ANNEX B
METHODOLOGY

B1.1 INTRODUCTION

This Annex presents the methodologies used in the SEIA Assessment and associated proposals for mitigating measures. Other information included in this annex is hydrological survey data and laboratory reports for air, noise, water quality and soils. National Standards for water and inorganic constituents are also incorporated.

B1.2 PHYSICAL ENVIRONMENT

B1.2.1 Soil Erosion Hazard Assessment

B1.2.1.1 Slope Elevation and the Universal Soil-Loss Equation

In this study 1:50,000 topographic maps were used. Owing to the large contour intervals (from 100 ft to 250 ft) in the topographic map, small hill slopes that were observed during site visit could not be delineated from the maps and thus limiting the resolution of the analyses to broad areas only.

The entire Project area was divided into cells with dimensions of 500 m x 500 m. Benta I was thus divided into 3317 cells. The number of cells in Benta IIC was 1273. Based on the map contours in the published 1:50,000 topographic maps, the slope gradient within each cell were estimated. These were digitised and modelled as contoured gradient maps (**Figure 4.3.1**).

The modelled gradient maps that essentially illustrate the distribution pattern of the steepness of the slopes, are used to present slope hazard areas. The other application is to use the digitised data for soil erosion distribution maps.

Areas with high slope stability hazards are coloured red. These are steep slopes where soil and rock failures are expected.

The grids used for digitising are shown in **Figure 4.3.2** and **Figure 4.3.3**.

The essence of modelling soil loss with the Universal Soil-Loss Equation (USLE) is to evaluate each factor that influence soil loss and quantify its effect with a numerical unit. These factors are multiplied in order to calculate the amount of soil loss. Although it was developed as a design tool for conservation planning, the USLE method is widely used to estimate soil erosion rates. However, it is not considered appropriate to use it to estimate sediment yield from drainage basins, or to predict gully and stream bank erosion.

The equation is presented in the form

$$A = R \times K \times L \times S \times C \times P$$

Where:

A = soil loss in tons per hectare per year.

R = rainfall erosivity index – a number which indicates the erosivity of the rainfall on a scale based on the Morgan Method (1974).

K = soil erodibility factor- a number which reflects the liability of a soil type to erosion.

L = the length factor – a ratio which compares the soil loss with that from a field of specified length of 22 metres.

S = the slope factor – a ratio which compares the soil loss with that from a field of specified slope (9 %).

C = crop management factor – a ratio which compares the soil loss with that from a field under a standard treatment.

P = conservation practice factor - a ratio that compares the soil loss with that from a field with no conservation practice.

The application of this numerical equation is to predict soil erosion losses in a given environment. In a given situation the value of each factor is fixed. For each of these factors the appropriate numerical value is selected, and when multiplied together they give the amount of erosion predicted to occur in this given situation. Changes in the soil loss can be predicted by altering the conditions i.e. the values of any of the above factors.

The values for the above factors are continually revised and fine tuned to suit local conditions.

The input values are site-specific data. The site is first divided into an appropriate number of cells similar to the digital analyses method mentioned earlier for slope evaluation and as shown in **Figure 4.3.2** and **Figure 4.3.3** in **Chapter 4**, where each individual cell is measured for its L (average slope length) and S (average slope) input. The relief of the site determines the size of each cell. Owing to the limited contouring of the available topographic maps, 500 m x 500m cell dimensions are used. Other parameters such as K (soil erodibility factor) are also determined. The soil erosion rate for each cell is calculated and digitised.

Rainfall Erosivity, R

Soil loss is closely related to rainfall partly through the detaching power of raindrops reaching sticking the soil surface directly and partly through the contribution of rain to runoff. The most suitable expression of the erosivity of rainfall is an index based on the kinetic energy of the rain. The rainfall erosivity index is adopted from the Morgan's Formula which is widely used in tropical climates. The equation is shown below:

$$R = [(9.28 \times P) - 8838.15] \times 75 \times 0.102/173.6$$

Where P is the annual rainfall, and 75 is the value for I30 (rainfall intensity) for a 2-year return period.

Since there are no meteorological stations available at the proposed Project site, data were obtained from the nearest meteorological stations, i.e. the Kalabakan Town (managed by the Department of Irrigation and Drainage, Sabah), Luasong Forestry Centre (managed by Rakyat Berjaya Sdn Bhd) and Tawau (managed by the Meteorological Department of Malaysia). The average annual rainfall ranges from 2,119 mm (13 years average) in

Kalabakan town to 2,782mm in Luasong (6 years average from 1995-2000) and 2,670mm in Tawau (1980-1998).

The rainfall erosivity indices, R, calculated from these stations are shown in the table below:

Table B1.1: Rainfall Erosivity Index

Location	R
Kalabakan Town	477.08
Luasong	748.20
Tawau	702.40

Generally the rainfall is more or less evenly distributed over the year with a drier period from January to April followed by a wetter period between May and November as recorded in Kalabakan. Luasong Forestry Centre experiences a drier period from April to July and a wetter period from August onwards with heavy rainfall recorded in December. Tawau, on the other hand, receives more-or-less even rainfall distribution throughout the year.

Soil Erodibility, K

The soil erodibility index is defined as the mean annual soil loss per unit of R for a standard condition of bare soil, recently tilled up-and-down slope with no conservation practice and on a slope of 5^{o} and 22 m length. Estimates of the K value were accomplished with the following:

Using a Wischmeier nomogram;

Calculating K based on grain-size distribution, organic content, textural composition and;

Assigning K directly based on previous soil studies.

The results showed that K values range from 0.22 to 0.32 as shown in the table below.

Table B1.2: K values for various soils

Soil Association	Estimated Soil Erodibility K
10 & 12 (Labau & Brantian)	0.26
29 (Kalabakan)	0.26
30 (Mawing)	0.28
33 (Kretam)	0.28
39 (Lokan)	0.23
40 (Bang)	0.26
41 (Bidu-Bidu)	0.25
42 (Mentapok)	0.25
44 (Malubok)	0.22
46 (Gumpal)	0.26
47 (Crocker)	0.32 (calculated)
48 (Maliau)	0.25 (calculated)

The K values of Maliau and Crocker were calculated based on laboratory tests on the soil samples collected on 24th and 25th November 2004 during the field visit (see results in **Annex B1.7**). The soil samples were collected at the following GPS positions:

1. S1 – Geminchau : 4° 39.687' N, 117° 27.355' E - Maliau

2. S2 – Brantian : 4° 39.356' N, 117° 32.627' E - Crocker

3. S3 – Anjeranjermut : 4° 31.142' N, 117° 13.524' E - Crocker

Factors of Slope S and Slope Length L

The factors of slope length (L) and slope steepness (S) are combined in a single index which expresses the ratio of soil loss under a given slope steepness and slope length to the soil loss from the standard condition of a 5^o and 22 m long. Factor L and S can be evaluated from the topographic map. The combined slope-length factor can be obtained from the equation presented as below.

Factors L = (l/22)x

S = $(0.065 + 0.045s + 0.0065s^2)$

Where

s = slope steepness

l = slope length

x = 0.5 for slopes >4%, 0.4 for slopes of 3%, 0.3 for slopes <3%.

(In this case, 0.5 is adopted)

Crop management **C**

The crop management factor represents the ratio of soil loss under a given crop to that from bare soil. The effect of crop management is very different for each type of crop. The worst practice has a C value of 1, but good management techniques have C values down to 0.005. Natural, undisturbed environments in balance may be even lower. In the Universal Soil Loss Equation, factor C for various condition are given as below.

Bare soil,	C = 1.0
Grass land (logged over forest)	C = 0.007 (adopted for project area)
Forest (Primary forest)	C = 0.001

When the cover crop is established over subsequent years, the C factor is reverted to grassland conditions or better, generally at 0.005.

Conservation practice **P**

Values for the erosion conservation practice factor are obtained from tables of the ratio of soil loss where the practice is applied to the soil loss where it is not. P values adopted for normal conservation practice is 0.5, and 1.0 for worst cases or without any conservation practice. In other words, the soil loss would be reduced to 50% under 'normal' conservation practices.

Results of Soil Loss Estimation for the Proposed Project Area

Benta I

Table B1.3 presents an example of the soil loss estimation under existing conditions (E), worst conditions (W) and managed conditions, normal conservation practice (N) (after the cover crop is established) in Benta I. Currently, the project area is covered by logged forest and 10 % are covered by undisturbed primary forest. Calculated results showed that the soil loss erosion rate is generally low for existing condition (E), ranging from 0.22 t/ha/yr to

128.48 t/ha/yr with an average of 12.76 t/ha/yr. It is estimated that 999,005 tons of soil sediments would be eroded from this area every year. It should be noted here that average erosion rates over such a large area with diverse relief has little meaning.

During the development phase, vegetation within the project area will be cleared. In a worst-case scenario, the entire area excluding steep terrain is left bare for one whole year and no conservation undertaken (worst condition W). The rate of soil loss will increase drastically when compared with the existing environment, ranging from 234.97 t/ha/yr to 36,708 t/ha/yr. On the higher end, this is equivalent to about 2.3 m of soil, eroded from steep terrain. The calculated average rate of 3,920 t/ha/yr is not applicable to this scenario. The annual soil loss including the uncultivated steep terrain is estimated at 245,989,748 tons. This scenario is unlikely to occur for obvious economic reasons, and the impracticality of clearing such a large plot of land and leaving them bare in one year.

Using a factor **P** of 0.5 for normal conservation practice, the rate of soil loss would theoretically be reduced to half. The soil loss rate would range from 117.49 t/ha/yr to 18,354 t/ha/yr, with an average of 1960 t/ha/yr. However, it is grossly inaccurate to apply the average value to the entire Project area due to the following reasons:

- Areas of steep gradients (in excess of 25°) will not be cultivated. This means that erosion rates of steep gradients will revert to its existing conditions.
- The area to be planted will be developed in stages over a number of years. Thus the actual loss will depend on the percentage of the area planted in that year, the weather conditions during the clearing phase, and the period in months for which the cleared area is exposed.
- After the cover crop and terracing is established, the rate of soil loss will revert to existing conditions or even better.

