CHAPTER 3

METHODOLOGIES

3.1 FIELD SURVEY

Field survey had been carried out from 20th December 2006 to 26th February 2007, on weekly basis. The purpose of this field survey was to determine the status of certain characteristics of Paya Indah including the physical (seasonal weather, lake systems, hydrology and land use) and the biological components (flora and fauna) in relation to the water quality and pollution level. The main aim was to determine the water quality condition and to identify the sources of the water quality degradation within 5km radius, as it is a standard practice in Environmental Impact Assessment procedure. The field survey was conducted to determine the changes in the environment of Paya Indah in natural conditions. Apart from that, the information obtained from the field survey and previous literatures, as well as existing geographical data of Paya Indah vicinity derived from the relevant authorities were used to briefly describe the existing environment of Paya Indah.

3.2 DATA COLLECTION

Secondary raw water quality data of Paya Indah were first obtained from the Hydrology and Water Resources Division, Department of Irrigation and Drainage (DID) through an appointed consultant. These data were studied under prior approval from DID, as the attached letter in Appendix 1.

3.3 DATA REVIEW

Based on the water quality data derived from the DID, water quality sampling exercises were carried out between December 2006 and February 2007. Fifteen (15) locations had been designated within the study area as water quality sampling stations. Briefly, all sampling stations were located at channels that connect each lake from upstream to downstream, based on the hydrological pattern as addressed in the previous chapter. The details of each sampling station are described in Table 3.1, including the coordinates of each sampling station and their physical descriptions. Figure 3.1 shows the exact location of the sampling stations. Within the period, the changes in water quality were monitored. Thus factors that influence changes of the water quality within that period were determined or identified.

For all physical parameters (pH, dissolved oxygen and temperature), in-situ procedures were used, while for chemical parameters, water samples were collected in clean bottles, stored temporarily in cooler box to maintain low temperature before the samples were analysed in laboratory within six (6) hours after sampling exercise by referring to American Public Health Association (APHA) methods 1996, as detailed in Table 3.2.

Two sets of data were collected namely the baseline data and the critical data. The baseline water quality exercises were carried out on two dates (21^{st} December 2006 and 25^{th} February 2007). The baseline data set comprises physical and chemical parameters, including heavy metals and other chemical compounds (other than heavy metals). The purpose of baseline data collection is to identify the existing water quality condition at Paya Indah during its closure from the public.

Table 3.1
Description of water quality sampling station

Station Code	Coordinates		Description
	Longitude	Latitude	
W1	101°37.161’	2°53.578’	Canal C2, at ELITE Expressway, near Dengkil R&R, flow into Visitor Lake
W2	101°38.814’	2°51.281’	Canal C4, at ELITE Expressway, flow into Lotus Lake
W3	101°37.876’	2°51.880’	Visitor Lake
W4	101°37.663’	2°51.711’	Upstream of a channel connecting a shallow pond near Visitor Lake and Crocodile Lake
W5	101°37.670’	2°51.686’	Downstream of a channel connecting a shallow pond near Visitor Lake and Crocodile Lake
W6	101°37.802’	2°51.578’	Upstream of a channel connecting Hippo Lake and Lotus Lake
W7	101°37.798’	2°51.567’	Downstream of a channel connecting Hippo Lake and Lotus Lake
W8	101°37.219’	2°51.842’	At a channel connecting Visitor Lake and Main Lake
W9	101°37.045’	2°52.627’	Main Lake, near a ground helipad
W10	101°36.787’	2°52.427’	At a connection channel between Main Lake and Petaling Tin Lake
W11	101°36.696’	2°51.870’	At Perch Lake
W12	101°36.675’	2°51.672’	Downstream of a channel connecting Perch Lake and Marsh Lake
W13	101°36.677’	2°51.659’	Downstream of a channel connecting Marsh Lake and Paddy Lake
W14	101°36.807’	2°51.493’	First bridge at an interconnection channel from Chalet Lake to Lotus Lake in front of Malay House
W15	101°36.774’	2°51.488’	Second bridge at an interconnection channel from Chalet Lake to Lotus Lake

