CHAPTER 5 MONITORING PROGRAMME FOR THE PILOT PROJECTS

5.1 GENERAL

The main objective of the monitoring programme for the Pilot Project is to evaluate the effect of landfill closure and the rehabilitation works. Certain parameters or components of the monitoring such as the leachate quality and landfill gas composition can be best evaluated over a long-term basis. Significant effects of the rehabilitation improvements may not be apparent or readily observed during such a short period of the Pilot Project. However, for these components, the monitoring programme will only be able to provide short-term observation. Nevertheless they should act as examples of good monitoring practices for MHLG or the Local Authorities to follow and to continue until the stabilisation process has been achieved at the sites.

In the planning of the environmental monitoring programme, it is crucial to clearly define the purpose of the monitoring and targeted improvements in relations to the risk of the improvement work. The risk indicators associated with the improvement works and the proposed monitoring parameters are shown in **Table 5.1.1**.

Table 5.1.1 Risk Indicator and Monitoring of the Pilot Projects

No	Risk Indicator	Improvement Work	Monitoring Parameters
1	Waste scattering, Vectors, Odour and Fire	Provide final soil cover	Visual inspection, odour measurement, record the number of resident complaints
2	Overflow of waste	Provide bund structure	Visual inspection
3	Slope collapse	Provide slope improvement and rainwater drainage system	Visual inspection, check the angle of the slopes, check final height of the waste and check the number of slope steps
4	Leachate production	Provide final soil cover and rain water drainage system	Cover thickness, cover material, measure the leachate quality, surface water quality and groundwater, installation of monitoring wells
5	Landfill gas related accidents	Provide gas ventilation system	Measurement of gas composition and check the conditions of the gas venting facility
6	Land subsidence	Provide gas ventilation system (to accelerate stabilisation process)	Measurement of gas composition and the amount of subsidence
7	Surface water pollution	Provide leachate collection system and re-circulation system	Measure both the leachate quantity and quality, and also the surface water quality, installation of monitoring well and measure quality of groundwater
8	Groundwater contamination	Provide leachate treatment facility, bottom liner or vertical liner	Measure both the leachate quantity and quality, and also the surface water, quality, installation of monitoring well and measure quality of groundwater
9	Landscape	Provide planting and vegetation	Visual inspection

5.2 MONITORING PARAMETERS FOR WATER QUALITY AND LANDFILL GAS COMPOSITION

The water quality parameters for monitoring of leachate, surface water and groundwater are based on the recommended effluent standard applied to all the landfill sites in Malaysia (i.e. The Environment Quality Act, Standard B). The recommended water quality parameters and landfill gas composition parameters together with their analytical methods are shown in **Table 5.2.1** and **5.2.2,** respectively.

Table 5.2.1 Analytical Parameters : Water Quality

	Water Quality Analysis		Method
1	Water temperature	°C	APHA 2550B
2	pH	-	APHA 4500 H+ B
3	Conductivity	mS/cm	APHA 2510 B
4	DO (Dissolved oxygen)	mg/l	APHA 4500-O G
5	Turbidity	NTU	APHA 2130B
6	ORP (Oxidation-reduction potential)	mV	APHA 2580B
7	BOD5 at 20degree C	mg/l	APHA 5210 B
8	COD	mg/l	APHA 5220 D
9	Suspended solids (SS)	mg/l	APHA 2540 D
10	Total nitrogen	mg/l	APHA 4500
11	Mercury (Hg)	mg/l	APHA 3112 B
12	Cadmium (Cd)	mg/l	APHA 3112 B
13	Chromium, hexavalent (Cr^{+6})	mg/l	APHA 3500- Cr D
14	Arsenic (As)	mg/l	APHA 3120 B
15	Cyanide	mg/l	APHA 4500 CN C
16	Lead (Pb)	mg/l	APHA 3120 B
17	Chromium, Trivalent (Cr^{+3})	mg/l	APHA 3500 Cr D & 3120 B
18	Copper (Cu)	mg/l	APHA 3120 B
19	Manganese (Mn)	mg/l	APHA 3120 B
20	Nickel (Ni)	mg/l	APHA 3120 B
21	Tin (Sn)	mg/l	APHA 3120 B
22	Zinc (Zn)	mg/l	APHA 3120 B
23	Boron (B)	mg/l	APHA 3120 B
24	Iron (Fe)	mg/l	APHA 3120 B
25	Phenol	mg/l	APHA 5530 D
26	Chloride ion	mg/l	APHA 4500 Cl G
27	Sulphide	mg/l	APHA 4500 S2- D
28	Fat and oil	mg/l	APHA 5520 B
29	Ammonium-nitrogen	mg/l	APHA 4500 NH3 G
30	Nitrate-nitrogen	mg/l	APHA 4500 NO3- H
31	Nitrite –nitrogen	mg/l	APHA 4500 NO2- B

Note: APHA = American Public Health Association

Table 5.2.2 Analytical Parameters : Gas Quality

	Gas Quality Analysis		Method
1	Oxygen (O_2)	%	Galvanic cell sensor
2	Nitrogen (N_2)	%	Computation as residual gas
3	Methane (CH_4)	%	Infra-red absorption
4	Carbonic dioxide (CO_2)	%	Infra-red absorption

In addition to the sampling and laboratory analysis of the water and landfill gas quality, the following measurements will also be included in the monitoring programme.

(1) Measurement of Land Subsidence

The topographic survey should be carried out to measure the changes in height between the pre-determined point at the bottom ground and at the top of the landfill.

(2) Measurement of Groundwater Table at the Monitoring Well

The depth of the water table at the monitoring wells should be measured to monitor and determine the rate of groundwater flow and its direction.

(3) Metrological and Tidal Conditions

The metrological and tidal conditions may influence the various monitoring parameters prior to the sampling, i.e. the rainfall and the tides. These conditions should be recorded during the Pilot Project period.

(4) Landscape

The landscape of the site before and after the Pilot Project should be kept by taking regular photographic records of the site.

5.3 SAMPLING SCHEDULE

The monitoring programme recommended sampling to be carried out 4 times during the Study Period, i.e. once before the Pilot Project implementation and 3 times after construction in accordance to the schedule as shown in **Table 5.3.1** (● = sampling carried out).

Table 5.3.1 Sampling Schedule

Sample type	2003					2004							
	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Surface water	●						●			●		●	
Leachate	●						●			●		●	
Groundwater	●						●			●		●	
Gas	●						●			●		●	

5.3.1 Sampling Methods

The field sampling and measurements were carried out before implementation of the Pilot Projects in order to ascertain the conditions of the site prior to the improvement of the site. A series of "Baseline Data" were taken in accordance to the recommended parameters and their corresponding specific preservation methods as tabulated in **Table 5.3.2**. The instruments that were used for the sampling and analysis are tabulated in **Table 5.3.3**.

Table 5.3.2 Water Sample Preservation and Containers Used

Parameter	Preservative	Type of Sampling Bottle
Metals	HNO_3	Plastic Bottle
Nitrate, Nitrite, Ammonium, COD	H_2SO_4	Amber Glass Bottle
Oil & Grease, Phenol$_{(APHA)}$,	H_2SO_4	Amber Glass Bottle
Cyanide	$Cd(NO_3)_2$ + NaOH	Plastic Bottle
pH, BOD, conductivity (EC), turbidity, suspended solids (SS)	None	Plastic Bottle
Chromium, hexavalent (Cr^{+6})	None	Plastic Bottle
Sulphides	Zinc Acetate + NaOH	Plastic Bottle
Iron (Fe)	HCl	Plastic Bottle

Table 5.3.3 Instruments for Sampling and Analysis

Samples	Type of Equipment	Make/Model
Groundwater	Hand Bailer	Clear-View PW-153
Groundwater	Deep well submersible pump	
Groundwater	Water level Meter	RST / Model 3001
Groundwater, surface water & leachate	pH meter	Hanna HI 98127
Groundwater, surface water & leachate	ORP meter	WITEG W-100
Groundwater, surface water & leachate	Conductivity meter	Cyberscan CON 10
Groundwater, surface water & leachate	DO meter	Hach DO175
Groundwater, surface water & leachate	Turbidimeter	Hach 2100P
Landfill gas	Gas analyser	GA 2000

The gas analyser, model GA2000, was used to analyse the landfill gas emissions at the discharge of the gas vents and boreholes. The analyser is able to measure and provide readings for the presence of methane (CH_4) and carbon dioxide (CO_2) in percentage of infra-red measurement Carbon monoxide (CO) and hydrogen sulphide (H_2S) were measured in ppm, and oxygen (O_2) was measure in percentage of internal electrochemical cell measurement.

The laboratory analysis of the surface water, groundwater and leachate were in accordance with the Standard Methods for the Examination of Water and Wastewater, 19th Edition 1995, American Public Health Association. The analytical parameters are shown in **Table 5.2.1** above.

5.3.2 QA/QC Procedures

The quality assurance (QA) and quality control (QC) are the two important components in environmental monitoring. It is essential that proper QA/QC procedures are adhered to when carrying the field sampling and the laboratory analysis. The recommended procedures are tabulated in **Table 5.3.4** and **Table 5.3.5** respectively.

Table 5.3.4 QA/QC Procedures for Field Sampling

No.	Method	Definition	To monitor	QC Frequency
1.	Trip Blank	A sample bottle of the analyte free media must be taken from the laboratory to the sampling site and returned to the laboratory unopened	Possible contamination during shipping and field handling. Most applicable to the volatile analysis	For every field sampling carried out
2.	*In-situ* Parameter (e.g. pH, Conductivity, DO, Turbidity)	-	-	Calibration of equipment prior to sampling
3.	Equipment Rinsate	A sample of the reagent water used to rinse the sampling equipment between documentation and sampling steps	Equipment decontamination	1 per sample batch analysed

Table 5.3.5 QA/QC Procedures for Laboratory Testing

No	Method	Definition	To monitor	QC Frequency
1.	Method blank	An analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation	Contamination introduced in the laboratory	1 per QC lot per analytical method
2.	Calibration curve	A set of matrix-free samples (usually n=6) spiked with standards at different concentrations	Linearity and quantification range for the analysis	1 per every run
3.	Precision check via duplicate analysis - Duplicate control sample	A known interference free matrix spiked with target analytes	Preparation technique reproducibility (precision)	1 per QC Lot per analytical method
4.	Accuracy check using spike recovery - Surrogate Spike	Compounds similar in composition and behaviour to the target analytes but not commonly found in the environment	Matrix interference on sample basis	Surrogates are added to all samples and QC samples and are reported for semi-volatile and volatile scans, BTEX, PCB and pesticides. Surrogates are not analysed in the TPH analysis
	- Matrix Spike (MS)	An intra-laboratory split sample spiked with target analytes prior to sample preparation and analysis	Method bias in a given sample matrix	1 per sample batch or 1 in 20 samples per analytical method
	- Matrix Spike Duplicate (MSD)	An intra-laboratory split sample spiked as per the MS	Method precision and bias in a given sample matrix	1 per sample batch or 1 in 20 samples per analytical method
	- Post Digestion Matrix Spike	An intra-laboratory split of sample digested spiked with target metals	Method bias in a given, homogeneous sample matrix.	1 per 10 samples or 1 per sample batch whichever the more frequent

CHAPTER 6 AMPANG JAJAR LANDFILL SITE (PULAU PINANG)

6.1 LANDFILL OPERATIONS AND SITE CHARACTERISTICS

The brief description of the landfill operations and site characteristics are summarised in **Table 6.1.1**.

Table 6.1.1 Ampang Jajar Landfill Operations and Site Characteristics

Operational Characteristics	Site Characteristics
⇒ Started operations in 1980s and scheduled for to closure in June 2003 but was later closed in November 2003. ⇒ Upgraded to a Level 3 landfill in 1988 with the installation of leachate collection pipes, pond, recirculation system, and gas vents ⇒ After the upgrading, it was operated as a semi-aerobic landfill ⇒ About 2.2 million tonnes of waste has been disposed at the landfill(about 400t/d)	⇒ Located on a wetland area ⇒ The site occupied and area of about 17 ha and the landfill height is about 20m ⇒ The western side of the landfill was developed as a riverside park ⇒ The North-South Highway passes along the eastern side

6.2 THE SAFE CLOSURE PLAN

The entire site occupied an area of about 17 ha but for the purpose of Study, the Pilot Project area only concentrated on a certain area that is along the eastern slopes, covering the southern portion of approximately 250m of the slopes. The PP area is about one-third the entire stretch alongside the North-South Highway.

The main activities of the Ampang Jajar Pilot Project were:

(1) Reformation of the slopes, provision of cover soil and planting of grass and vegetation along the slopes.

(2) Provide improvements to the drainage system along the slope by the installation of surface drains and leachate drainage pipes

(3) Installation of gas venting pipes

(4) Provide improvements to the access road alongside the slopes.

6.3 PILOT PROJECT IMPLEMENTATION AND SCHEDULE

(1) Topography Survey

The topography survey for the Ampang Jajar PP only focused on the area where the PP works will be conducted. The survey was carried out in August 2003 and produced the final survey plans that included the following:

- Locations of the 2 survey control point benchmarks.

