Project 2

Installation of leachate collection pipe

Storm water drainage below access road



U-shaped drainage

Gas ventilation pipe

Storm water drainage at upper valley

Improvement of access road and drain

6.6.4 Environmental Monitoring – Ampang Jaya PP

(1) Monitoring Programme

1) Sampling Quantity, Schedule and Locations

The following **Table 6.6.5** summarizes the sampling quantity of monitoring for Ampang Jaya pilot project site.

Table 6.6.5 Sample Number at Ampang Jaya Pilot Project Site

Sample type	Ampang jaya (Number of locations)
Surface water	2
Leachate	2
Groundwater	2
Gas	2

Sampling schedule and specific consideration is same as that applied for Ampang Jajar site. **Figure 6.6.4** shows the location of monitoring for each sample type.

2) Geological setting and Installation of monitoring well

The site is undulating hills with the elevation of approximately RL+90m to RL+190m. In general, the north-eastern part of the site is higher and it is sloping towards the western part of the site.

3) *Geological Background*

The site is located in the granitic area. Due to tropical climate, weathering generally extends to great depth into the granite body and the top portions are usually weathered into residual soils. The residual soil is composed of silt, clay and sometimes sand, depending on the degree of weathering and composition of parent rocks. The orientation of the soil profile is indicated in **Figure 6.6.5**.

4) Laboratory analysis

Analytical methods as well as QC/QA program are as same as that of Ampang Jajar and Pekan Nenasi.

The results of the laboratory analysis for both the sampling exercises are shown in **Table 6.6.6** and **Table 6.6.7**.

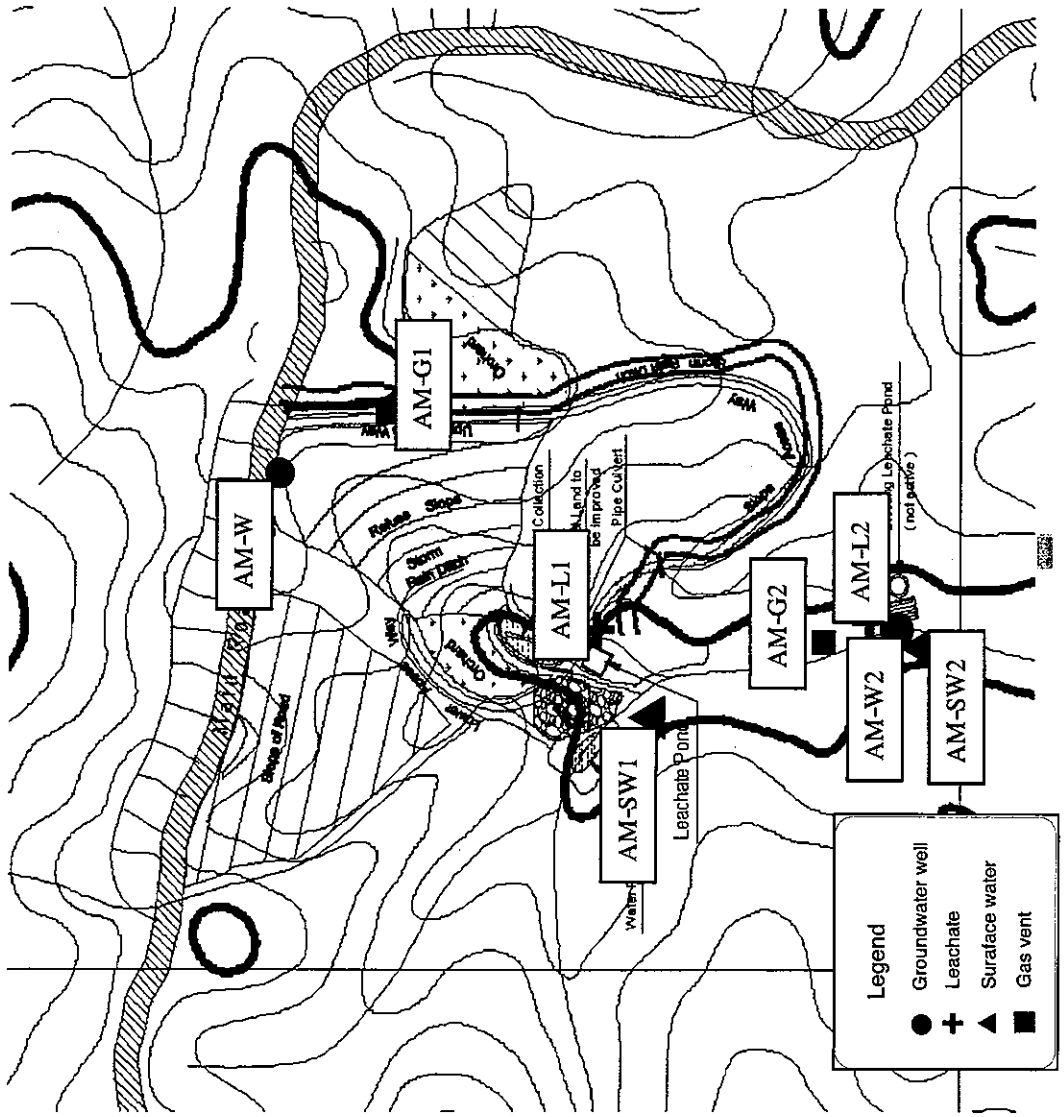


Figure 6.6.4 Map of Sampling Location for Monitoring, Ampang Jaya

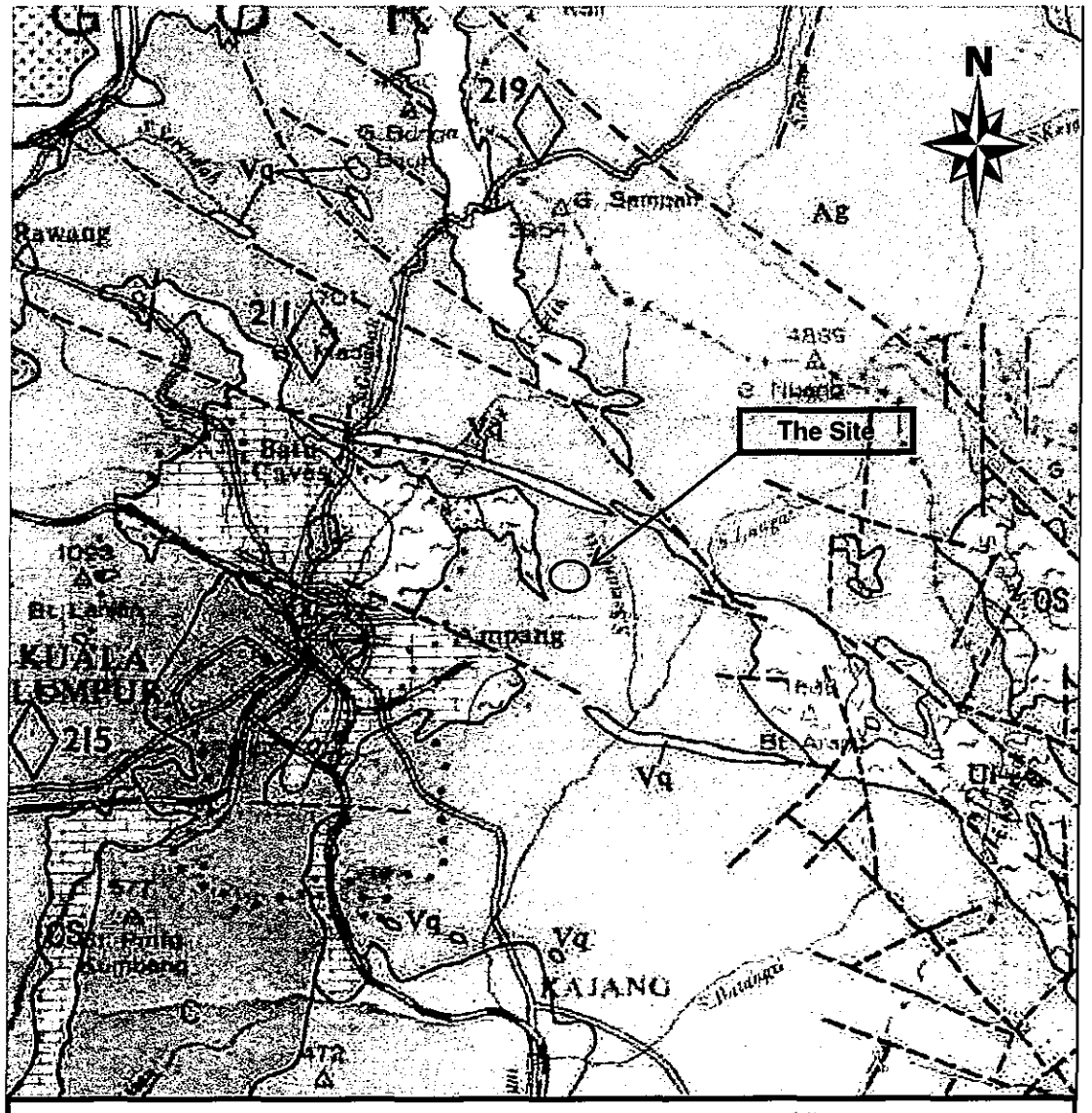


Figure 6.6.5 Map of Geological Setting, Ampang Jaya (reproduced from geological map published by Geological Survey Malaysia, 1985)

Table 6.6.6 Summary of Results - Physical Parameters

Samples taken on		*25/8/03*					
Test Parameters	Units	W1 09:45hrs	W2 13:15hrs	L1 10:45hrs	L2 11:50hrs	SW1 10:00hrs	SW2 11:30hrs
pH (*in-situ*)	-	7.5	5.9	8.2	6.9	6.0	6.9
Temperature (*in-situ*)	^{0}C	29	29	31	30	27	29
ORP	mV	10	-162	7	-18	66	25
Conductivity	mS/cm	0.25	1.16	5.15	1.89	0.031	0.301
Turbidity	NTU	23.2	200	72.8	58.4	46.9	60.5
DO	mg/l	0.75	2.85	1.92	3.13	4.13	4.17
BOD_5 at 20^{0}C	mg/l	8	18	67	14	1	17
COD	mg/l	28	251	813	130	8	45
Total suspended solid	mg/l	107	26	154	35	19	29
Samples taken on		*06/2/04*					
Test Parameters	Units	W1 15:10hrs	W2 12:55hrs	L1 12:35hrs	L2 11:50hrs	SW1 11:25hrs	SW2 12:10hrs
pH (*in-situ*)	-	7.1	6.7	8.5	8.1	6.9	6.8
Temperature (*in-situ*)	^{0}C	29	30	29	29	28	30
ORP	mV	-56	-44	77	-33	326	57
Conductivity	mS/cm	0.349	1.05	4.87	2.62	0.034	0.320
Turbidity	NTU	17.8	24.7	27.2	80.2	14.3	20.5
DO	mg/l	0.78	0.91	0.55	1.52	3.21	2.87
BOD_5 at 20^{0}C	mg/l	9	12	113	12	2	8
COD	mg/l	20	26	294	191	3	24
Suspended solid	mg/l	21	11	52	33	7	11
Samples taken on		*19/5/04*					
Test Parameters	Units	W1 13:50hrs	W2 12:45hrs	L1 11:10hrs	L2 12:10hrs	SW1 10:40hrs	SW2 12:20hrs
pH (*in-situ*)	-	7.4	6.0	8.3	6.9	6.4	6.9
Temperature (*in-situ*)	^{0}C	30	31	29	31	30	30
ORP	mV	-110	-82	0.44	-102	112	53
Conductivity	mS/cm	0.39	1.86	4.51	2.79	0.34	0.91
Turbidity	NTU	83.4	23.1	17.1	43.7	32.8	27.4
DO	mg/l	2.72	1.27	1.50	2.14	2.14	4.38
BOD_5 at 20^{0}C	mg/l	5	32	92	78	11	15
COD	mg/l	11	66	755	142	14	46
Suspended solid	mg/l	50	32	28	22	16	6
Samples taken on		*29/6/04*					
Test Parameters	Units	W1 -	W2 09:40hrs	L1 10:20hrs	L2 11:02hrs	SW1 11:07hrs	SW2 11:35hrs
pH (*in-situ*)	-	-	6.1	8.0	6.6	6.2	6.6
Temperature (*in-situ*)	^{0}C		31	30	29	30	31
ORP	mV		-89	75	-220	126	-126
Conductivity	mS/cm		1.69	4.62	0.48	0.06	2.03
Turbidity	NTU		2.83	71	60.4	34.4	143
DO	mg/l		2.62	7.45	8.11	2.16	4.43
BOD_5 at 20^{0}C	mg/l		10	81	10	1	14
COD	mg/l		110	830	39	3	180
Suspended solid	mg/l		56	128	9	12	22

Table 6.6.7 Summary of Results - Landfill Gases

Samples taken on		*25/8/03*	
Test Parameters	Units	AM-G1 15:45hrs	AM-G2 12:35hrs
Methane (CH_4)	%	37.1	36.6
Carbon Dioxide (CO_2)	%	30.8	30.8
Oxygen (O_2)	%	Not Detectable	Not Detectable
Nitrogen (N_2)	%	32.6	32.9
Hydrogen Sulphide (H_2S)	ppm	3	3
Carbon Monoxide (CO)	ppm	12	14
Samples taken on		*06/2/04*	
Test Parameters	Units	AM-G1 14:45hrs	AM-G2 13:25hrs
Methane (CH_4)	%	25.9	28.6
Carbon Dioxide (CO_2)	%	26.9	28.7
Oxygen (O_2)	%	2.5	1.2
Nitrogen (N_2)	%	44.7	41.7
Hydrogen Sulphide (H_2S)	ppm	18	3.7
Carbon Monoxide (CO)	ppm	21.7	16
Samples taken on		*19/5/04*	
Test Parameters	Units	AM-G1 13:30hrs	AM-G2 13:10hrs
Methane (CH_4)	%	29.0	38.6
Carbon Dioxide (CO_2)	%	25.7	32.7
Oxygen (O_2)	%	4.0	0.4
Nitrogen (N_2)	%	41.7	27.7
Hydrogen Sulphide (H_2S)	ppm	8.2	10.7
Carbon Monoxide (CO)	ppm	12.7	18.3
Samples taken on		*06/2/04*	
Test Parameters	Units	AM-G1 13:05hrs	AM-G2 12:05hrs
Methane (CH_4)	%	27.1	35.4
Carbon Dioxide (CO_2)	%	24.1	31.6
Oxygen (O_2)	%	4.2	0.5
Nitrogen (N_2)	%	44.5	32.5
Hydrogen Sulphide (H_2S)	ppm	6	3
Carbon Monoxide (CO)	ppm	20.0	15.0

6.6.5 Considerations

(1) Consideration - Baseline

The monitoring data for August 2003 represents the baseline data.

1) Groundwater Quality

The monitoring well AM-W1 was installed at the top of the ridge and AM-W 2 is at the bottom of the valley. Since AM-W1 is at the top, the ground contamination will be lesser than that for AM-W2. The results indicated that the iron ad manganese values exceeded the permitted benchmarked limits. As explained in Chapter 7, for the Pekan Nenasi PP, the high levels of iron and manganese are readily found in the soil and not influenced by the landfill contaminants. The results showed relatively high levels or ammonia, electric conductivity and COD for AM-W2, thus indicating contamination.

2) Groundwater Flow

The groundwater levels measured during the sampling exercise are shown in **Table 6.6.8**.

Table 6.6.8 Groundwater Levels at Ampang Jaya PP Site

Monitoring Well	Elevation (MSL m)	Groundwater level from the top of the well (m)	Groundwater level (MSL m)
AM-W1	188.0	16.05	171.95
AM-W2	96.0	1.65	94.35
AM-G1	191.0	13.85	177.15

With the groundwater levels, the contour map for groundwater was generated and shown in **Figure 6.6.6**. The direction of groundwater flow is deduced to flow from the north to the south.

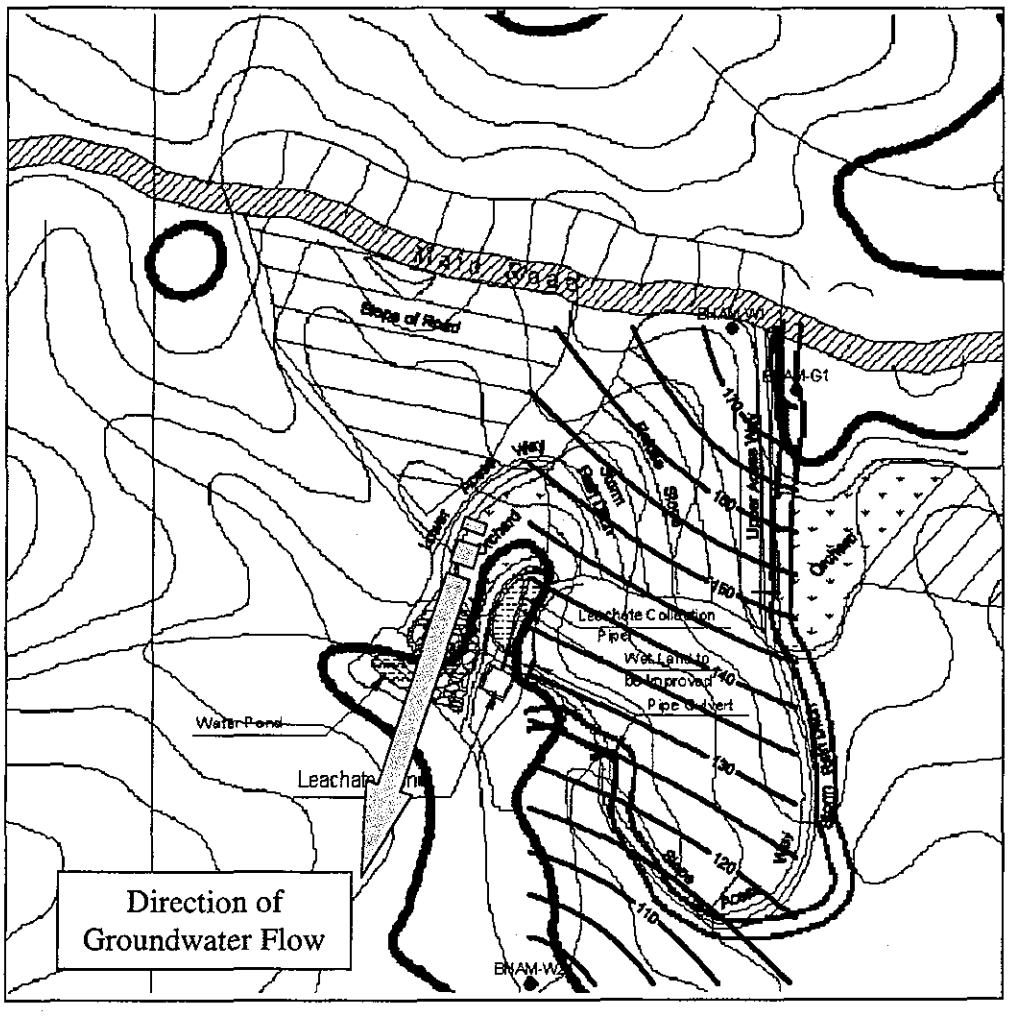


Figure 6.6.6 Groundwater Level Contour Map - Ampang Jaya PP

3) Leachate and Surface water quality

The Ampang Jaya closed landfill site is situated upstream of the water intake point, about 8km away. The EQA effluent standard A must be applied. The results for the water quality parameters are shown in **Table 6.6.9**.

Table 6.6.9 Leachate and Water Quality

	Standard A	L1	L2	SW1	SW2
BOD_5 at 20° C	20	***67***	14	1	17
COD	50	***813***	***130***	8	45
Boron	1.0	***1.4***	0.4	<0.2	<0.2
Iron	1.0	***2.04***	***5.04***	0.29	0.61
Manganese	0.2	0.02	***0.22***	0.11	***0.30***

From the above table, the results for AM-L1 exceeded almost the parameters. The results of the other parameters were within the standard A. The results for surface water analysis showed that for SW1, that is upstream of the river, was not influenced much by the leachate. But for SW2, that is down stream was heavily influenced by the leachate. Only Manganese exceeded the standard A for SW2. .