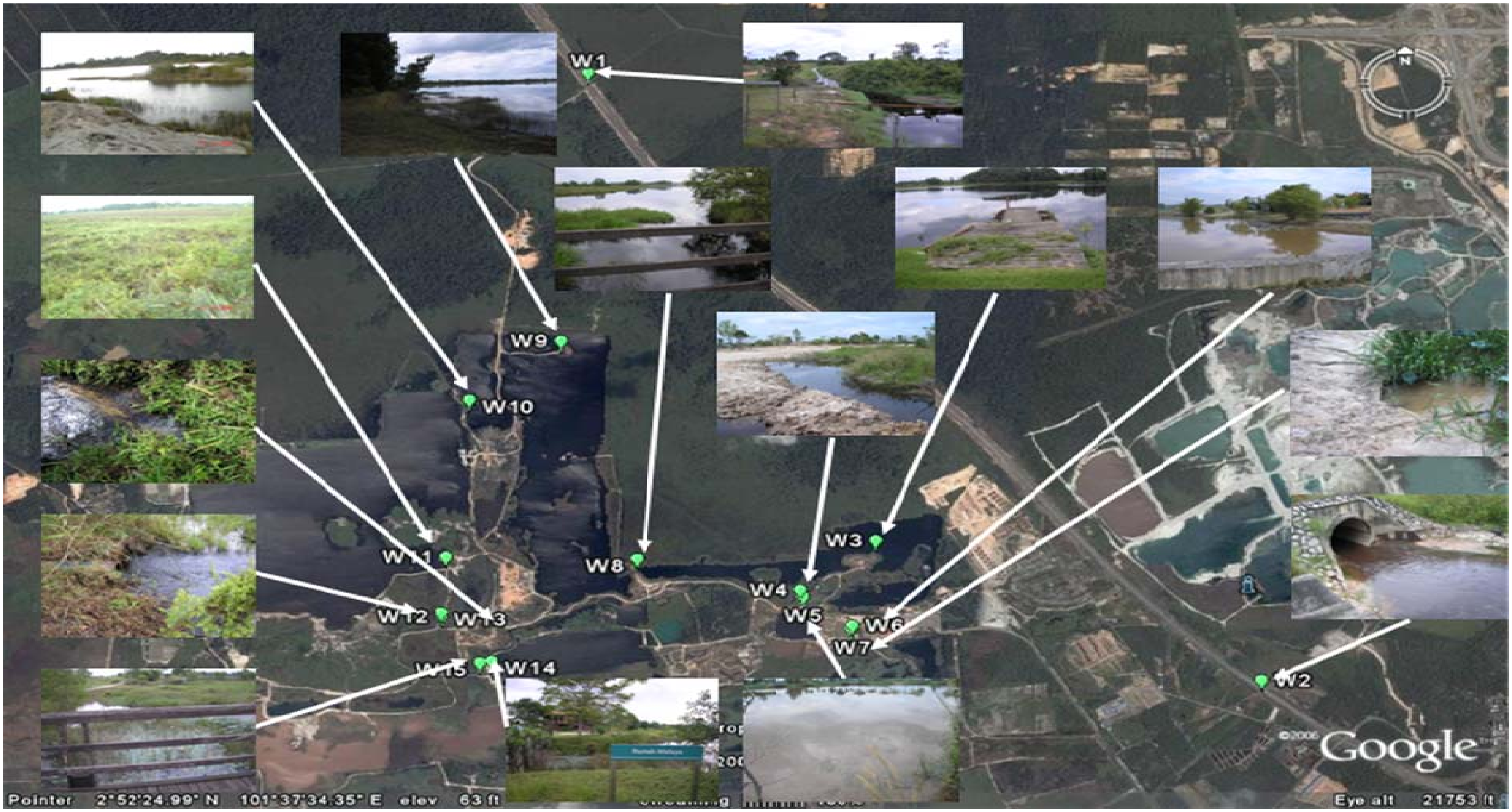

Figure 3.1: Location of water quality sampling stations with pictures showing the sampling stations' landmarks
Source: Google earth.com, accessed on 3/1/2007

Table 3.2
List of parameters and relevant methods

Parameters	Unit	Method Used
pH Value	-	In-situ
Dissolved Oxygen	mg/l	In-situ
Biochemical Oxygen Demand @ 5 days at 20°C	mg/l	APHA 5210 B, 1995
Chemical Oxygen Demand	mg/l	APHA 5220 B, 1995
Total Suspended Solids	mg/l	APHA 2540 D, 1995
Mercury as Hg	mg/l	US EPA Method 245.1,1991
Cadmium as Cd	mg/l	APHA 3111 B, 1995
Arsenic as As	mg/l	PE:B3505: As(1994)
Total Chromium	mg/l	APHA 3500 Cr D, 1995
Cyanide as CN	mg/l	APHA 4500 CN C&F, 1995
Lead as Pb	mg/l	APHA 3111 B, 1995
Copper as Cu	mg/l	APHA 3111 B, 1995
Manganese as Mn	mg/l	APHA 3111 B, 1995
Nickel as Ni	mg/l	APHA 3111 B, 1995
Tin as Sn	mg/l	PE: B 3505:Sn (1994)
Zinc as Zn	mg/l	APHA 3111 B, 1995
Boron as B	mg/l	ISO (9390: 1990E)
Iron as Fe	mg/l	APHA 3111 B, 1995
Phenol	mg/l	APHA 5530 B&D, 1995
Free Chlorine as Cl_2	mg/l	In-House Method Based on BS 1427, 1962
Sulphide as S^{2-}	mg/l	APHA 4500-S^{2-}F, 1995
Ammoniacal Nitrogen as N	mg/l	APHA 4500-NH_3 E 1992
Total Phosphorus	Mg/l	APHA 4500-P B&D, 1995