- Plane table survey (spot levelling, approx. 17 hectares) and mapping (1:1,000 scale)
- Cross section and longitudinal section levelling and mapping (1:1,000 – 1:2,000 scale, for horizontal direction and 1:100 – 1:200 scale for vertical direction)
- Indication of existing salient features on the site such as buildings, pipelines etc.

(2) Soil Investigations

The soil investigations exercise was carried out from July 17 to August 6, 2003. The fieldwork required the drilling and sampling at 4 locations, and the installation of 3 water monitoring wells and 1 gas monitoring well. The undisturbed soil samples and selected disturbed Standard Penetration Test (SPT) soil samples were taken to the laboratory for analysis.

The first 3 boreholes (i.e. AJ-W1, AJ-W2 and AJ-W3) are located at the bottom of the slopes and were later converted to the 3 groundwater monitoring wells. The last borehole (i.e. AJ-G1) was drilled on top of the landfill for the sole purpose of installing the gas monitoring well and no field tests and sampling were taken.

The summary of the fieldworks and types of laboratory tests for the Ampang Jajar PP is tabulated in **Table 6.3.1**. The information for the soil stratifications are summarised in **Table 6.3.2**.

Table 6.3.1 Soil Investigation Borehole Specifications and Test Results

Boreholes	AJ-W1	AJ-W2	AJ-W3	AJ-G1	Total
1. Geographical coordinates					
North	5°25'14.1"	5°25'10.5"	5°24'52"	5°25'9"	-
East	100°24'16.9"	100°24'28.4"	100°24'27"	100°24'27"	-
Elevation (RL m)	2.37	2.06	2.09	18.22	-
2. Field Work					
Total drilling (m)	31.45	21.45	24.00	16.20	92.35
Standard Penetration Test (no.)	26	18	20	3	67
Undisturbed Soil Samples (no.)	3	3	3	0	9
3. Laboratory Tests (numbers)					
Unit weight	4	4	3	0	11
Moisture content	14	13	13	0	40
Specific gravity	14	13	13	0	40
Atterberg limit	5	5	9	0	19
Grain size analysis	14	13	13	0	40
Consolidation test	3	3	3	0	9
Unconfined Compression Test	3	3	3	0	9

Table 6.3.2 Soil Stratification at Ampang Jajar Landfill Site

Layer	Description
Miscellaneous fill material	The miscellaneous fill material covered the entire top surface area of the landfill site varying from 0.8m think in AJ-W2 to more than 16.2m think in AJ-G1. The fill material comprises of yellowish brown to reddish brown, dark brown to brownish grey clayey silt and domestic waste with presence of sand, fine gravel, organic putrefactions and highly decomposed household wastes with a distinctive odour.
Quaternary deposits	Composed of four sub-layers.
a) Marine clay	This layer covered the entire subsoil level of the project site. It comprises of dark grey to greenish grey silt and clayey silt with the presence of seashell fragments, organic matters and traces of fine sand. The thickness varied from 5.6m in AJ-W1 to 9.1m in AJ-W3. Lenses of Very Loose-to-Loose Sand layer with a thickness of 2.4m and traces of Medium Stiff Clay with thickness of 0.7m were also found in this layer.
b) Medium stiff clay	This layer comprises of light grey to grey silt or clay with the presence of fine to medium grained sand and fine gravel. The thickness of the Medium stiff layer varied from 3m in AJ-W3 to 3.2m in AJ-W1. The pockets or lenses of the Medium stiff clay also occurred in this layer.
c)Very loose to loose sand	This layer comprises of light grey to grey silty sand or clayey sand with presence of sub-angular quartz gravels and occasionally with seashell fragments and organic decays. Layer thickness varied from 2m to 3.7m.
d) Medium dense sand	This layer comprises of yellowish brown to light grey, fine to coarse-grained with the presence of fine quartz gravels. Layer thickness varied from 6m in AJ-W3 to 9.45m in AJ-W1. Lenses of Medium stiff clay and Very Loose to Loose Sand layer with thickness of 3m and 2m, respectively also occurred in this layer.

The water levels below ground that were monitored in the water standpipes throughout the period of the fieldwork, ranged from 0.46m to 2.01m. The engineering properties of the soil layers were obtained from the in-situ analysis and laboratory tests, and are summarised in **Table 6.3.3.**

Table 6.3.3 Ampang Jajar Landfill Site Soil Engineering Properties

	Unit	Marine Clay	Medium stiff clay	Very loose to loose sand	Medium dense sand
1. Grading texture					
Gravel	(%)	0 – 3	0 – 5	2 – 28	10 – 45
Sand	(%)	3 – 31	3 – 31	53 – 86	40 – 82
Silt	(%)	31 – 61	19 – 59	0 – 18	0 – 20
Clay	(%)	21 – 59	37 – 67	0 – 20	0 – 12
2. Unit weight	Mg/m^3	1.42 – 1.63	1.6	1.63-1.77	-
3. Waterbury limits					
Liquid limit	(%)	65-125	41 -80	-	-
Plastic limit	(%)	32 -61	19 -49	-	-
Plasticity index	-	33 -65	22 -31	-	-
4. Natural water content	(%)	56-124	30-71	14-46	14-47
5. Specific gravity		2.63-2.72	2.62-2.71	2.63-2.73	2.62-2.75
6. SPT Values (range)	N	0-5	4-6	0-9	10-27
7. Unconfined Compressive Strength	kPa	10-48	23-61	-	-
8. Consolidation properties					
Pre-consolidation pressure	Pc(kPa)	65-110	150-290	-	-
Compression Index	-	0.61-1.03	0.45-0.67	-	-

The coefficient of permeability (k) obtained from in-situ analysis and laboratory testing are summarised in **Table 6.3.4**.

Table 6.3.4 Ampang Jajar Landfill Site Soil Coefficient of Permeability

Borehole	Depth (m)	Soil layer	Coefficient of Permeability, k (m/sec)			Drainage Character-istics
			Field	Laboratory		
				Permeability test	Consolidation test	
AJ-W1						
(UP1)	4.00-4.80	Silt	NA	$2.82x10^{-8}$	$6x10^{-9}$	Practically impervious
(UP2)	10.00-10.80	Silt	NA	$2.03x10^{-8}$	$4x10^{-9}$	
(PT1)	21.00-21.90	Silty sand	$5.8x10^{-5}$	NA	NA	Good
(UDS1)	27.00-27.80	Silt	NA	$1.15x10^{-8}$	$2x10^{-10}$	Practically impervious
AJ-W2						
(UDP1)	6.00-6.80	Silt	NA	$1.01x10^{-7}$	$2.03x10^{-9}$	Poor to practically impervious
(UDP2)	8.00-8.80	Clayey silt	NA	$9.64x10^{-9}$	$2x10^{-9}$	Practically impervious
(UDP3)	12.00-12.40	Silt	NA	$9.22x10^{-9}$	$6x10^{-10}$	
(PT1)	19.00-20.00	Silty sand	$6.4x10^{-6}$	NA	NA	Good
AJ-W3						
(UDP1)	4.00-4.80	Silt	NA	$2.50x10^{-9}$	$1x10^{-9}$	Practically impervious
(UDP2)	9.00-9.80	Silt	NA	$1.62x10^{-8}$	$4x10^{-9}$	
(UDP3)	16.00-16.80	Clay	NA	$2.71x10^{-8}$	$1x10^{-9}$	
(PT1)	23.00-24.00	Silty sand	$3.8x10^{-6}$	NA	NA	Good

6.4 AMPANG JAJAR PILOT PROJECT IMPLEMENTATION

Subsequent to the PP tender and evaluation exercise, the Ampang Jajar Pilot Project was eventually awarded the successful contracting company, Asia Demand Sdn Bhd, and 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 6.4.1**.

The detailed design was completed and approved by the Study Team within one month from the project commencement date. Samples of the design drawings are shown in **Figure 6.4.2** and **Figure 6.4.3**. 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 6.4.1, Plate 6.4.2** and **Plate 6.4.3** respectively.

The brief description and Bill-of-Quantities (BQ) of the Pilot Project is summarised in **Table 6.4.1**.

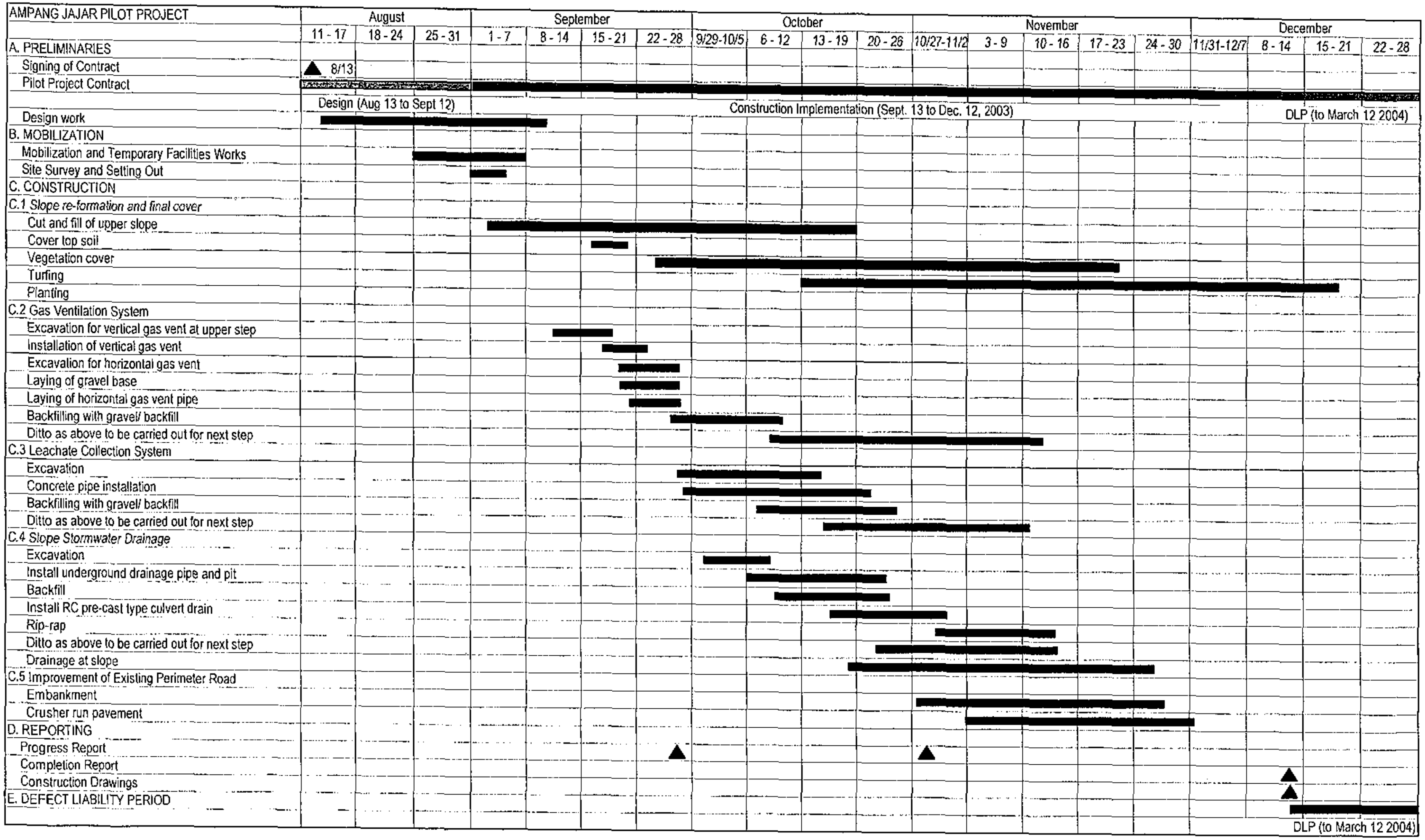
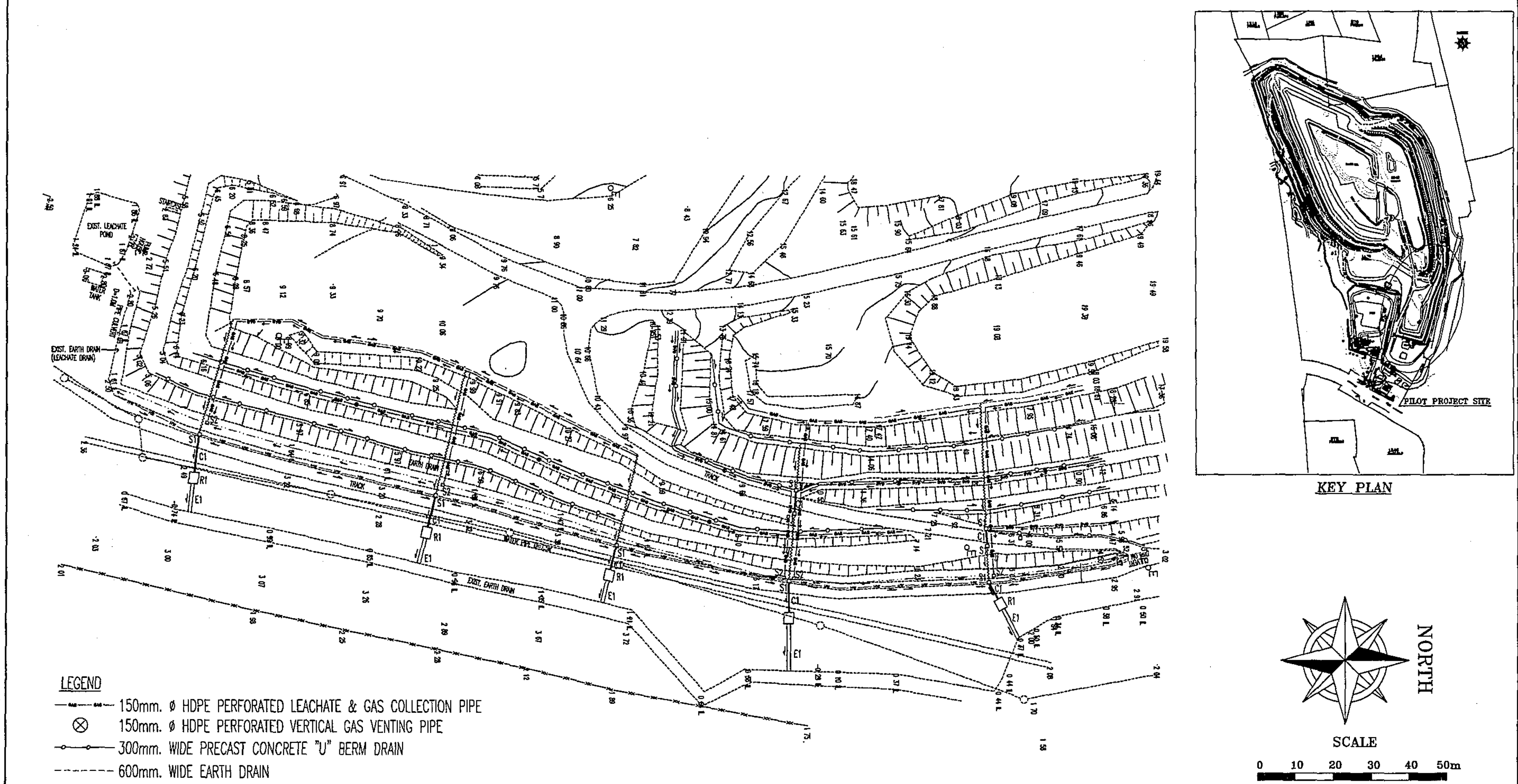