4) Landfill gas

The results for landfill gas at AM-G1 and AM-G2 showed similar gas composition with 37% of methane and 31% of carbon dioxide.

(2) Considerations - After the PP improvements

As evaluation of the PP improvement will be discussed in the later section (Chapter 6-9), brief result of environmental monitoring is discussed for three aspects, i.e., environmental impact, safety and stabilization process.

1) Environmental impact

For surface water and leachate, their water quality were compared with effluent standard A. As noted in **Table 6.6.9**, five parameters, i.e., BOD_5, COD, Boron, Iron and Manganese exceeds in some points during baseline sampling before PP improvement. **Table 6.6.10** summarises the result of monitoring for those parameters exceeding the effluent standard A. While leachate constantly exceeded in BOD_5, COD, Iron and Manganese, surface water also often exceeded Iron and Manganese. L1 sample also slightly exceeded in Boron and Arsenic.

In legally speaking, the leachate at the site, which exceeds standard in various parameters, should not be discharged without treatment. Also as water intake point exists at the downstream, water treatment facility is urgently required.

Table 6.6.10 Monitoring Value Exceeding Effluent Standard A

	Sampling point	BOD_5 (mg/l)	COD (mg/l)	Boron (mg/l)	Iron (mg/l)	Manganese (mg/l)	Arsenic (mg/l)
Effluent standard A		20	50	1.0	1.0	0.2	0.05
Feb/04	L1	***113***	***294***	***1.5***	***4.25***	0.03	***0.08***
	L2	12	***191***	0.5	***18.3***	***0.33***	***0.06***
	SW1	2	3	<0.2	0.45	0.12	<0.05
	SW2	8	24	<0.2	0.57	***0.4***	<0.05
May/04	L1	***92***	***755***	***1.4***	***4.54***	0.09	***0.08***
	L2	***78***	***142***	0.4	***12.7***	***1.3***	<0.05
	SW1	11	14	<0.2	***2.03***	0.15	<0.05
	SW2	15	46	<0.2	***3.94***	***0.51***	<0.05
June/04	L1	***81***	***830***	***1.6***	***4.75***	0.04	<0.05
	L2	10	39	<0.2	0.44	***0.42***	<0.05
	SW1	1	3	<0.2	0.67	0.09	<0.05
	SW2	14	***180***	0.3	***23***	***1.52***	<0.05

Groundwater quality of the monitored samples was also exceeding bench mark value for Iron and Manganese. From the hydrogeological view point, groundwater at the site will join to the surface water at somewhere in downstream. Therefore, separate environmental impact consideration is not required.

2) Safety

For landfill gas, methane has been generated at the concentration over 5% at the wells. Any use of fire around such methane generation should be controlled.

Risk of slope collapse is major problem at the site. Any work at the top, middle and bottom of the slope shall be prohibited to prevent accident.

3) Stabilization process

Leachate and landfill gas composition indicated active aerobic and anaerobic degradation of organic matter inside the landfill. Also land subsidence measurement at the site showed still substantial subsidence at the top of slope (59mm at 8 month period). It is estimated that stabilization of the site require longer period.

6.6.6 Continuous Operations & Maintenance and Monitoring

(1) Operation and maintenance of landfill facilities

All the facilities provided and installed at the landfill site, such as the soil cover, leachate collection pipes, gas ventilation systems, surface drainage etc, should be operated and maintained properly, up until the closed landfill site has stabilised.

It is highly recommended that the Local Authority or the operator of the site should carry out the regular inspection and maintenance work at the site, and to ensure that the facilities are in good working conditions. The types of work required are as follows;

a. Leachate collection and treatment facilities

Although only the leachate collection pipes and the leachate pond have been provided, such facilities should be maintained and inspected regularly.

However, due to restraints of the Pilot Project and the lack of support from the Local Authority concerned, it was not possible to provide the essential leachate treatment facilities such as the aerators, recirculation systems and filtration system. It is strongly recommended that, since the Ampang Jaya site is situated up stream of the water intake point, it is essential that MHLG or the Local Authority should continue with the rehabilitation upgrading work by providing the necessary leachate treatment systems. Such work should include the provision of power supply to bottom valley of the site.

b. Gas ventilation pipes

The gas ventilation pipes act as the gas vents and also air supply pipes to supply oxygen to the waste layers and accelerate the waste degradation process. The gas ventilation pipes should be maintained over the long term and new ventilation pipes be installed where necessary.

c. Surface drainage

The surface drainage system should be inspected and maintained regularly, and cleared of any debris and blockages. Drains may also be damages as a result of uneven ground settlements. In such cases, all damaged section should be maintained or replaced. Since the PP works included the provision of stormwater drains along the access road, it is crucial that these drains are also maintained and inspected regularly.

d. Other supporting facilities

Other supporting facilities like the access road and the vegetation growth on the top/slopes should be maintained where necessary for a long period of time. For the PP, a large portion of the works involved the repair and upgrading of the access road. This access road is the only access to the site and should be maintained properly. Furthermore, since the gradient of the access road is rather steep, and prone to erosion and wash out by heavy rain water, it is crucial that the road surface is constantly repaired and protected.

The typical example of the maintenance items of the landfill facilities, method and scale/frequency are shown in **Table 6.6.11**.

Table 6.6.11 Summary of Maintenance Items

Facilities	Items	Methods	Scale/ Frequency
Top cover & dykes	Cracks, pools and soil erosion on the surface, State of plants	Periodic visual inspections	The entire site, weekly
Surface drainage on the top cover	Clogging by soil/leaves, Damage by sedimentation	Periodical visual inspections	The entire site, weekly (more frequent during the rain season)
Cut-off drainage around the site	Clogging by soil/leaves, Damage by traffic	Periodical visual inspections	The entire site, weekly (more frequent during the rain season)
Gas ventilation pipes	Clogging, damage to pipes, corrosion	Periodical visual inspections	all pipes, weekly
Leachate collection	Clogging, damage to	Periodical inspections &	daily

pipes	pipes, corrosion	comparison of the effluent quantity data	
Leachate treatment facility	Quality of treated effluent	Daily inspections (colour of effluent) Periodical effluent analysis	daily monitoring frequency
Monitoring facility	Conditions of the monitoring wells	Periodical inspections	all wells, weekly

(2) Monitoring of environment and landfill stabilisation

In accordance with the Guideline, for the Post Closure Management for Ampang Jaya, the following monitoring programme has been recommended, as shown in **Table 6.6.12**.

Table 6.6.12 Monitoring Programme

Monitoring media/parameters	Item and parameters	Frequency	Location
Leachate	• pH • BOD • COD • Nitrogen (Ammonia, Nitrate, Nitrite) • ORP • EC • TOC	4 times / year	1 point/ leachate pond
Landfill gas	• Oxygen (O_2) • Nitrogen (N_2) • Methane (CH_4) • Carbon Dioxide (CO_2) • Hydrogen Sulfide • Temperature	2 times/ year	2 points/ site
Land subsidence	Topographic height of the top of the landfill	Once a year	1 point/ landfill block
Groundwater	Groundwater benchmark parameters	Once a year	3 points/ site
Surface water	Effluent standard parameters	Once a year	2 points/ stream

The site specific recommendations are as follows.

1) Leachate

Leachate should be monitored according to the guideline. In view of the existing water intake downstream of the site, strict monitoring programme should be observed.

2) Landfill gas

Continued monitoring of the gas composition is recommended.

3) Land subsidence

The rate of land subsidence can provide a good measure of the stabilization of the site. The settlement plates that were provided under the Pilot Project should be measured once a year as a good indicator of stabilisation process.

4) Groundwater

Although groundwater is contaminated, it will ultimately outflow to the surface water sources. Continuous monitoring at the current wells is recommended but no additional well is required.

5) Surface water

Surface water should be monitored regularly in accordance with the guideline. In view of the existing water intake point downstream of the site, strict monitoring programme should be observed.

6.7 PILOT PROJECT EVALUATION

6.7.1 Technical Evaluation

(1) General

The Pilot Project sites were selected to reflect the 3 different types of site conditions, i.e;

- A landfill site operated under improved conditions and closed recently (Ampang Jajar)
- A site located in wetland area and currently still under operations (Pekan Nenasi), and
- A site closed for a number of years ago and which was poorly located and operated (Ampang Jaya).

The evaluation of the 3 Pilot Projects should take into consideration not only on the technical issues and outcome of the Pilot Project works but also on the performance of the stakeholders, local counterparts, consultants, and others. Such evaluation criteria includes the degree of technology transfer, confirmation of the technical capabilities of the Malaysian consultants and contractors, and enhancing the understanding of Local Authorities on safe closure.

The summary of the evaluation items is shown in **Table 6.7.1**.

Table 6.7.1 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 woks 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 woks 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) 1st Training Workshop	O			Topic: Evaluation of landfill sites and planning of pilot projects. Attendees: Federal/state government and local authorities.
(6) 2nd 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

(2) Achievement of Pilot Projects

The technical achievement of the Pilot Projects were evaluated based on 2 main criteria, i.e. whether the projects were carried out in accordance with the design and Pilot Project Plan, and whether the works were carried out satisfactory.

The scope of works, i.e. the facilities that were installed and the works completed are summarised below.

1) Ampang Jajar Pilot Project

No.	Installed Facilities	Achievements and Remarks
1	Slope Re-formation and Final Cover	
	Re-formation of the 1st Step Slope and final cover	The slopes are now more gradual and well compacted. The new slopes are less likely to slip and slide.
	Application of cover soil on the upper layer of the 2nd Step Slope (t = 300mm)	Some areas exhibited soil settlements and were most likely due to poor soil compaction during construction and also the due to rain water soil erosion.
	Vegetation cover (t = 150mm)	Topsoil were used and laid on the surface of the slopes and steps.
	Turfing (slope protection)	It was observed that the grass at certain areas at the top of the slopes did not grow as fast and as healthy as those at the bottom of the slopes. This could be due to lack of irrigation and nutrients. More time should be allowed for the grass to mature.
	Planting (1 tree/25m^2)	Small trees that were selected by MPSP were planted at the steps as specified.
2	Leachate collection system (Main Pipe)	
	Blind (buried) leachate collection pipe (dia. 450mm)	The pipes achieved their purpose as leachate has been observed flowing from the pipes.
3	Gas venting system	
	Vertical gas venting pipes (150mm)	The pipes achieved their purpose, as the odour from gas can be smelled around the pipe discharge area.
4	Improvement of existing perimeter roads	
	Crusher-run pavement (t = 200mm)	The road level was raised with the laying of the crusher run, and compacted. The road is now wider and easier to access.
5	Slope storm water drainage	
	Drainage at steps	It was noticed that the open drains were

No.	Installed Facilities	Achievements and Remarks
	Drainage at slope (sloping part)	filled with debris and soil, and thus restricting the rainwater flow. The drains must be inspected and cleared regularly, especially during the raining season.
	Drainage pipes at step crossings and under perimeter road (dia. 300mm)	
	Earth drain (300 & 900 wide)	The earth drain was constructed at the top of the slope and well compacted. Nevertheless, the earth drain should be inspected regularly and repaired when necessary.
	Drainage pits at steps and perimeter road.	Weeds and shrubs were observed overgrown into the facilities and require clearing. Regular inspection, clearing and maintenance of the drainage pits etc are required.
	Rip Rap (3000mm x 2500mm x 900mm depth) with cement mortar	
	Drainage at toe (600 x 450 pieces U Drain)	

2) Pekan Nenasi Pilot Project

No.	Installed Facilities	Achievements and Remarks
1	Leachate Collection System	
	Excavation of solid waste	The excavated waste was placed in the adjacent active cell.
	Main leachate collection pipe (dia. = 450mm) installed in two lines	The pipes achieved their purpose as leachate has been observed flowing from the pipes at the discharge end to the leachate pond.
2	Gas venting system	
	Vertical gas venting pipe	oil drums were used and placed over the manhole chambers, i.e. at the connection points for the main and branch pipes. Since the PP area is rather shallow, at present not much gas has been detected.
3	Leachate pond	
	Excavation for leachate pond	The pond was excavated and the sides were compacted. The depth is about 2m.
	Earth berm along the leachate pond (h = 1.0m, L = 145m)	The nearby existing clay soil was used and compacted.
	Access road embankment (t = 200mm) between dike and leachate pond	The access road was constructed to allow easy access to the pump shelter for installation and maintenance purposes, and was constructed as specified. This road should not be used by heavy vehicles or by the waste disposal trucks.
	Crusher-run pavement for access road	

No.	Installed Facilities	Achievements and Remarks
	Aerator (7.5 kw)	The surface aerator complete with electrical control panel was installed. MD Pekan provided the main power supply cables and poles.
	Re-circulation pump (5 kw)	The pump was installed in the pump shelter constructed on the side of the access road nearer to the pond. Flexible hoses were connected from the pump discharge to the 4 sprinklers installed at the top of each gas vent.

3) Ampang Jaya Pilot Project

No.	Installed Facilities	Achievements and Remarks
1	Access way through the site	
	Excavation and fill work	Excavation and fill work were carried to widen and improve the access road to the bottom of the valley.
	Access way construction (w = 7.0m)	The access way was widen to 7m and compacted.
	Crusher-run pavement (t = 200mm)	The 3.5m wide road was provided with 150mm thick crusher run layer and sprayed with asphalted tack coat.
	Surface storm water plastered drains (width 450 to 600mm) at the higher road elevation section.	Plastered drains (cast-in-situ cement drain) were provided initially but due to the rains, and ease of construction, these were later replaced with 600mm pre-cast V type concrete drains.
	Surface storm water drainage (w = 600 to 900mm) installed at the lower road section as it descends into the valley	These areas must be monitored and inspected regularly. The drains should also be cleared of sand and debris regularly.
	Pipe culvert at crossings (dia. = 1m)	Installed as per specifications.
2	Leachate collection	
	Main leachate collection pipes (dia. = 450mm)	The specified concrete pipes were replaced with similar diameter HDPE pipes, with the approval of the Study Team. The lighter HDPE pipes were used as it was easier to transfer to the site. The installation work was also easier as it required less use of heavy machinery. The pipes achieved their purpose as leachate has been observed flowing from the pipes to the pond.
3	Gas venting system and branch leachate pipes	
	Vertical gas venting pipe (dia. = 150mm)	Horizontal branch pipes were installed at

No.	Installed Facilities	Achievements and Remarks
	Horizontal leachate and gas venting pipe (dia. = 100mm)	13 points. The last sections at the end of the branches were turned upwards to form vertical gas vents. The branch pipes act as both leachate collection pipes and also as gas ventilation pipes.
4	Surrounding wetland areas	
	Site clearing	The site clearing was completed as specified without cutting down of the large trees. Cover soil were laid on area where waste has been exposed.
	Storm water drainage (w = 600)	The surface water is now collected from the surface, bypassing the waste filled area and discharged to the stream.
	Excavation of the swampy area	The existing pond was excavated, widen and deepen to provide a new earth leachate pond.
5	Storm water drainage in the downstream area	
	Storm water drainage (w = 1,000 mm).	The modification allows better drainage of the drain water and leachate to the stream.

(3) Achievement of Safe Closure Requirements – Pilot Projects

The PP Plans for the 3 PPs were set up in order to determine the suitability and sustainability of implementing safe closure for the landfill sites in Malaysia. The results of the PPs, the achievements and experiences gained will be used to establish and review the Guideline for Safe Closure in Malaysia.

As with all projects, the actual implementation of the PPs will differ slightly from the original concept designs due to changes necessary to accommodate the variations at the site and also due to circumstances that were faced with during the construction period.

However, in all cases, the initial objectives of the PP should be preserved. The achievements and the degree of satisfaction have been identified and evaluated, and the shortcomings and remarks are as follows;

1) Suitability of the Guideline on landfills under different conditions

From the results and experiences gained from the PPs, it was concluded that the guidelines presented in the Draft Guideline were generally sufficient and were adopted satisfactory for the 3 PPs. However, there are certain areas that may require on-site considerations, i.e. the technical details on local materials selection, local compaction methods and testing could be addressed.

2) Construction methods and materials

The local construction methods employed in the PPs were general satisfactory and were in accordance with normal practices. However, it was noted that the skills necessary to

compact the waste on the slopes were lacking and can be improved. Care must be taken during excavation of the old waste as noxious fumes and gases will be released, and are hazardous to the workers.

The selection of local construction material were also satisfactory and all the required materials were available locally and readily available. However, since the PP only required small quantities of the perforated concrete pipes, these were more difficult to attain and had to be modified at the site, i.e. the perforations were drilled at site.

3) Constructions costs

The estimates for the construction cost were initially prepared by the Study Team and subsequently tenders were called for the actual works. The actual PP implementation cost was within the estimated budget.

4) Construction period

The actual construction period differed for the 3 PPs, nevertheless all construction works were completed within the 3 months period, i.e. from September to December 2003. The Ampang Jajar PP experienced some delay towards the end of the construction period due to the heavy rainfalls, but eventually was completed in time. The Pekan Nenasi PP construction work actually completed in time but the equipment installations, i.e. the pump and aerator, were slightly delayed. The power supply cables were provided in time and were provided and coordinated by MD Pekan. The Ampang Jaya PP actually completed ahead of schedule due to the contractor's desire to complete the work before the anticipated rainy season.

5) Local technical capabilities in design, construction and maintenance

For the PP, only the conceptual designs and specifications were prepared by the Study Team. The detailed designs and the works were prepared and provided by the local consultants and contractors. Based on the outcome of the detailed design work and overall construction performance, the capabilities of the local consultants and contractors were considered good and satisfactory.

The topographical surveys and soil investigations were all completed without major difficulties. The construction works were also completed satisfactorily without major technical difficulties except for the rain falls that delayed the progress of the works.

6) The effect of safe closure and rehabilitation of landfills

All the 3 PPs have contributed to the improvement of the sites based on both the environmental standpoints and also the aesthetic viewpoints.

For Ampang Jajar, the PP works have improved the eastern slopes and put in leachate collection facilities. The aesthetics also improved tremendously and are now more acceptable by the public, both at the park side and view from the highway. However, recent observations showed that the grass at the top of the slopes did not fair as well as those at the bottom. The vegetation growth at the site should be monitored regularly and looked after. All dead patches of grass should be replaced and all over grown areas should be cut and maintained.

For Pekan Nenasi, this site is still in operations and hence the PP effect may not be as obvious in a short period of PP. Nevertheless, with the installation of the leachate collection system, this will improve conditions of the site and will accelerate the decomposition process. All these will reduce the negative environmental effects during the life span of the site and will more the task of safe closure must easier in the future. However, proper operations and maintenance of the facilities are required. The aerator and recirculation pump must be operated continuously thorough the life span of the site.

For Ampang Jaya, this site has been abandoned but nevertheless the improvement works will ensure that the leachate are now being collected in the pond and retained before discharge to the stream. It is strongly urged that MHLG or the Local Authority should implement additional improvement works by installing better mechanical treatment systems such as aerators and recirculation pumps. This will improve the quality of the leachate further. It must be reiterated that the Hulu Langat water intake point is situated downstream of the site and thus is it essential that the untreated leachate from this site should not contaminate the river source.

(4) Proposal for Continuous Operation and Maintenance

The sustainability and continuous improvement of the PP sites can only be achieved with proper care in the operations and maintenance of the installed facilities. As such the following have been proposed.

1) Ampang Jajar Pilot Project

The Local Authority will have to arrange for the necessary the manpower and budget to operate and maintain the Pilot Project area, and to continue with the improvements to the remaining area in order to implement safe closure for the entire site. The following activities have been proposed:

1. To carry out monthly inspections and maintenance of the open drains, and manholes to ensure that they are clear of debris and the passage not restricted.

2. To carry out monthly inspections and maintenance of the gas vents to ensure that the pipes are straight and the passages not restricted.

3. To carry out monthly inspections and maintenance of the main leachate pipe outlets that are discharging into the leachate pond to ensure the passages are not restricted.

4. To carry out monthly inspections of the leachate pond, the aerators, and the re-circulation system to ensure that all the facilities are functioning properly.

5. To carry out inspections on the plants and turfing growth, and to replace any damaged plants.

6. To carry out monthly inspections of the slopes and to look out for areas with soil erosions or failures , and to carry out all necessary maintenance and repair works by adding more soil and proper compaction.

7. To prepare the budget for the design and construction of the remaining sections to continue with the safe closure works.