**Bolded parameters are critical parameters.*

The water quality sampling exercises for critical parameters were carried out on weekly basis for six (6) consecutive weeks, starting from 21st December 2006 to 25th January 2007. The critical parameters are defined as the most basic parameters and have significant impact on water quality if changes in one or more parameters' characteristic had occurred. The critical parameters of water quality comprises pH, Temperature, Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Suspended Solids (TSS) and Ammoniacal Nitrogen (NH_3-N).

Water quality sampling for critical parameter is normally done also as prerequisite for water quality and hydrological modeling which is the subject of a different exercise. For this study, the critical water quality data were known as weekly data.

3.4 DATA ANALYSIS

The water quality raw data of Paya Indah were analysed by using Microsoft Excel 2003. This includes calculation of Water Quality Index, average and standard deviations of WQI and critical parameters at each sampling station, and determining the significance of fluctuations of each parameter within the period through the calculation of percentages of standard deviations against average on WQI and each parameter. Graphical analyses were also performed to depict the pattern of water quality.

The average and standard deviation of the parameters at each sampling station were calculated with the following formulas to determine the degree of fluctuation (high, gradual) of parameters within six weeks.

Calculation of statistical average:

$$\bar{x} = \frac{x_1 + x_2 + \ldots x_n}{n} \longrightarrow \text{Equation (1)}$$

Where $\bar{x}$ = average, x = values and n = sample size

Calculation of standard deviations:

$$\sigma = \sqrt{\frac{\sum (x - \bar{x})^2}{(n-1)}} \longrightarrow \text{Equation (2)}$$

Where σ = standard deviation, $\bar{x}$ = average, x = values and n = sample size

Then, percentages of the standard deviation against the average were calculated at each sampling station to determine the fluctuation significance. If a sampling station has a percentage of standard deviation against average of more than 20 percent, the fluctuation of parameter values within the six weeks period were considered as significant.

Calculation of percentage of standard deviation against average (%):

$$\% = \frac{\sigma}{\bar{x}} \times 100 \longrightarrow \text{Equation (3)}$$

Where σ = standard deviation, $\bar{x}$ = average

3.4.1 Analysis on Water Quality Index (WQI)

Water Quality Index (WQI) indicates the overall conditions of the water quality, thus it was the first to be calculated and analysed . WQI were calculated by using the following WQI calculation formula (DOE, 2006):

$$WQI = 0.22(SIDO) + 0.19(SIBOD) + 0.16(SICOD) + 0.15(SIAN) + 0.16(SISS) + 0.12(SIpH)$$

Where: WQI =Water Quality Index; and

SI = Sub-Index.

The calculations of the sub-index were carried out in accordance to the sub-index calculation formula in Table 3.3. The calculations of WQI were done on weekly basis within the study period. The weekly values were then averaged, and standard deviation and percentages of standard deviation against average were calculated to determine the significance of WQI fluctuation on each week within the study period.

The general rating scales for WQI (%) are as follows (DOE, 2006):

WQI = 80 – 100 - Clean water;

WQI = 60 – 79 - Slightly polluted water; and

WQI = 0 – 59 - Polluted water.

Table 3.3
Best-fit Equations for the Estimation of the Various Sub-Index Values

Sub-Index	Equation	Concentration
DO (% saturation)	SIDO = 0 or 100 SIDO = $-0.395 + 0.030x^2 - 0.00020x^3$	For $x \leq 8$ or $x \geq 92$ For $8 < x < 92$
BOD (mg/L)	SIBOD = 100.4 -4.23x SIBOD = $108 * e^{-0.055x} - 0.1x$	For $x \leq 5$ For $x > 5$
COD	SICOD = -1.33x + 99.1 SICOD = $103 * e^{-0.0157x} - 0.04x$	For $x \leq 20$ For $x > 20$
AN	SIAN = 100.5 -105x SIAN = $94 * e^{-0.0573x} - 5 * \lvert x-2 \rvert$ SIAN = 0	For $x \leq 0.3$ For $0.3 < x < 4$ For $x \geq 4$
SS	SISS = $97.5 * e^{-0.00676x} + 0.05x$ SISS = $71 * e^{-0.0016x} - 0.0015x$ SISS = 0	For $x \leq 100$ For $100 < x < 1000$ For $x \geq 1000$
pH	SIpH = $17.2 - 17.2x + 5.02x^2$ SIpH = $-242 + 95.5x - 6.67x^2$ SIpH = $-181 + 82.4x - 6.05x^2$ SIpH = $536 - 77.0x + 2.76x^2$	For $x < 5.5$ For $5.5 \leq x < 7$ For $7 \leq x < 8.75$ For $x \geq 8.75$

Source: Department of Environment, 2006

Where x = concentration of parameters; and

* = multiplied by.