The erosion rate patterns for Existing conditions, Worst conditions, and Normal conservation practice are illustrated in **Figure B1.2.1** to **Figure B1.2.3**.

Including soil loss in uncultivated terrain the amount would be 122,854,742 tons for the total Benta I Project area and over a period of 6 years. Based on the phasing schedule, the soil loss in each year is estimated assuming that the whole area excluding steep hills is cleared and left bare as shown in the table below:

Table B1.3: Benta I – Estimated soil loss based on the USLE method

Year	Area cleared and planted (ha)	Soil Loss Existing condition	Max. Soil Loss Worst condition	Max. Soil Loss Normal practice
2005	2,500	38,100	8,997,283	4,502,642
2006	6,500	126,638	29,593,097	14,810,476
2007	12,300	266,003	60,158,211	30,117,275
2008	17,300	242,320	64,507,051	32,274,859
2009	17,400	267,064	66,883,896	33,461,769
2010	3,000	58,880	15,370,340	7,687,721
	Total	**999005**	**245,509,878**	**122,854,742**

Under cultivated, crop managed conditions, the total soil loss is 767,927 tons.

Benta IIC

Table B1.4 represents an example of the soil loss estimation under existing conditions (E), worst conditions (W) and normal conservation practice conditions (N) for the proposed project area. Under existing conditions, nearly the entire project area is covered with logged over forest and about 10 % exists as undisturbed primary forest. The results show that the soil loss erosion rate is generally low for the existing conditions, varying from 0.15 t/ha/yr to 77.90 t/ha/yr with an average of 8.15 t/ha/yr. It is estimated that 239,729 tons of soil or sediments would be eroded from this project area every year.

Table B1.4: Benta IIC – Estimated soil loss based on the USLE method

Year	Area cleared and planted (ha)	Max. Soil Loss Existing condition	Max. Soil Loss Worst condition	Max. Soil Loss Normal practice
2006	2,500	12,150	2,539,019	1,267,872
2007	4,000	5,783	165,238	82,619
2008	4,500	63,286	11,200,185	5,612,214
2009	4,500	86,851	15,740,772	7,896,616
2010	5,500	71,651	12,905,683	6,472,740
	Total – 5 years	**239,721**	**42,550,879**	**21,332,061**

During construction or operation phase, vegetation within the Project area will be cleared. If it is assumed that the area is left bare for one whole year and no conservation was undertaken (worst condition), then the soil loss rate will increase drastically, ranging from 42.63 t/ha/yr to 31,164 t/ha/yr, giving an average rate of 2680 t/ha/yr. It is expected that 42,550,879 tons of soil will be eroded from this area per year under cleared conditions.

Using a factor **P** of 0.5 for normal conservation practice, the rate of soil loss would theoretically be reduced to approximately half, i.e. 21,332,061 tons. Again for reasons mentioned above, these figures are theoretical figures only. Under ideal conditions, when the estate is established and cover crops occupy the planted areas, the soil erosion rate is expected to revert to its existing conditions or better (C factor is 0.005). An estimate of the soil loss is 197,050 tons/year.

The erosion patterns for Existing, Worst, and Normal Practice conditions are illustrated in **Figure B1.2.1** to **Figure B1.2.3**.

TABLE B1.5: Calculation of soil loss in Benta I – an example

Note: CN here refers to established plant cover, Soil loss(N) – after plant cover is established

E	East	South	Horizontal (m)	Height (m)	%SLOPE	LS	R	K	CE	AE	PE	CW	AW	PW	CN	AN	PN	Area (%)	Soil loss t/yr (E)	Soil loss t/yr (W)	Soil loss t/yr (N)
E1S19	4697750	1429250	150	38.1	25.40	14.21	748.2	0.25	0.007	0.5	9.31	1.0	1.0	2658.57	0.005	0.5	6.65	20	46.53	13292.87	33.23
E1S20	4697750	1428750	350	38.1	10.89	5.33	748.2	0.25	0.007	0.5	3.49	1.0	1.0	997.12	0.005	0.5	2.49	60	52.35	14956.74	37.39
E2S18	4698250	1429750	200	60.96	30.48	22.71	748.2	0.25	0.007	0.5	14.87	1.0	1.0	4247.69	0.005	0.5	10.62	30	111.50	31857.69	79.64
E2S19	4698250	1429250	400	99.06	24.77	22.20	748.2	0.25	0.007	0.5	14.53	1.0	1.0	4152.15	0.005	0.5	10.38	80	290.65	83043.05	207.61
E2S20	4698250	1428750	250	30.48	12.19	5.37	748.2	0.25	0.007	0.5	3.52	1.0	1.0	1004.61	0.005	0.5	2.51	30	26.37	7534.58	18.84
E3S16	4698750	1430750	150	15.24	10.16	3.14	748.2	0.25	0.007	0.5	2.06	1.0	1.0	587.81	0.005	0.5	1.47	15	7.71	2204.28	5.51
E3S17	4698750	1430250	350	76.2	21.77	16.59	748.2	0.25	0.007	0.5	10.86	1.0	1.0	3102.30	0.005	0.5	7.76	75	203.59	58168.10	145.42
E3S18	4698750	1429750	650	137.16	21.10	21.41	748.2	0.25	0.007	0.5	14.02	1.0	1.0	4005.66	0.005	0.5	10.01	100	350.50	100141.55	250.35
E3S19	4698750	1429250	600	60.96	10.16	6.29	748.2	0.25	0.007	0.5	4.11	1.0	1.0	1175.62	0.005	0.5	2.94	80	82.29	23512.36	58.78
E4S15	4699250	1431250	250	45.72	18.29	10.40	748.2	0.23	0.007	0.5	6.27	1.0	1.0	1790.53	0.005	0.5	4.48	45	70.50	20143.45	50.36
E4S16	4699250	1430750	500	60.96	12.19	7.60	748.2	0.23	0.007	0.5	4.57	1.0	1.0	1307.08	0.005	0.5	3.27	95	108.65	31043.05	77.61
E4S17	4699250	1430250	500	60.96	12.19	7.60	748.2	0.25	0.007	0.5	4.97	1.0	1.0	1420.73	0.005	0.5	3.55	100	124.31	35518.36	88.80
E4S18	4699250	1429750	500	60.96	12.19	7.60	748.2	0.25	0.007	0.5	4.97	1.0	1.0	1420.73	0.005	0.5	3.55	100	124.31	35518.36	88.80
E4S19	4699250	1429250	400	60.96	15.24	9.72	748.2	0.25	0.007	0.5	6.36	1.0	1.0	1817.81	0.005	0.5	4.54	75	119.29	34083.86	85.21
E4S20	4699250	1428750	150	60.96	40.64	33.22	748.2	0.25	0.007	0.5	21.75	1.0	1.0	6213.35	0.005	0.5	15.53	5	27.18	7766.68	19.42
E5S13	4699750	1432250	100	25.908	25.91	12.02	748.2	0.23	0.007	0.5	7.24	1.0	1.0	2068.11	0.005	0.5	5.17	10	18.10	5170.27	12.93
E5S14	4699750	1431750	350	60.96	17.42	11.34	748.2	0.23	0.007	0.5	6.83	1.0	1.0	1951.72	0.005	0.5	4.88	70	119.54	34155.16	85.39
E5S15	4699750	1431250	500	60.96	12.19	7.60	748.2	0.23	0.007	0.5	4.57	1.0	1.0	1307.08	0.005	0.5	3.27	100	114.37	32676.89	81.69
E5S16	4699750	1430750	500	60.96	12.19	7.60	748.2	0.23	0.007	0.5	4.57	1.0	1.0	1307.08	0.005	0.5	3.27	100	114.37	32676.89	81.69
E5S17	4699750	1430250	500	60.96	12.19	7.60	748.2	0.26	0.007	0.5	5.17	1.0	1.0	1477.56	0.005	0.5	3.69	100	129.29	36939.10	92.35
E5S18	4699750	1429750	650	60.96	9.38	5.81	748.2	0.26	0.007	0.5	3.95	1.0	1.0	1129.27	0.005	0.5	2.82	100	98.81	28231.73	70.58
E5S19	4699750	1429250	500	60.96	12.19	7.60	748.2	0.26	0.007	0.5	5.17	1.0	1.0	1477.56	0.005	0.5	3.69	100	129.29	36939.10	92.35
E5S20	4699750	1428750	500	76.2	15.24	10.87	748.2	0.26	0.007	0.5	7.40	1.0	1.0	2113.66	0.005	0.5	5.28	40	73.98	21136.64	52.84
E6S11	4700250	1433250	300	152.4	50.80	71.13	748.2	0.25	0.007	0.5	46.57	1.0	1.0	13304.42	0.005	0.5	33.26	35	407.45	116413.66	291.03
E6S12	4700250	1432750	500	152.4	30.48	35.91	748.2	0.25	0.007	0.5	23.51	1.0	1.0	6716.19	0.005	0.5	16.79	75	440.75	125928.57	314.82
E6S13	4700250	1432250	500	76.2	15.24	10.87	748.2	0.23	0.007	0.5	6.54	1.0	1.0	1869.78	0.005	0.5	4.67	100	163.61	46744.49	116.86
E6S14	4700250	1431750	650	60.96	9.38	5.81	748.2	0.23	0.007	0.5	3.50	1.0	1.0	998.97	0.005	0.5	2.50	100	87.41	24974.22	62.44
E6S15	4700250	1431250	550	45.72	8.31	4.48	748.2	0.26	0.007	0.5	3.05	1.0	1.0	871.55	0.005	0.5	2.18	100	76.26	21788.87	54.47
E6S16	4700250	1430750	650	45.72	7.03	3.86	748.2	0.26	0.007	0.5	2.63	1.0	1.0	750.07	0.005	0.5	1.88	100	65.63	18751.79	46.88
E6S17	4700250	1430250	650	45.72	7.03	3.86	748.2	0.26	0.007	0.5	2.63	1.0	1.0	750.07	0.005	0.5	1.88	100	65.63	18751.79	46.88
E6S18	4700250	1429750	600	45.72	7.62	4.14	748.2	0.32	0.007	0.5	3.47	1.0	1.0	990.62	0.005	0.5	2.48	100	86.68	24765.43	61.91