2) Pekan Nenasi Pilot Project

The Pekan Nenasi landfill site is still an operating site and the operator, Alam Flora Sdn Bhd, has already taken steps to introduce similar improvement scheme to the adjacent cell. The following activities have been proposed for the operator to implement.

1. To carry out regular monitoring of the leachate level in the leachate pond to ensure that the level should be below the leachate collection pipe discharge outlet.

2. To carry out monthly inspections and maintenance of the gas vents to ensure that the pipes are straight the passages not restricted.

3. To ensure the aerator is operated daily for around 5 to 8 hours.

4. To operate the leachate re-circulation system during the dry season continuously and as required during the wet season to maintain the leachate level in the leachate retention pond.

5. For the adjacent cell already being developed by Alam Flora Sdn Bhd, it is necessary to construct the new leachate pond and install an aerator and re-circulation system.

3) Ampang Jaya Pilot Project

The Ampang Jaya Landfill was initially operated by the Ampang Jaya Municipal Council (MPAJ) and was subsequently transferred to the Kajang Municipal Council (MPKj) after its abrupt closure. MPKj has expressed their reluctance to undertake or be involved in the safe closure works for the site. The Study Team propose that MHLG should take responsibility for the site and be involved in the PP activities, including the long term post closure management activities.

1. To carry out monthly inspections and maintenance of the gas vents to ensure that the pipes are straight and the passages are not restricted.

2. To carry out monthly inspections of the leachate pond and the leachate drainage pipe to ensure that the passages are not restricted.

3. To carry out monthly inspections of the leachate collection pipes to ensure that the piping network is in proper condition, and to remove any debris or weeds that may be restricting the passages.

4. To carry out monthly inspections of the stormwater drains to ensure that they are in proper conditions, and to remove any debris and weeds that may be restricting the passages.

5. To develop a plan to provide and install an aerator in the leachate pond and introduction of re-circulation system for treatment of the leachate prior to discharging into the stream.

(5) Degree of Satisfaction of the Local Authorities where PP are located

The 3 Pilot Projects sites are under the management and stewardship of the Seberang Perai Municipal Council (MPSP), the Pekan District Council (MDP) and the Kajang Municipal Council (MPKj). As explained earlier, the MPKj did not participate in the Pilot Project, nevertheless, all the 3 LocalAuthorities were regularly informed of the status of the PP.

Information of the works were disseminated through presentations at the technical working group levels, reports submitted by the team, meetings with the respective design consultants and contractors and videos showing the phases of implementation.

i. Majlis Perbandaran Seberang Perai (MPSP) – Ampang Jajar PP

MPSP showed great enthusiasts for the Pilot Project and is now preparing their own development plan for the remaining area not covered under the PP. One concern raised by MPSP was the delay in handing over and the lack of clarity of responsibility for maintenance of the already damaged works.

ii. Majlis Daerah Pekan (MDP) – Pekan Nenasi PP

MDP are satisfied with the Pilot Project and have carried out with their site operator, Alam Flora Sdn Bhd, the development of the adjacent cell on the same principle as the pilot project. However they have requested more explanation by the Study Team on the operation system of the pilot project (aerator and re-circulation system operation).

iii. Majlis Perbandaran Kajang (MPKj) – Ampang Jaya PP

Since MPKj did not participate in the PP works, the overall supervisory management of the works were handled by the Counterpart members of MHLG. The Counterpart members expressed their satisfaction with the PP works and the site has since been used as the "exhibition" site for others to visit and to appreciate the PP works.

6.7.2 Environmental Evaluation

(1) Evaluation of Ampang Jajar Pilot Project

Since the PP works were only limited to the southeastern slopes of the site, the monitoring points around the area are important for the environmental evaluation. The sampling points are;

AJ-L1	Leachate monitoring at south section
AJ-SW2	Surface water monitoring at northeastern section
AJ-W3	Groundwater monitoring at south section
AJ-G1	Landfill gas monitoring at north section
AJ-G2	Landfill gas monitoring at south section

1) Leachate and surface water

Figure 6.7.1 shows the results of monitoring for BOD_5, COD, total-nitrogen (T-N) and electric conductivity of AJ-L1. These parameters are considered as basic water quality indicators used to observe the changes in the water quality.

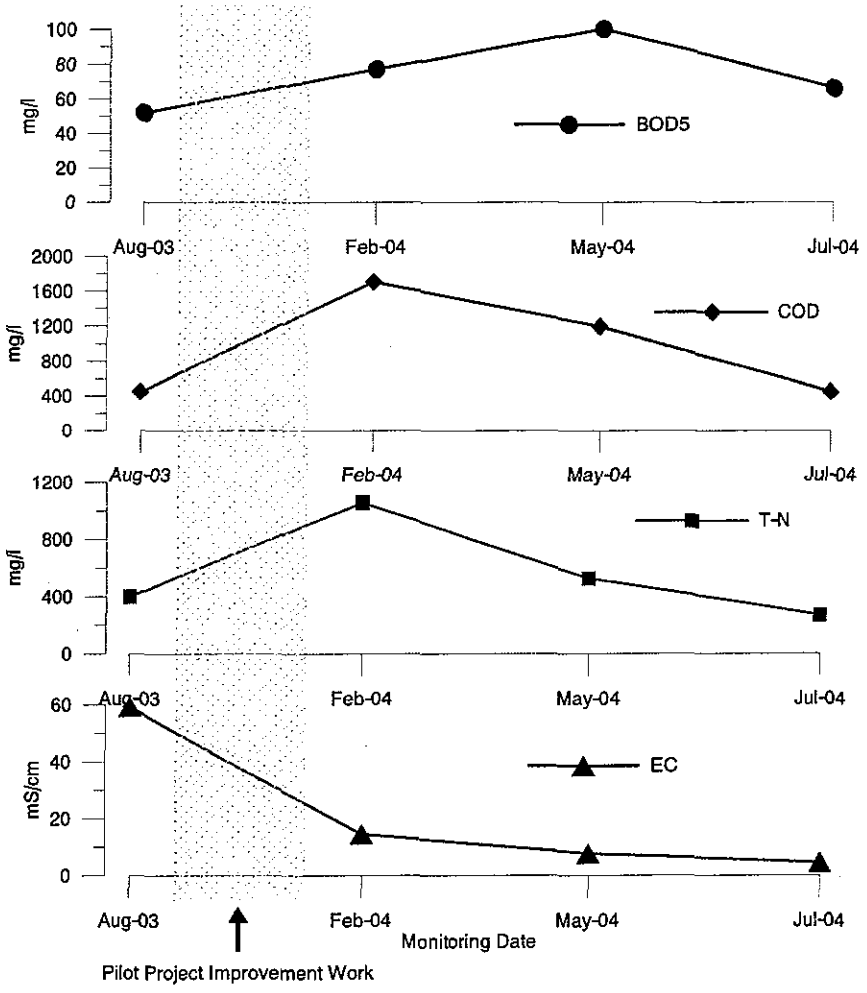


Figure 6.7.1 Ampang Jajar Leachate (L1) Monitoring Results

After the PP works, the BOD_5, COD and total-nitrogen (T-N) increased in concentration during the February, 2004 monitoring. These could be due to the effects of improved rainwater drainage system provided by the PP works. Since lesser surface water got into the waste layers, the leachate concentration temporally increased. However, the COD, total-nitrogen (T-N) decreased for both the May and July, 2004 monitoring. These may indicate the long-term effects of the PP works. The segregation of the rainwater could have increased and promoted the organic degradation inside the landfill layers. Continuous monitoring of these parameters is necessary in order to reach the conclusions the assumption. The BOD_5 results did not show such clear trends of improvement. This may be due to the fact that this section of the landfill site is already quite old and the biodegradable organic are already in low concentration range. The electric conductivity showed consistent improvements.

Figure 6.7.2 shows the results of monitoring for BOD_5, COD, total-nitrogen (T-N) and electric conductivity of AJ-SW2. It should be noted that SW2 is small a canal water

located downstream of the improved area and of AJ-L1. As expected, the monitoring results of AJ-SW2 were more or less similar to those of AJ-L1, but at the lower (diluted) concentration range. The COD, total-nitrogen (T-N) and electric conductivity value started to decrease from the baseline values immediately after the PP works. This was considered reasonable as lesser surface water seeping into the landfill layers caused the initial increase in the concentration of the leachate, and also resulted in fewer overflow of the leachate into the surface water system.

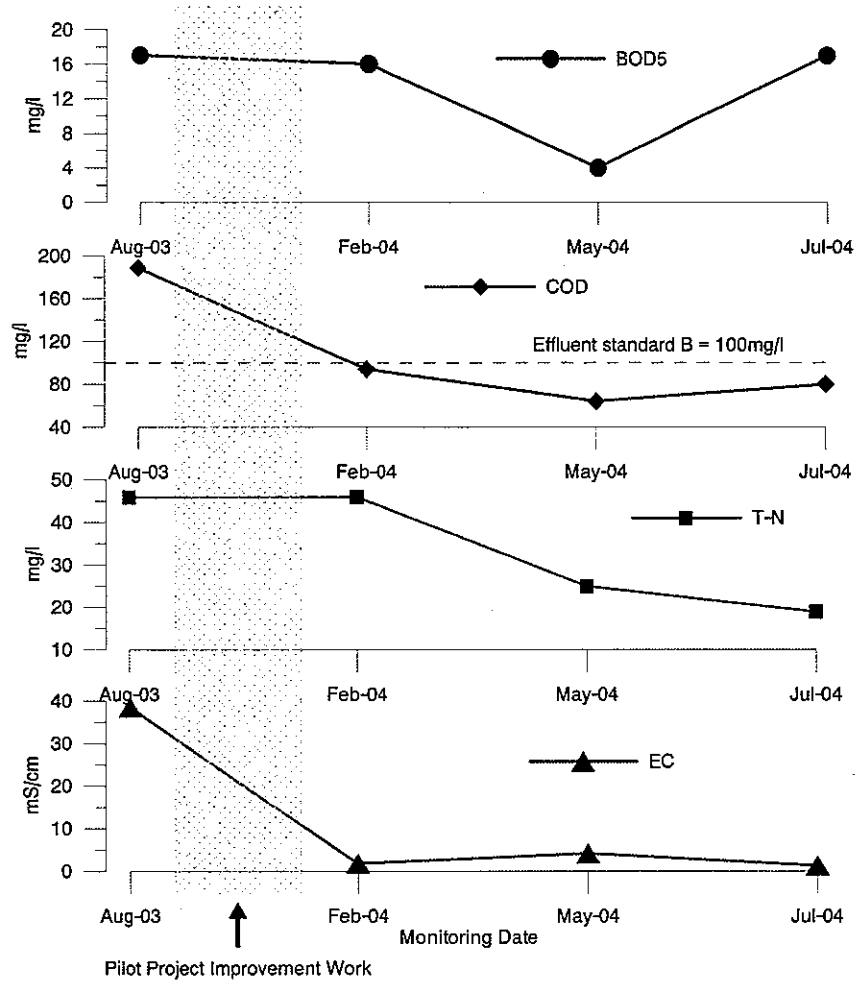


Figure 6.7.2 Ampang Jajar Surface Water (SW2) Monitoring Results

The COD in AJ-SW2 exceeded the Effluent Standard B limits during the baseline survey in August 2003. After the PP works, the COD results have been constantly lower than the effluent standard B as shown in **Figure 6.7.2**.

The Boron and Iron values for AJ-L1 and SW2 were plotted in **Figure 6.7.3**. These values also exceeded the Effluent Standard B limits during the baseline survey in August 2003. After the PP works, the results for the Boron and Iron tended to decrease and at the recent monitoring in July, 2004, their values were all below the Standard B limits.

These are considered as positive effects of the PP improvement works.

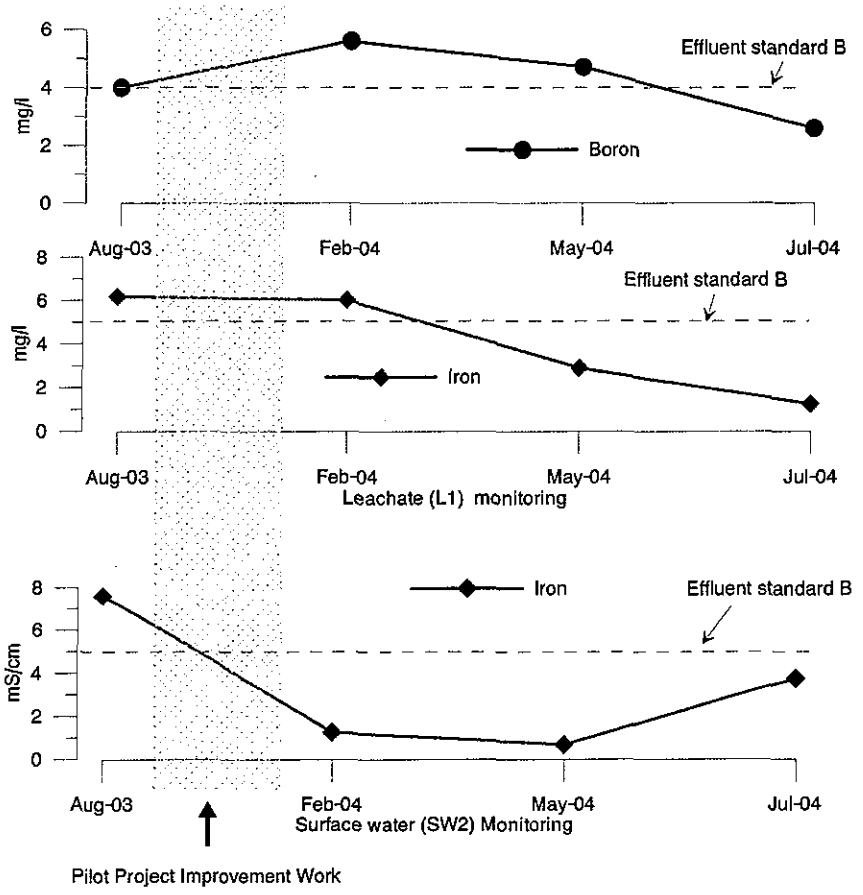


Figure 6.7.3 Ampang Jajar Leachate (L1) and Surface Water (SW2) Monitoring : Boron and Iron Data

2) Groundwater

Figure 6.7.4 shows the results of the monitoring for BOD_5, COD, total-nitrogen (T-N) and electric conductivity of AJ-W3. It should be noted that W3 is a groundwater well south (downstream direction of groundwater flow) of the PP improved area. As previously discussed in Chapter 6, the groundwater flow of the area is expected to be about 2.0-20 m/year. Obviously, any changes in the water quality at the landfill area will take years before it reaches and affects the water quality at AJ-W3. In this view, the results as appeared in **Figure 6.7.4** seemed to be reasonable.

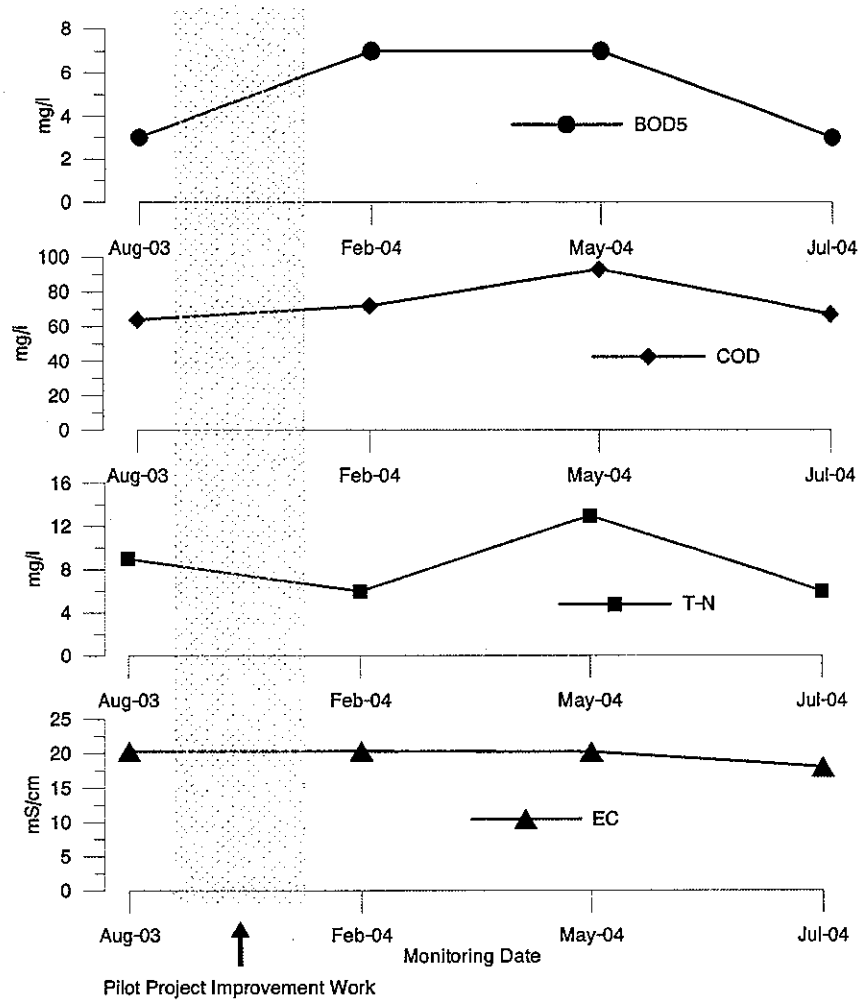


Figure 6.7.4 Ampang Jajar Groundwater (W3) Monitoring Results

3) Landfill gas

Figure 6.7.5 shows the results of the monitoring for CH_4, CO_2, O_2 and N_2 of AJ-G1 and AJ-G2. It was found that the measurements taken in July, 2004 were not entirely correct due to some measurement error and therefore new measurements were taken in August, 2004.

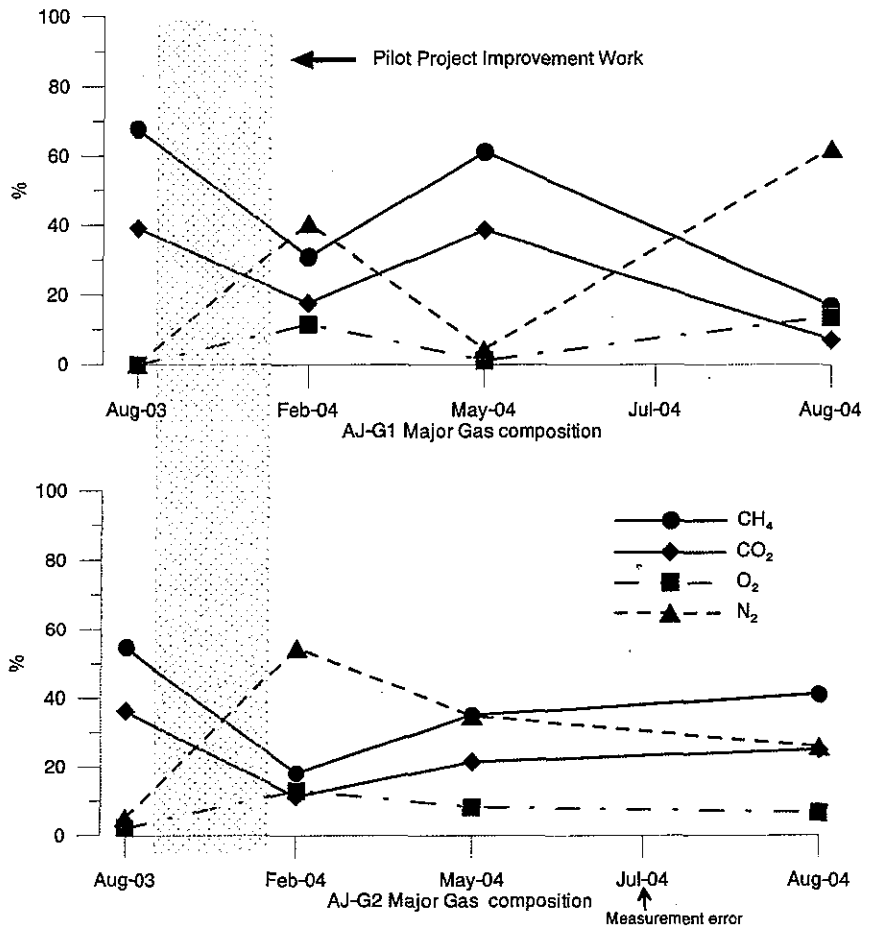


Figure 6.7.5 Ampang Jajar Landfill Gas Monitoring Results

The results for AJ-G1 showed fluctuated data for all the parameters. It seemed that the landfill gas generated by the organic decay, namely CH_4 and CO_2 tend to decrease after the PP works. The results for AJ-G2 also showed similar trends. It is premature at this early stage to conclude about the long-term effects of the PP improvement from the limited current data.