Figure 6.4.1 Project Implementation Schedule for Ampang Jajar PP

Table 6.4.1 Ampang Jajar PP Description

No.	Item/Description	Quantity
1	Slope Re-formation and Final Cover	
	Re-formation of the 1st Step Slope and final cover *Improvement of the lowest slope to 1:2, and supply and compaction of impermeable clayey soil on the slope. Height of the step varies from 3.2 to 7.1m.*	1,580m^3
	Application of cover soil on the upper layer of the 2nd Step Slope (t = 300mm) *Supply and compaction of clayey soil on the slope and steps with a thickness of 300mm to improve the existing slope. Number of steps above the first step range from 2 to 5 steps.*	8,000m^2
	Vegetation cover (t = 150mm) *Application of rich organic field soil.*	11,385m^2
	Turfing (slope protection) *Spot turfing for protection of the slope.*	11,385m^2
	Planting (1 tree/25m^2) *Selected tree type should be able to grow under the landfill conditions*	240 trees
2	Leachate collection system (Main Pipe)	
	Blind (buried) leachate collection pipe (dia. 450mm) *Supply and installation of perforated spun concrete pipe class H, of nominal diameter 450mm including placing of gravel around the pipe, partial excavation and laying with crusher-run of 200mm thickness, on wooden sleeper/wedge.*	275m
3	Gas venting system	
	Vertical gas venting pipe (150mm) *Supply and installation of vertical gas venting perforated HDPE pipe, of diameter 150mm in pits surrounded by gravel (50 to 150mm), to a depth of 3.5m penetrating the solid waste. Locations were selected mostly midway of the slope. Connecting pipes were installed at heights of about 1.5m above ground*	6 units
	Gas at slope (HDPE, 150mm) *Supply and installation of inclined vents (perforated 150mm HDPE) to vent the gas and collect leachate. Pipes are located at four (4) sections along the slope and connect with vertical and horizontal pipes for leachate and gas. Pipes are laid below ground in trenches of 50 x 50cm and surrounded by gravel.*	185m
	Horizontal gas and leachate collection branch pipes (150mm) *Supply and installation of horizontal gas venting perforated HDPE pipe, diameter 150mm buried in trenches of 500mm x 500mm and surrounded by gravel of size 25mm. These pipes are laid along the upper two steps.*	600m
4	Improvement of existing perimeter roads	
	Crusher-run pavement (t = 200mm) *Supply, level and compaction of the crusher-run for pavement of width 3.5m and thickness of t=200mm, including bed grading, along the road running adjacent to the foot of the slope.*	192.5m^3
5	Slope storm water drainage	
	Drainage at steps *Supply and place RC pre-cast type drainage ducts of dimensions 300 x 300mm along the steps.*	700m
	Drainage at slope (sloping part) *Supply and placement of RC pre-cast type cascading drainage ducts of dimensions 600 x 600 mm, at 5 locations along the slope.*	190m
	Drainage pipes at step crossings and under perimeter road (dia. 300mm) *Supply and installation of pipe culvers of spun concrete, diameter 300mm under the steps and the perimeter road.*	50m
	Earth drain (300 & 900 wide) *Earth drain of 300 x 300mm shall also be laid along the top of the slope.*	214m
	Drainage pits at steps and perimeter road. *Square brick drainage pits of base dimensions S1=750x750mm and S2=900x900mm are installed at the intersections of leachate main and branch pipes and at the intersections of horizontal and cascading drains and the main drainage pipe.*	14 units

No.	Item/Description	Quantity
	Rip Rap (3000mm x 2500mm x 900mm depth) with cement mortar *Riprap is installed at the 5 locations where the concrete drainage pipe connects with the wide earth drain to drain the collected storm water to the existing earth drain.*	5 units
	Drainage at toe (600 x 450 pieces U Drain) *RC pre-cast drains of dimensions 600 x 450mm are laid along the foot of the slope to receive.*	275m



LEGEND

- 150mm. ø HDPE PERFORATED LEACHATE & GAS COLLECTION PIPE
- ⊗ 150mm. ø HDPE PERFORATED VERTICAL GAS VENTING PIPE
- 300mm. WIDE PRECAST CONCRETE "U" BERM DRAIN
- 600mm. WIDE EARTH DRAIN
- 600mm. WIDE PRECAST CONCRETE "U" DRAIN
- CASCADING DRAIN @ ±50M CENTRES
- 450mm. ø PERFORATED SPUN CONCRETE CLASS "H" LEACHATE COLLECTION PIPE
- → DIRECTION OF FLOW FOR LEACHATE AND GAS COLLECTION PIPE
- DIRECTION OF FLOW FOR DRAINAGE
- S1 900mm. SQ. x 750mm. DEEP BRICK SUMP
- C1 300mm. ø HEAVY DUTY CONCRETE PIPE CULVERT
- R1 2500mm. x 3000mm. x 900mm. DEEP RIPRAP
- E1 900mm. WIDE EARTH DRAIN
- S2 750mm. SQ. BRICK SUMP

Figure 6.4.2 Layout Plan (Ampang Jajar Pilot Project)

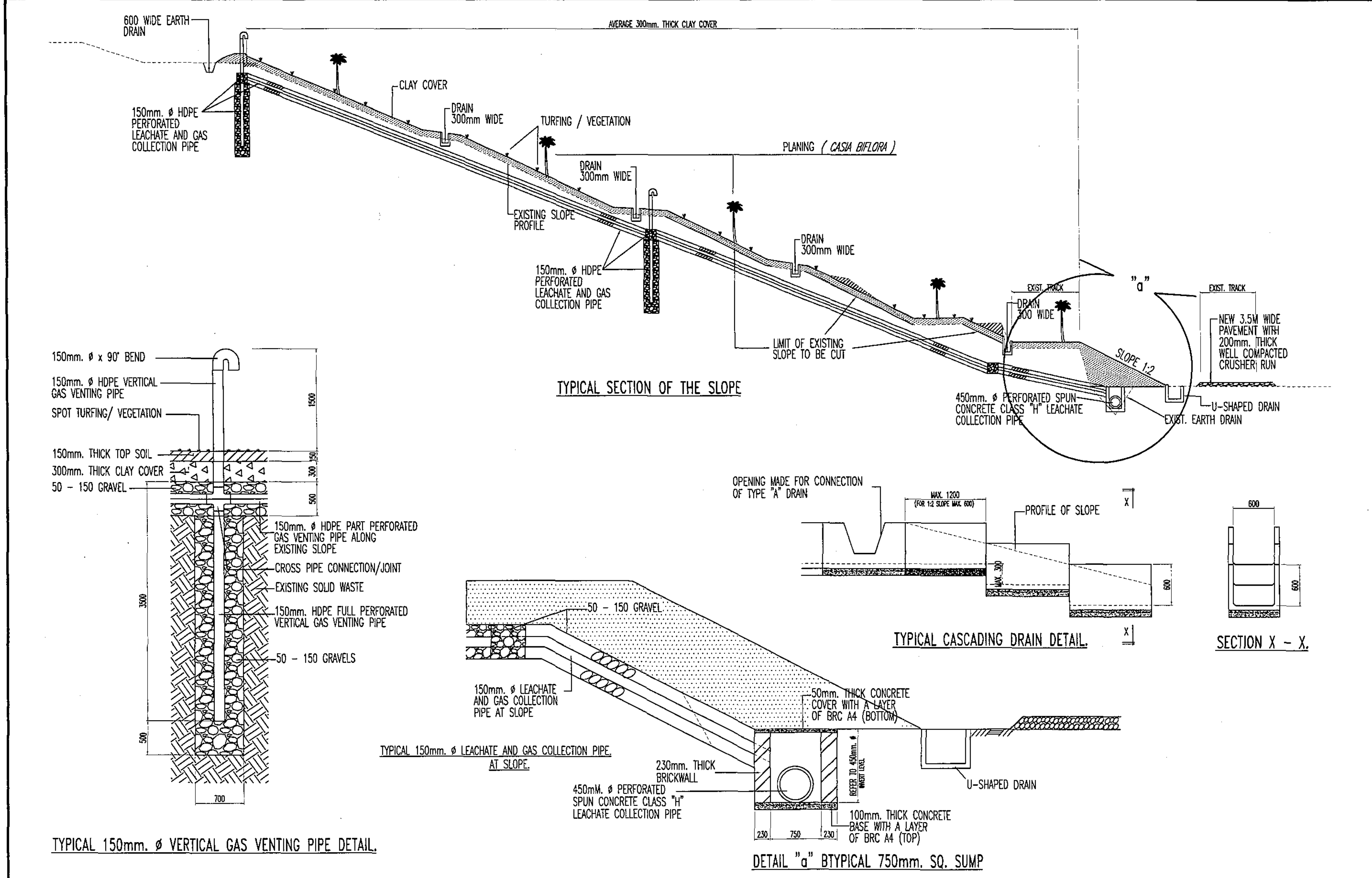


Figure 6.4.3 Typical Sections (Ampang Jajar Pilot Project)