TABLE B1.6: Calculation of Soil Loss in Benta IIC – an example

Note: CN here refers to established plant cover, Soil loss(N) – after plant cover is established

Grid	East	North	L (M)	H(M)	% Slope	LS	R	K	CE	AE	PE	CW	AW	PW	CN	AN	PN	% Area	Soil loss t/yr (E)	Soil loss t/yr (W)	Soil loss t/yr (N)
E2S70	4698250	1403250	475	121.92	25.67	25.76	477.07	0.25	0.007	0.5	10.75	1.0	1.0	3072.83	0.005	0.5	7.68	60	161.32	46092.42	115.23
E2S71	4698250	1402750	200	45.72	22.86	13.65	477.07	0.25	0.007	0.5	5.70	1.0	1.0	1627.43	0.005	0.5	4.07	40	56.96	16274.32	40.69
E3S70	4698750	1403250	125	22.86	18.29	7.36	477.07	0.25	0.007	0.5	3.07	1.0	1.0	877.49	0.005	0.5	2.19	25	19.20	5484.32	13.71
E3S71	4698750	1402750	525	228.6	43.54	70.60	477.07	0.25	0.007	0.5	29.47	1.0	1.0	8420.22	0.005	0.5	21.05	95	699.93	199980.14	499.95
E3S72	4698750	1402250	475	68.58	14.44	9.70	477.07	0.25	0.007	0.5	4.05	1.0	1.0	1156.51	0.005	0.5	2.89	90	91.08	26021.54	65.05
E3S73	4698750	1401750	100	45.72	45.72	33.73	477.07	0.25	0.007	0.5	14.08	1.0	1.0	4023.36	0.005	0.5	10.06	25	88.01	25145.99	62.86
E3S79	4698750	1398750	150	15.24	10.16	3.14	477.07	0.25	0.007	0.5	1.31	1.0	1.0	374.80	0.005	0.5	0.94	15	4.92	1405.50	3.51
E3S80	4698750	1398250	500	60.96	12.19	7.60	477.07	0.25	0.007	0.5	3.17	1.0	1.0	905.89	0.005	0.5	2.26	60	47.56	13588.41	33.97
E3S81	4698750	1397750	550	60.96	11.08	6.87	477.07	0.25	0.007	0.5	2.87	1.0	1.0	819.34	0.005	0.5	2.05	75	53.77	15362.65	38.41
E3S82	4698750	1397250	300	91.44	30.48	27.81	477.07	0.25	0.007	0.5	11.61	1.0	1.0	3317.13	0.005	0.5	8.29	100	290.25	82928.35	207.32
E3S83	4698750	1396750	350	259.08	74.02	156.68	477.07	0.25	0.002	0.5	18.69	1.0	1.0	18686.52	0.005	0.5	46.72	75	350.37	350372.16	875.93
E3S84	4698750	1396250	50	22.86	45.72	23.85	477.07	0.25	0.007	0.5	9.96	1.0	1.0	2844.94	0.005	0.5	7.11	10	24.89	7112.36	17.78
E4S69	4699250	1403750	150	15.24	10.16	3.14	477.07	0.25	0.007	0.5	1.31	1.0	1.0	374.80	0.005	0.5	0.94	25	8.20	2342.51	5.86
E4S70	4699250	1403250	350	53.34	15.24	9.09	477.07	0.25	0.007	0.5	3.79	1.0	1.0	1084.22	0.005	0.5	2.71	80	75.90	21684.33	54.21
E4S71	4699250	1402750	450	205.74	45.72	71.56	477.07	0.25	0.007	0.5	29.87	1.0	1.0	8534.83	0.005	0.5	21.34	100	746.80	213370.82	533.43
E4S72	4699250	1402250	525	106.68	20.32	18.04	477.07	0.25	0.007	0.5	7.53	1.0	1.0	2151.28	0.005	0.5	5.38	100	188.24	53782.08	134.46
E4S73	4699250	1401750	300	114.3	38.10	41.72	477.07	0.25	0.007	0.5	17.41	1.0	1.0	4975.62	0.005	0.5	12.44	70	304.76	87073.44	217.68
E4S74	4699250	1401250	100	30.48	30.48	16.06	477.07	0.25	0.007	0.5	6.70	1.0	1.0	1915.15	0.005	0.5	4.79	30	50.27	14363.61	35.91
E4S75	4699250	1400750	75	7.62	10.16	2.22	477.07	0.25	0.007	0.5	0.93	1.0	1.0	265.02	0.005	0.5	0.66	5	1.16	331.28	0.83
E4S79	4699250	1398750	525	76.2	14.51	10.28	477.07	0.25	0.007	0.5	4.29	1.0	1.0	1226.32	0.005	0.5	3.07	75	80.48	22993.45	57.48
E4S80	4699250	1398250	575	60.96	10.60	6.56	477.07	0.25	0.007	0.5	2.74	1.0	1.0	782.68	0.005	0.5	1.96	100	68.48	19566.97	48.92
E4S81	4699250	1397750	300	152.4	50.80	71.13	477.07	0.25	0.007	0.5	29.69	1.0	1.0	8483.21	0.005	0.5	21.21	100	742.28	212080.29	530.20
E4S82	4699250	1397250	400	228.6	57.15	102.48	477.07	0.25	0.007	0.5	42.78	1.0	1.0	12223.07	0.005	0.5	30.56	100	1069.52	305576.77	763.94
E4S83	4699250	1396750	400	190.5	47.63	72.80	477.07	0.25	0.007	0.5	30.39	1.0	1.0	8682.42	0.005	0.5	21.71	100	759.71	217060.42	542.65
E4S84	4699250	1396250	250	91.44	36.58	35.34	477.07	0.25	0.003	0.5	6.32	1.0	1.0	4214.87	0.005	0.5	10.54	70	110.64	73760.30	184.40
E4S85	4699250	1395750	50	15.24	30.48	11.35	477.07	0.25	0.007	0.5	4.74	1.0	1.0	1354.21	0.005	0.5	3.39	5	5.92	1692.77	4.23
E5S67	4699750	1404750	150	15.24	10.16	3.14	477.07	0.25	0.007	0.5	1.31	1.0	1.0	374.80	0.005	0.5	0.94	15	4.92	1405.50	3.51
E5S68	4699750	1404250	525	106.68	20.32	18.04	477.07	0.25	0.007	0.5	7.53	1.0	1.0	2151.28	0.005	0.5	5.38	50	94.12	26891.04	67.23
E5S69	4699750	1403750	550	121.92	22.17	21.45	477.07	0.25	0.007	0.5	8.95	1.0	1.0	2558.29	0.005	0.5	6.40	75	167.89	47967.86	119.92
E5S70	4699750	1403250	650	259.08	39.86	66.72	477.07	0.25	0.007	0.5	27.85	1.0	1.0	7957.22	0.005	0.5	19.89	100	696.26	198930.38	497.33
E5S71	4699750	1402750	550	167.64	30.48	37.66	477.07	0.25	0.007	0.5	15.72	1.0	1.0	4491.42	0.005	0.5	11.23	100	393.00	112285.52	280.71

B1.2.2 River system and road network

The river system is presented in the slope map (**Figure 4.3.1** in **Chapter 4**) as a separate layer overlaying the layer with the slope data. The river data has been derived from the national 1:50,000 maps. A verification of the data by ground surveying was not carried out. Therefore, slight differences between the river system on ground and the river system presented on the slope maps may occur. However, for the purpose of an over-all assessment, such differences are considered insignificant.

The road network shown in the slope map (**Figure 4.3.1** in **Chapter 4**) is based on the road network presented in coupe plans in the scales of 1:10,000 or 1:25,000. The location of the roads may not surveyed the field and, therefore, only approximate locations are used. The road alignment was vectorized and afterwards superimposed on the slope maps.

The information related to river system and road network should be taken as indicative and not absolute.

B1.2.3 Water Quality Sampling

In order to characterise the water quality of the primary watercourses and water bodies of the Project Area, baseline water quality data has been collected during November 2004. Collection of the data involves establishment and sampling of surface water sampling stations within the vicinity of the Project site. The locations of the water sampling points are shown in **Figure B1.2.4** and **Plate B1-1**. The description of each river is also presented in **Table B1.7**.

The water samples taken were analysed and the results are summarised in **Tables B1.8** and the Laboratory Reports are attached at the end of this **Annex B**.

The National Water Quality Standard (NWQS) for Malaysia is used as a guideline in the assessment of water quality of the affected rivers. The NWQS is shown at the end of **Annex B**. For this Project, Class IIB is used as to compare the existing rivers water quality to that of the standard recommendation. Class IIB is chosen as the reference standard as the water is used for navigation and fishing and hence, it falls under the category of usage with body contact.

From **Table B1.8**, the analysis revealed that certain parameters were beyond the Class IIB limits. Turbidity at all the water sampling points except W7 and W8 is high and over the limit. Identically, Total Suspended Solid level is also relatively high at these points. These higher levels could be attributed to the on-going logging activities on the upstream which is likely have affected the sedimentation of the waterways. The increased sediments invariably led to increase turbidity of the waterways.

The analyses also revealed that the Total Coliform Count at W6, W13 and W14 is high. As for Faecal Coliform Count, the levels are within Class IIB with the exception of W4, W5, W6 and W18. This could be due to animal droppings and improper management of human sewage from base camps and settlements.