(2) Evaluation of Pekan Nenasi Pilot Project

At the Pekan Nenasi site, the monitoring points listed below are important for the environmental evaluation. The sampling points are;

PN-L1	Leachate monitoring at improved landfill cell
PN-SW2	Surface water monitoring at eastern section
PN-W2	Groundwater monitoring at south section

Figure 6.7.6 shows the results of the monitoring for BOD_5, COD, total-nitrogen (T-N) and electric conductivity of PN-L1. The COD, T-N and electric conductivity showed decreasing tendency after the PP works. The results for BOD_5 seemed they were not changed by the PP works.

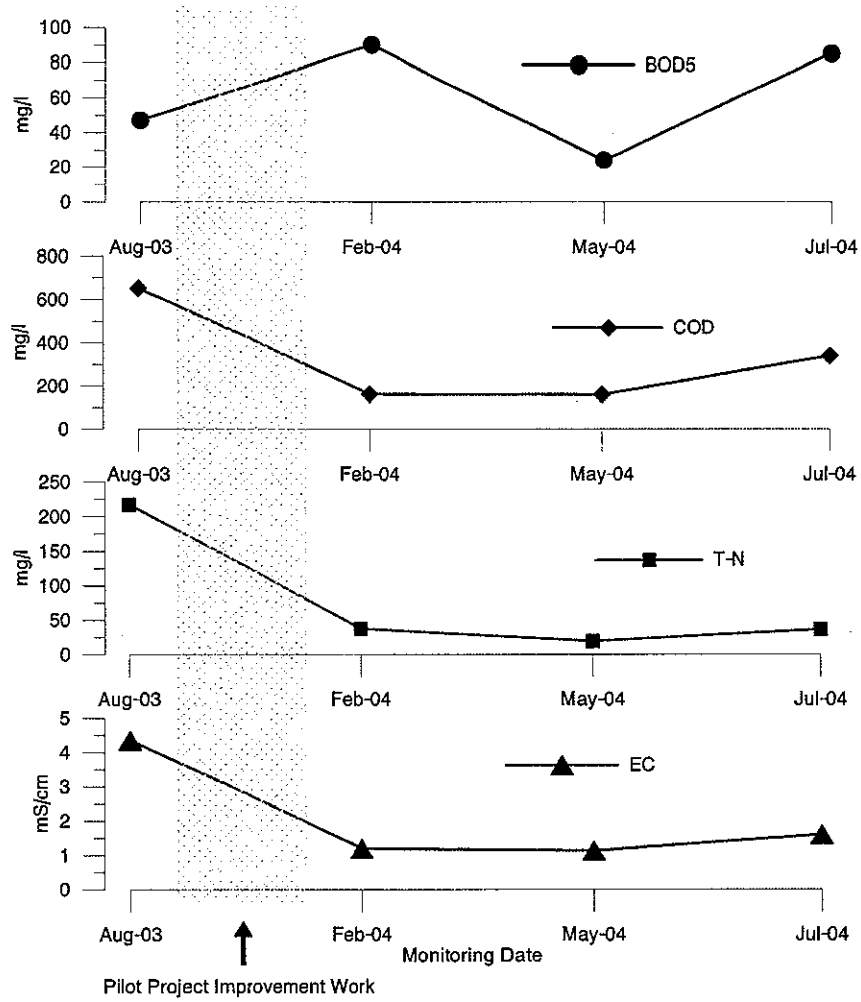


Figure 6.7.6 Pekan Nenasi Leachate (L1) Monitoring Results

Figure 6.7.7 shows the results of the monitoring for BOD_5, COD, total-nitrogen (T-N) and electric conductivity of PN-SW2. In general, the surface water around the site was stagnated. The concentrations of the above same parameters at SW2 were all at very low levels. It seemed that SW2 was not contaminated by the leachate from the site.

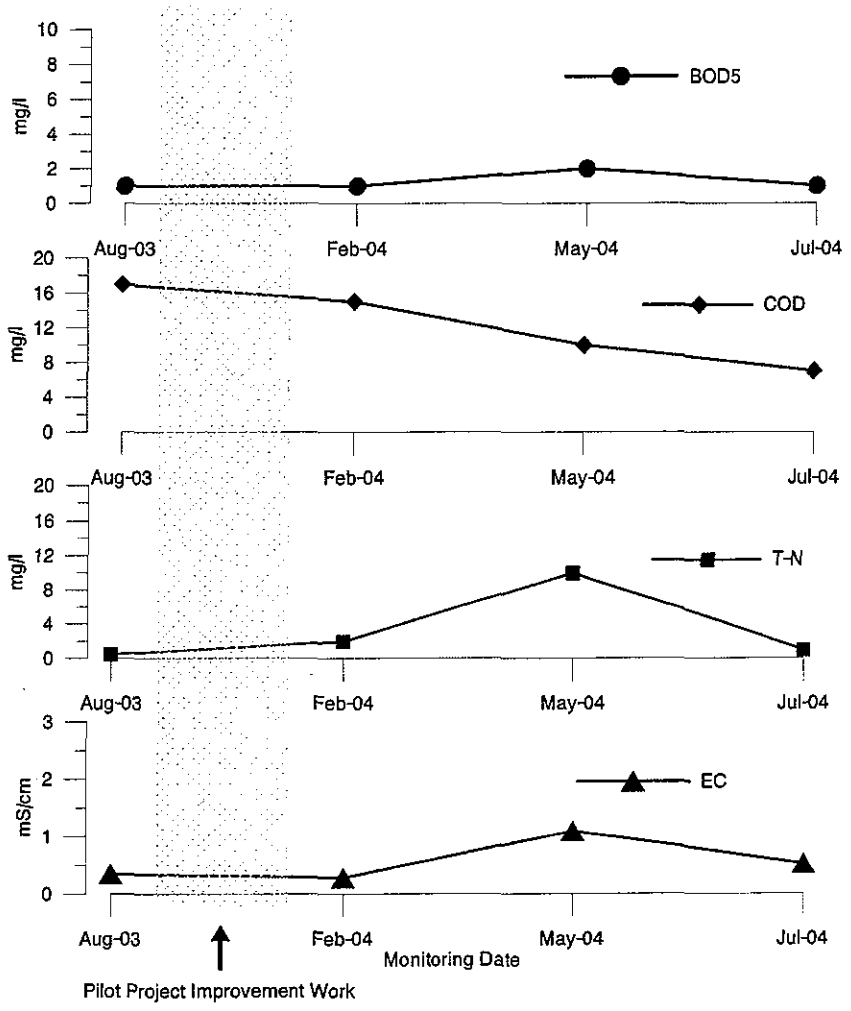


Figure 6.7.7 Pekan Nenasi Surface Water (SW2) Monitoring Results

1) *Groundwater*

Figure 6.7.8 shows the results of the monitoring for BOD_5, COD, total-nitrogen (T-N) and electric conductivity of PN-W2. The W2 is a groundwater well at the middle of the site and just southeast of the PP improved area. There was no clear tendency of change in the water quality parameters. This was considered reasonable considering the slow groundwater flow and the presence of the sewage sludge disposal area adjacent to the site

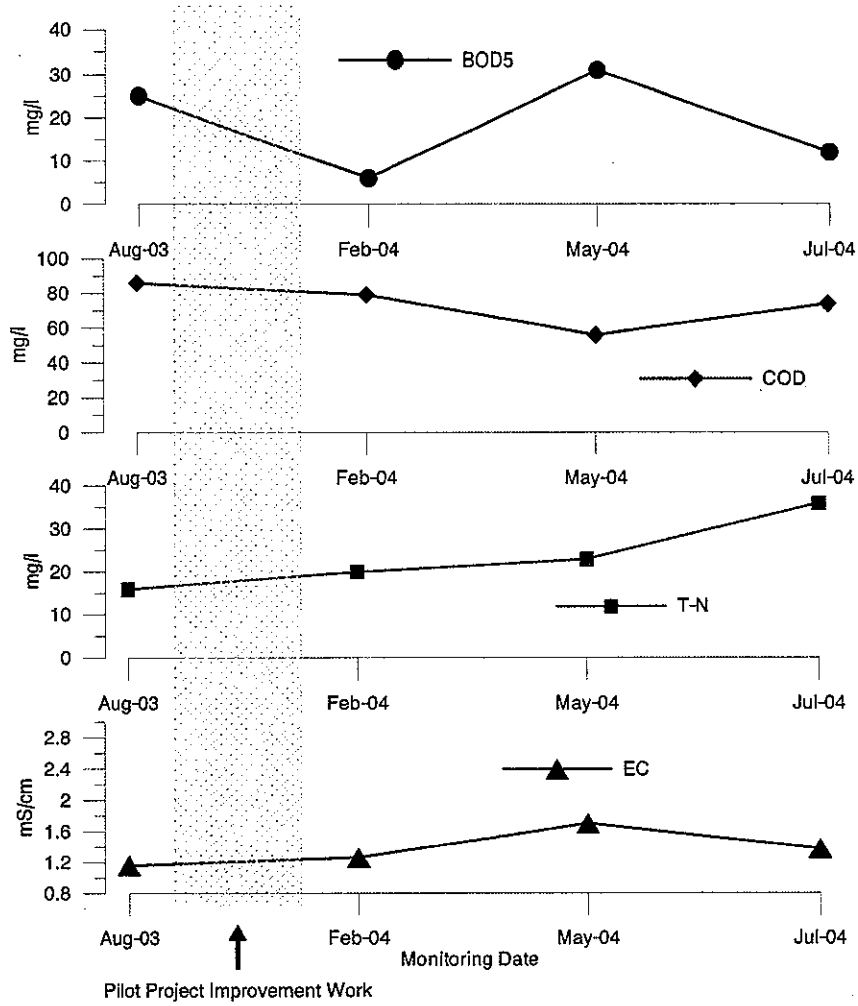


Figure 6.7.8 Pekan Nenasi Groundwater (W2) Monitoring Results

(3) Evaluation of Ampang Jaya Pilot Project

At the Ampang Jaya site, the monitoring points listed below are important for the environmental evaluation. The sampling points are;

AM-L1	Leachate monitoring at discharge of leachate pond
AM-L2	Leachate monitoring at south of leachate pond
AM-SW2	Surface water monitoring at downstream
AM-W2	Groundwater monitoring at downstream area
AM-G1, G2	Landfill gas monitoring

1) Leachate and surface water

Figure 6.7.9 and **Figure 6.7.10** show the results of the monitoring for BOD_5, COD, total-nitrogen (T-N) and electric conductivity of AM-L1 and AM-L2, respectively. The PP works at the site included the leachate collection system but without the leachate circulation or leachate treatment. Therefore, the leachate quality was not expected to improve much. **Figure 6.7.9** shows almost constant leachate quality for the AM-L1 samples taken at the discharge of the leachate pond. The AM-L2 samples, as shown in **Figure 6.7.10**, indicated improving quality for the COD, T-N and electric conductivity after February, 2004. The PP works resulted in the leachate being collected and thus minimise the penetration of the leachate into the ground and discharge to the waterways downstream. The monitoring of AM-L2 was taken here. Also as the result of the PP works, , the leachate is now discharged straight to the surface water drains from the pond, which also reduce the leachate quantity at the AM-L2 location.

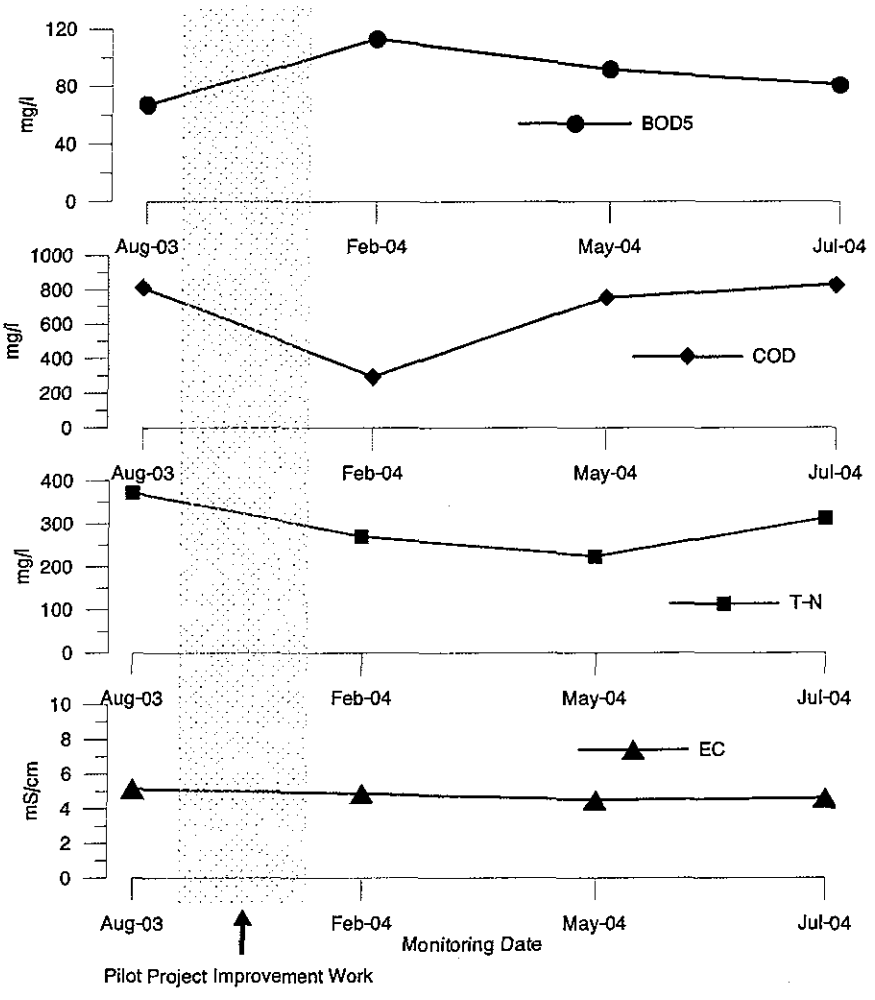


Figure 6.7.9 Ampang Jaya Leachate (L1) Monitoring Results

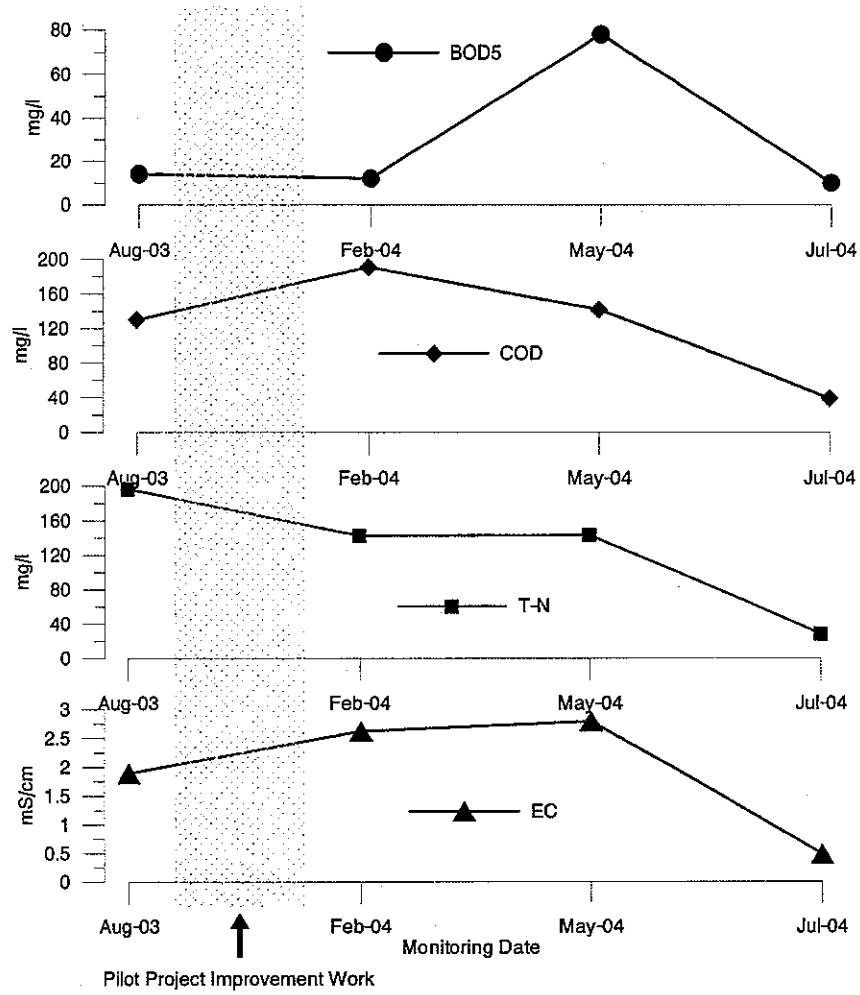


Figure 6.7.10 Ampang Jaya Leachate (L2) Monitoring Results

Figure 6.7.11 shows the results of AM-SW2. The COD, T-N and electric conductivity showed increased tendency after the PP works. This was considered reasonable as more leachate were collected by collection system and directly discharged to the waterway. It was noted that the COD values exceeded the Effluent Standard A limits.

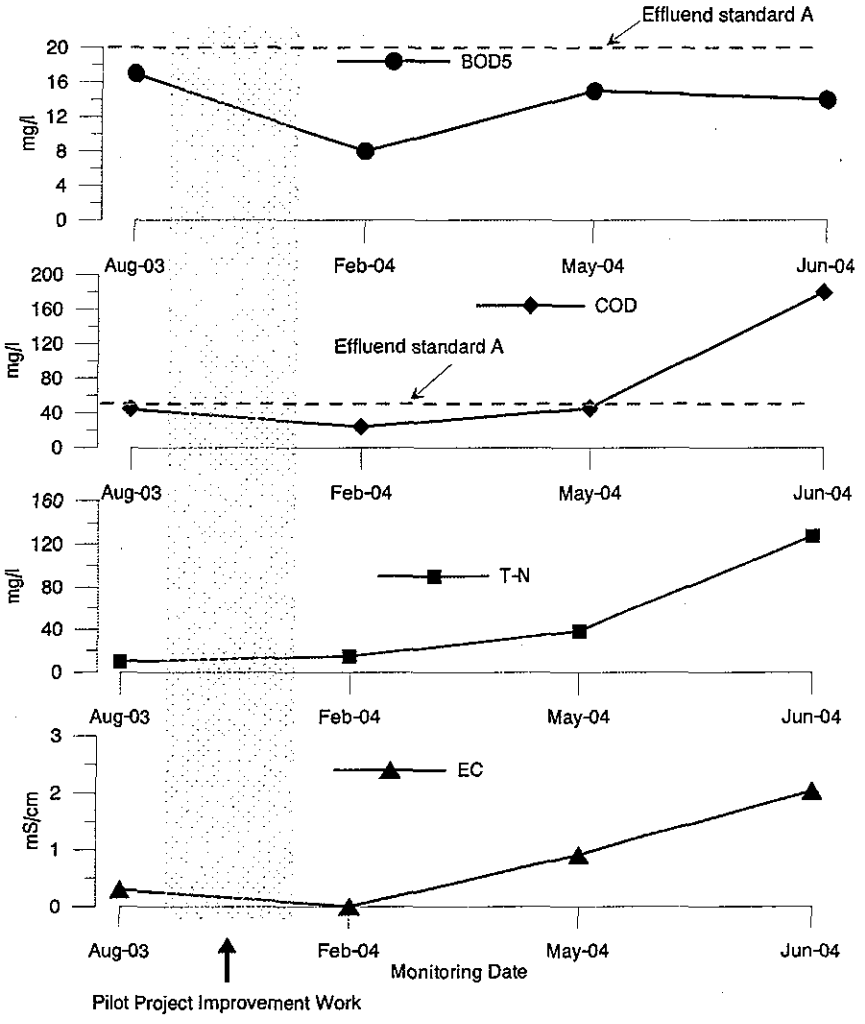


Figure 6.7.11 Ampang Jaya Surface Water (SW2) Monitoring Results

It was observed during the baseline survey that concentrations of Boron, Iron and Manganese were high in the leachate. **Figure 6.7.12** was prepared to confirm the condition of the 3 parameters at AM-SW2. The Boron in well below the Effluent Standard A, but Iron and Manganese have exceeded the limits. They also exhibited the tendency to increase upwards.