Plate 6.4.1 Ampang Jajar Pilot Project 1

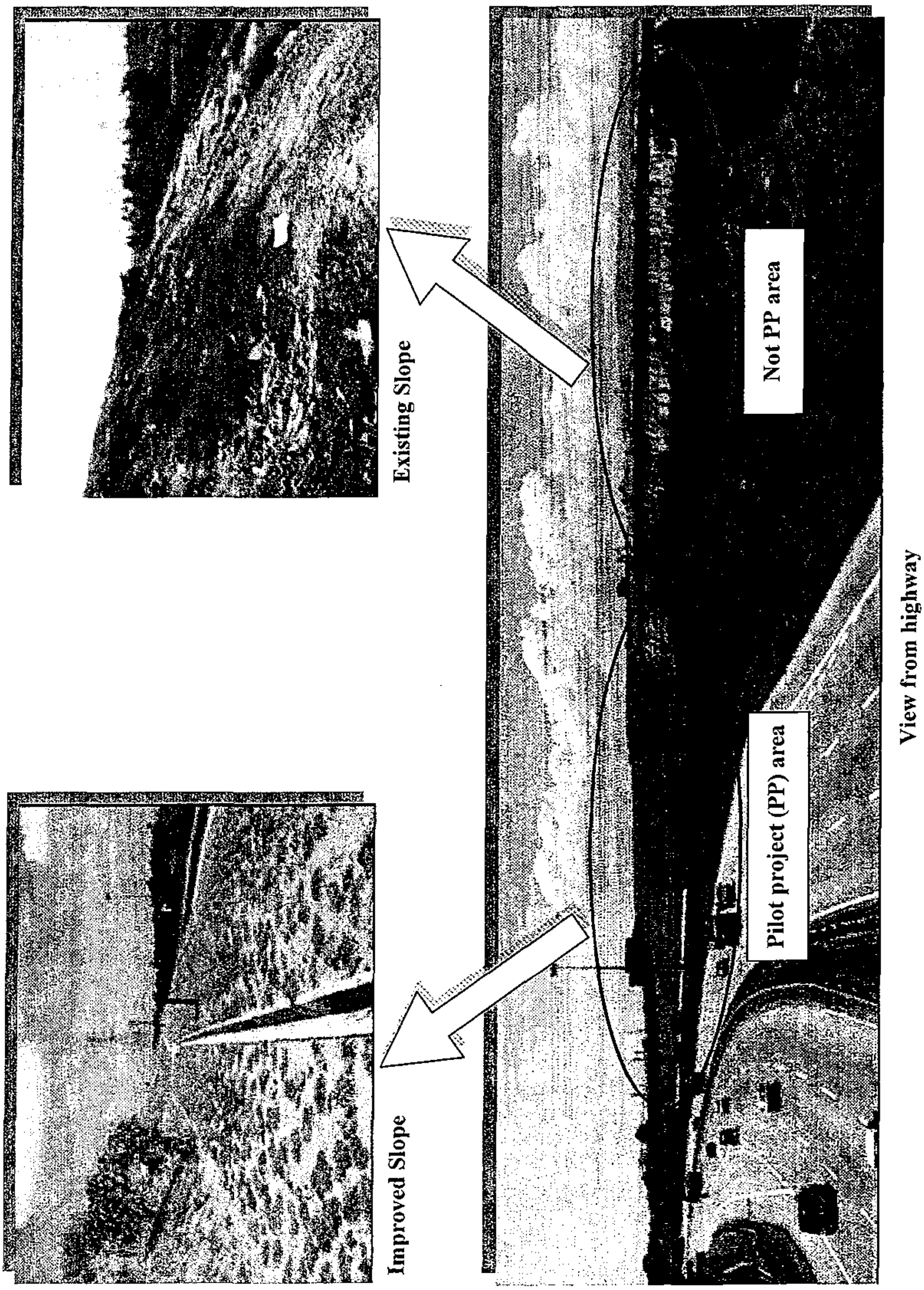
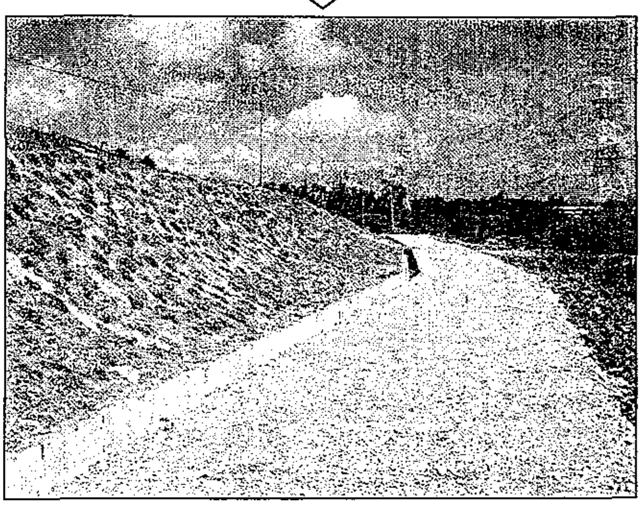


Plate 6.4.2 Ampang Jajar Pilot Project 2

Before pilot project (PP)

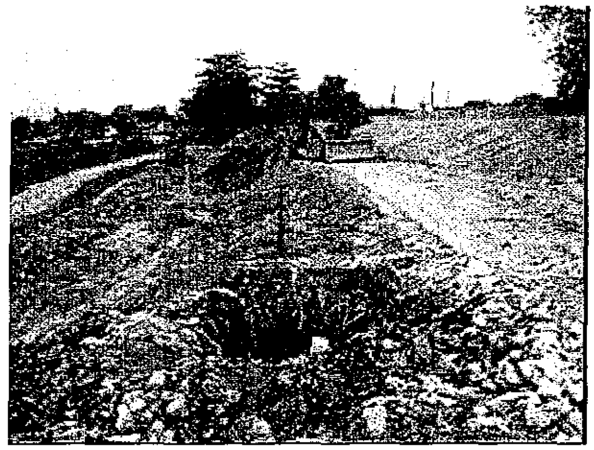
During PP



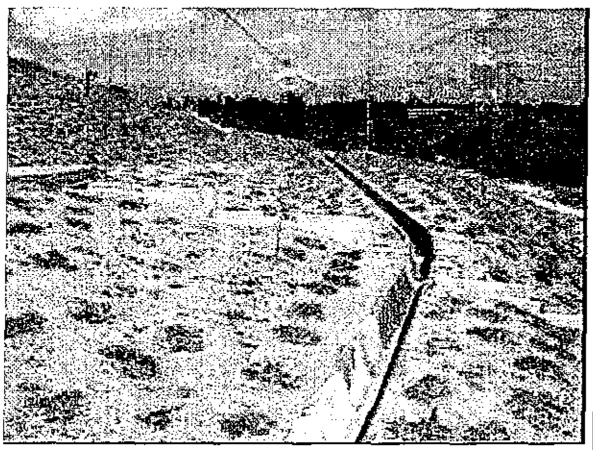
After PP
(Improved slope, drainage, leachate collection (not visible) and access road)

Plate 6.4.3 Ampang Jajar Pilot Project 3

Installation of leachate pipe/drain



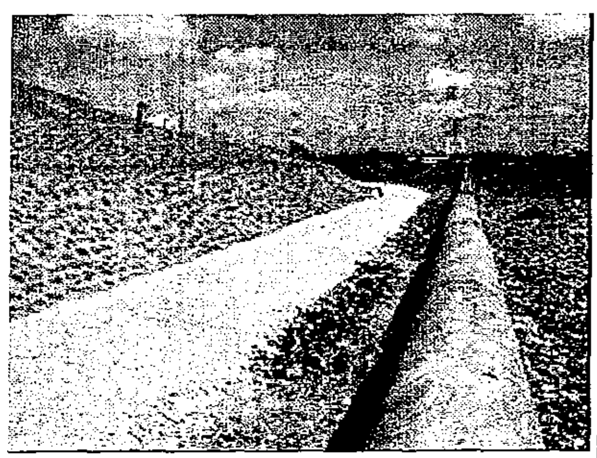
Installation of gas pipe



Storm water drainage - 1

Storm water drainage - 2

Gas ventilation pipe



PP Site and water pipeline

6.5 ENVIRONMENTAL MONITORING

6.5.1 Monitoring program

(1) Monitoring parameters for water quality and gas composition

Water quality parameters and gas composition parameters, as well as their analytical method are as shown in **Table 5.2.1**, in the previous **Section 5.2**.

(2) Sampling Quantity, Schedule and Locations

The following **Table 6.5.1** summarizes the sampling quantity of monitoring for Ampang Jajar pilot project site.

Table 6.5.1 Sample Number at Ampang Jajar Pilot Project Site

Sample type	Ampang Jajar (Number of locations)
Surface water	2
Leachate	2
Groundwater	3
Gas	2

For each location, samples will be taken four times (once before the pilot project improvement and three times after the project) according to the schedule shown in **Table 5.3.1** in the previous section.

Figure 6.5.1 shows the location of monitoring for each sample type.

(3) Other Measurements and Special Considerations

In addition to the sampling and laboratory analysis of the water and gas, following measurement will be also included in the monitoring program.

(A) Measurement of land subsidence

Topographic survey will be carried out to measure the height change between pre-determined ground surface points and top of the landfill (may be platform of the gas vent pipe).

(B) Measurement of groundwater table at monitoring well

Depth to water table at the monitoring wells will be measured to monitor the groundwater flow direction.

(C) Metrological condition

Various monitoring parameters may be influenced by the metrological condition prior to the sampling. Therefore metrological condition of the three sites shall be recorded during the pilot project period.

(D) Landscape

Landscape of the site before and after the project will be recorded by taking photo of each scene.

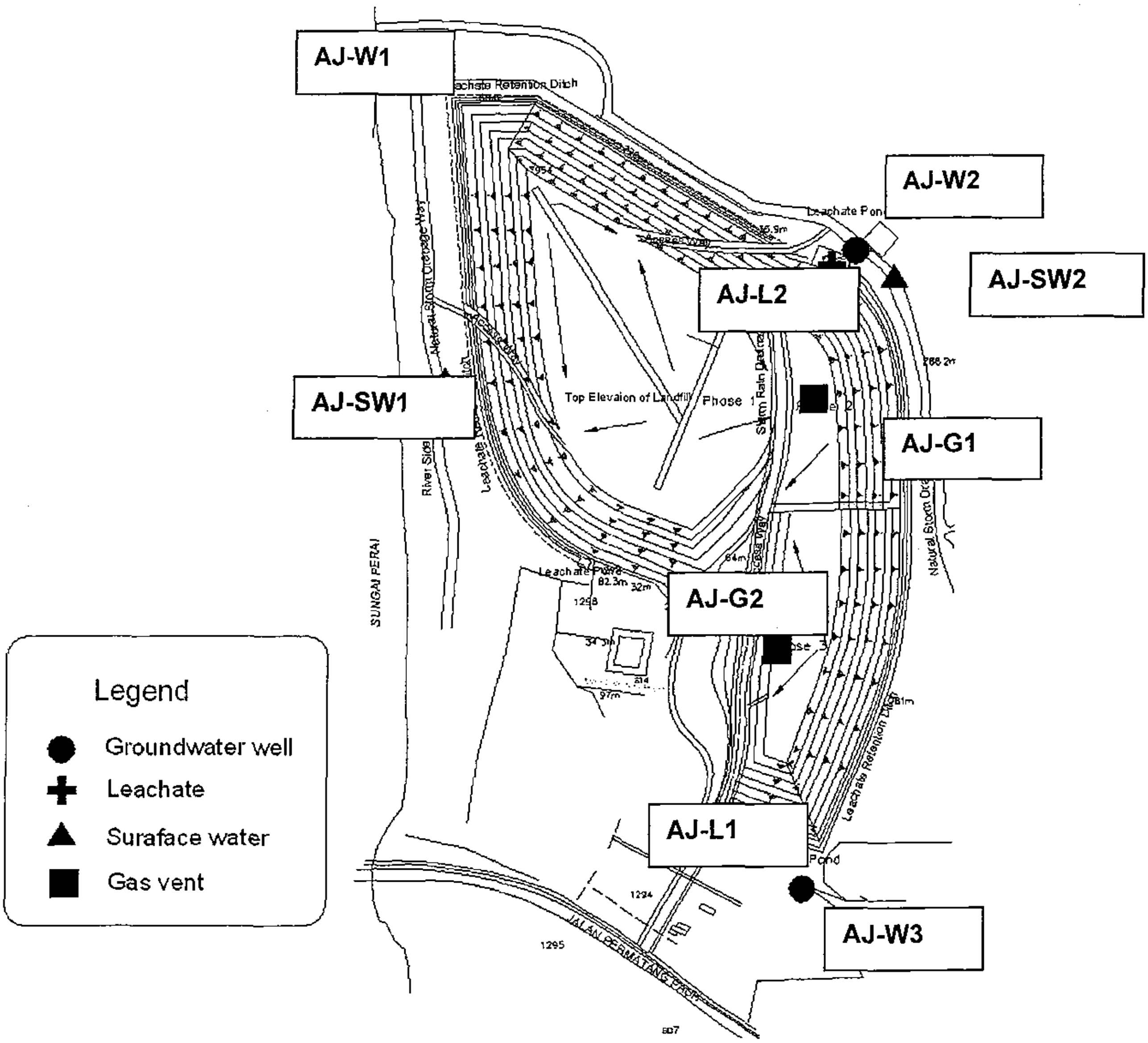


Figure 6.5.1 Map of Sampling Location for Monitoring, Ampang Jajar

(4) Geological setting and Installation of monitoring well

The water monitoring wells are installed at the base of slope, while the gas monitoring well is installed at the hill top. The elevation of the present ground level varies from approximately RL+2m to RL+20m.

<Geological Background>
Figure 6.5.2 shows a geological map of the site and its surrounding areas. It is reproduced from a geological map published by Geological Survey Department of Malaysia. As shown in the figure, the site is located in an area of Quaternary Deposits. The granitic rock and Phylite/Schist/Slate crop out at the east of the site.

The Quaternary Deposits comprise of beach sand, high and low terrace deposits, laterite, gravel, sand, silt and clay. The base rock at the site is considered to be granite.

<Soil Stratification>
Based on the results of the exploratory drilling, 2 soil profiles are prepared. The orientation of the soil profile is indicated in **Figure 6.5.3** whereas the profiles are shown in **Figure 6.5.4** and **Figure 6.5.5**. As can be seen in the soil profile, the subsurface ground conditions at the site can be divided into 2 major geological units:

a) Miscellaneous Fill
b) Quaternary Deposits

<Miscellaneous Fill>
The miscellaneous fill covers the entire area of the landfill site with the thickness varying from 0.8m in AJ-W2 to more than 16.2m in AJ-G1. The fill comprises of yellowish brown to reddish brown, dark brown to brownish grey clayey silt and residential waste with presence of sand, fine gravel, organic decays and highly decomposed household materials with distinct smell.