Table B1.7: General Description of the Water Sampling Locations and Conditions (November 2004)

Sampling No	Date of Sampling	Geographical coordinates	Name of River	Weather Condition	Width of River (approx)	Depth of River water (approx only)	General Landuse
W1 (i)	23/11/04	N 4º 53.523' E 117º 13.122'	Sg. Kuamut	Cloudy	15 m	3 – 5 m	Forest / logging
W1 (ii)	23/11/04	N 4º 53.523' E 117º 13.122'	Sg. Kuamut	Cloudy	15 m	3 – 5 m	Forest / logging
W1 (iii)	23/11/04	N 4º 53.523' E 117º 13.122'	Sg. Kuamut	Cloudy	15 m	3 – 5 m	Forest / logging
W2 (i)	23/11/04	N 4º 51.567' E 117º 18.741'	Sg. Imbak	Cloudy	5 m	1 – 2 m	logging
W2 (ii)	23/11/04	N 4º 51.567' E 117º 18.741'	Sg. Imbak	Cloudy	5 m	1 – 2 m	logging
W3 (i)	24/11/04	N 4º 39.659' E 117º 27.314'	Sg. Geminchau	Fine	5 m	0.1 – 05 m	logging
W4 (i)	24/11/04	N 4º 43.670' E 117º 32.039'	Sg. Ulu Brantian	Fine	10 m	0.1 – 0.2 m	Plantation / logging
W5 (i)	24/11/04	N 4º 38.356' E 117º 32.627'	Sg. Brantian	Fine	5 m	0.2 – 0.5 m	logging
W6 (i)	24/11/04	N 4º 37.980' E 117º 34.002'	Sg. Bang	Fine	5 m	0.2 – 0.5 m	logging
W7 (i)	25/11/04	N 4º 31.142' E 117º 13.524'	Sg. Anjeranjermut	Fine and Cloudy	5 m	0.1 – 0.2 m	Forest / logging
W7 (ii)	25/11/04	N 4º 31.142' E 117º 13.524'	Sg. Anjeranjermut	Fine and Cloudy	10 m	0.1 – 0.5 m	Forest / logging

Sampling No	Date of Sampling	Geographical coordinates	Name of River	Weather Condition	Width of River (approx)	Depth of River water (approx only)	General Landuse
W8 (i)	25/11/04	N 4º 30.490' E 117º 15.751'	Sg. Anjeranjermut	Fine and Cloudy	15 m	1 – 2 m	Forest / logging
W9 (i)	25/11/04	N 4º 28.030' E 117º 22.221'	Sg. Kalabakan	Fine and Cloudy	5 m	2 – 3 m	Forest / logging
W9 (ii)	25/11/04	N 4º 28.030' E 117º 22.221'	Sg. Kalabakan	Fine and Cloudy	5 m	2 – 3 m	Forest / logging
W10 (i)	25/11/04	N 4º 27.834' E 117º 24.253'	Sg. Kalabakan	Rain	10 m	0.2 - 0.5 m	Forest / logging
W11 (i)	25/11/04	N 4º 24.022' E 117º 30.212'	Sg. Kalabakan	Rain	10 m	5 – 10 m	Town / log yard
W11 (ii)	25/11/04	N 4º 24.022' E 117º 30.212'	Sg. Kalabakan	Rain	10 m	5 – 10 m	Town / log yard
W11 (iii)	25/11/04	N 4º 24.022' E 117º 30.212'	Sg. Kalabakan	Rain	10 m	5 – 10 m	Town / log yard
W12 (i)	26/11/04	N 4º 36.801' E 117º 22.814	Sg. Mukandut	Fine	10 m	0.1 – 0.3 m	Plantation
W13 (i)	26/11/04	N 4º40.617' E 117º18.770	Sg. Tiagau	Fine	2 – 3 m	0.1 – 0.5 m	Forest / logging
W14 (i)	26/11/04	N 4º36.412z E 117º 27.336	Sg. Mawing	Rain	5 m	0.1 – 0.5 m	Plantation
W15 (i)	26/11/04	N 4º 31.060 E 117º 34.585	Sg. Brantian	Cloudy	5 – 8 m	3 – 4 m	Plantation

Table B1.8: Results of Laboratory Analysis of Water (November 2004)

	W1 (i) Sg. Kuamut	W1 (ii) Sg. Kuamut	W1 (iii) Sg. Kuamut	W2 (i) Sg. Imbak	W2 (ii) Sg. Imbak	W3 (i) Sg. Geminchau	W4 (i) Sg. Ulu Brantian	W5 (i) Sg. Brantian	W6 (i) Sg. Bang	**NWQS (Class IIB)**
Temperature, ^{o}C *(in-situ)*	27.5	27.1	27.2	28.2	27.2	24.6	25.1	28.8	27.8	Normal ± 2
pH Value *(in-situ)*	6.5	6.6	6.8	7.4	7.0	7.5	7.7	7.9	7.0	6.0 - 9.0
Dissolved Oxygen, mg/l *(in-situ)*	6.7	3.8	3.8	4.9	3.0	5.0	5.3	4.3	4.1	5 - 7
Conductivity @ 25^{o}C, µmhos/cm	56	56	52	128	118	94	91	122	74	-
Salinity, g/kg	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	-
BOD_5, mg/l	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	3
Chemical Oxygen Demand, mg/l	15.2	17.1	19.0	7.6	30.5	11.4	22.9	17.1	40.0	25
Oil & Grease, mg/l	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	N
Colour, Hazen Unit	100	90	100	90	100	80	160	140	400	-
Turbidity (NTU)	75	75	80	100	400	55	210	200	800	50
Total Suspended Solids, mg/l	42.0	38.8	43.8	48.8	512	25.0	56.3	42.4	358	50
Total Dissolved Solids, mg/l	55.3	67.5	82.0	123	119	108	149	190	288	-
Ammoniacal-Nitrogen (as N), mg/l	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.3	0.3
Nitrate Nitrogen (as N), mg/l	0.17	0.18	0.16	0.29	0.30	0.13	0.18	0.14	0.66	-
Potassium (as K), mg/l	1.63	1.58	1.60	3.22	4.32	2.86	3.85	4.32	10.8	200
Total Coliform Count MPN/100 mL, 37±1°C/48 h	3.0×10^{2}	1.1×10^{2}	2.8×10^{3}	1.7×10^{2}	5.0×10^{3}	3.0×10^{3}	3.0×10^{3}	3.0×10^{3}	1.6×10^{4}	5000
Fecal Coliform Count MPN/100 mL, 44.5±0.2°C/24 h	14	30	30	1.4×10^{2}	90	3.0×10^{2}	2.8×10^{3}	8.0×10^{2}	1.7×10^{3}	400

Organo-chlorinated Pesticides										
Aldrin, mg/l	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003	
Dieldrin, mg/l	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003	
Chlordane, mg/l	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	
DDT, mg/l	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
Heptachlor, mg/l	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003	
Heptachlor Expoxide, mg/l	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003	
Lindane, mg/l	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
Methoxychlor, mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	
Hexachlorobenzene, mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	
Organophosphorated Pesticides										
Methamidaphos, mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	
Herbicides										
Paraquat, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	
Glyphosate, mg/l	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	
Aminomethylphosphonic Acid, mg/l	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	

Note: N - Free from visible film, sheen, discolouration and deposits

(A)	Water collected at the surface
(B)	Water collected at >0.5m
(C)	Water collected >1.0m
	Grey denotes values exceed the Class IIB requirements or limits.

Table B1.8: Results of Laboratory Analysis of Water (November 2004) (cont'd)

	W7 (i) Sg. Anjeranjermut	W7 (ii) Sg. Anjeranjermut	W8 (i) Sg. Anjeranjermut	W9 (i) Sg. Kalabakan	W9 (ii) Sg. Kalabakan	W10 (i) Sg. Kalabakan	W11 (i) Sg. Kalabakan	W11 (ii) Sg. Kalabakan	W11 (iii) Sg. Kalabakan	**NWQS (Class IIB)**
Temperature, ^{o}C (in-situ)	28.0	28.9	29.0	29.3	28.9	29.1	27.8	27.1	26.6	Normal ± 2
pH Value (in-situ)	6.5	6.3	6.5	7.4	7.9	7.5	7.1	7.9	8.0	6.0 - 9.0
Dissolved Oxygen, mg/l (in-situ)	4.7	5.1	4.3	5.1	5.1	4.9	4.7	4.7	4.2	5 - 7
Conductivity @ 25^{o}C, μmhos/cm	74	74	76	68	70	83	80	73	72	-
Salinity, g/kg	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	-
BOD_5, mg/l	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	3
Chemical Oxygen Demand, mg/l	11.4	15.2	7.6	11.4	11.4	22.8	13.3	15.2	32.4	25
Oil & Grease, mg/l	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	N
Colour, Hazen Unit	60	50	70	200	200	160	200	160	60	-
Turbidity (NTU)	16	15	45	270	250	200	260	260	280	50
Total Suspended Solids, mg/l	6.2	5.0	17.5	81.3	62.5	67.5	180	146	189	50
Total Dissolved Solids, mg/l	100	76.3	92.5	210	180	200	162	133	245	-
Ammoniacal-Nitrogen (as N), mg/l	<0.2	<0.2	<0.2	<0.2	0.2	<0.2	0.2	0.2	<0.2	0.3
Nitrate Nitrogen (as N), mg/l	0.14	0.10	0.16	0.27	0.29	0.51	0.59	0.57	0.58	-
Potassium (as K), mg/l	1.77	1.73	2.15	4.22	4.25	3.92	4.29	4.26	4.26	200
Total Coliform Count MPN/100 mL, 37±1°C/48 h	5.0×10^3	1.7×10^3	8.0×10^2	5.0×10^3	5.0×10^3	$\geq 1.6 \times 10^4$	2.4×10^3	$\geq 1.6 \times 10^4$	3.0×10^3	5000
Fecal Coliform Count MPN/100 mL, 44.5±0.2°C/24 h	5.0×10^2	50	36	1.4×10^2	3.0×10^2	80	2.8×10^2	$\geq 1.6 \times 10^4$	2.3×10^2	400

Organochlorinated Pesticides										
Aldrin, mg/l	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003	
Dieldrin, mg/l	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003	
Chlordane, mg/l	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	
DDT, mg/l	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
Heptachlor, mg/l	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003	
Heptachlor Expoxide, mg/l	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003	
Lindane, mg/l	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
Methoxychlor, mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	
Hexachlorobenzene, mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	
Organophosphorated Pesticides										
Methamidaphos, mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	
Herbicides										
Paraquat, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	
Glyphosate, mg/l	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	
Aminomethylphosphonic Acid mg/l	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	

Note: N - Free from visible film, sheen, discolouration and deposits

(A)	Water collected at the surface
(B)	Water collected at >0.5m
(C)	Water collected >1.0m
	Grey denotes values exceed the Class IIB requirements or limits.