It is strongly recommended that the leachate treatment system should be provided, as there is a water intake point downstream of the site.

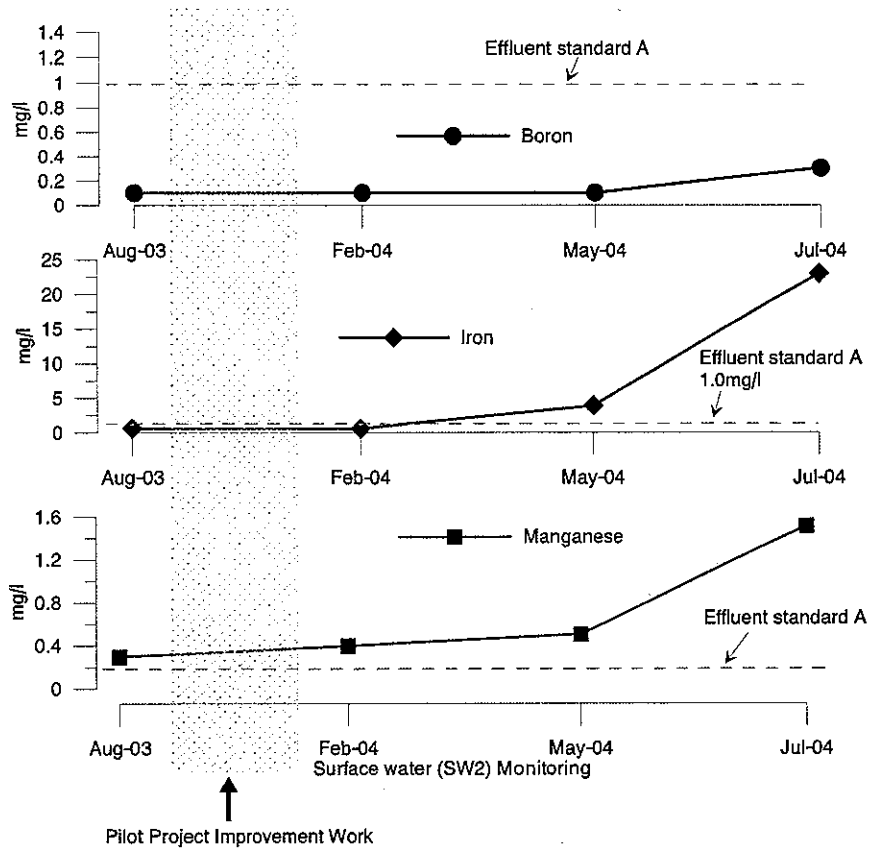


Figure 6.7.12 Ampang Jaya Surface Water (SW2) Monitoring : Boron, Iron and Manganese Data

2) Groundwater

Figure 6.7.13 shows the monitoring results of AM-W2. Since the PP works provided the better leachate collection to reduce the ground penetration, the groundwater quality should improve in the long-term. However within the present monitoring period of the pilot project, the changes cannot be observed.

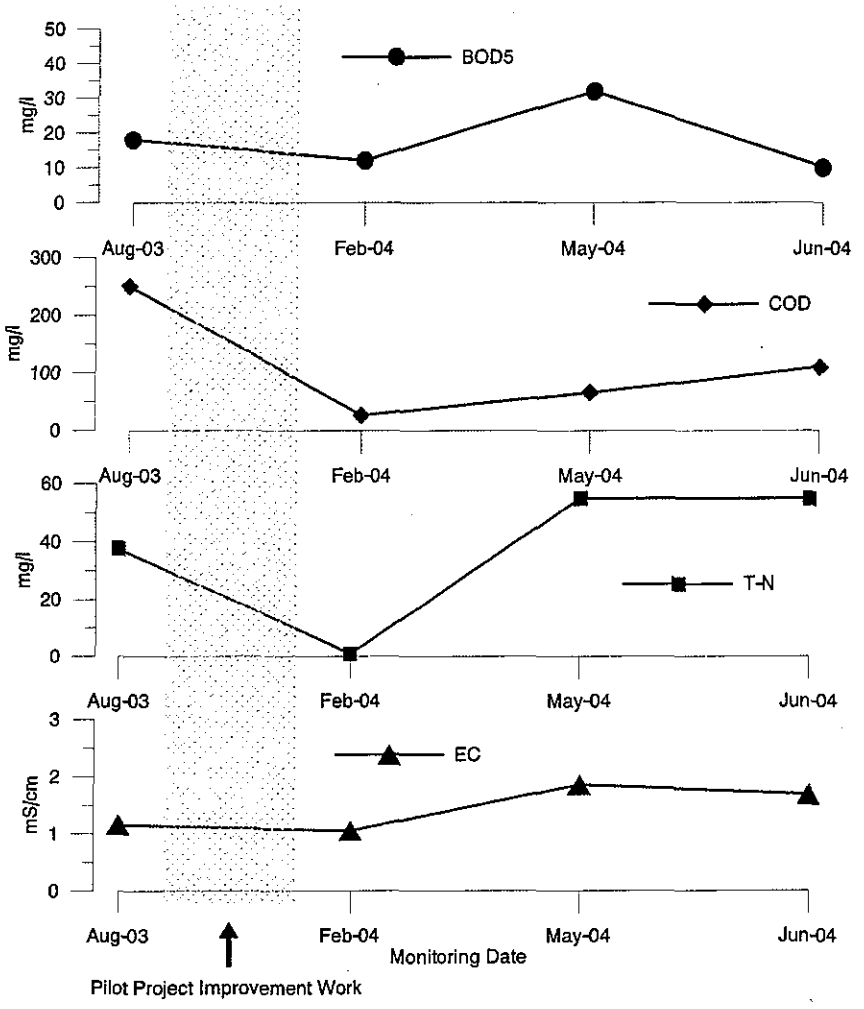


Figure 6.7.13 Ampang Jaya Groundwater (W2) Monitoring Results

3) Landfill gas

Figure 6.7.14 shows the monitoring results of the landfill gas at AM-G1 and AM-G2. AM-G1 showed slight decrease in CH_4 and CO_2 and increase in N_2. This may indicate better air circulation into the waste layers. On the other hand, AM-G2 showed the opposite tendency with slight increase in CH_4 and CO_2 and decrease in N_2. In both points, the changes were not so significant and cannot be related definitely to the PP improvement works.

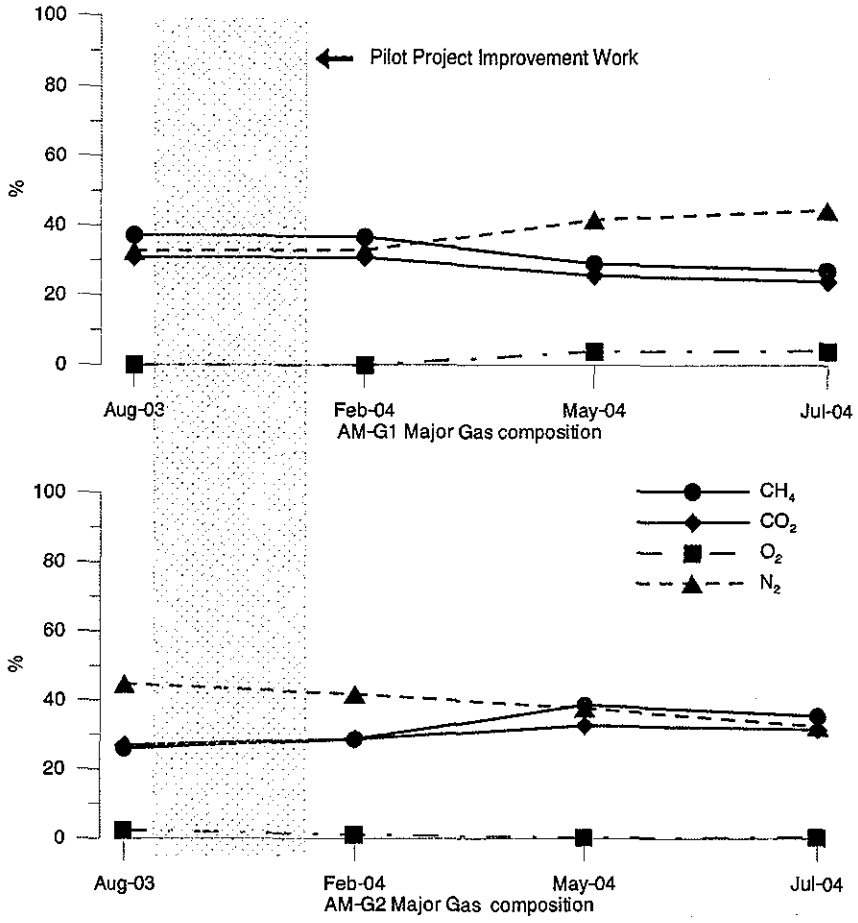


Figure 6.7.14 Ampang Jaya Landfill Gas Monitoring Results

6.7.3 Summary and conclusions

The PP works have provided positive effects in certain points whilst the other points did not show any changes or negative effects. The evaluation of the PP improvement from the environmental points of view are summarised in **Table 6.7.2**.

Table 6.7.2 Summary of Environmental Evaluation

	Ampang Jajar PP	Pekan Nenasi PP	Ampang Jaya PP
Leachate	**Positive effect.** Quality deteriorated after PP due to lesser dilution, but started to improve later.	**Positive effect.** Quality generally improved.	No change in quality but now in better controlled with leachate collection system.
Surface water	**Positive effect** Quality very well improved.	No change. No significant influence of leachate.	Negative effect. As leachate is directly discharge.
Groundwater	No change.	No change.	No change.

	Flow is slow.	Flow is slow.	Flow in slow.
Landfill gas	Fluctuating data. Require continuous monitoring.	No change. No landfill gas.	Slight change. Require continuous monitoring.
Note			Urgently requires leachate treatment system.

6.8 THE EVALUATION OF THE IMPROVEMENT OF AMPANG JAJAR LANDFILL SITE

6.8.1 Background

Ampang Jajar landfill at MPSP (Majlis Perbandaran Seberang Perai: Seberang Perai Municipal Council) was chosen by the JICA Study team as one of the landfill sites for the implementation of the improvement works. Evaluation of the site was done through monitoring. However, the evaluation on the comprehensive effects and the feasibility of improvement is difficult at this time since post monitoring of the improvement is carried out in a very short period of time. Due to the constraint, the Study Team decided to implement the survey on public opinion for the improvement in line with a contingent valuation method (CVM), in which widely used to estimate economic values for all kinds of environmental services, in order to take into account aspect of the willingness to pay for the project. With the cooperation from MPSP, the survey was carried out on August 14, 2004 during the "Health Awareness Campaign" workshop, which was organised by MPSP with cooperation of the local community association.

6.8.2 Methodology

(1) Procedures

Two types of questionnaires was prepared by the Study Team and forwarded to MPSP in July, 2004. MPSP has made sufficient copies of the questionnaires and distributed them during the workshop. The actual procedures of the survey at the workshop are as follows.

(i) The questionnaires were given to every participant during the registration.

(ii) A local Study Team member made a presentation the overview of the project

(iii) The presenter later explained every questions and how to answer them.

(iv) The questionnaires were collected by the staff of MPSP after the presentation

(v) The completed questionnaires were handed to the Study Team

(vi) The delivered questionnaires were analysed by the Study Team

(2) Questionnaires

The questionnaires are designed to gather the public opinion on the pilot project, especially the cost sharing aspect for the improvement of landfill site. The period for post-closure management (PCM) for the Ampang Jajar landfill site may need a period

of at least 10 years. In the questionnaire, the question on the willingness to pay for the project was asked in Q1. If the public are willing to pay, then he or she should answer Q2 by writing the annual amount they are willing to pay for a period of 10 years for every household. However, if the public are willing to pay but have no idea about the amount, they are guided in Q3 where they can select the amount ranging from RM2.00 to RM20.00/household/year with an increment of RM2.00. They are required to choose any of the amount stated. On the other hand, if the public are not willing to pay, they should proceed to Q4 where they are required to state the reason for their decision on why they are not willing to pay. For those who cannot make any decision or have no idea at all, they should proceed to Q5 to state their reasons or comments.

The contents of questionnaires are as follows:

Q1. Willingness to pay for the project

Q2. How much will you pay for the project in the next 10 years?

Q3. Willingness to pay 2-20RM/household/year for 10 years

50 percent of the number of copies of the questionnaires are made in such a way that the amount is written in ascending order, i.e. from RM2.00 to RM20.00 in RM2.00 increment while another 50 percent of the number of copies of the questionnaires show the amount is written in descending order; i.e. from RM20.00 to RM2.00 with the same RM2.00 interval. Hereinafter, the former questionnaire is expressed as "***Q2-20***" and the latter is as "***Q20-2***".

Q4. Reason why the respondents are not willing to pay in relation to Q1

Q5. Reason why the respondents have not decided to pay in relation to Q1

The questionnaires are attached at the end of this report for reference.

6.8.3 Result of the survey

(1) Basic description of the attendees and the completed questionnaires

The number of the attendees at the workshop and the questionnaires collected are shown at **Table 6.8.1**.

Table 6.8.1 The Numbers of Attendees and Questionnaires Submission

The number of attendees (A)	216
The number of "***Q2-20***" (B) (RM2.00-RM20.00:ascending)	43
The number of "***Q20-2***" (C) (RM20.00-RM2.00: descending)	36
The number of questionnaires collected (D = B + C)	79
Cover ratio: (D/A) x 100 (%)	37%

Note: The collected questionnaires with no response are excluded
About 1/3 of attendees (A) were junior and/or high school students, and questionnaire was not delivered to them.

(2) Analysis of the questionnaires

1) Willingness to pay (Q1)

The number of the attendees who expressed their willingness to pay as per Q1 is shown in **Table 6.8.2**.

Table 6.8.2 Willingness to Pay for the Project

	Q2-20	Q20-2	Total
The number of questionnaires collected (A)	43	36	79
Attendees expressing the willingness to pay (B)	25	24	49
Attendees not willing to pay (C)	9	12	21
Attendees showed "No Idea" (D)	9	0	9
Attendees showed any opinions (E = B + C)	34	36	70
Ratio of attendees showed the willingness to pay (F = B/E x 100)	74%	67%	70%

Note: The number of attendees who marked "No Idea" in the questionnaire with no written reasons is not counted

The analysis showed that more than half of the attendees (70%) are willing to pay for the project. Although majority of them expressed their willingness to pay for the project, some refused to pay. The reasons of their reluctance to pay are given in Q4 of the questionnaire. Five attendees who answered "**Q2-20**" mentioned that "MPSP should finance the project since they are already paying tax to the council". Similar reason was put forward by 4 attendees who answered "**Q20-2**". Although these nine attendees refuse to share the cost of financing the project, they support the improvement works and appreciate the importance. Taking this into consideration, the total attendees that support the project are 58 i.e. 30 attendees who answered questionnaire type "**Q2-20**" and 28 attendees who answered questionnaire type "**Q20-2**". The ratio of support for the project is shown in **Table 6.8.3** which is about 80% in total.

Table 6.8.3 Attendees Showed the Support for the Project

	Q2-20	Q20-2	Total
Attendees expressed opinions (A)	34	36	70
Attendees who are willing to pay (B)	25	24	49
Attendees who are not willing to pay in Q1 but support in Q4 (C)	5	4	21
Attendees support the project (D= B + C)	30	28	58
Ratio of attendees showed their support for the project (F = D/A x 100)	88%	78%	83%

2) The amount that is willing to pay based on Q2: Attendees input

From the feedback on Q2, some of the attendees who indicated their willingness to pay for the project, stated the amount they are willing to pay. The amount is shown in **Table 6.8.4**. The table shows that more than 60% of the attendees have expressed their

willingness to pay and provide the actual amount that they are willing to pay. This answer is the reflection of those who are really determined to pay for the project. But the feedback indicates clearly that values of "**Q2-20**" are lower than those of "**Q20-2**" (See **Figure 6.8.1**). There are two peaks of RM2.00 and RM12.00 in **Figure 6.8.1 (1)**, but there is no significant relationship observed. **Figure 6.8.1 (2)** does not show any relationship too. Therefore, it is to be concluded that the characteristic of attendees response cannot be described in any special probability function.

There is supposed to be an influence of the figures on the list in Q3. The list of questionnaire type "**Q2-20**" starts from RM2.00 but that of "**Q20-2**" is RM20.00. The total average will be applied for the evaluation, in order to wipe the influence away.

Table 6.8.4 Amount to be Paid for the Project

	Q2-20	Q20-2	Total
Attendees expressing their willingness to pay in Q1(A)	25	24	49
Attendees who has given actual amount they are willing to finance in Q2 (B)	17	16	33
B/A x 100 %	68%	67%	67%
Maximum value (RM)	*20*	*50*	*50*
Minimum value (RM)	*1*	*2*	*1*
Arithmetic mean (RM)	*7.2*	*14.8*	*10.9*
Geometric mean (RM)	*4.1*	*9.8*	*6.3*

Table 6.8.4 shows that those who have expressed their willingness to pay for the project and had also provide the average annual amount that they are willing to pay is RM6.30/household for 10 years. Two distributions of answers are shown in **Figure 6.8.1**.

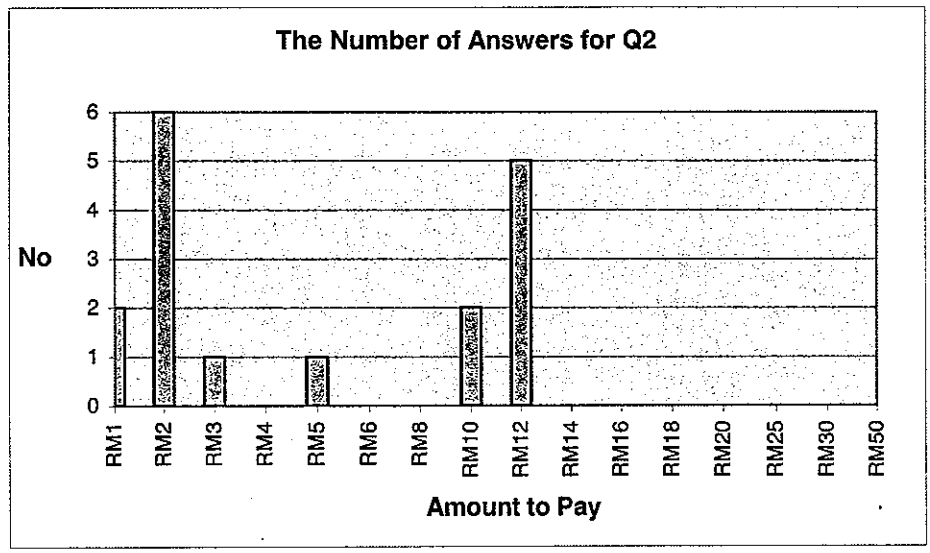


Figure 6.8.1 (1) Distribution of Answers of Q2 for "Q2-20"

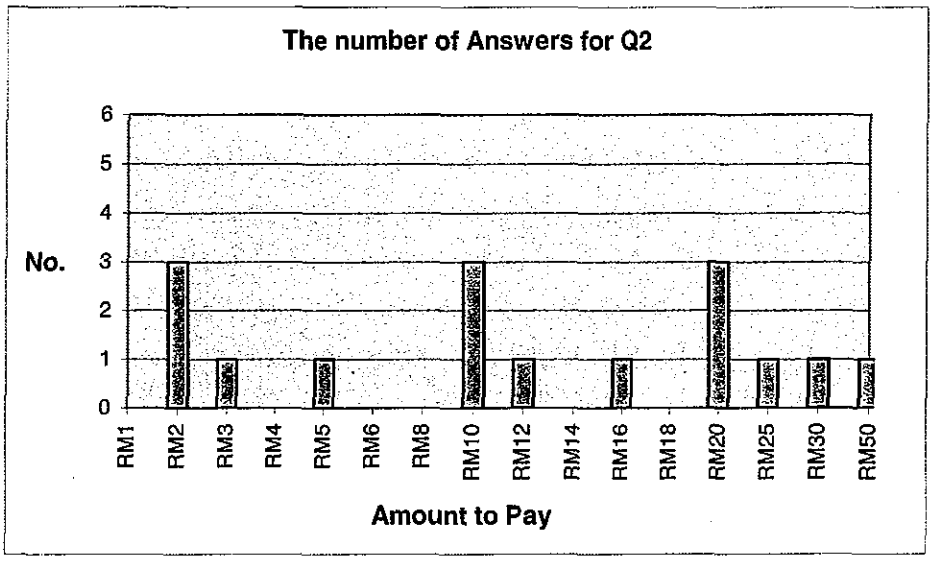


Figure 6.8.1 (2) Distribution of Answers of Q2 for "Q20-2"

3) The amount to pay (Q3): Selection from RM2.00 to RM20.00

Although some of the attendees indicated their willingness to pay, they did not provide the actual amount to be paid. In order to guide them, certain amount is proposed value ranging from RM2.00 and RM20.00 with every an increase of RM2.00 interval and this is shown as 10 sub questions of Q3. The result is summarised in **Table 6.8.5**. Although only a few answers are received, it clearly shows that the amount stated for "**Q2-20**" are lower than those for "**Q20-2**". Similar to Q2, it does not also indicate any specific relationship. The arithmetic means for "**Q2-20**" and "**Q20-2**" is RM6.8/household/year and RM16.8/household/year respectively. The value is lower than Q2 for questionnaire "**Q2-20**" and higher than Q2 for "**Q20-2**". However, the differences were not very significant. Therefore, the answer for Q2 and Q3 seemed to indicate that the group that replied to Q3 is the same sample group that replied to Q2.