Before the calculation of WQI could be made, the Dissolved Oxygen values (in mg/l) were converted to the percentage of saturation (%-sat) by using the following equation as proposed by Weiss (1970):

$$DO\ (percentage\ saturation) = \frac{measured\ DO\ (mg/l)}{DO\ (mg/l)\ at\ 100\%\ saturation} \longrightarrow \text{Equation (4)}$$

The DO concentration at 100% saturation was obtained from the "Solubility of Oxygen in Water at Various Temperatures and Pressures" by Weiss (1970) (Appendix 2). The temperatures were based on the in-situ reading and the pressure was set to 760 mm hg for Paya Indah.

The WQI values that were below DOE classification 80% were then identified to determine the sub-index parameters which influence the respective WQI value. Then the fluctuation degrees of WQI values at each sampling station within six weeks were determined by calculating average and standard deviation, as discussed in detail in Section 3.3 above. The significance of fluctuation at each sampling station within six weeks was determined by calculating percentage of standard deviation against average.

3.4.2 Analysis on Water Quality Parameters

Critical water quality parameters as indicated in Table 3.2 above were compared with Class III of DOE Interim National Water Quality Standards (INWQS), as shown in Table 3.4 to identify non-conformity.

Table 3.4
DOE Interim National Water Quality Standards

Parameter (mg/l)	Class					
	I	*IIA*	*IIB*	*III*	*IV*	*V*
pH	6.5-8.5	6.5 – 9	6.5 - 9	5 – 9	5 - 9	-
Salinity (ppt)	0.5	1	-	-	2	-
Conductivity (μS/cm)	1000	1000	-	-	6000	-
Dissolved Oxygen (DO)	7	5-7	5-7	3-5	<3	<1
Total suspended solids (TSS)	25	50	50	150	300	>300
BOD_5	1	3	3	6	12	>12
COD	10	25	25	50	100	>100
E.Coli (N/100ml)	10	100	400	5000	5000	-
Amm. Nitrogen	0.1	0.3	0.3	0.9	2.7	>2.7
Oil & Grease	NL	40	No sheen	no sheen	no sheen	no sheen
Mercury (Hg)	NL	0.001	-	0.0001	0.002	>0.002
Cadmium (Cd)	NL	0.005	-	0.001	0.01	>0.01
Lead (Pb)	NL	0.05	-	0.01	5	>5
Chromium (Cr_{3+})	NL	-	-	2.53	-	-
Copper (Cu)	NL	0.02	-	-	0.2	>0.2
Manganese (Mn)	NL	0.1	-	0.1	0.2	>0.2
Nickel (Ni)	NL	0.05	-	0.09	-	>0.2
Zinc (Zn)	NL	5	-	-	2	>2
Iron (Fe)	NL	0.3	-	1	1	>1
Phenol (C_6H^5OH)	Absent	10	-	-	-	-

Notes
1. NL: Natural levels
2. Class I: Conservation of the natural environment; minimal treatment required; protection of very sensitive aquatic species.
3. Class IIA: Water supply with conventional treatment; protection of sensitive aquatic species
4. Class IIB: Recreational use with body contact
5. Class III: Water supply with extensive treatment required; water for livestock drinking; moderately tolerant species of aquatic life.
6. Class IV: Water for irrigation.
7. Class V: Water is unsuitable for any of the above uses.

Source: Department of Environment, 2006

Class III of INWQS was chosen because referring to the INWQS classifications, Class III is for livestock drinking, suitable for moderately tolerant species of aquatic life and it still can be used as water supply with extensive treatment. Therefore water quality that stood within Class IV or Class V of INWQS is not suitable for aquatic life as the pollution level could not be tolerated. The values which do not comply with Class III of INWQS were discussed. Then, the same method of determining fluctuation degrees and significance of WQI values were applied to determine the fluctuation degrees of parameters at each sampling station within six weeks and the significance of fluctuation at each sampling station.

The analyses on heavy metals (Mercury, Cadmium, total Chromium, Lead, Copper, Nickel, Tin and Zinc), Iron, Manganese, other chemical compounds (Arsenic, Cyanide, Boron, Phenol, Sulphide and total Phosphorus), Oil and Grease, free Chlorine and *E. coli* from baseline data were also carried out in accordance to Class III of INWQS.