Table B1.8 Results of Laboratory Analysis of Water (November 2004) (cont'd)

	W12 (i) Sg. Mukandut	W13 (i) Sg. Tiagau	W14 (i) Sg. Mawing	W15 9i) Sg. Brantian	**NWQS (Class IIB)**
Temperature, °C *(in-situ)*	30.1	30.3	26.4	27.8	Normal ± 2
pH Value *(in-situ)*	8.9	7.3	6.5	7.3	6.0 – 9.0
Dissolved Oxygen, mg/l *(in-situ)*	3.9	4.5	5.1	5.9	5 – 7
Conductivity @ 25°C, µmhos/cm	92	144	147	108	-
Salinity, g/kg	<4.0	<4.0	<4.0	<4.0	-
BOD_5, mg/l	<2.0	<2.0	<2.0	<2.0	3
Chemical Oxygen Demand, mg/l	20.9	5.7	13.3	11.4	25
Oil & Grease, mg/l	<1.5	<1.5	<1.5	<1.5	N
Colour, Hazen Unit	200	80	120	180	-
Turbidity (NTU)	150	110	130	220	50
Total Suspended Solids, mg/l	27.5	37.0	49.4	130	50
Total Dissolved Solids, mg/l	170	143	247	88.8	-
Ammoniacal-Nitrogen (as N), mg/l	<0.2	<0.2	<0.2	<0.2	0.3
Nitrate Nitrogen (as N), mg/l	0.50	0.23	0.98	0.45	-
Potassium (as K), mg/l	4.85	3.50	4.57	4.90	200
Total Coliform Count MPN/100 mL, 37±1°C/48 h	2.4×10^3	1.6×10^4	1.6×10^4	2.8×10^3	5000
Fecal Coliform Count MPN/100 mL, 44.5±0.2°C/24 h	3.0×10^2	2.2×10^2	5.0×10^3	2.2×10^3	400

Organochlorinated Pesticides					
Aldrin, mg/l	<0.00003	<0.00003	<0.00003	<0.00003	
Dieldrin, mg/l	<0.00003	<0.00003	<0.00003	<0.00003	
Chlordane, mg/l	<0.0002	<0.0002	<0.0002	<0.0002	
DDT, mg/l	<0.0001	<0.0001	<0.0001	<0.0001	
Heptachlor, mg/l	<0.00003	<0.00003	<0.00003	<0.00003	
Heptachlor Expoxide, mg/l	<0.00003	<0.00003	<0.00003	<0.00003	
Lindane, mg/l	<0.0001	<0.0001	<0.0001	<0.0001	
Methoxychlor, mg/l	<0.001	<0.001	<0.001	<0.001	
Hexachlorobenzene, mg/l	<0.001	<0.001	<0.001	<0.001	
Organophosphorated Pesticides					
Methamidaphos, mg/l	<0.001	<0.001	<0.001	<0.001	
Herbicides					
Paraquat, mg/l	<0.01	<0.01	<0.01	<0.01	
Glyphosate, mg/l	<0.02	<0.02	<0.02	<0.02	
Aminomethylphosphonic Acid, mg/l	<0.02	<0.02	<0.02	<0.02	

Note: N - Free from visible film, sheen, discolouration and deposits

(A) Water collected at the surface

(B) Water collected at >0.5m

(C) Water collected >1.0m

Grey denotes values exceed the Class IIB requirements or limits.

B1.2.4 Hydrology Analysis

B1.2.4.1 Method of Approach

For this study, we have used the U.S soil conservation service method (USDA, 1972) to estimate direct runoff from storm rainfall. The direct runoff was then routed through for the catchments (**Figure 3.8.2**) and a flood hydrograph was obtained at the point of interest considering the channel storage effect. The computer programme RORB (Lawrenson E.M and RG Mein, 1985) was used for this purpose.

B1.2.4.2 SCS Method

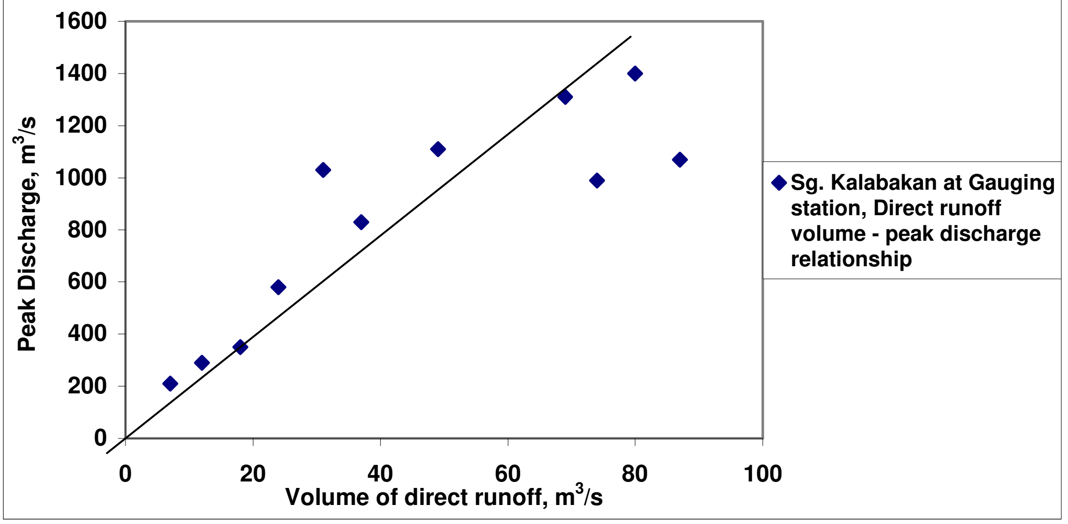
The Soil Conservation Service (Chemsain Konsultant Sdn Bhd, 2002) developed a method for computing abstractions from storm rainfall. For the storm as a whole, the depth of excess rainfall or direct runoff **Q** is always less than or equal to the depth of rainfall **P**. By study of the results from many small experimental basins, an empirical relation was developed.

$$\mathbf{Q} = \frac{(\mathbf{P} - 0.25)^2}{\mathbf{P} + 0.8\mathbf{S}}$$

Where **S** = Potential maximum retention

Plotting the data for **P** and **Q** for many catchments, the SCS found curves of the type of **Figure B1.2.5**. To standardize these curves, a dimensionless curve number CN is defined so that 0 ≤ CN ≤ 100. For impervious and water surface, CN = 100 ; for natural surface CN ≤ 100.

Figure B1.2.5 : Sg. Kalabakan at Gauging station, Direct runoff volume - peak discharge relationship

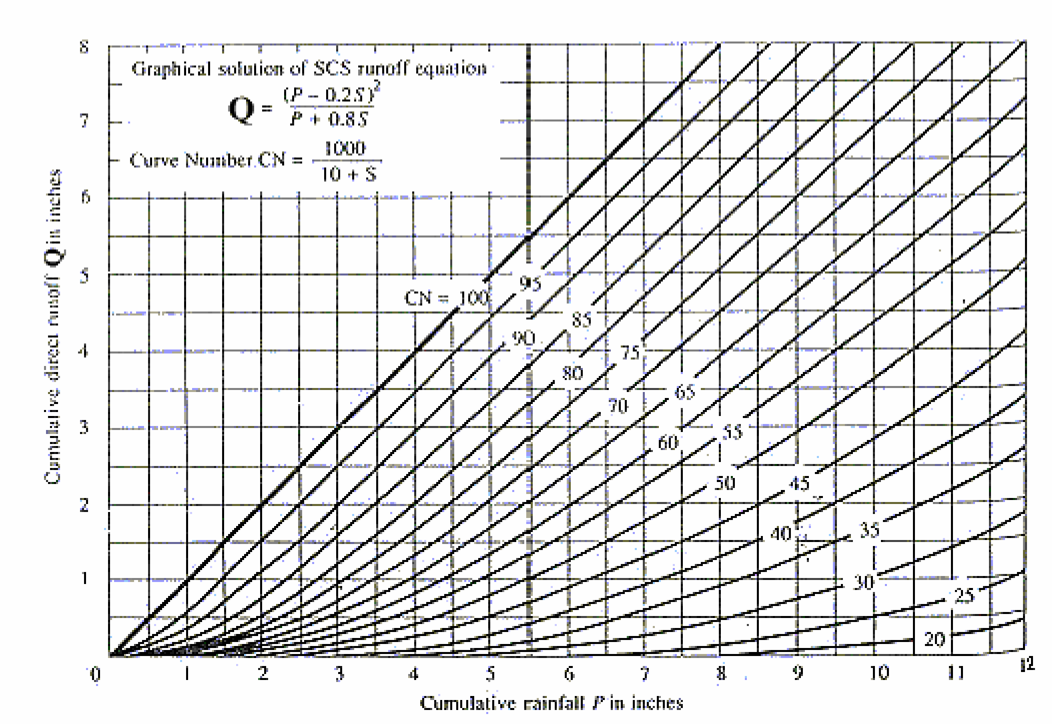


The curve number and S are related by

$$S = \frac{1000}{CN} - 10$$

where S is in inches. The curve numbers shown in **Figure B1.2.6** apply for normal antecedent moisture condition (AMC II) (average condition).

Figure B1.2.6: Solution for the SCS runoff-equations



Curve numbers have been tabulated by the Soil Conservation Service on the basis of soil type and land use. Four soil groups are defined :

Group A (Low runoff potential), soils having high infiltration rate even when thoroughly wetted and consisting chiefly of deep, well to excessively drained sands or gravels. These soils have a high rate of water transmission.

Group B : Soils having moderate infiltration rate when thoroughly wetted and consisting chiefly of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission.

Group C : Soils having slow infiltration rates when thoroughly wetted and consisting chiefly of soils with a layer that impedes downward movement of water, or soils with moderately fine to fine texture. These soils have a slow rate of water transmission.

Group D : (High runoff potential) Soils having very slow infiltration rates when thoroughly wetted and consisting chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a clay-pan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very slow rate of water transmission. The values of CN (curve number) for various land uses on these soil types are given in SCS (Innoprise Corporation Sdn Bhd, 2001) and Chow et, al, (Chow V.T et. al., 1988). **Table B1.9** shows the value taken from Chow *et al*.