Table 6.8.5 Answers Selected fromRM2.00 to RM20.00

Amount to pay	Numbers of answer		Total
	Q2-20	Q20-2	
RM2.00	2	0	2
RM4.00	0	0	0
RM6.00	0	0	0
RM8.00	0	0	0
RM10.00	3	0	3
RM12.00	0	2	2
RM14.00	0	0	0
RM16.00	0	0	0
RM18.00	0	0	0
RM20.00	0	3	3
Total number of answers	5	5	10
Maximum value (RM)	10	20	20
Minimum value (RM)	2	12	2
Arithmetic mean (RM)	6.8	16.8	11.8

4) Complete answers available for cost sharing

Even though there are several ironical answers for Q3, those data seems to be reliable because they explained the reason in Q4 and provide the actual amount in Q3. Therefore these data can also be summed up into one group.

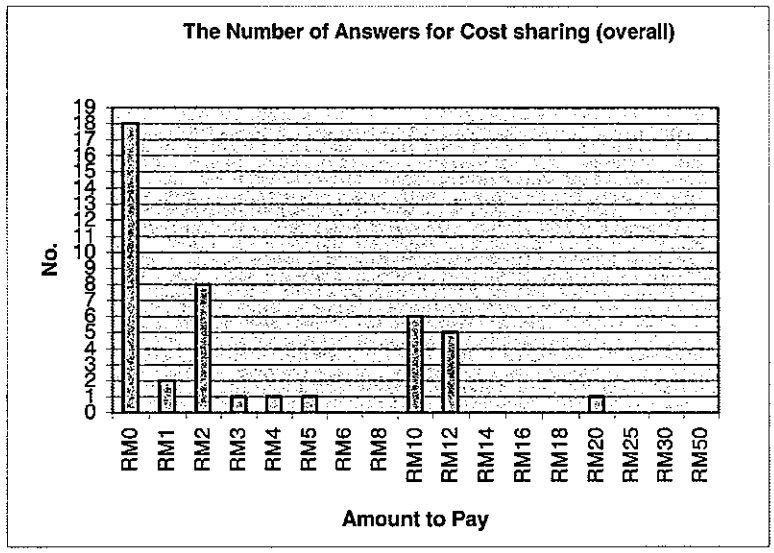


Figure 6.8.2 (1) Distribution of Amount to Pay for "Q2-20"

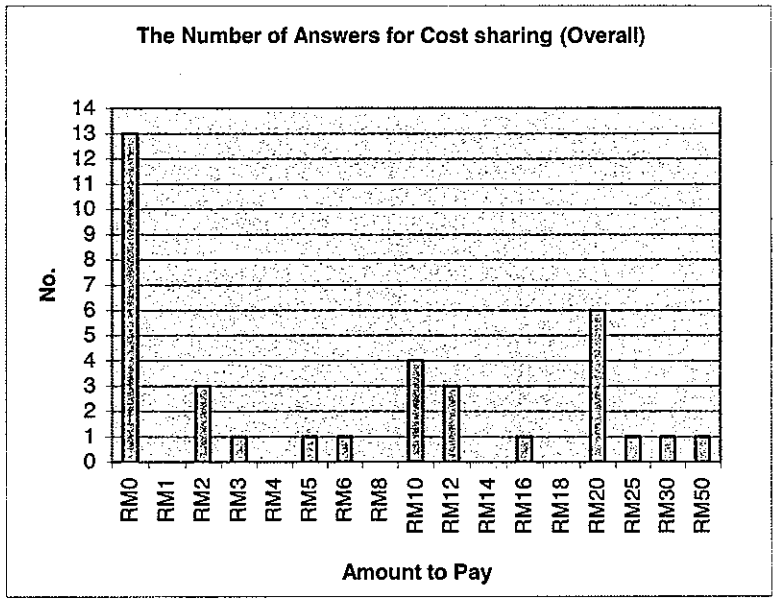


Figure 6.8.2 (2) Distribution of Amount to Pay for "Q20-2"

5) Total answers on amount that is willing to be paid

In order to balance the effect of orders of the values shown in Q3, the answers for both questionnaires can be summed up and treated as one group, because the total number of answers is not so different and neither both groups show any specific distribution functions.

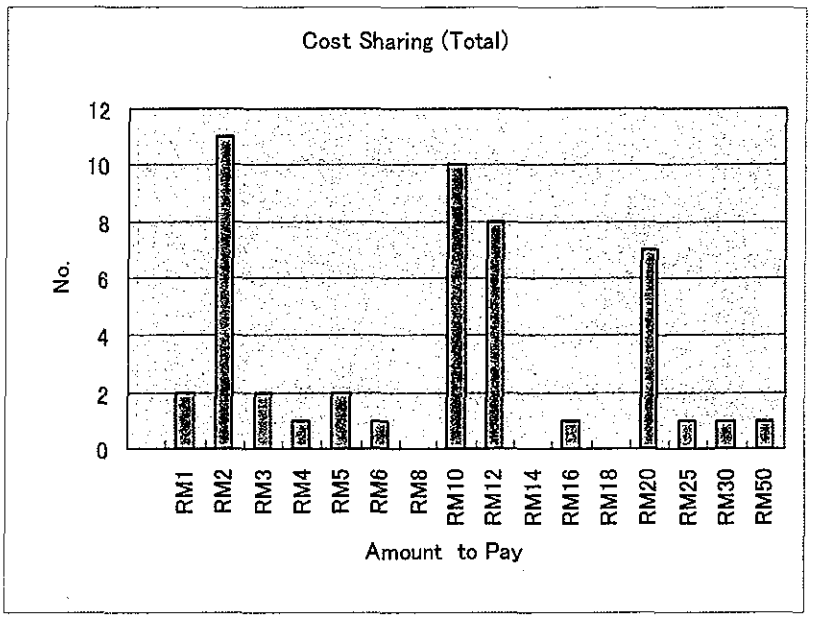


Figure 6.8.3 Distribution of Cost sharing for "Q2-20" and "Q20-2"

The arithmetic mean for the data shown in

Figure 6.8.3 is 11.0. This mean is not so much different from that of **Table 6.8.4**. Therefore, the amount that the public are willing to finance the cost of the project is estimated as 11RM/household/year based on the public of MPSP who attended the workshop.

6) Estimation of project cost

In order to evaluate the value for the improvement of the Ampang Jajar landfill site as one of pilot projects, the study team apply the figure from the survey and calculate the value of willingness to pay. The JICA Study Team is standing at pessimistic position, the lower values of the figure are applied for calculation. Based on the survey, the public opinion on the improvement project in Ampang Jajar landfill site are summarized into as follows.

(i) 70% of households are in favour of the project and are willing to pay. (See **Table 6.8.2**.)

(ii) The amount they are willing to pay for the project is estimated to be RM6.30/household/year. (See **Table 6.8.4**.)

Basic conditions for the project in Ampang Jajar landfill site are as follows:

(a) The number of the households in MPSP is 166,266 in the year of 2003

(b) In the workshop, it is explained that the project covered 20% of whole area of the site. Therefore, the attendees at the workshop recognized a scale of the project and evaluate the cost based on this scale.

(c) In the workshop and questionnaires, it is explained that period of 10 years is required to finance the project. But a few of the attendees possibly might not realise the period and expressed the willingness to pay for 1 year period.

Based on above conditions, value of willingness to pay for the project implementation can be estimated as follows:

70% x *166,266* households x RM*6.30*/household/year x *100/20* x *10* years = RM*36,662,000*

Meanwhile, in accordance with the pilot project cost and O/M cost estimation by the JICA study, project cost can be estimated as follows.

RM*669,805* x *100/20* + RM*241,699* x *10* years = RM*5,766,000*

Compare with above two values, it can be assumed that the project cost can be covered by the value of willingness to pay.

CHAPTER 7 FORMULATION OF LANDFILL DATABASE

7.1 LANDFILL INVENTORY IN MALAYSIA

7.1.1 Outline of the Survey

(1) Objectives

The "Landfill Inventory in Malaysia" was prepared for the purpose of using the data as references for future development and management of the landfill sites.

The objectives of the landfill site surveys were as follows:

- To gather information, collate and prepare the Landfill Inventory.
- To arrange and prioritise the landfill sites for safe closure and rehabilitation.
- To formulate landfill database

The survey work will help to identify issues arisen at the sites in order for the Study Team to evaluate the risks of environment pollution and hazards caused by the landfill sites. The inventory will provide useful information and necessary data to determine and verify the closure conditions of the landfill sites, and to examine the potentials for post closure utilisation and developments.

(2) Landfill sites to be covered in the survey

The landfill site survey has been carried out for landfills located in the Peninsular Malaysia, and the types of landfill sites covered in the survey were as follows.

- Landfill sites that receive municipal solid waste.
- Landfills that are still in operations or have been closed.

(3) Survey Procedure

Based on recommendations and assistance from MHLG, the JICA Study Team visited a total of 34 Local Authorities within Peninsular Malaysia. On the other hand, questionnaires on landfill sites inventory have been sent to all local authorities in Peninsular Malaysia.

Generally, most of the visits started with some introductory meeting and brief discussions with representatives from the Local Authorities. This gave the opportunity for the Study Team members to interview the officials to obtain key information such as the number of landfill sites, the operational status and details, environmental impact conditions and post-closure land utilisation. Following the discussions, the subsequent visits to the sites were usually escorted by the officials. .

A total of 64 landfill sites were visited and the field surveys carried out (i.e. 38 sites still in operations and 26 closed sites). While, questionnaire answer for other 83 landfill sites were submitted by the LAs. Therefore, landfill database has been formulated for total of 147 landfill sites, i.e. operating 92 sites and closed 55 sites.

The field surveys were carried out by the JICA Study Team members in two teams, i.e. Team A and Team B. Generally, all Local Authorities visited were very cooperative and responsive. Hence the task of data collection progressed smoothly and the entire survey exercise was completed in time.

The summary of the details of the visited landfill sites is shown in **Table 7.1.1**.

Table 7.1.1 Overview of Site Visiting (actual field survey)

Team	State	Local Authority	Operating	Closed	Total	Date
Team A, B (6-8 Mar)	Selangor	M.P. Petaling Jaya	0	1	1	06-Mar
		M.P. Klang	1	0	1	06-Mar
		M.P. Kajang	1	0	1	07-Mar
		M.P. Selayang	1	0	1	07-Mar
		D.B. Kuala Lumpur	1	0	1	08-Mar
Team A (10- 25 Mar)	N. Sembilan	M.P. Nilai	1	1	2	10-Mar
		M.P. Seremban	1	0	1	10-Mar
		M.P. Port Dickson	2	2	4	11-Mar
	Melaka	M.D. Alor Gajah	1	1	2	12-Mar
		M.B. Melaka	1	1	2	13-Mar
		M.D. Jasin	0	1	1	14-Mar
	Johor	M.D. Tangkak	0	1	1	14-Mar
		M.P. Muar	1	0	1	14-Mar
		M.P. Johor Baharu Tengah	1	3	4	17-Mar
		M.D. Kota Tinggi	1	1	2	18-Mar
		M.D. Mersing	3	0	3	19-Mar
	Pahang	M.D. Rompin	1	0	1	20-Mar
		M.D. Pekan	1	0	1	20-Mar
		M.P. Kuantan	1	2	3	21-Mar
	Terengganu	M.P. Kemaman	2	2	4	22-Mar
		M.P. K.Terengganu	1	2	3	23-Mar
	Kelantan	M.P. Kota Baru	1	1	2	24-Mar
		M.D. Kuala Krai Selatan	1	1	2	25-Mar
Team B (10-21 Mar)	Perak	M.D. Kinta Selatan	1	2	3	10-Mar
		M.B. Ipoh	1	1	2	11-Mar
		M.P. Taiping	1	1	2	12-Mar
	Penang	M.P. Pulau Pinang	1	0	1	13-Mar
		M.P. Seberang Prai	2	0	2	14-Mar
	Kedah	M.P. Kulim	1	0	1	15-Mar
		M.D. Baling	1	1	2	16-Mar
		M.P. Sungai Petani	1	1	2	17-Mar
		M.P. Kota Setar	1	0	1	18-Mar
		M.D. Kubang Pasu	1	0	1	19-Mar
	Perlis	M.P. Kangar	1	0	1	20-Mar
	Perak	M.D. Tapah	2	0	2	21-Mar
Total of Visit Sites			**38**	**26**	**64**	
Total Number of Sites (Information from MHLG)			168	99	267	
Cover Ratio			**23%**	**26%**	**24%**	

As per the official lists of landfills provided by MHLG, the total number of officially registered landfill sites for the whole for Malaysia is 267 (i.e. 168 sites still in operations and 99 closed sites). Due to time constraints, the JICA Study Team field survey exercise only managed to cover approximately 24% of the 267 landfill sites in all over Malaysia. However, it was noted that some of the closed sites visited were not listed in the official MHLG landfill site lists, and thus it is strongly recommended that MHLG should continue the work and complete the inventory of all the remaining sites, and to identify any existing sites that were not included in the list. **Table 7.1.2** shows

the outline of 147 landfill sites covered by the landfill inventory survey of the JICA Study.

Table 7.1.2 List of Landfill Sites Covered by the JICA Study

ID	State	No.	Name of LA	Name of Site	Landfill Level	Category	Year Start	Year End	Area (ha)	Environ-mental Risk	Value of Land Utilization	The necessity of the safe closure				Group	Closure Level
												C1	C2	C3	C4		
1	Selangor	SL-01	MP Petaling Jaya	Kelana Jaya	Level 1	Closed	1990	1996	8.1	0.28	0.80	0.46				CL-C	C2
2	Selangor	SL-02	MP Klang	Telok Kapas	Level 1	Operation	2000	2003	32.4	0.40	0.28	0.44	0.55	0.43		OP-D	C2
3	Selangor	SL-03	MP Kajang	Sungai Kenbong	Open Dump	Operation	1996	2008	16.2	0.64	0.29	0.76	0.63	1.00		OP-B	C3
4	Selangor	SL-04	MP Selayang	Kundang	Level 1	Operation	1996	2005	32.4	0.34	0.00	0.44	0.48	0.43		OP-D	C2
5	DBKL	DB-01	DB Kuala Lumpur	Taman Beringin	Level 2	Operation	1996	2004	12.0	0.43	0.52	0.54	0.63	0.47		OP-A	C3
6	N.Sembilan	NS-01	MP Nilai	Pajam	Level 1	Operation	1996	2018	27.9	0.23	0.28	0.42				OP-D	C1
7	N.Sembilan	NS-02	MP Nilai	Kuala Sawah	Level 1	Closed	1998	2003	10.1	0.53	0.11	0.58	0.63	1.00		CL-B	C3
8	N.Sembilan	NS-03	MP Seremban	Sikamat	Level 1	Operation	1986	2003	5.3	0.39	0.58	0.68	0.45	0.25		OP-C	C3
9	N.Sembilan	NS-04	MP Port Dickson	Quarters MPPD	Open Dump	Closed	1950	1960	0.4	0.24	0.23	0.22				CL-D	C1
10	N.Sembilan	NS-05	MP Port Dickson	Bukit Palung	Open Dump	Operation	1975	2013	25.0	0.41	0.22	0.78	0.33	0.25		OP-B	C3
11	N.Sembilan	NS-06	MP Port Dickson	Pengkalan Kempas	Open Dump	Closed	1990	2002	1.2	0.28	0.33	0.25		0.21		CL-D	C2
12	N.Sembilan	NS-07	MP Port Dickson	Sua Betong	Open Dump	Operation	1998	2008	3.2	0.47	0.06	0.78	0.52	0.47		OP-B	C3
13	Melaka	ML-01	MD Alor Gajah	Air Molek	Open Dump	Operation	1970	2013	2.4	0.35	0.19	0.78				OP-D	C1
14	Melaka	ML-02	MD Alor Gajah	Pulau Sebang	Open Dump	Closed	1960	2002	0.8	0.45	0.13	0.69	0.63			CL-B	C2
15	Melaka	ML-03	MB Melaka	Krubong	Level 2	Operation	1994	2005	27.7	0.45	0.28	0.78	0.52	0.47		OP-B	C3
16	Melaka	ML-04	MB Melaka	Krubong A	Open Dump	Closed	1974	1994		0.32	0.72	0.34				CL-C	C2
17	Melaka	ML-05	MB Melaka	Kota Laksamana	Open Dump	Closed	1950	1973		0.30	0.71	0.35				CL-C	C2
18	Melaka	ML-06	MD Jasin	Lipat Kajang	Level 1	Closed	1967	2000	3.2	0.43	0.42	0.31		0.57		CL-B	C3
19	Melaka	ML-07	MD Jasin	Batang Melaka	Open Dump	Closed	1970	2001	1.5	0.28	0.42	0.39				CL-D	C1
20	Melaka	ML-08	MD Jasin	Kesang Pajak	Open Dump	Closed	2001	2002	9.2	0.59	0.52	0.40	0.26	0.70	0.43	CL-A	C4
21	Johor	JH-01	MD Tangkak	Chohong	Open Dump	Closed	1970	2000	1.0	0.58	0.38	0.34	0.29	0.57	0.43	CL-B	C4
22	Johor	JH-02	MP Muar	Bakri	Level 1	Operation	1993	2005	14.6	0.32	0.46	0.31	0.37	0.21		OP-C	C3
23	Johor	JH-03	MP JB Tengah	Ulu Tiram	Level 2	Operation	1997	2003	17.4	0.46	0.18	0.95	0.75	0.47		OP-B	C3
24	Johor	JH-04	MP JB Tengah	Lima Kedai	Open Dump	Closed	1992	1997	2.5	0.22	0.14	0.27				CL-D	C1
25	Johor	JH-05	MP JB Tengah	Kempas	Open Dump	Closed	1988	1997	0.9	0.27	0.42	0.34				CL-D	C1
26	Johor	JH-06	MP JB Tengah	Taman Mega Ria	Open Dump	Closed	1988	1997	6.5	0.37	0.45	0.27	0.40	0.47		CL-D	C2
27	Johor	JH-07	MD Kota Tinggi	Batu Empat	Open Dump	Operation	1988	2004	6.0	0.69	0.09	1.00	0.63	1.00		OP-B	C3
28	Johor	JH-08	MD Kota Tinggi	Sungai Rengit	Open Dump	Operation	1998	2008		0.36	0.10	0.95	0.23			OP-D	C2
29	Johor	JH-09	MD Kota Tinggi	Bandar Kota Tinggi	Open Dump	Closed		1988	1.6	0.44	0.68	0.34		0.53		CL-A	C3
30	Johor	JH-10	MD Mersing	Jemaluang	Open Dump	Operation	1993	2013	4.0	0.27	0.07	0.47				OP-D	C1
31	Johor	JH-11	MD Mersing	Endau	Open Dump	Operation	1993	2013	4.9	0.27	0.20	0.47				OP-D	C1
32	Johor	JH-12	MD Mersing	Sri Pantai	Open Dump	Operation	1993	2013	4.0	0.38	0.36	0.86	0.26			OP-D	C2
33	Pahang	PH-01	MD Rompin	Kampong Feri	Level 1	Operation	1983	2020	5.0	0.26	0.50	0.59				OP-C	C2