<Quaternary Deposits>

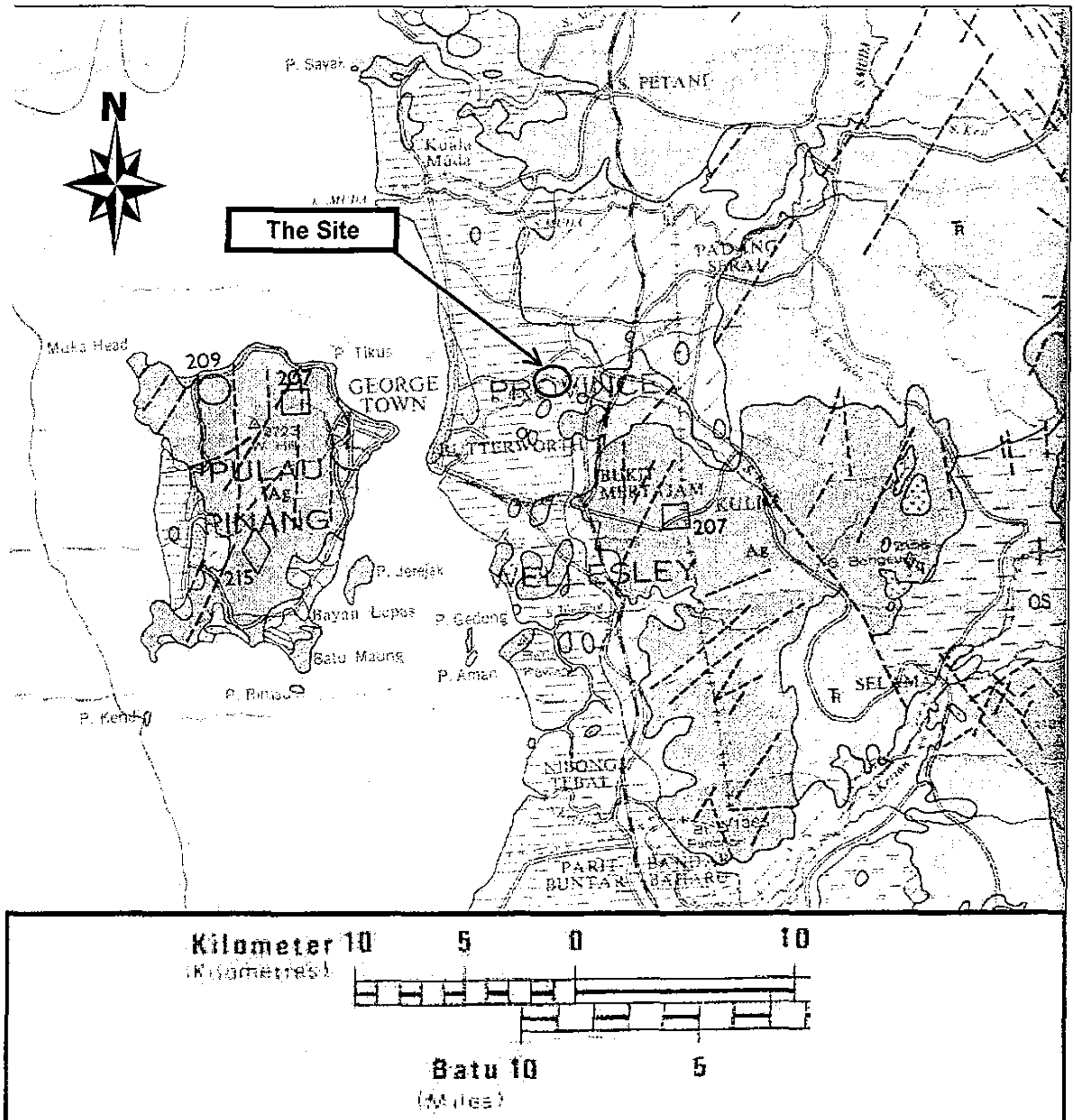
The quaternary deposits consist of the following 4 sub-layers:

a) Marine Clay
b) Medium Stiff Clay
c) Very Loose to Loose Sand
d) Medium Dense Sand

<Marine Clay>
The marine clay covers the entire project site. It comprises of dark grey to greenish grey, dark grey silt and clayey silt with presence of seashell fragments, organic matters and traces of fine sand. The thickness of Marine Clay layer ranges from 5.60m in AJ-W1 to 9.10m in AJ-W3. The lenses of Very Loose to Loose Sand layer with the thickness of 2.4m and traces of Medium Stiff Clay with thickness of 0.70m is found in Marine Clay in AJ-W1.

<Medium Stiff Clay>

The Medium Stiff Clay comprises of light grey to grey silt or clay with presence of fine to medium grained sand and fine gravel. The thickness of the Medium stiff layer ranges from 3m in AJ-W3 to 3.2m in AJ-W1. The pockets or lenses of the Medium stiff clay also occur in the Marine clay layer.



Q	Quaternary	Marine and continental deposits: clay,silt,sand,peat with minor gravel
	Silurian - Ordovician	Phylite, schist and slate
Ʀ	Middle Jurassic-Upper Triassic	Mainly shale and sandstone with volcanic strata
		Acid intrusives (Granite)

Figure 6.5.2 Map of Geological Setting, Ampang Jajar (reproduced from geological map published by Geological Survey Malaysia, 1985)