Table B1.9: Runoff Curve Number For Selected Agricultural Land Uses (AMC II Conditions)

Land Use	Hydrologic Soil Group			
	A	B	C	D
Fallow[1]	77	86	91	94
Cultivated Land[2] :				
Without conservation treatment	72	81	88	91
With conservation treatment	62	71	78	81
Pasture or Rangeland :				
Poor condition	68	79	86	89
Fair condition	49	69	79	84
Good condition	39	61	74	80
Meadow : Good Condition	30	58	71	78
Wood or Forest Land :	45	66	77	83
Thin stand poor cover				
Fair	36	60	73	75
[3] Good cover	25	55	70	77

1 Bare soil
2 Row crops
3 Good cover is protected from grazing and litter and brush cover soil.

B1.2.4.3 SCS Method and Sg. Tekam data

Storm rainfall and runoff data were analysed for the Sg. Tekam catchments for 24 selected runoff hydrographs (DID, 1989). Runoff coefficients were also calculated for calibration, transition and evaluation period. The dominant soil types of Sg. Tekam are Munchong Series, Segamat Series and Katong Series. The characteristics of these soils are :

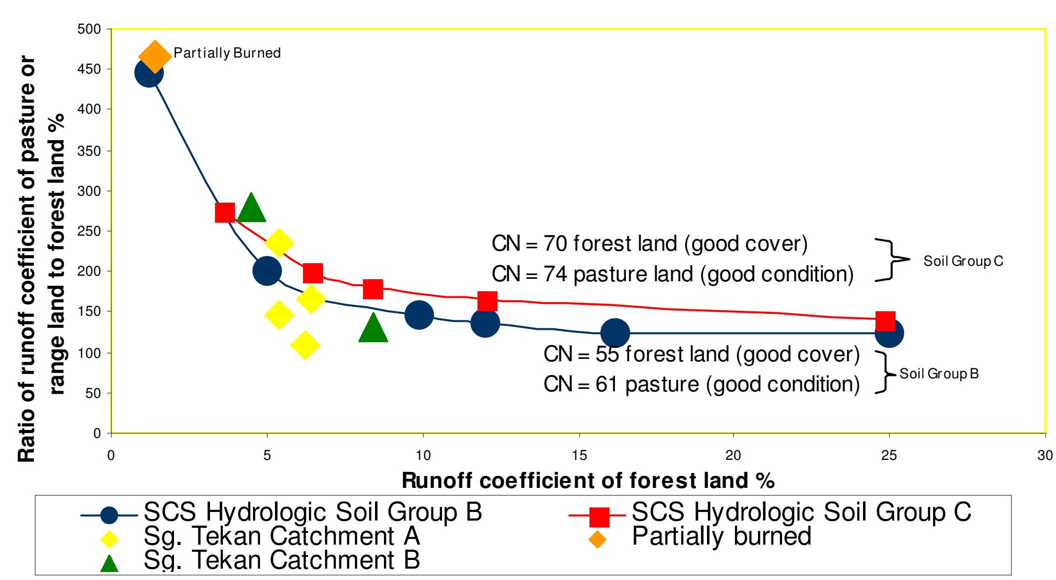
- Munchong Series
  - Moderately fine textures, well drained
- Katong Series
  - Moderately fine textures, well drained
- Segamat Series
  - High infiltration rate and excessively drained. Clay particle are aggregated to form pseudo-silts and pseudo-sands making the soil more porous even though it is clayey in texture.

Type B hydrologic soil group is adopted for catchment A and sub-catchment B of the Sg. Tekam experimental basins.

The rainfall and direct runoff data collected for catchment A and B occurred mainly in the period where logging and felling were carried our before burning of logs and the period after the full establishment of cover crops and secondary vegetation after the burning of logs. Land use for the transition period was taken as pasture in rangeland (grassland) with good condition. The ratio of runoff coefficient of pasture to runoff coefficient of forestland of Sg. Tekam catchments were plotted against runoff coefficient of forestland as shown in **Figure**

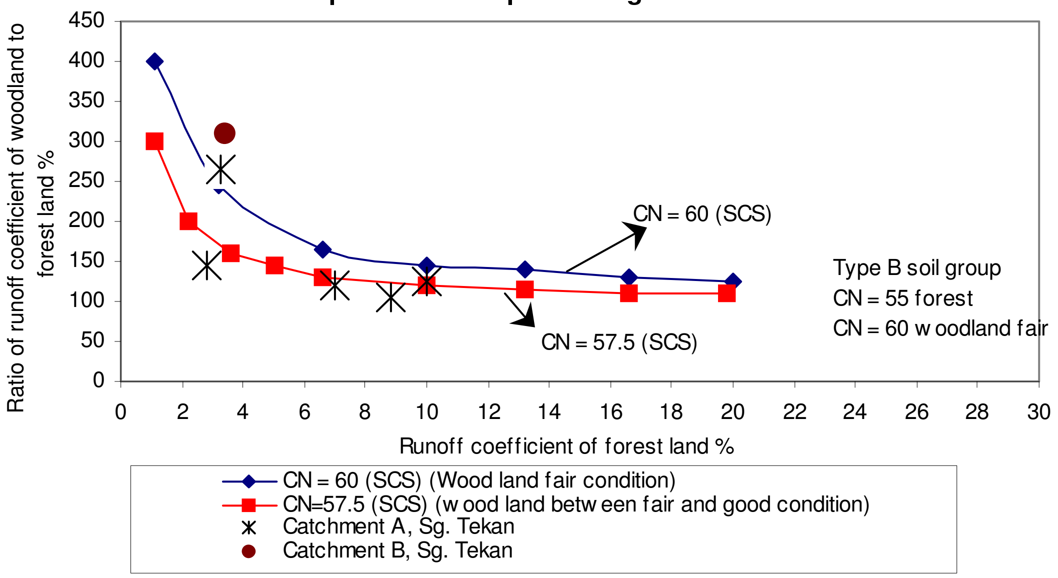
B1.2.7. The curves for Type B and Type C soils groups were also plotted in the same graph. It can be seen from the graph that Type B soil group fits the data of Sg. Tekam better than the Type C soil.

Figure B1.2.7 - Increase in runoff coefficient for different land use



Hydrographs and direct runoff, runoff coefficient data are also available when catchment A and B were planted with shading trees and cocoa and oil palm and the trees were fully established. A plot of the runoff coefficient for the tree crops and forestland is shown in **Figure B1.2.8**. The curve with Type B soil group and a curve number between good and fair cover for woodland fits the data of Sg. Tekam better than that with woodland with fair condition. No data are available for the period when the logs were burnt and the soil left bare to establish the runoff coefficient for bare soil as compared to the SCS runoff curve number.

Figure B1.2.8 - Increase in runoff coefficient with forest and oil palm/ tree crops from Sg. Tekan



B1.2.4.4 The Runoff Routing Model

The RORB (runoff routing model) (Lawrenson E.M and RG Mein, 1985) is an interactive runoff and streamflow routing that calculates catchment losses and streamflow hydrographs resulting from rainfall events and or other forms of inflow to channel networks. It is used for:

- Flood estimation
- Spillway and retarding basin design and
- Flood routing

In flood estimation applications, the programme may be used on rural, urban or partly rural and partly urban catchments. It is mostly used for design flood investigations.

The programme provides event type modelling procedure. Rainfall is operated on by a loss model to produce rainfall excess. Rainfall and loss are processes that occur on the catchment surface before the water enters the channel network. The rainfall excess is operated by a catchment storage model, representing the effects of overland flow storage and channel storage to produce the runoff hydrograph.

The programme, available in PC and mainframe versions, is intended to be usable on any catchments or stream network. The model is already distributed, non linear, and based upon a storage routing procedure.

In typical flood estimation applications, the catchment is divided into subareas bounded by drainage divider. Rainfall on each subarea is adjusted to allow for infiltration and other losses. A subarea rainfall-excess is assumed to enter the channel network at a point near the centroid of the subarea. There, it is added to any existing flow in channel, and the combined flow is routed through a storage by a linear or non-linear storage routing procedure based on continuing and a storage function.

S = KQM

Where S = storage in m^3

Q = outflow discharge m^3/s

M = dimensionless exponent

K = dimensional empirical coefficient

The exponent m is a parameter to be fitted in FIT run. The coefficient K is formed as the product of two factors :

K = Kc Kr

Where Kc is an empirical coefficient applicable to the entire catchment and stream network and Kr is a dimensionless ratio called the relative delay time, applicable to an individual reach storage.

The overall catchment storage is represented in the model by a network of such storages arranged like the actual channel network. Each model storage represents the actual storage between two nodes of the model. The nodes represent sub-area inflow points, stream confluence, inflow points and other points of interest.

On gauged catchments, FIT runs (runs on data to calibrate or 'fit' the model) would be used first with data for one or more of the available recorded floods to evaluate the model's parameters. On ungauged catchments, normally only DESIGN runs are used. For cases where the peak discharge is known, such as from frequency analysis, FIT runs can be carried out to estimate the model parameters so that the designer discharge can be reproduced. It has been shown by McMahon and Muller (Memahon UM and DK Muller, 1986) that using Kc/dav value of a calibrated catchment, where dav = average travel distance of the catchment, the result can be extrapolated to use in adjacent catchments.

The above assumed that Kc/dav is constant for all catchment having similar storage characteristics.

B1.2.4.5 Hydrologic Soil Group of the Catchments in the Project Area.

Details of soil textures, drainage and depth of soil to rock for the soils associations in the study area are presented in the report "The Soils of Sabah, Classification and Description, Volume 1". From this information, each relevant soil association has been assigned to one hydrological soil group.

The hydrologic soil groups assigned to the soils are presented below :

Soil Association	Hydrologic Soil Group
Labau	C
Brantian	B
Sinarun	C
Kalabakan	C
Mawing	C
Kretam	B
Lokan	B+
Baung	C
Bidu-Bidu	C
Mentapok	C
Malubok	C
Gumpal	C
Crocker	B
Maliau	C
Serundong	C

B+ is soil type between B and C

Figure B1.2.9 shows the distribution of the hydrologic soil group.

B1.2.4.6 Catchment Rainfall

As the time taken for development will not be very long, a return period of 20 years is adjusted for flood estimation. The 20 year average rainfall for Tawau and Kuamut is used for design purposes. The point rainfall for the various durations are as follows :

Duration (Hrs)	1	3	6	9	12	18	24	32	36	48
Rainfall Depth (mm)	99	129	150	162	186	212	234	251	265	283

Actual reduction factors of Hydrological Procedure No. 26 (DID, 1982) were applied to obtain the catchments rainfall for the various catchments.