ID	State	No.	Name of LA	Name of Site	Landfill Level	Category	Year Start	Year End	Area (ha)	Environ-mental Risk	Value of Land Utilization	The necessity of the safe closure				Group	Closure Level
												C1	C2	C3	C4		
34	Pahang	PH-02	MD Pekan	Pekan Nenasi	Level 2	Operation	1988	2023	22.7	0.26	0.22	0.49	0.30	0.21		OP-D	C2
35	Pahang	PH-03	MP Kuantan	Taman Bandar	Open Dump	Closed	1983	1986	2.0	0.24	0.58	0.20				CL-C	C2
36	Pahang	PH-04	MP Kuantan	Gambang	Open Dump	Closed	1965	2001	2.0	0.28	0.18	0.53				CL-D	C1
37	Pahang	PH-05	MP Kuantan	Indera Mahkota	Level 1	Closed	1985	1993	50.0	0.26	0.55					CL-C	-
38	Pahang	PH-06	MP Kuantan	Jabor Jerangau	Level 2	Operation	1993	2018	55.0	0.30	0.18	0.36	0.55	0.43		OP-D	C2
39	Terengganu	TR-01	MP Kemaman	Fikri	Open Dump	Closed	1976	1985	2.0	0.26	1.00	0.22				CL-C	C2
40	Terengganu	TR-02	MP Kemaman	Gelugor	Open Dump	Closed	1981	1992	1.2	0.22	0.40	0.22				CL-D	C1
41	Terengganu	TR-03	MP Kemaman	Gelugor	Open Dump	Operation	1993	2006	10.0	0.32	0.50	0.59				OP-C	C2
42	Terengganu	TR-04	MP Kemaman	Mak Cili Paya	Open Dump	Operation	1985	2006	5.0	0.28	0.46	0.54				OP-C	C2
43	Terengganu	TR-05	MP K.Terengganu	Tok Jembal	Open Dump	Closed	1985	1994	8.1	0.28	0.55	0.22				CL-C	C2
44	Terengganu	TR-06	MP K.Terengganu	Wakaf Tok Keh	Open Dump	Closed	1975	1985	4.0	0.29	0.68	0.29				CL-C	C2
45	Terengganu	TR-07	MP K.Terengganu	Kubang Ikan	Open Dump	Operation	1998	2004	13.3	0.53	0.49	1.00	0.63	0.47		OP-A	C3
46	Kelantan	KL-01	MP Kota Baru	Panji	Open Dump	Closed	1961	1987	4.0	0.26	0.80	0.22				CL-C	C2
47	Kelantan	KL-02	MP Kota Baru	Tebing Tinggi	Open Dump	Operation	1987	2003	19.0	0.55	0.20	0.81	0.70	0.47		OP-B	C3
48	Kelantan	KL-03	MD K.Krai Selatan	Sungai Sam	Open Dump	Closed	1984	2000	0.3	0.32	0.00	0.46	0.29			CL-D	C2
49	Kelantan	KL-04	MD K.Krai Selatan	Bukit Tembeling	Open Dump	Operation	2000	2013	4.0	0.39	0.00	0.90	0.34			OP-D	C2
50	Perak	PR-01	MD Kinta Selatan	Sg. Siput Selatan	Level 2	Operation	1990	2028	26.7	0.20	0.46	0.41				OP-C	C2
51	Perak	PR-02	MD Kinta Selatan	Kg. Batu Putih (Kg. Tersusun)	Open Dump	Closed	1980		2.0	0.26	1.00	0.22				CL-C	C2
52	Perak	PR-03	MD Kinta Selatan	Taman Sri Kampar	Open Dump	Closed	1960	1970	4.0	0.49	0.40	0.44	0.40	0.30	0.30	CL-B	C4
53	Perak	PR-04	MB Ipoh	Bercham	Level 1	Operation	1986	2007	50.0	0.49	0.57	0.80	0.63	0.47		OP-A	C3
54	Perak	PR-05	MB Ipoh	Buntong	Open Dump	Closed	1970	1986	20.0	0.28	0.96	0.22				CL-C	C2
55	Perak	PR-06	MB Taiping	Jebong	Open Dump	Operation	2000	2008	20.0	0.70	0.48	0.85	0.75	0.47	0.81	OP-A	C4
56	Perak	PR-07	MB Taiping	Tekkah Jaya	Open Dump	Closed	1980	1999	40.0	0.39	0.67	0.59			0.37	CL-C	C3
57	Perak	PR-08	MD Tapah	Pekan Getah	Level 1	Operation	1985	2004	21.5	0.52	0.62	0.95	0.63	0.47		OP-A	C3
58	Perak	PR-09	MD Tapah	Bidor	Level 1	Operation	1980	2013	2.1	0.60	0.38	0.95	0.86	0.47		OP-B	C3
59	Penang	PP-01	MP Pulau Pinang	Jeti Jelutong	Level 1	Operation	1980	2001	20.0	0.53	0.62	0.73	0.82	0.47		OP-A	C3
60	Penang	PP-02	MP Seberang Perai	Ampang Jajar	Level 3	Operation	1980	2003	17.0	0.32	0.50	0.68	0.60	0.43		OP-C	C3
61	Penang	PP-03	MP Seberang Perai	Pulau Burong	Level 3	Operation	1980	2009	64.0	0.28	0.09	0.44	0.48	0.43		OP-D	C2
62	Kedah	KD-01	MP Kulim Kedah	Padang Cina	Open Dump	Operation	1996	2023	56.0	0.57	0.05	0.88	0.82	0.47		OP-B	C3
63	Kedah	KD-02	MD Baling	Pulai	Level 3	Operation	2001	2018	6.8	0.65	0.09	0.44	0.59	1.00	0.81	OP-B	C4
64	Kedah	KD-03	MD Baling	Kuala Pegang	Open Dump	Closed	1989	2002	11.0	0.35	0.12	0.63				CL-D	C1
65	Kedah	KD-04	MP Sungai Petani	Semeling	Level 1	Operation	1989	2013	51.0	0.45	0.23	0.80	0.63	0.47		OP-B	C3
66	Kedah	KD-05	MP Sungai Petani	Jeniang	Open Dump	Closed	1985	2001	1.5	0.23	0.12	0.22				CL-D	C1
67	Kedah	KD-06	MP Kota Setar	Bukit Tok Bertandok	Level 2	Operation	1983	2009	9.7	0.61	0.35	0.58	0.78	0.96		OP-B	C3
68	Kedah	KD-07	MD Kubang Pasu	Paya Kemunting	Level 2	Operation	1974	2005	5.0	0.41	0.23	0.90	0.60	0.43		OP-B	C3
69	Perlis	PL-01	MP Kangar	Kuala Perlis	Open Dump	Operation	1983	2003	8.0	0.52	0.70	0.95	0.52	0.25		OP-A	C3

ID	State	No.	Name of LA	Name of Site	Landfill Level	Category	Year Start	Year End	Area (ha)	Environ-mental Risk	Value of Land Utilization	The necessity of the safe closure				Group	Closure Level
												C1	C2	C3	C4		
70	Kelantan	KL-05	MD K.Krai Selatan	Dabong	Open Dump	Operation	1996	2006	0.2	0.34	0.24	0.49				OP-D	C1
71	Pahang	PH-07	MP Kuantan	Atabara	Open Dump	Closed	1984	1985	20.0	0.26	0.46					CL-D	-
72	Pahang	PH-08	MD Bentong	Sungai Sematut	Level 1	Closed			2.0	0.41	0.30	0.45	0.23	0.36	0.36	CL-B	C4
73	Pahang	PH-09	MD Bentong	Chamang	Open Dump	Operation	1995	2006	3.0	0.46	0.30	0.43	0.23	0.36	0.36	OP-B	C4
74	Pahang	PH-10	MP Temerloh	Ulu Tualang	Level 3	Operation	1998	2006	7.3	0.20	0.54	0.26				OP-C	C2
75	Pahang	PH-11	MD Cameron Highlands	Tapak Pelupusan Sisa Pepejal MDCH (Simpang Pulai)	Open Dump	Operation	2001	2008	0.4	0.40	0.30	0.24	0.26	0.30	0.21	OP-B	C4
76	Pahang	PH-12	MD Cameron Highlands	Tapak Pelupusan Sisa Pepejal MDCH (Cameron Highlands)	Open Dump	Closed	1990	2001	0.4	0.34	0.62	0.51				CL-C	C2
77	Selangor	SL-05	MD Kuala Langat	Tapak Pelupusan Sampah	Open Dump	Operation		2007	6.1	0.47	0.35	0.53		0.64		OP-B	C3
78	Selangor	SL-06	MD Kuala Langat	Tapak Pelupusan Tanjung Sepat	Open Dump	Closed	1985	1995	1.0	0.23	0.41					CL-D	-
79	Selangor	SL-07	MD Kuala Langat	Tapak Pelupusan Banting	Open Dump	Closed	1985	1998	3.0	0.48	0.76	0.47	0.36	0.36	0.32	CL-A	C4
80	Pahang	PH-13	MD Jerantut	Kg.Mat Lilau	Level 2	Operation	1997	2005	4.4	0.68	0.18	0.65	0.94	1.00		OP-B	C3
81	Pahang	PH-14	MD Jerantut	Batu 57	Open Dump	Closed	1984	1996	2.0	0.32	0.76	0.33				CL-C	C2
82	Pahang	PH-15	MD Maran	Tapak Sampah Maran	Level 2	Operation	1988	2013	4.0	0.30	0.24	0.47	0.36	0.26		OP-D	C2
83	Pahang	PH-16	MD Maran	Tapak Sampah Jengka 10	Level 1	Operation	1997	2030	8.0	0.42	0.24		0.22	0.90		OP-B	C3
84	Pahang	PH-17	MD Raub	Sg.Ruan	Level 3	Operation	1997		3.4	0.22	0.40	0.43			0.21	OP-D	C2
85	Pahang	PH-18	MD Raub	Cheroh	Level 3	Operation	1991	2008	4.9	0.30	0.54	0.43	0.31	0.30	0.21	OP-C	C3
86	Perak	PR-10	MD Hilir Perak	MDHP (Teluk Intan)	Open Dump	Operation	1993	2008	20.3	0.35	0.35	0.55				OP-D	C1
87	Perak	PR-11	MD Hilir Perak	Tapak Sampah MDHP (Kaw. Pekan Jenderata)	Open Dump	Operation	1979	2006	0.4	0.35	0.22	0.55				OP-D	C1
88	Perak	PR-12	MD Hilir Perak	Tapak Sampah MDHP (Kaw. Bagan Datoh)	Open Dump	Operation	1979	2006	1.2	0.39	0.32	0.51				OP-D	C1
89	Perak	PR-13	MD Kuala Kangsar	MDKK	Open Dump	Operation	1986	2006	13.4	0.48	0.30	0.57	0.23	0.36	0.36	OP-B	C4
90	Perak	PR-14	MD Lenggong	Air Kala	Open Dump	Operation	1989	2008	1.5	0.34	0.30	0.53				OP-D	C1
91	Perak	PR-15	MD Lenggong	Kuak	Open Dump	Closed	1979	1999	1.2	0.31	0.29	0.33				CL-D	C1
92	Kelantan	KL-06	MD Jeli	MD Jeli (Bato 'O')	Open Dump	Closed	1990	2000	0.4	0.36	0.33	0.57				CL-D	C1
93	Kelantan	KL-07	MD Jeli	MD Jeli (Kg.Sg.Mengkong)	Open Dump	Operation	2000	2015	2.4	0.42	0.05	0.61	0.36	0.26		OP-B	C3
94	Perak	PR-16	MD Pengkalan Hulu	Tapak Pelupusan Sisa Pepejal	Open Dump	Operation	1993	2009	8.4	0.52	0.30	0.45	0.44	0.26	0.61	OP-B	C4
95	Perak	PR-17	MD Selama	Tapak Pelupusan MDS	Open Dump	Operation	1991	2008	4.0	0.44	0.58	0.65	0.22			OP-A	C3
96	Perak	PR-18	MD Tanjong Malim	Panderas	Open Dump	Operation	1980	2010	2.5	0.73	0.60	0.87	0.54	0.69		OP-A	C3
97	Selangor	SL-08	MB Shah Alam	MPSA	Open Dump	Closed		1996	12.0	0.26	0.12					CL-D	-
98	Selangor	SL-09	MP Subang Jaya	Worldwide Landfills Sdn Bhd	Level 4	Operation	1995	2015	43.0	0.35	0.63	0.22	0.48	0.56	0.21	OP-C	C3
99	Selangor	SL-10	MD Kuala Selangor	Kubang Badak B.Berjuntai		Operation	1984		20.0	0.38	0.31	0.65	0.39	0.39		OP-D	C2
100	Selangor	SL-11	MD Sabak Bernam	Jalan Panchang Bedena	Level 3	Operation	1984	2006	4.0	0.18	0.30		0.22	0.26		OP-D	C2
101	Perak	PR-19	MD Kerian	Jalan Dnnistown Parit Buntar	Open Dump	Operation	1979	2003	0.8	0.64	0.60	0.69	0.79	0.56	0.21	OP-A	C4
102	Perak	PR-20	MD Kerian	Pematang Pasir Alor Pongsu (Beriah) Bagan Serai.	Open Dump	Operation	1983	2005	2.4	0.64	0.60	0.69	0.79	0.56	0.21	OP-A	C4
103	Terengganu	TR-08	MD Besut	Landfield (Sistem Tambus)	Open Dump	Operation	1993	2010	4.6	0.32	0.20	0.45				OP-D	C1
104	Terengganu	TR-09	MD Hulu Terengganu	Tapak Pelupusan MDHT	Open Dump	Operation	1982	2013	9.5	0.30	0.52				0.30	OP-C	C3
105	Terengganu	TR-10	MD Marang	MDM	Open Dump	Operation	1986	2004	2.5	0.29	0.04	0.39				OP-D	C1

ID	State	No.	Name of LA	Name of Site	Landfill Level	Category	Year Start	Year End	Area (ha)	Environmental Risk	Value of Land Utilization	The necessity of the safe closure				Group	Closure Level
												C1	C2	C3	C4		
106	Johor	JH-13	MD Labis	Pusat Membuang Sampah Jalan Temayar	Open Dump	Operation		2005		0.40	0.35	0.67	0.30	0.26		OP-D	C2
107	Johor	JH-14	MD Labis	Pusat Membuang Sampah Jalan Maskil	Open Dump	Operation	2003	2013		0.40	0.35	0.67	0.30	0.26		OP-D	C2
108	Johor	JH-15	MD Pontian	Tapak Pelupusan Jalan Sawah, Pekan Nenas	Open Dump	Operation	1998	2008	12.0	0.40	0.13	0.41	0.30	0.26		OP-D	C2
109	Johor	JH-16	MD Pontian	Tapak Pelupusan Rimba Terjun, Pontian	Open Dump	Operation	1980	2003	12.0	0.45	0.38	0.31	0.65	0.56		OP-B	C3
110	Johor	JH-17	MD Pontian	Tapak Pelupusan Sanglang, Ayer Baloi	Open Dump	Operation	1986	2006	1.2	0.55	0.14	0.55	0.21	0.24	0.51	OP-B	C4
111	Johor	JH-18	MD Segamat	Segamat Baru		Closed		2003	3.3	0.40	0.33	0.35	0.57	0.56	0.21	CL-D	C2
112	Johor	JH-19	MD Segamat	Jementah		Operation	1970	2023	10.0	0.27	0.20	0.41	0.30	0.26		OP-D	C2
113	Johor	JH-20	MD Segamat	Lebuh Raya Segamat / Kuantan		Operation	2003		90.0	0.36	0.29	0.39	0.57	0.56	0.21	OP-D	C2
114	Johor	JH-21	MD Tangkak	Simpang Bekoh	Open Dump	Operation	2000	2023	3.0	0.46	0.10	0.20	0.22	0.79		OP-B	C3
115	Johor	JH-22	MD Tangkak	Batu 16 Sengkang, Bukit Gambir	Open Dump	Operation	1970	2004	7.0	0.43	0.52	0.53	0.26	0.20		OP-A	C3
116	Johor	JH-23	MD Simpang Renggam	Simpang Renggam (Ladang Cep 1)	Open Dump	Operation	1996	2012	6.0	0.39	0.30	0.92	0.28			OP-D	C2
117	Johor	JH-24	MD Simpang Renggam	Machap	Open Dump	Closed	1986	1996	3.0	0.47	0.18	0.53	0.62	0.56		CL-B	C3
118	Johor	JH-25	MD Simpang Renggam	Renggam	Open Dump	Closed	1980	1984	2.0	0.34	0.22	0.33	0.22	0.26		CL-D	C2
119	Johor	JH-26	MD Simpang Renggam	Simpang Renggam (Jln Kulai Cina)	Open Dump	Closed	1990	1995	0.5	0.46	0.60	0.55	0.26	0.30		CL-A	C3
120	Johor	JH-27	MD Yong Peng	MDYP		Operation	1990		0.4	0.49	0.24	0.71	0.65	0.56	0.21	OP-B	C4
121	Kedah	KD-08	MP Langkawi	Tapak Pelupusan Sisa-Sisa Pepejal Majlis	Level 1	Operation	1988	2013	30.0	0.49	0.00	0.44	0.36	0.90		OP-B	C3
122	Kedah	KD-09	MD Padang Terap	MDPT	Open Dump	Operation	1988		2.0	0.53	0.42	0.83	0.57	0.56		OP-A	C3
123	Kelantan	KL-08	MD Bachok	Kg. Sungai Gali, Telong	Open Dump	Operation	1995	2009	10.0	0.40	0.30	0.65	0.27			OP-D	C2
124	Kelantan	KL-09	MD Bachok	Kg. Hujung Repek, Repek	Open Dump	Closed	1985	1995	2.5	0.49	0.52	0.51			0.59	CL-A	C4
125	Perak	PR-21	MD Gerik	MD Gerik (1)	Open Dump	Closed	1976	1997	1.8	0.28	0.10	0.24				CL-D	C1
126	Perak	PR-22	MD Gerik	MD Gerik (2)	Open Dump	Operation	1997	2032	2.0	0.49	0.18	0.47	0.48	0.56		OP-B	C3
127	Kelantan	KL-10	MD Machang	Air Berlaga	Open Dump	Operation	2002	2010	4.0	0.40	0.30	0.53	0.36	0.26		OP-B	C3
128	Kelantan	KL-11	MD Pasir Puteh	Tapak Pelupusan Bukit Gedombak	Open Dump	Operation	1982	2020	2.0	0.38	0.22	0.45	0.22			OP-D	C2
129	Kelantan	KL-12	MD Tumpat	Kok Bedollah	Level 1	Operation	1988		20.0	0.35	0.15	0.44	0.36	0.26		OP-D	C2
130	N.Sembilan	NS-08	MP Port Dickson	Bt.2, Jln Seremban		Closed		1972	2.0	0.22	0.27	0.37				CL-D	C1
131	N.Sembilan	NS-09	MD Jelebu	Pertang	Open Dump	Closed	1997	2002	2.4	0.33	0.17	0.41				CL-D	C1
132	N.Sembilan	NS-10	MD Jelebu	Sg.Muntuh	Open Dump	Operation	2002	2032	6.1	0.33	0.17	0.41				OP-D	C1
133	N.Sembilan	NS-11	MD Jempol	MD Jempol (Rompin)	Open Dump	Operation	1993		5.0	0.39	0.05	0.59				OP-D	C1
134	N.Sembilan	NS-12	MD Jempol	MD Jempol (Bahau)	Open Dump	Closed	1981	1993	1.2	0.26	0.38	0.28				CL-D	C1
135	N.Sembilan	NS-13	MD Rembau	Chembong	Open Dump	Operation	1982	2010	4.0	0.43	0.41	0.51	0.35	0.26		OP-A	C3
136	Kelantan	KL-13	MD Tanah Merah	KG.Cat Rimau	Open Dump	Closed	1981	1999		0.60	0.32	0.94	0.54	0.30	0.44	CL-B	C4
137	Perak	PR-23	MP Manjung	Sungai Wangi	Level 1	Operation	1980	2003	10.1	0.42	0.09	0.67	0.40	0.30	0.21	OP-B	C4
138	Perak	PR-24	MP Manjung	Tapak Pelupusan Teluk Cempedak	Level 1	Operation	1990	2005	2.0	0.34	0.44	0.47			0.21	OP-C	C3
139	Perak	PR-25	MP Manjung	Pantai Remis	Open Dump	Operation	1970		1.2	0.38	0.12	0.31	0.26	0.30	0.21	OP-D	C2
140	Perak	PR-26	MP Manjung	Beruas	Open Dump	Operation	1970		0.8	0.37	0.09	0.45	0.36	0.26		OP-D	C2
141	Selangor	SL-12		Ampang Jaya	Level 1	Closed	1980	1997	10.0	0.67	0.33	0.47	0.86	1.00		CL-B	C3