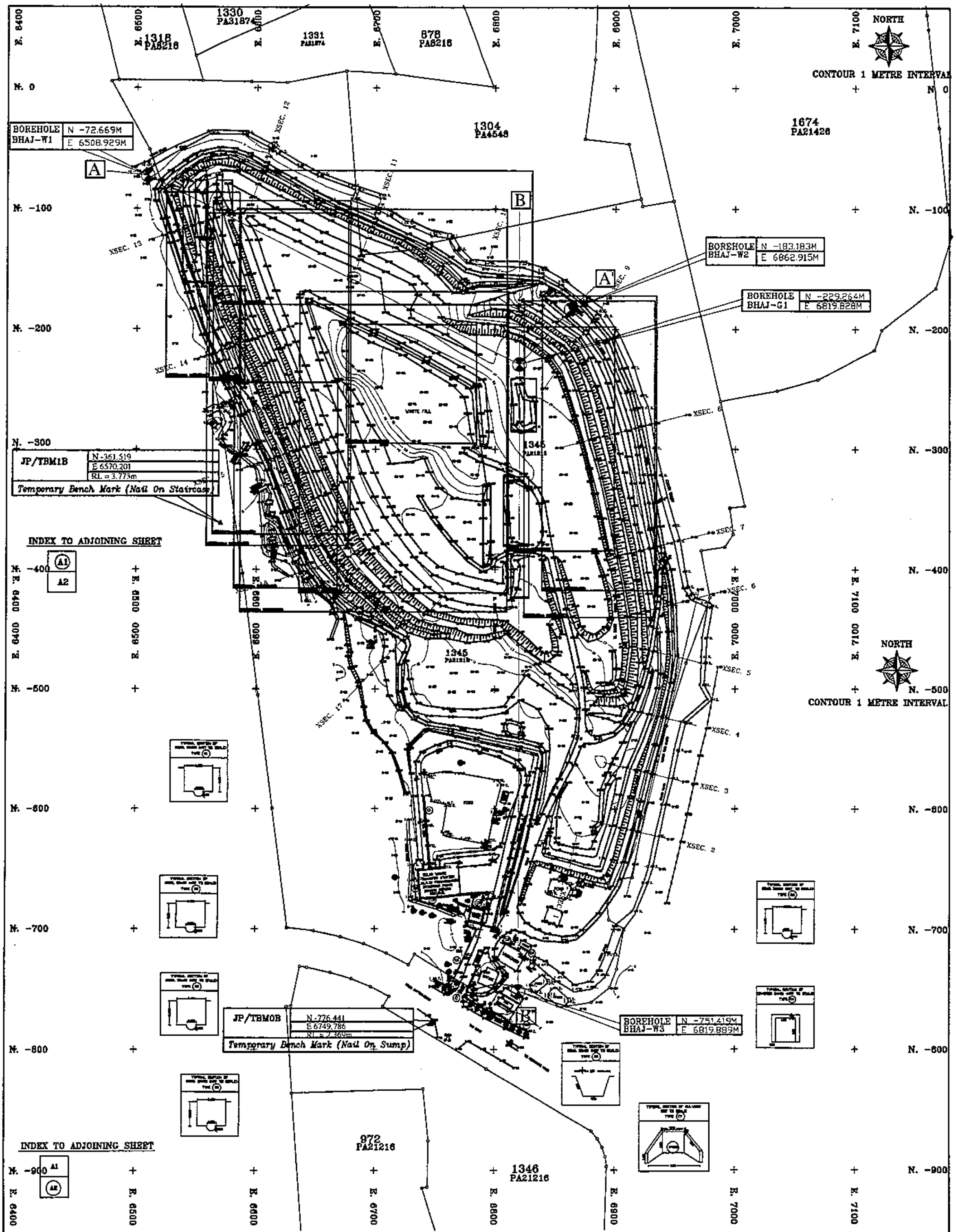


Figure 6.5.3 Map of Cross Section Line
Ampang Jajar Landfill, Pulau Pinang

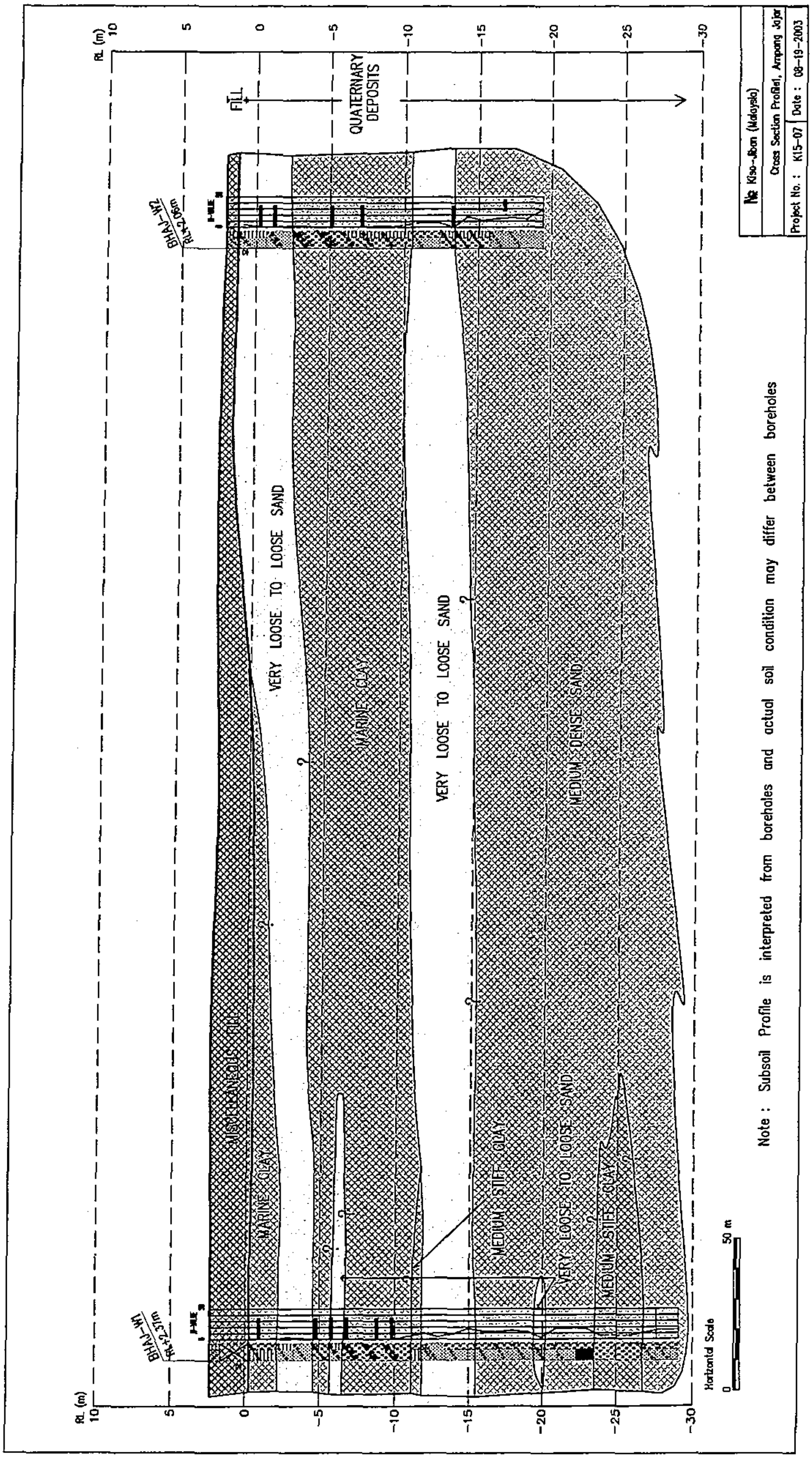


Figure 6.5.4 Cross Section Profile1, Ampang Jajar

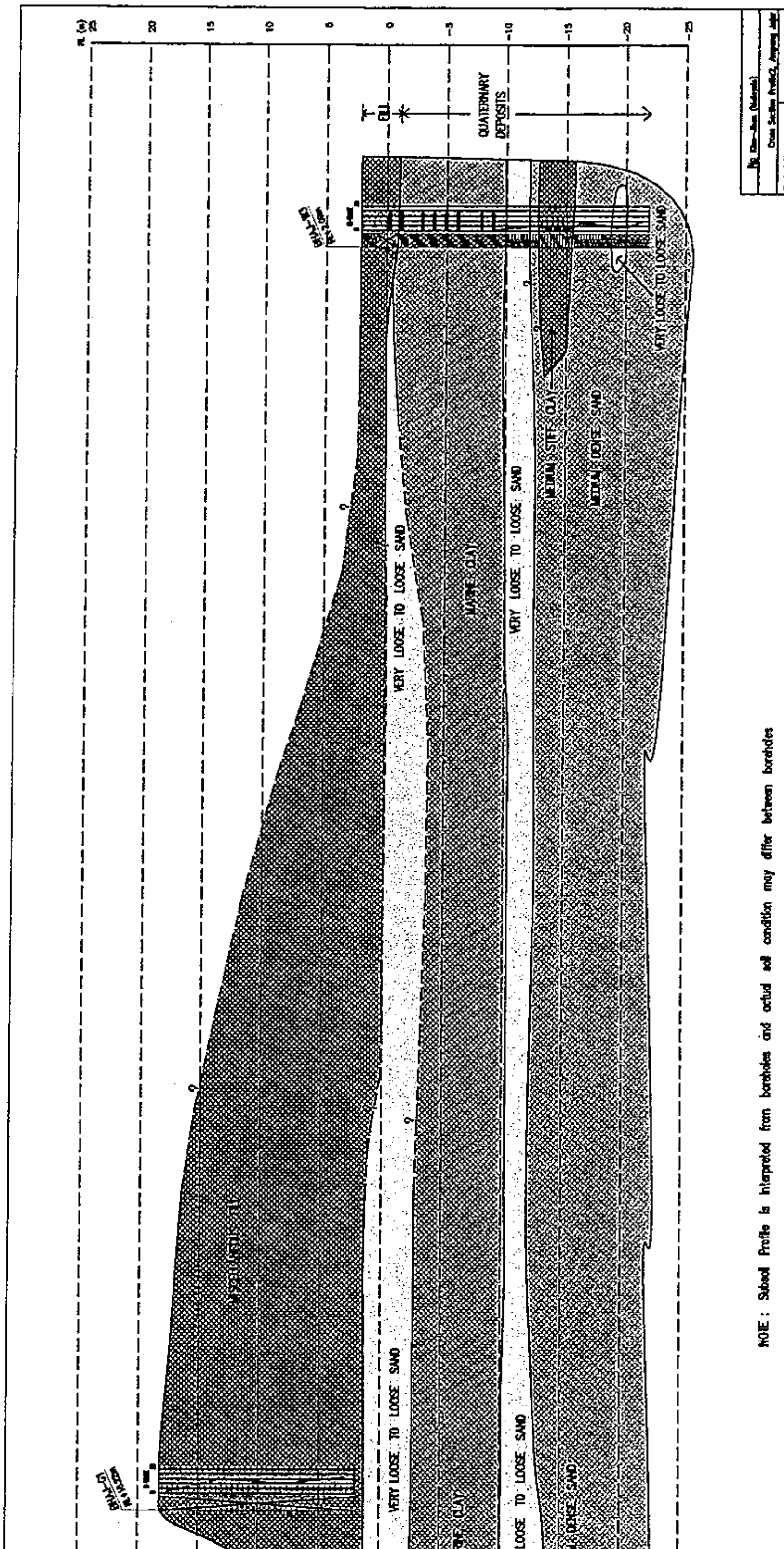


Figure 6.5.5 Cross Section Profile2, Ampang Jajar

<Very Loose to Loose Sand>

The Very Loose to Loose Sand comprises of light grey to grey silty sand or clayey sand with presence of sub-angular quartz gravels and occasionally with seashell fragments and organic decays. The thickness of Very Loose to Loose Sand varies from 2m to 3.70m in AJ-W2.

<Medium Dense Sand>

The Medium dense sand comprises of yellowish brown to light grey, fine to coarse grained with presence of fine quartz gravels. The thickness of Medium Dense Sand varies from 6.0m in AJ-W3 to 9.45m in AJ-W1. Lenses of Medium stiff clay and Very Loose to Loose Sand layer with thickness of 3m and 2m, respectively, also occur in the Medium dense sand.

(5) VIDEO SHOOTING

In order to maintain a record of the construction and monitoring programs at each Pilot Project site video shooting shall be implemented. The video scenes shot shall be edited and a 20 to 30 minute video produced for each pilot project site. Narration shall be in English. This shooting shall also be used in the production of the training module video. **Table 6.5.2** shows the frequencies of the video shooting.

Table 6.5.2 Program for the Video Tape Preparation

Item	Frequency	Time
1. Pilot project record	6 times/site x 3 sites = 18 times	In 2003
2. Monitoring	2 times/site x 3 sites = 6 times	During 2003
	2 times/site x 3 sites = 6 times	During 2004

6.5.2 Field sampling activity

Field samplings and measurement were carried out prior to the commencement of the works at the site for use as the baseline data. A similar set of sampling was also taken after the works. The sampling schedules are shown in **Table 6.5.3** and **Table 6.5.4**, respectively.

Table 6.5.3 Sampling Schedule -Before PP, for Baseline Data

Sampling points	Date	Time	Type of monitoring
AJ-W1	29 Aug 2003	10:10	Groundwater monitoring
AJ-W2	29 Aug 2003	11:30	
AJ-W3	29 Aug 2003	12:45	
AJ-G1	29 Aug 2003	12:35	Landfill gas monitoring
AJ-G2	29 Aug 2003	12:40	
AJ-L1	29 Aug 2003	11:50	Water & leachate monitoring
AJ-L2	29 Aug 2003	11:15	
AJ-SW1	29 Aug 2003	09:15	
AJ-SW2	29 Aug 2003	09:45	

Table 6.5.4 Sampling Schedule – After PP Improvements

Sampling points	Date	Time	Type of monitoring
AJ - W 1	10 Feb 2004	09:05	Groundwater monitoring
AJ - W 2	10 Feb 2004	10:15	
AJ - W 3	10 Feb 2004	11:30	
AJ - G1	10 Feb 2004	11:55	Landfill gas monitoring
AJ - G1	10 Feb 2004	12:15	
AJ - SW 1	10 Feb 2004	08:35	Water leachate monitoring
AJ - SW 2	10 Feb 2004	10:05	
AJ - L 1	10 Feb 2004	09:45	
AJ - L 2	10 Feb 2004	11:10	
AJ - W 1	21 May 2004	15:30	Groundwater monitoring
AJ - W 2	21 May 2004	14:45	
AJ - W 3	21 May 2004	13:45	
AJ - G1	21 May 2004	16:00	Landfill gas monitoring
AJ - G1	21 May 2004	16:20	
AJ - SW 1	21 May 2004	07:45	Water leachate monitoring
AJ - SW 2	21 May 2004	08:35	
AJ - L 1	21 May 2004	16:45	
AJ - L 2	21 May 2004	14:10	
AJ - W 1	1 July 2004	16:00	Groundwater monitoring
AJ - W 2	1 July 2004	16:20	
AJ - W 3	1 July 2004	15:00	
AJ - G1	1 July 2004	17:30	Landfill gas monitoring
AJ - G1	1 July 2004	17:40	
AJ - SW 1	1 July 2004	18:20	Water leachate monitoring
AJ - SW 2	1 July 2004	18:45	
AJ - L 1	1 July 2004	17:10	
AJ - L 2	1 July 2004	16:40	

The samples were taken in accordance with the parameters and specific preservation methods as explained in **Sections 5.2** and **5.3**.

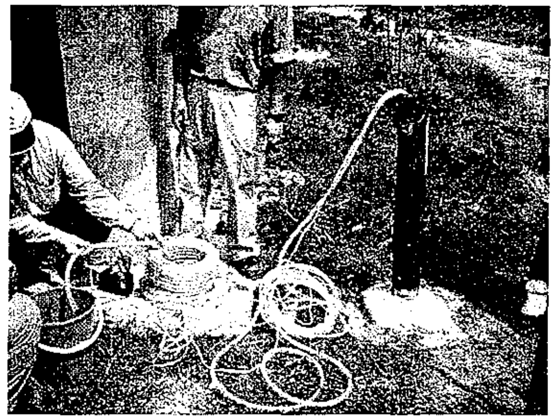
Plate 6.5.1 shows some of the photographs taken during the sampling exercise in August 2003.

Plate 6.5.1 Sampling Exercise in Ampang Jajar PP

AJ-SW1

AJ-SW2

AJ-W1



AJ-W2

AJ-L1

AJ-L2

6.5.3 Laboratory analysis

The results of laboratory analysis for both the sampling exercises are shown in **Table 6.5.5, 6.5.6** and **6.5.7**.

Table 6.5.5 Summary of Results - Physical Parameters

Samples taken on		*29/8/03*						
Test Parameters	Units	W1 10:10hrs	W2 11:30hrs	W3 12:45hrs	L1 11:50hrs	L2 11:15hrs	SW1 09:15hrs	SW2 09:45hrs
pH (*in-situ*)	-	7.1	6.9	6.1	7.7	8.1	7.5	7.8
Temperature (*in-situ*)	^0C	30.5	30.2	31.3	32.5	31.4	27.9	28.2
ORP	mV	-145	-108	-79	62	86	116	75
Conductivity	mS/cm	22.9	20.1	20.3	59.3	37.3	22.3	38.5
Turbidity	NTU	108	126	500	63.3	130	25.9	43.4
DO	mg/l	1.07	1.18	1.48	0.29	0.16	1.61	2.40
BOD_5 at 20^0C	mg/l	14	4	3	52	48	14	17
COD	mg/l	71	63	64	450	374	93	189
Total suspended solid	mg/l	22	56	343	23	94	26	28
Samples taken on		*10/2/04*						
Test Parameters	Units	W1 09:05hrs	W2 10:15hrs	W3 11:30hrs	L1 09:45hrs	L2 11:10hrs	SW1 08:35hrs	SW2 10:05hrs
pH	-	7.8	7.0	6.6	8.8	8.6	6.7	7.4
Temperature	^oC	29	28	28	29	28	26	28
ORP	mV	-336	-215	-154	-32	-94	240	50
Conductivity	mS/cm	6.42	19.1	20.3	14.5	10.1	7.12	1.82

Turbidity	NTU	7.73	13.7	3.94	24.6	46.6	13.7	24.3
DO	mg/l	0.89	0.92	0.76	0.41	1.54	4.79	2.30
BOD_5	mg/l	29	6	7	77	68	12	16
COD	mg/l	40	86	72	1705	670	60	94
Suspended Solids	mg/l	3	10	15	23	42	14	18
Samples taken on		*21/5/04*						
Test Parameters	Units	W1 15:30hrs	W2 14:45hrs	W3 13:45hrs	L1 16:45hrs	L2 14:10hrs	SW1 07:45hrs	SW2 08:35hrs
pH	-	7.5	6.8	6.3	8.0	8.0	7.2	7.4
Temperature	°C	31	30	30	33	31	27	27
ORP	mV	-255	-128	-89	-32	-49	-32	17
Conductivity	mS/cm	28.7	21.5	20.2	7.7	10.7	4.84	4.19
Turbidity	NTU	1.37	1.90	144	91.1	24.6	11.1	18.2
DO	mg/l	0.4	0.98	3.4	3.34	0.5	3.30	2.52
BOD_5	mg/l	3	5	7	100	187	10	4
COD	mg/l	123	110	93	1190	2460	70	64
Suspended Solids	mg/l	60	46	134	107	26	2	6
Samples taken on		*01/7/04*						
Test Parameters	Units	W1 16:00hrs	W2 16:20hrs	W3 15:00hrs	L1 17:10hrs	L2 16:40hrs	SW1 18:20hrs	SW2 18:45hrs
pH	-	7.0	6.7	6.4	8.0	8.0	6.8	6.9
Temperature	°C	30	30	30	35	35	30	32
ORP	mV	-154	-142	-101	44	-32	-51	24
Conductivity	mS/cm	25.6	19.4	18.0	4.5	3.9	2.3	1.3
Turbidity	NTU	3.41	2.97	12.6	43.4	33.4	40.3	62.7
DO	mg/l	0.64	0.87	0.69	2.39	1.51	2.04	1.11
BOD_5	mg/l	6	6	3	66	46	15	17
COD	mg/l	114	89	67	447	484	74	80
Suspended Solids	mg/l	14	24	84	20	12	13	22