B1.2.4.7 Flood Estimation

B1.2.4.7.1 Direct Runoff

Knowing the design catchment rainfall and the hydrologic soil group in the catchment, direct runoff of each subarea was estimated using the runoff curve number (CN) based on the land use and soil group.

The runoff curve numbers for the respective land use and soil group are as follows :

Land Use	**Soil Group**	**CN**
Forestland	B	55
Forestland	B+	62.5
Forestland	C	70
Oil Palm / Industrial trees	B	57.5
Oil Palm / Industrial trees	B+	64.5
Oil Palm / Industrial trees	C	71.5
Bare soil	B	86
Bare soil	B+	88.5
Bare soil	C	9.1

AMC II condition is adopted

The CN for woodland between good and fair condition has been used for oil palm. A land use map in the study area is shown in **Figure 3.8.3**.

B1.2.4.7.2 Flood Peak Discharge

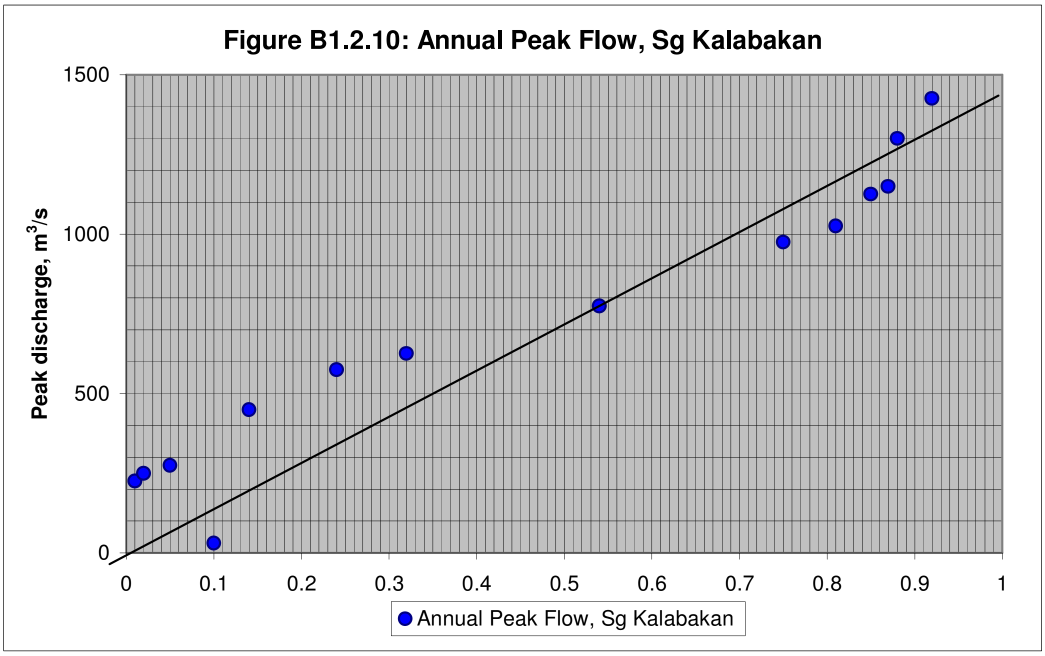
B1.2.4.7.2.1 RORB Subareas

The direct runoff for each catchment was converted into flood peaks at the point of interest using RORB which performed the channel routing.

The Sg. Kalabakan, Sg. Brantian and upper catchments of Sg. Kuamut were subdivided into subareas for RORB modelling as shown in **Figure 4.3.6**.

B1.2.4.7.2.2 Estimation of Kc for RORB

Attempts to establish a regional flood frequency relationship using the gauging records in the region was not achieved. As there is a gauging station at Sg. Kalabakan at Kalabakan, peak flow obtained from frequency analysis results (**Figure B1.2.10**) of Sg. Kalabakan for a 20 year return period was used to estimate the Kc of RORB assuming the M value of 1.1. This M value was used in Peninsular Malaysia and the Sarawak basin for flood estimation. The Kc value obtained for Sg. Kalabakan at gauging station is 4.92. This was achieved using rainfall for various durations near to the time of concentration for the catchment assuming the catchments is in natural condition. The critical duration is 32 hours. Taking the Kc/dav values at adjacent catchments the same as Kalabakan, Kc value of the catchments can be obtained as RORB will compute the dav of individual catchments using subarea areas and reach length.



B1.2.4.7.2.3 Results

The peak discharge obtained from RORB for the catchments in the Project area are presented in **Table 4.3.3**. The peak discharge for bare soil condition increased monthly for some catchments due to the large proportion of project area located in the catchment. Large scale clearance will increase the direct runoff volume. The flood hydrographs of Sg. Kalabakan and Sg. Brantian under various land use condition has already been presented in **Chapter 4, Section 4.3.3.3**.

Hydrological Procedure No. 4 (DID, 1974) "Magnitude and frequency of floods in Peninsular Malaysia" mentions that if a very long record (e.g. 1,000 years) were available it would be expected that the estimates of the value of flood peaks of a particular return period would be quite reliable. In e.g. 10 records were selected from the 1,000 year record, each of length 100 years, and the flood estimates examined for particular return periods for each record, it would be found that they were not all the same. A larger variation would be expected if 50 records each 20 year length were examined. By assuming an extreme value distribution for the long time record of flood peaks, it is possible to estimate the likely range of discharge estimates for a particular return period that might be obtained for looking at say the 50 x 20 year records. By using the data presented (DID, 1974) in the table below, it is possible to estimate a range of discharge values for a particular return period, such that two – thirds of all the flood peak estimates would be expected to fall within this range:

Data used to estimate the standard error of estimated discharge is presented in **Table B1.10** below:

Table B1.10: Standard Error of Estimated Discharge

	Return period in years					
	2	**5**	**10**	**20**	**13**	**50**
Standard error of estimated discharge	0.54R √n	0.86R √n	1.23R √n	1.73R √n	0.43R	0.43R

Where R = Q20 – Q2

Q20 = Peak discharge with 20 year return period

Q2 = Peak discharge with 2 year return period

n = record length in years

Using the method of Hydrological Procedure A, the estimated 20 year flood peak for Sg. Kalabakan at gauging station is 1,583 m^3/s and the standard error of the estimated discharge is 382 m3/s. This means that for a record length of 18 years, two thirds of the 20 years peak discharge estimates made from data samples of length 18 years would lie in the range 1,583 ± 320, i.e. from 1,202 to 1,965 m^3/s.

Since the true value of the estimated discharge can reasonably be expected to lie within the range of ± 24% of the estimated value for Sg. Kalabakan at gauging station, it is considered appropriate to say that the change in flood magnitude is not significant if it lies within the range. Land use changes such as forest clearance and planting of oil palm will increase the volume of runoff and consequently the peak discharge. As there are no other criteria to assess the significance of these flood discharges as compared to floods of the same catchment under natural condition, it is assumed that if the peak discharge for the catchment estimated with land use changes is more than 24% higher that the peak discharge of the catchment under natural condition, the change in flood discharge is significant. This has been discussed in **Chapter 4, Section 4.3.3.3**.

B1.2.4.8 Impact on Flood Levels

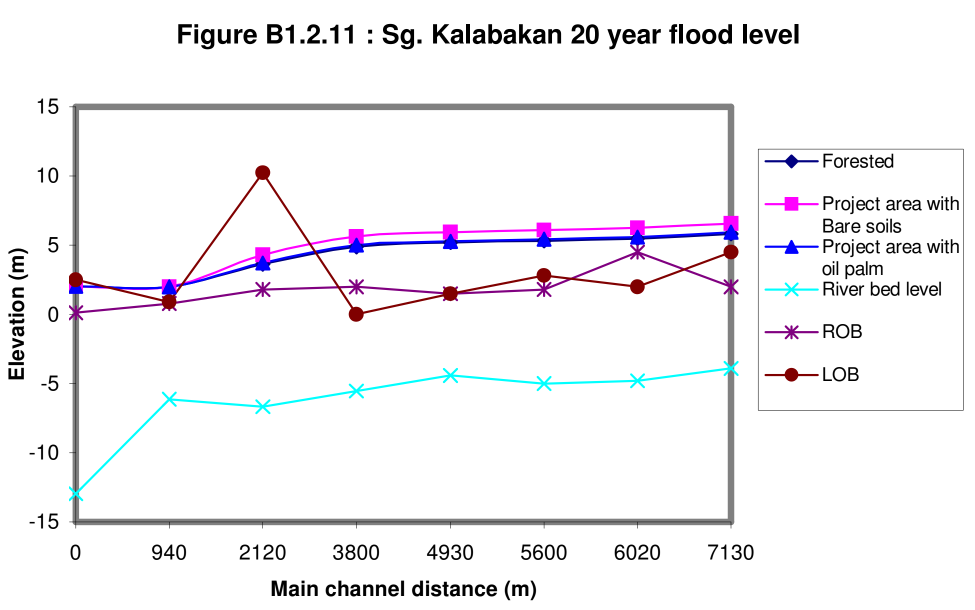
Increase in peak discharge will affect the flood level along the river when heavy rain occurs. Rating curve of Sg. Kalabakan is available from DID and river cross-sections are available at the downstream reach of Sg. Kalabakan and Sg. Brantian. The surveys cross-section ended at about 17 km from the river mouth for Sg. Kalabakan and 7 km for Sg. Brantian. The highest tide level is 2.03 m LSD for Sg. Kalabakan and 2.40 m LSD for Sg. Brantian.