ID	State	No.	Name of LA	Name of Site	Landfill Level	Category	Year Start	Year End	Area (ha)	Environ-mental Risk	Value of Land Utilization	The necessity of the safe closure				Group	Closure Level
												C1	C2	C3	C4		
142	DBKL	DB-02	DB Kuala Lumpur	Jinjang Utara	Level 2	Operation	1979		10.0	0.52	0.59	0.69	0.76	0.30		OP-A	C3
143	DBKL	DB-03	DB Kuala Lumpur	Sri Petaling	Level 1	Closed	1979	1991	21.0	0.35	0.59	0.26	0.30	0.26		CL-C	C3
144	DBKL	DB-04	DB Kuala Lumpur	Sungai Bersi	Level 2	Closed	1989	1995	14.0	0.36	0.59	0.26	0.44	0.26		CL-C	C3
145	DBKL	DB-05	DB Kuala Lumpur	Paka 2	Level 2	Closed	1989	1994	6.5	0.37	0.59	0.63	0.36	0.26		CL-C	C3
146	DBKL	DB-06	DB Kuala Lumpur	Paka 1	Level 1	Closed	1989	1994	6.5	0.40	0.75	0.63	0.36	0.26		CL-A	C3
147	DBKL	DB-07	DB Kuala Lumpur	Kampung Semarak (Brickfield)	Open Dump	Closed				0.44	0.63	0.63	0.36	0.26		CL-A	C3

7.1.2 Results of the Survey

(1) Basic information of the landfill site visited

The number and the status of landfill sites that were visited (64 landfills) are represented in the chart as shown in **Figure 7.1.1**. From the chart, it can be seen that in most of the States, the ratios between the number of operational and closed sites were almost equal. The data for Kedah, Pulau Pinang, Perlis and Selangor, showed the number of operational sites are more than the closed sites. Although there is no basis to assume that the number of operational sites should be the same for the closed sites, the Study Team however thinks that there is the possibly that information on some of the earlier closed sites was not properly kept and hence such sites were forgotten. Nevertheless, further investigation into these sites should be carried out and their existence recorded.

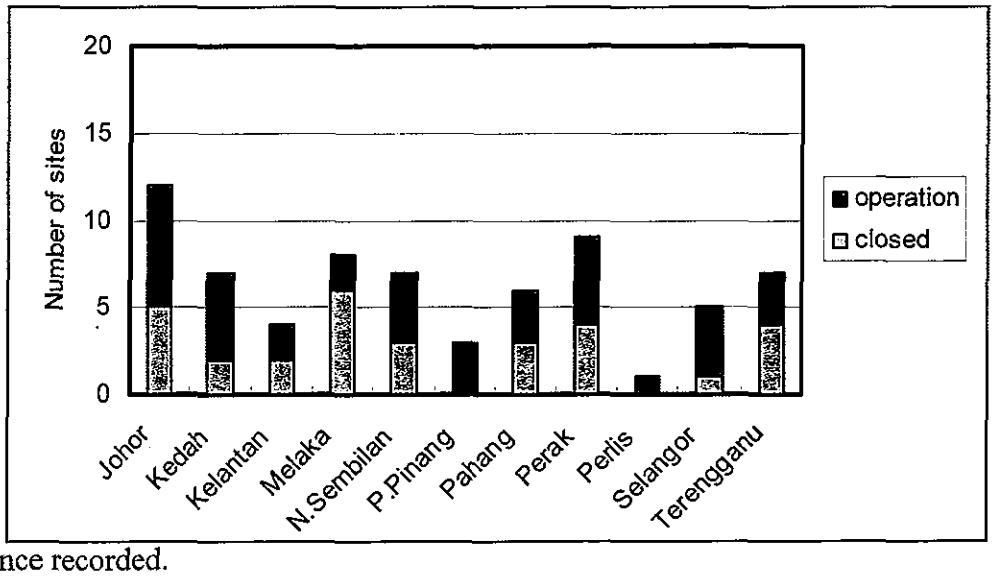


Figure 7.1.1 Number and Status of Landfill Sites in Peninsular Malaysia

The management and land ownership structure of the landfill sites covered by the landfill inventory survey (147 sites) are shown in **Table 7.1.3**.

Table 7.1.3 Management and Land Ownership of the Landfill Sites

Item		Status of landfill sites		Total
		Closed	Operational	
Managed by	Local Authority	48	65	113 (77%)
	Others (Private)	5	26	31 (21%)
	Unknown	2	1	3 (2%)
Land ownership	Government*	40	83	123 (84%)
	Others (Private)	9	7	16 (11%)
	Unknown	6	2	8 (5%)
Total		55	92	147 (100%)

Source: JICA Study Team and MHLG, 2003
Note: "Government" includes State and Local Authority.

The table shows that 48 of the 55 closed sites (about 87%) were managed by the Local Authorities during their operations. 65 of the 92 operational sites are operated by the LAs. As for the land, 84% of the landfill sites surveyed are situated on Government owned land, i.e. either State land or LA land.

(2) Environmental impact conditions

The general classification of landfill sites is tabulated in **Table 7.1.4**, ranging from Level 0, for open dumping grounds to the more sophisticated sanitary landfill Level 4.

The table shows that 65% of the surveyed landfill sites were classified as Level 0. Level 1 accounts for 16%, 9% at Level 2 and 5% at Level 3. There is only one set at Level 4. However, it was observed that although the some of the sites were designed at higher levels, they were operated poorly and the facilities lacked care and maintenance. In essence, majority of the sites were operated as open dumping grounds. It was learnt that the Local Authorities lacked sufficient funds to construct new facilities and also lack the experience and knowledge in the operations and maintenance of such facilities.

Table 7.1.4 Classification of Landfill Sites

State	Unknown	Level 0	Level 1	Level 2	Level 3	Level 4	Total
Johor	4	21	1	1	-	-	27
Kedah	-	4	2	2	1	-	9
Kelantan	-	12	1	-	-	-	13
Melaka	-	6	1	1	-	-	8
N.Sembilan	1	9	3	-	-	-	13
P.Pinang	-	-	1	-	2	-	4
Pahang	-	7	4	4	3	-	18
Perak	-	20	5	1	-	-	26
Perlis	-	1	-	-	-	-	1
Selangor	1	5	4	-	1	1	12
Terengganu	-	10	-	-	-	-	10
DBKL		1	2	4			7
Total	6 (4%)	96 (65%)	24 (16%)	13 (9%)	7 (5%)	1 (1%)	147 (100%)

Source: JICA Study Team & MHLG, 2003
Note: Level 0: Open dumping Grounds
Level 1: Landfill with control tipping
Level 2: Landfill with a bund and daily cover soil
Level 3: Landfill with leachate recirculation system
Level 4: Landfill with leachate treatment system

Majority of the Local Authorities that were visited are located along the coast and hence majority of the landfill sites surveyed are situated in swampy areas or on flatlands and near the coast. Most of the landfill sites are situated downstream to the water intake points and about 11% of the surveyed landfill sites are upstream of the water intake points. Special caution shall be paid for these landfill sites. These sites are mostly situated in Johor, Kedah and Melaka. (refer to **Table 7.1.5**)

The general distribution of the landfill sites visited (64 sites) is shown in **Figure 7.1.2**, together with the locations of the water intake points as references.

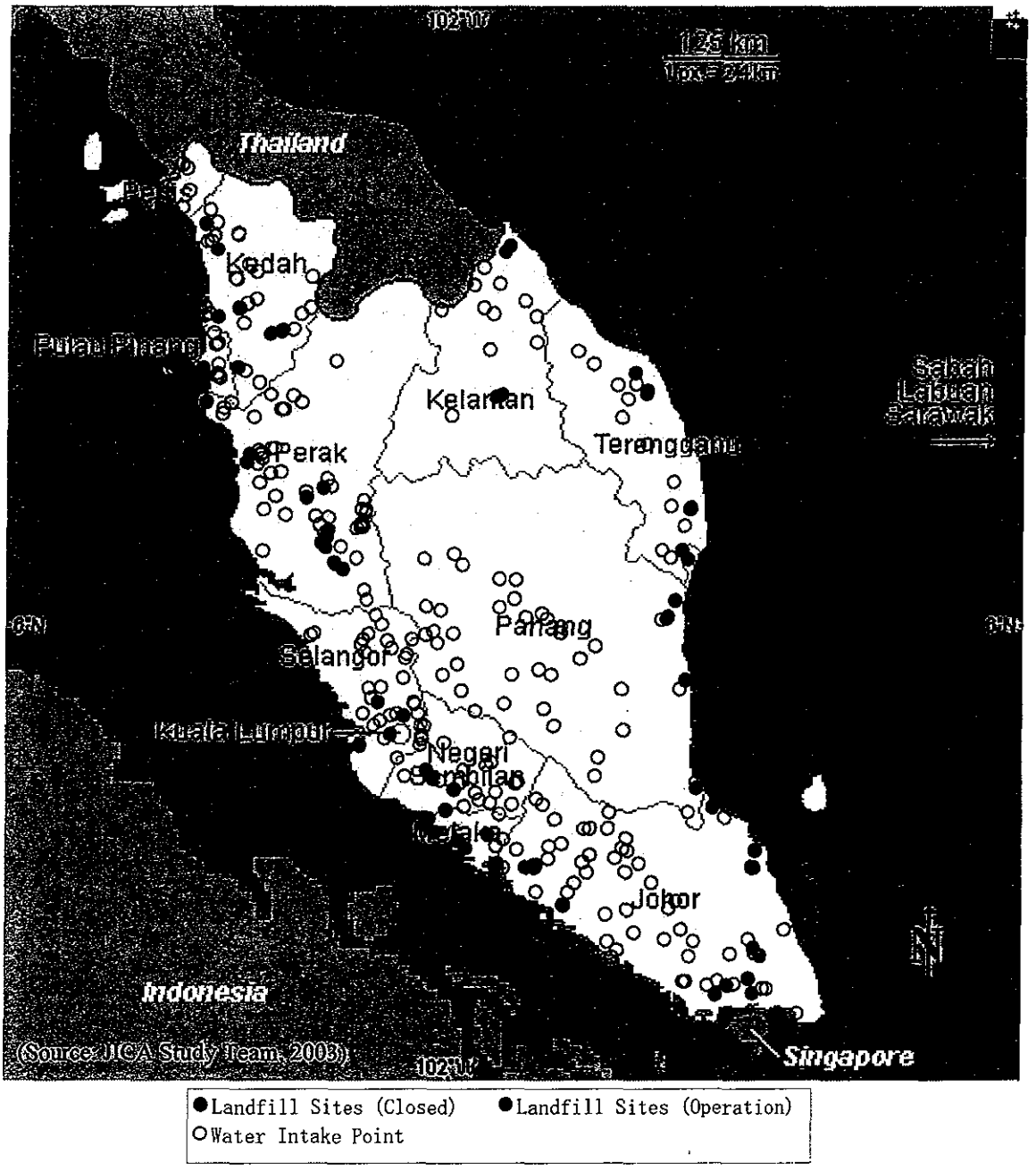


Figure 7.1.2 Distribution of Landfill Sites Visited by the JICA Study Team (64 Landfills) in Malaysia

Table 7.1.5 Location of Landfill Sites to Water Intake Points

State	Number of sites upstream of intake points	Number of sites downstream of intake points	No intake points nearby	Unknown	Total of landfill sites
Johor	4	3	19	1	12
Kedah	3	1	5	-	7
Kelantan	-	1	12	-	4
Melaka	2	1	5	-	8
N.Sembilan	1	1	11	-	7
P.Pinang	-	-	3	-	3
Pahang	2	2	12	2	6
Perak	1	5	18	1	9
Perlis	-	1	-	1	1
Selangor	3	2	4	3	5
Terengganu	-	3	7	-	7
DBKL	-	-	7	-	-
Total	16 (11%)	20 (14%)	103 (70%)	8 (5%)	147 (100%)

Source: JICA Study Team & MHLG, 2003

(3) Post closure land utilisation

From the survey of the closed sites, the various post closure land utilisation are summarised in **Table 7.1.6**. The data shows that about 50% of the 55 closed landfill sites were left vacant and about 9% of the closed landfill sites were used for housing development.

Table 7.1.6 Land Use of Closed Landfill Sites

Land Use	Number	
Vacant	25	(45%)
Housing	5	(9%)
Industry/commerce	9*(4+1)	(16%)*
Recreation	7*(4)	(13%)*
Agriculture	8*(1)	(15%)*
Others	3	(5%)
Unknown	3	(5%)
Total	55	(100%)*

Source: JICA Study Team & MHLG, 2003 *Due to multiple answer

The level and potential for post closure land use of the landfill sites are summarised **Table 7.1.7**. From the table, about 15% of the surveyed sites have been planned or are already being developed for high population density utilisation, i.e. for housing projects. This level of utilisation is referred to as "high" usage. About 10% were regarded as "medium" usage, i.e. for industrial or commercial developments, and 22% were regarded as "low" usage, i.e. for recreational or agricultural purposes. The remaining 53% were considered either left vacant or considered "unknown" as no information was available concerning their potential utilisation.

Table 7.1.7 Level and Potential for Post Closure Land Use of the Landfill Sites

Level of Land Use	Closed sites	Operation sites	Total	
High	12	10	22	(15%)
Medium	10	5	15	(10%)
Low	16	16	32	(22%)
Unknown	17	61	78	(53%)
Total	55	92	147	(100%)

Source: JICA Study Team & MHLG, 2003

7.1.3 Formulation of the Landfill Database

The data collated from the landfill inventory survey have been formulated into the database format. The database comprises of spatial data and attribute data (or landfill site data) for both the operational sites and the closed sites. The overall flow diagram is shown in **Figure 7.1.3**.

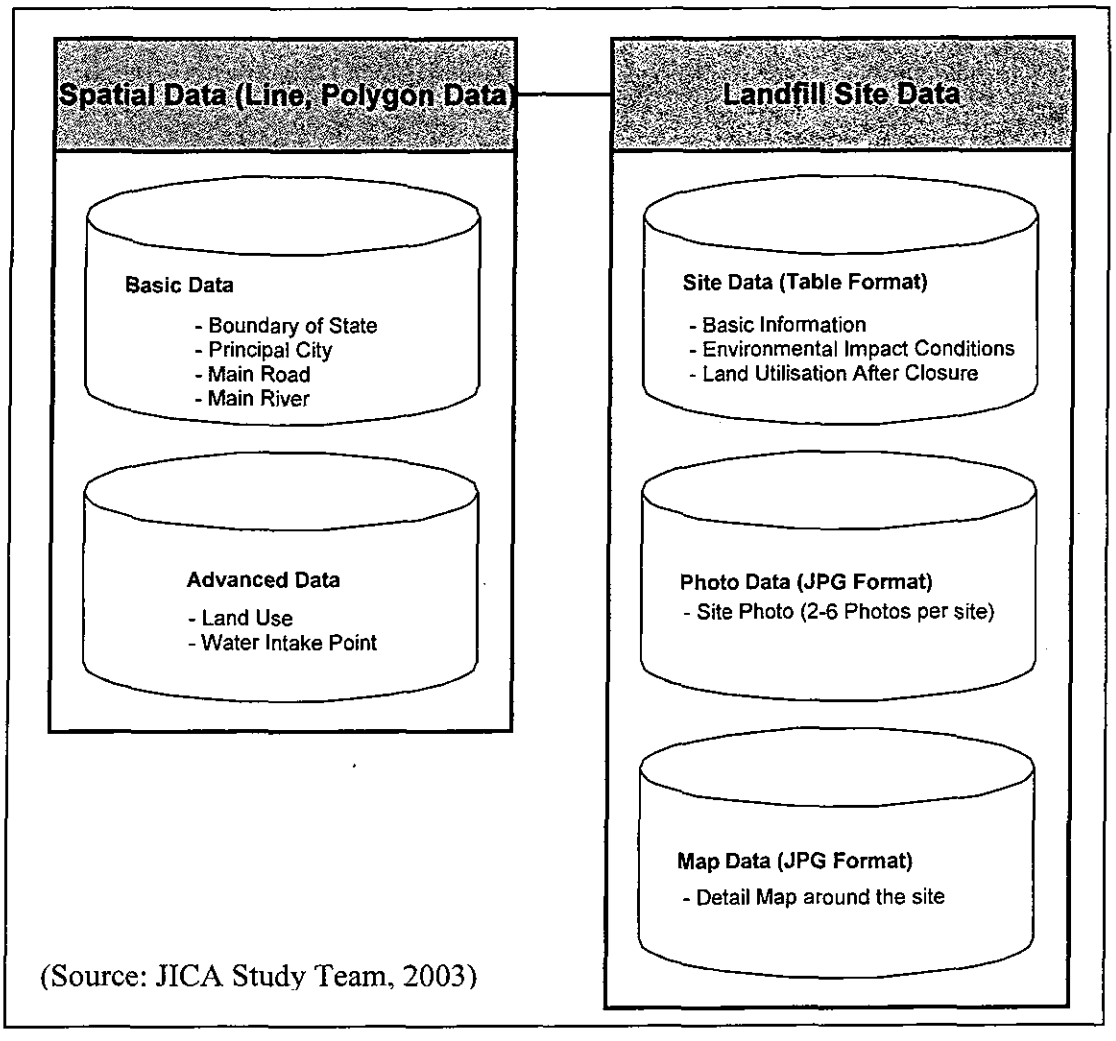


Figure 7.1.3 Formation of Landfill Database

The spatial data consists of mostly geographical data or map data in the form of lines and polygons for visual display purposes. These data are used to represent the graphical GIS based geographical coordinates of physical objects such as the administrative boundaries, location of major cities and town, etc. It also holds the real geographical coordinates of the individual landfill sites, and can be used for plotting onto the distribution map of Malaysia.

The attribute database, or the landfill site data, comprises the actual information of the landfill sites obtained and collated during the survey. Such information includes the characteristics data, photograph images and map images and reference notes. The photographs and maps were either taken digitally or were scanned and saved as digital images. The attribute data are further subdivided into 3 categories, they are the basic information, the environmental impact conditions and the post-closure land utilisation information. Details of the categories are summarised in **Table 7.1.8**.

Table 7.1.8 Site "Attribute" Data Items (Table Format)

Category	Item
Basic Information	State Name of the LA Name of the landfill Location of the landfill Status of the landfill Remaining life span Year start of operation Year cease of operation Managed by Land ownership Gazetted or not Area Waste disposed daily Reasons for closure
Environmental Impact Condition	Landfill level Site condition Waste covered Type of vegetation Landslide Soil subsidence Vector and animals Odour, gas and smoke Leachate quantity Location of water intake point Distance from intake point (km) Location of drinking water well Geological condition Number of complaints per year Nearest residential areas
Land Utilisation after Closure	Existing land use Surrounding area Post closure land use Local Development Plans Potential for development Distance from town centre (km)

Source: JICA Study Team, 2003