Table 6.5.6 Summary of Results - Metals and Other Test Parameters

Samples taken on		*29/8/03*						
Test Parameters	Units	W1 10:10hrs	W2 11:30hrs	W3 12:45hrs	L1 11:50hrs	L2 11:15hrs	SW1 09:15hra	SW2 09:45hrs
Arsenic	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Boron	mg/l	1.8	1.8	1.3	4.0	1.5	0.6	1.1
Cadmium	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Hexavalent Chrome	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Trivalent Chrome	mg/l	0.06	0.08	0.07	<0.05	<0.05	<0.05	<0.05
Copper	mg/l	<0.01	0.02	0.03	0.02	0.04	0.02	0.02
Iron	mg/l	1.36	1.36	5.32	6.19	1.34	2.25	7.62
Lead	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Manganese	mg/l	0.50	0.20	0.59	0.07	0.05	0.13	0.66
Mercury	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Nickel	mg/l	<0.01	<0.01	<0.01	0.03	0.03	<0.01	0.03
Tin	mg/l	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Zinc	mg/l	0.12	0.10	0.12	0.11	0.14	0.04	0.16
Cyanide	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Sulphide	mg/l	0.11	0.09	<0.01	0.06	0.09	0.09	0.12
Chloride ion	mg/l	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Phenol	mg/l	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Oil & Grease	mg/l	<1	<1	<1	<1	<1	<1	<1
Total Nitrogen	mg/l	26	11	9	402	272	60	46
Ammonia Nitrogen	mg/l	26.4	10.7	7.94	402	272	59.6	45.8
Nitrate Nitrogen	mg/l	<0.01	<0.01	<0.01	0.04	0.03	0.01	0.01
Nitrite Nitrogen	mg/l	<0.01	<0.01	<0.01	0.11	0.11	0.01	<0.01

Samples taken on		*10/2/04*						
Test Parameters	Units	W1 09:05hrs	W2 10:15hrs	W3 11:30hrs	L1 09:45hrs	L2 11:10hrs	SW1 08:35hrs	SW2 10:05hrs
Arsenic	mg/l	< 0.05	< 0.05	< 0.05	0.61	< 0.05	< 0.05	< 0.05
Boron	mg/l	0.5	1.6	1.1	5.6	3.5	0.7	0.5
Cadmium	mg/l	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Hexavalent Chrome	mg/l	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Trivalent Chrome	mg/l	< 0.05	< 0.05	< 0.05	0.06	< 0.05	< 0.05	< 0.05
Copper	mg/l	< 0.01	< 0.01	< 0.01	0.13	0.09	0.01	0.03
Iron	mg/l	0.65	0.68	1.49	6.03	4.34	0.18	1.28
Lead	mg/l	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Manganese	mg/l	0.83	0.07	0.29	0.10	0.07	0.27	0.19
Mercury	mg/l	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Nickel	mg/l	< 0.01	< 0.01	< 0.01	0.14	0.06	< 0.01	< 0.01
Tin	mg/l	0.2	0.1	< 0.1	0.6	0.1	0.1	0.1
Zinc	mg/l	0.05	0.04	0.05	2.14	0.09	0.04	0.08
Cyanide	mg/l	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Sulphide	mg/l	6.89	0.51	0.38	0.08	0.16	0.02	0.06
Chloride ion	mg/l	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Phenol	mg/l	< 0.001	0.04	0.04	< 0.001	0.05	0.04	0.03
Oil & Grease	mg/l	ND(<1)	ND(<1)	ND(<1)	ND(<1)	ND(<1)	ND(<1)	ND(<1)
Total Nitrogen	mg/l	7	17	6	1,060	515	16.4	46
Ammonium-nitrogen	mg/l	5.0	16.0	5.0	983	516	15.3	40.0
Nitrate-nitrogen	mg/l	5.0	16.0	5.0	983	516	15.3	40.0
Nitrite-nitrogen	mg/l	< 0.01	< 0.01	0.05	0.17	0.03	0.37	0.15

Samples taken on		*21/5/04*						
Test Parameters	Units	W1 15:30hrs	W2 14:45hrs	W3 13:45hrs	L1 16:45hrs	L2 14:10hrs	SW1 07:45hrs	SW2 08:35hrs
Arsenic	mg/l	<0.05	<0.05	0.07	0.64	<0.05	<0.05	<0.05
Boron	mg/l	2.2	2.0	1.4	4.7	6.9	0.7	0.7
Cadmium	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Hexavalent Chrome	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Trivalent Chrome	mg/l	<0.05	<0.05	<0.05	<0.05	0.11	<0.05	<0.05
Copper	mg/l	<0.01	<0.01	<0.01	0.19	0.37	<0.01	<0.01
Iron	mg/l	4.89	10.9	3.81	2.91	7.00	0.61	0.69
Lead	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Manganese	mg/l	0.79	0.07	0.35	0.07	0.10	0.45	0.20
Mercury	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Nickel	mg/l	<0.01	<0.01	<0.01	0.08	0.19	<0.01	<0.01
Tin	mg/l	<0.1	<0.1	<0.1	<0.1	0.3	<0.1	<0.1
Zinc	mg/l	0.04	0.03	0.03	0.08	0.24	0.08	0.03
Cyanide	mg/l	<0.05	<0.05	<0.05	<0.05	0.09	<0.05	<0.05
Sulphide	mg/l	0.19	0.03	<0.01	0.03	0.01	0.01	<0.01
Chloride ion	mg/l	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Phenol	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Oil & Grease	mg/l	<1	<1	<1	<1	<1	<1	<1
Total Nitrogen	mg/l	16	12	13	529	1300	21	25
Ammonium-nitrogen	mg/l	5.35	4.08	5.90	429	1160	20.0	20.9
Nitrate-nitrogen	mg/l	<0.01	<0.01	<0.01	0.10	<0.01	0.35	<0.01
Nitrite-nitrogen	mg/l	<0.01	<0.01	<0.01	0.02	0.47	1.35	0.18

Samples taken on		*01/7/04*						
Test Parameters	Units	W1 16:00hrs	W2 16:20hrs	W3 15:00hrs	L1 17:10hrs	L2 16:40hrs	SW1 18:20hrs	SW2 18:45hrs
Arsenic	mg/l	<0.05	<0.05	<0.05	<0.05	0.06	<0.05	<0.05

Boron	mg/l	2.2	2.0	1.3	2.6	1.7	0.5	0.3
Cadmium	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Hexavalent Chrome	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Trivalent Chrome	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Copper	mg/l	<0.01	<0.01	<0.01	0.40	0.43	0.01	<0.01
Iron	mg/l	5.1	2.44	15.8	1.26	0.79	5.89	3.76
Lead	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Manganese	mg/l	0.79	0.05	0.62	0.33	0.26	1.79	0.38
Mercury	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Nickel	mg/l	<0.01	<0.01	<0.01	0.05	0.05	0.01	<0.01
Tin	mg/l	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Zinc	mg/l	0.04	0.03	0.03	0.32	0.34	0.23	0.16
Cyanide	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Sulphide	mg/l	0.11	<0.01	0.02	<0.01	0.02	<0.01	<0.01
Chloride ion	mg/l	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Phenol	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Oil & Grease	mg/l	<1	<1	<1	<1	<1	<1	<1
Total Nitrogen	mg/l	7	4	6	270	295	18	19
Ammonium-nitrogen	mg/l	6.48	3.58	5.45	250	242	6.5	14.7
Nitrate-nitrogen	mg/l	<0.01	<0.01	<0.01	7.27	14.6	0.80	0.06
Nitrite-nitrogen	mg/l	<0.01	<0.01	<0.01	0.84	0.45	0.07	<0.01

Table 6.5.7 Summary of Results - Landfill Gases

Samples taken on		*25/8/03*	
Test Parameters	Units	AJ-G1 12:35hrs	AJ-G2 12:40hrs
Methane (CH_4)	%	67.8 (*1)	30.9
Carbon Dioxide (CO_2)	%	39.2 (*2)	17.7
Oxygen (O_2)	%	Not Detectable	11.7
Nitrogen (N_2)	%	Not Detectable	40.6
Hydrogen Sulphide (H_2S)	ppm	50	3
Carbon Monoxide (CO)	ppm	42	11
Samples taken on		*04/2/04*	
Test Parameters	Units	AJ-G1 11:55hrs	AJ-G2 12:15hrs
Methane (CH_4)	%	54.5	18.1
Carbon Dioxide (CO_2)	%	36.2	11.4
Oxygen (O_2)	%	2.27	13.2
Nitrogen (N_2)	%	5.03	54.6
Hydrogen Sulphide (H_2S)	ppm	22	1
Carbon Monoxide (CO)	ppm	28	12.7
Samples taken on		*21/5/04*	
Test Parameters	Units	AJ-G1 16:00hrs	AJ-G2 16:20hrs
Methane (CH_4)	%	61.2	35.1
Carbon Dioxide (CO_2)	%	38.7	21.5
Oxygen (O_2)	%	1.3	8.4
Nitrogen (N_2)	%	4.4	34.9
Hydrogen Sulphide (H_2S)	ppm	29	1.0
Carbon Monoxide (CO)	ppm	35.7	16.7

Samples taken on		*01/7/04(24/8/2004)*	
Test Parameters	Units	AJ-G1 17:30hrs	AJ-G2 17:40hrs
Methane (CH_4)	%	6.0(16.7)	3.4(41.1)
Carbon Dioxide (CO_2)	%	2.1(7.1)	1.1(25.1)
Oxygen (O_2)	%	16.6(13.8)	17.3(6.8)
Nitrogen (N_2)	%	75.2(62.2)	78.2(26.0)
Hydrogen Sulphide (H_2S)	ppm	12	Not detectable
Carbon Monoxide (CO)	ppm	7.0	7.5

Note: *1 *2 = Reason for why the sum of the percentage of all the parameters exceed 100 may be due to the anomalies in the results and measurement error
Landfill gas in AJ-G1 and G2 were re-tested again in August 24, 2004 because of significant change in measured gas composition in July 1, 2004.

6.5.4 Considerations

(1) Considerations - Baseline

The monitoring data taken in August 2003 represent the baseline data.

1) Groundwater Quality

The monitoring wells were installed to a depth below the near surface layer of the marine clay layer of over 5m thick. In principle, the 5m thick marine clay layer provides a good barrier as clay has very low permeability. The contamination of the groundwater at the site should be minimal. However, based on the analysis results, the water quality at the 3 monitoring wells were rather poor. For instance, points W1, W2 and W3 all showed fairly high conductivity and turbidity. The COD value exceeded 50mg/l and iron and manganese concentration also exceeded the benchmark value for groundwater quality as set by DOE. Furthermore, the ammonia concentrations are over 10mg/l. Generally, these results indicated that the groundwater is not suitable for human consumption. How the contaminant pass through the thick layer of clay is not clear at this moment. Probably there were cracks at the clay layer in some part of the land filled area. In spite of the long distance between the monitoring wells, the water qualities of the 3 wells were about the similar range. This indicates that contamination of groundwater is not taking place in small spot but in wide area around the landfill sites.

2) Groundwater Flow

The groundwater levels measured during the sampling exercise are shown in **Table 6.5.8**.

Table 6.5.8 Groundwater Levels at Ampang Jajar PP Site

Monitoring Well	Elevation (MSL m)	Groundwater level from the top of the well(m)	Groundwater level (MSL m)
AJ-W1	2.37	1.63	0.74
AJ-W2	2.06	1.51	0.55
AJ-W3	2.09	2.01	0.08
AJ-G1	18.22	11.5	6.72

With the groundwater levels, the contour map for the groundwater was generated and shown in **Figure 6.5.6**. The general direction of the groundwater flow can be deduced by considering its flow perpendicular to the contour lines, from the higher elevation to the lower elevation. Thus, from the contour map, the groundwater flow was deduced to be from the north to the south and similar to the direction of flow of the nearby river. However, it should be noted that leachate flows from the landfill layers to into surrounding area in all directions. The leachate may have infiltrated into the groundwater at AJ-W1 even though its location is in upstream of groundwater flow.

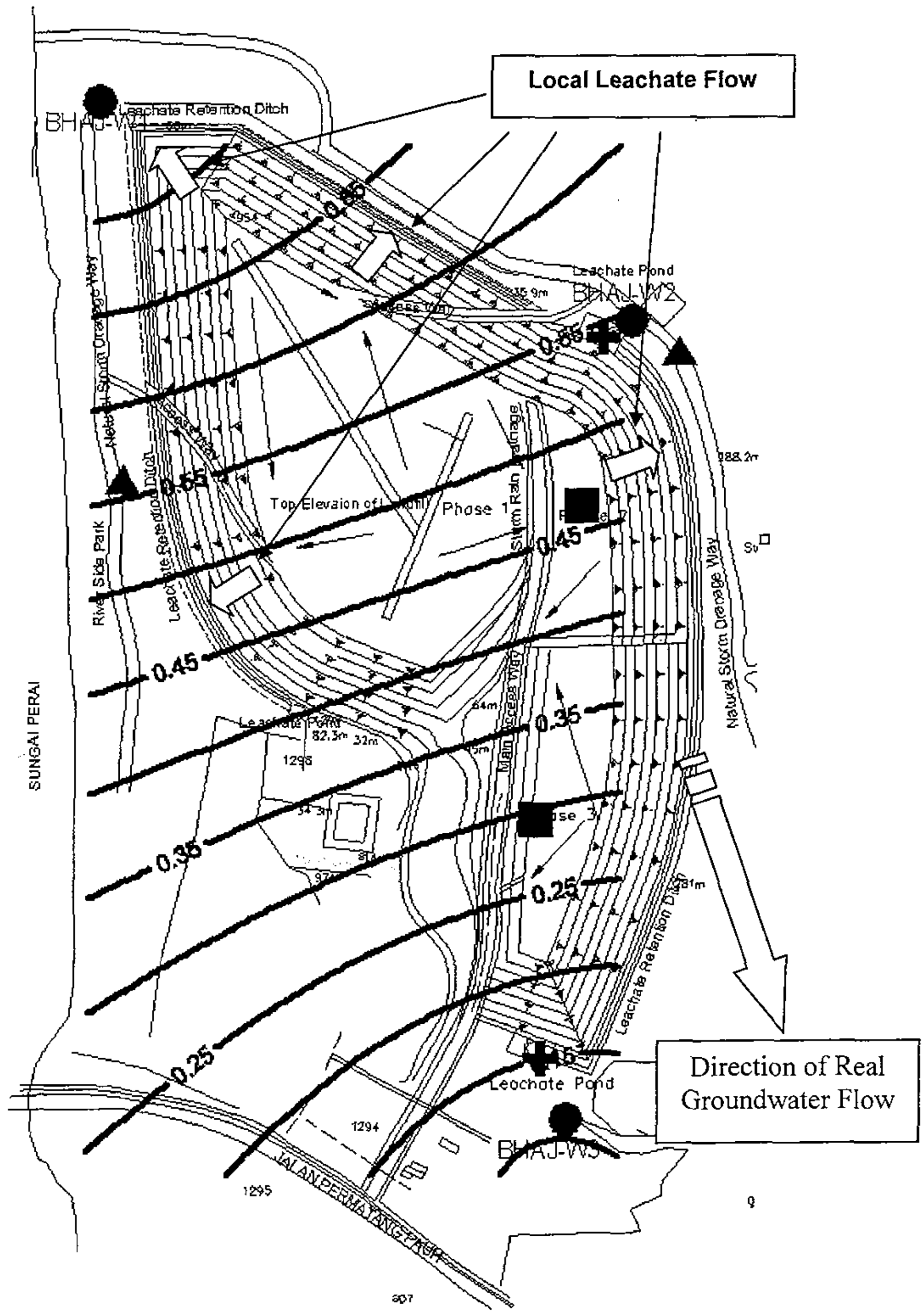


Figure 6.5.6 Groundwater Level Contour Map - Ampang Jajar PP

3) Leachate and Surface water quality

Inline with the EQA effluent quality standards, the results for the water quality are shown in **Table 6.5.9.** Since there is no water intake point downstream of the Ampang Jajar site, the Standard B limits were applied.

Table 6.5.9 Leachate and Water Quality

	Standard B	L1	L2	SW1	SW2
BOD_5 at 20° C (mg/l)	50	***52***	48	14	17
COD (mg/l)	100	***450***	***374***	93	***189***
Boron (mg/l)	4.0	***4.0***	1.5	0.6	1.1
Iron (mg/l)	5.0	***6.19***	1.34	2.25	***7.62***

From the above table, it shows that for sampling point L1, all the results exceeded the Standards. Generally, it was noticed that the COD of all the samples tend to exceed the prescribed limit.

The relationship between the quality of leachate, surface water and groundwater can be expressed in their total-nitrogen (T.Nitrogen) and electric conductivity (EC), as shown in **Figure 6.5.7**. These two parameters were selected because of their consistency, as they do not vary much during the degradation process.

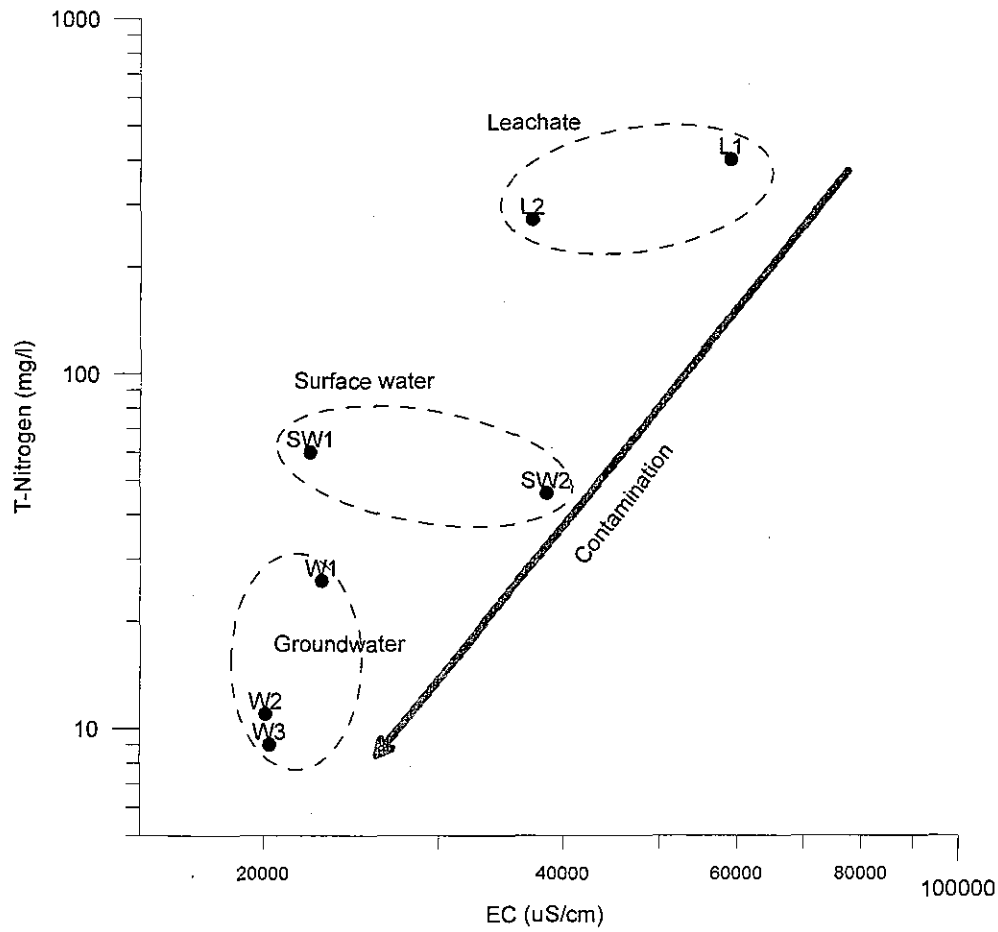


Figure 6.5.7 Water Quality Relationship - Ampang Jajar PP

From the chart, it clearly shows the 3 sample groups are quite distinctive, with leachate as the most contaminated, followed by surface water and then the groundwater. It is noted that approximate ratio of the total-nitrogen and the electric conductivity are almost the same for each of the 3 groups. This implied that the contamination may be coming from the same source.

4) Landfill gas

The results for AJ-G1 gas sampling show a high Methane (CH_4) concentration of over 65%. No oxygen and nitrogen were detected. As for AJ-G2, the results show lower Methane concentration of just over 30% with 18% CO_2. The oxygen and nitrogen were detected at 1:4 ratio thus indicating they may be due to atmospheric air contribution.

(2) Considerations - after the PP improvements

The evaluation of the PP improvement will be discussed in Volume 4, Chapter 9. The brief results of the environmental monitoring will be discussed for three aspects, i.e., environmental impact, safety and stabilisation process.

1) Environmental impact

For surface water and leachate, their water quality was compared with effluent standard B. As noted in **Table 6.5.9**, for the 4 parameters, i.e., BOD_5, COD, Boron and Iron, it shows that the results already exceeded the limits in some points during the baseline sampling before the PP improvement. **Table 6.5.10** summarised the results of monitoring for those parameters that exceeded the effluent standard B. Although leachate samples often exceeded the standard for the various parameters, the surface water samples did not, except for Iron and Manganese for the SW points in July 2004 sampling. It is noted that arsenic were found at leachate L1 samples during the February and May, 2004 samplings. Arsenic in leachate requires special attention for future monitoring.

In accordance with the EQA, the leachate from the site, which exceeds the prescribed standard in the various parameters, should not be discharged without treatment. However from the scientific view point, considering the large volume of flow of the Perai river, and the fact that there is no water intake point downstream, the environmental impact caused by the inflow of these surface water from SW1 and SW2 may not be serious.

Table 6.5.10 Monitoring Value Exceeding Effluent Standard B

	Sampling point	BOD_5 (mg/l)	COD (mg/l)	Boron (mg/l)	Iron (mg/l)	Manganese (mg/l)	Arsenic (mg/l)
Effluent standard B		50	100	5.0	5.0	1.0	0.1
Feb/04	L1	***77***	***1705***	***5.6***	***6.03***	0.1	***0.61***
	L2	***68***	***670***	3.5	4.34	0.07	<0.05
	SW1	12	60	0.7	0.18	0.27	<0.05
	SW2	16	94	0.5	1.28	0.19	<0.05
May/04	L1	***100***	***1190***	4.7	2.91	0.07	***0.64***
	L2	***187***	***2460***	***6.9***	***7***	0.1	<0.05
	SW1	10	70	0.7	0.61	0.45	<0.05
	SW2	4	64	0.7	0.69	0.2	<0.05
July/04	L1	***66***	***447***	2.6	1.26	0.33	<0.05
	L2	***46***	***484***	1.7	0.79	0.26	***0.06***
	SW1	15	74	0.5	***5.89***	***1.79***	<0.05
	SW2	17	80	0.3	3.76	0.38	<0.05

The groundwater quality of the monitored samples was not suitable for human consumption. As the flow of the groundwater is towards the southern direction, it is recommended that additional monitoring well should be installed at the lower gradient (south direction). According to the baseline survey, hydraulic gradient of the area is approx. 1/1,000 and permeability ranged between 6.4 x 10-6 to 5.8 x 10-5 m/sec. Assuming effective porosity at 10%, the approximate velocity of groundwater flow should be about 2.0-20 m/year. The estimated velocity is not significant. However these are preliminary estimates based on currently available limited data. Any use of the groundwater at the southern direction of the site within approximately 500m should be strictly supervised to avoid any negative health effect.

2) Safety

For the landfill gas, methane has been detected at over 5%.concentration at the wells. In order to prevent gas explosions or fire, no burning should be permitted within these areas.

The slope improvement at the PP site reduced the risk of landslides and collapse at the south-eastern side of the site. However, the other areas of the site still possess risk of slope collapse and therefore caution is required when working under the slopes or at the top.

3) Stabilisation process

The leachate composition showed relatively lower BOD_5 value than COD. This implies that the organic degradation within the landfill site has progressed. On the other hand, the landfill gas composition indicated active aerobic and anaerobic degradation of organic matter inside the landfill. As long as high concentration of methane and CO_2 are detected, the stabilisation of the landfill has not been reached.

6.6 CONTINUOUS OPERATIONS & MAINTENANCE AND MONITORING

6.6.1 Operation and maintenance of landfill facilities

All the facilities provided and installed at the landfill site, such as the final cover, leachate collection and treatment systems, 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

The proper operation and maintenance of the leachate collection and treatment facilities is essential for the treatment of the leachate prior to discharging the effluent into the drains. The equipments such as the aerators, pumps and filtration system must be maintained and serviced regularly and should be in good working conditions. Filter media should be replaced where necessary.

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. Top cover

For the PP, only the top cover at the slopes and steps were provided. Some subsidence and erosion of the slopes may occur over a period of time. Nevertheless it is necessary to maintain the top cover for the entire site to prevent the percolation of rainwater into the waste layers and to protect the landfill site.

d. 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.

e. 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.

The typical example of the maintenance items of the landfill facilities, method and scale/frequency are shown in **Table 6.6.1**.

Table 6.6.1 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 pipes	Clogging, damage to pipes, corrosion	Periodical inspections & comparison of the effluent quantity data	daily
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

In accordance with the Guideline, for the Post Closure Management for Ampang Jajar, the following monitoring programme has been recommended, as shown in **Table 6.6.2.**

Table 6.6.2 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

For the Pilot Project, only 2 samples from the 2 leachate ponds were monitored. As there are four leachate ponds at the site, it is recommended that samples should be taken at all the four ponds. Also it is recommended to analyze for the presence of Arsenic, as several high concentration levels were observed during the Pilot Project.

(2) Landfill gas

Continuous monitoring of the gas composition is recommended.

(3) Land subsidence

Under the Pilot Project, settlement plates to determine the rate of land subsidence were provided. The level of the settlement plates should be measured once a year as the good indicator of the stabilisation process.

(4) Groundwater

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

(5) Surface water

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