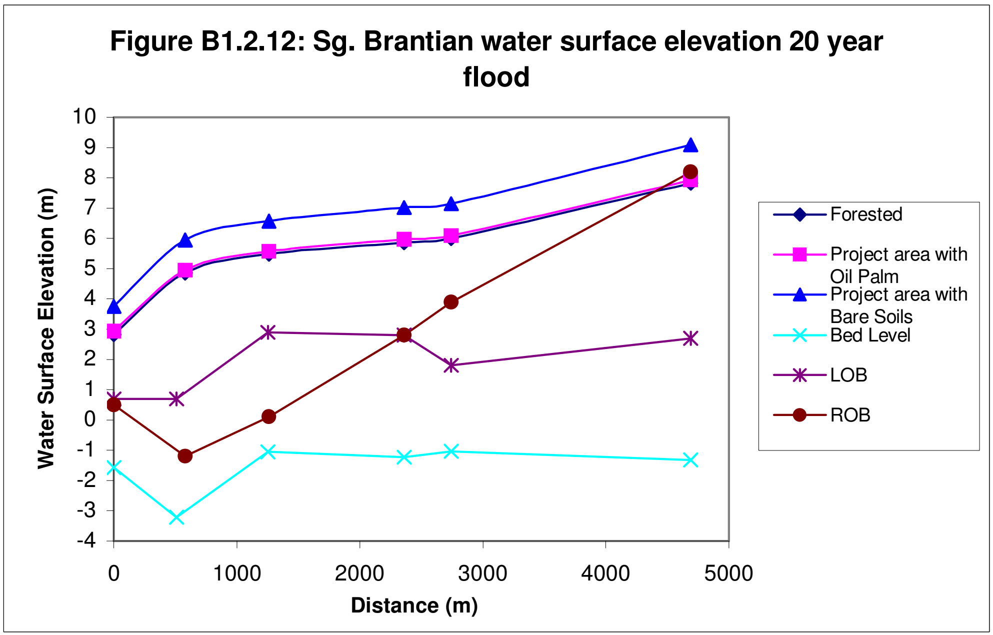
Using the DID rating curve and the peak discharge obtained from the computer model, the 20 year flood levels of Sg. Kalabakan at gauging station are 11.2, 12.1 and 11.3 m (chart datum) for forested, project area in bare soil condition, and projected planted with oil palm. The increases for the flood levels are 0.9m and 0.1m for the respective change in land use for the project area.

The HEC-2 water surface profile programme is used to estimate the flood level using the peak discharge obtained from RORB and the recorded maximum tide level as boundaries conditions.

Results are shown in **Figures B1.2.11** and **B1.2.12**. For Kalabakan, the flood level will increase 0.79m for project area changing from forested to bare soil condition. The increase in flood level for the case when land use is changed from forest to oil palm is 0.11 m. As for the Brantian catchment, maximum increase in flood level is 1.27 m for the Project area changing from forested to completely cleared and under bare soil condition, and 0.11 m when the land use is changed to oil palm. There is a higher increase in flood level for Sg. Brantian because the project area in the Brantian catchment occupied almost the whole catchment.

The increase in peak discharge for Sg Kalabakan and Sg Brantian are 22% and 53% respectively for bare soil condition, compared to natural condition, which is significant. This is shown also from the flood level obtained from modelling. However, the increase in peak discharge and flood level when the Project area is planted with oil palm is not significant. The increase in flood peak discharge are only 3% and 4% for Kalabakan and Brantian.





B1.2.4.9 Phase Development

It has been proposed to develop the project area with different phases from 2005 to 2010. A development plan is shown in **Figure 3.5.1**. For the phase development, the forest will be cleared and oil palm trees will be planted and established in that particular phase.

B1.2.4.9.1 Flood discharge for phase development.

The runoff volumes were estimated for areas of the phases completely cleared, with palm oil trees planted and well established. Using the SCS curve numbers and rainfall-runoff relationships presented in section 5.2 RORB was used to route the runoff through the channel network to obtain the peak discharges. Results and the significance of change in flood discharges are presented in **Tables B1.11** to **B1.16**. **Figures B1.2.13** and **B1.2.14** show the design flood hydrograph for Kalabakan and Sg. Brantian for various phases. For Sg. Kalabakan , Sg. Brantian and Kuamut K1, the significance of flood discharge increase has been greatly reduced due to the reduction of Project area cleared during phase development.

Table B1.11: 1 in 20 year peak discharge (direct runoff), Sg. Kalabakan near Kg. Kalabakan, phase development

Phase	Year of development	Peak discharges m^3/s	Critical storm duration	Progress of development	Significance of flood discharge
1	2006	1,617	32	Phase 1 area cleared	Peak 2% higher than peak of catchment in natural condition, not significant.
2	2007	1,623	32	Phase 2 area cleared Phase 1 with oil palm	Peak 3% higher than peak of catchment in natural condition, flood peak not significant.
3	2008	1,640	32	Phase 3 area cleared Phase 1,2 with oil palm	Peak 4% higher than peak of catchment in natural condition, flood peak not significant.
4	2009	1,641	36	Phase 4 area cleared Phase 1, 2, 3 with oil palm	Peak 4% higher than peak of catchment in natural condition, flood peak not significant.
5	2010	1,649	32	Phase 5 area cleared Phase 1 to 4 with oil palm	Peak 4% higher than peak of catchment in natural condition, flood peak not significant.

Note : Peak discharge for catchment under natural condition is 1580 m^3/s.

Table B1.12: 1 in 20 year peak discharge (direct runoff), Sg. Brantian near Kg. Brantian, phase development

Phase	Year of development	Peak discharges m^3/s	Critical storm duration	Progress of development	Significance of flood discharge
1	2005	1,004	12	Phase 1 area cleared	Peak 15% higher than peak of catchment in natural condition, not significant.
2	2006	914	12	Phase 2 cleared Phase 1 with oil palm	Peak 5% higher than peak of catchment in natural condition, not significant.
3	2007	1,071	12	Phase 3 cleared Phase 1,2 with oil palm	Peak 23% higher than peak of catchment in natural condition, not significant.
4	2008	1,012	12	Phase 4 cleared Phase 1 to 3 with oil palm	Peak 16% higher than peak of catchment in natural condition, not significant.
5	2009	1,015	12	Phase 5 cleared Phase 1 to 4 with oil palm	Peak 16% higher than peak of catchment in natural condition, not significant.
6	2010	909	12	Phase 6 cleared Phase 1 to 5 with oil palm	Peak 13% higher than peak of catchment in natural condition, not significant.

Note : Peak discharge for catchment in natural condition : 873 m^3/s.

Table B1.13: 1 in 20 year peak discharge (direct runoff), Sg. Kuamut catchment K1, Phase development

Phase	Year of development	Peak discharges m^3/s	Critical storm duration	Progress of development	Significance of flood discharge
1	2005	459	9	Phase 1 area cleared	Peak 22% higher than peak of catchment with natural condition, not significant.
2	2006	486	9	Phase 2 cleared Phase 1 with oil palm	Peak 29% higher than peak of catchment with natural condition, significant.
3	2007	456	9	Phase 3 cleared Phase 1,2 with oil palm	Peak 21% higher than peak of catchment with natural condition, not significant.
4	2008	497	9	Phase 4 cleared Phase 1-3 with oil palm	Peak 32% higher than peak of catchment with natural condition, significant.
5	2009	434	9	Phase 5 cleared Phase 1-4 with oil palm	Peak 15% higher than peak of catchment with natural condition, not significant.

Note : Peak discharge for catchment in natural condition : 873 m^3/s.

xTable B1.14: 1 in 20 year peak discharge (direct runoff) of Sg. Kuamut catchment K2, phase development

Phase	Year of development	Peak discharges m^3/s	Critical storm duration	Progress of development	Significance of flood discharge
1	2008	356	4	Phase 1 cleared	Peak 184% higher than peak under natural condition, significant.

Note : Peak discharge for catchment under natural condition : 125 m^3/s.

Table B1.15: 1 in 20 year peak discharge (direct runoff) of Sg. Kuamut catchment K3, phase development

Phase	Year of development	Critical storm duration hrs	Progress of development	Significance of flood discharge
1	2009	1	126	Peak 19% higher than peak flow of catchment under natural condition, not significant
2	2010	1	221	Peak 108% higher than peak flow of catchment under natural condition, significant

Note : Peak discharge for catchment under natural condition : 106 m^3/s.

Table B1.16: 1 in 20 year peak discharge (direct runoff) of Sg. Kuamut catchment K4, phase development

Phase	Year of development	Peak discharges m^3/s	Critical storm duration	Progress of development	Significance of flood discharge
1	2008	372	3	Phase 1 cleared	Peak 19% higher than peak under natural condition, not significant.

Note : Peak discharge under natural catchment condition : 313 m^3/s.

Figure B1.2.13: Sg. Kalabakan in 20 year flood hydrograph (direct runoff) phase development.

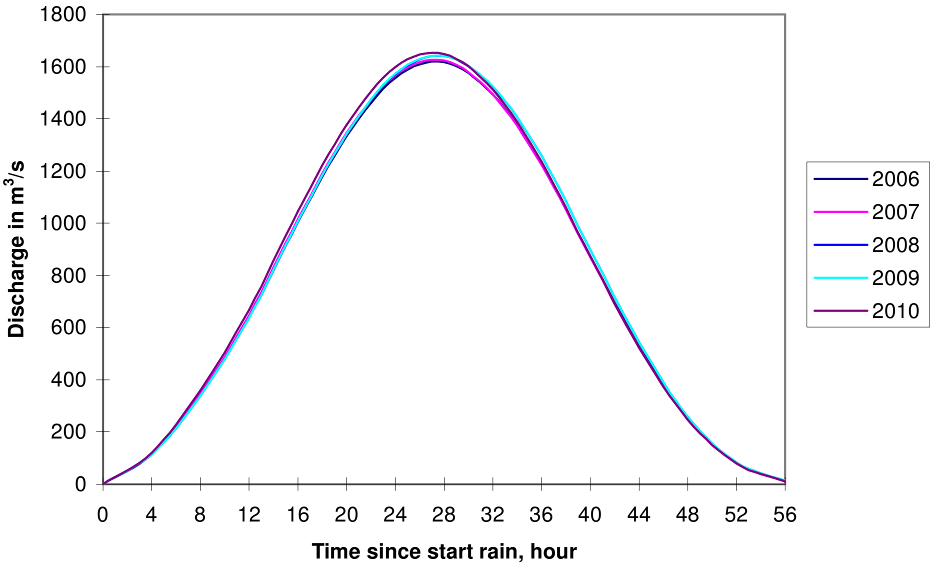
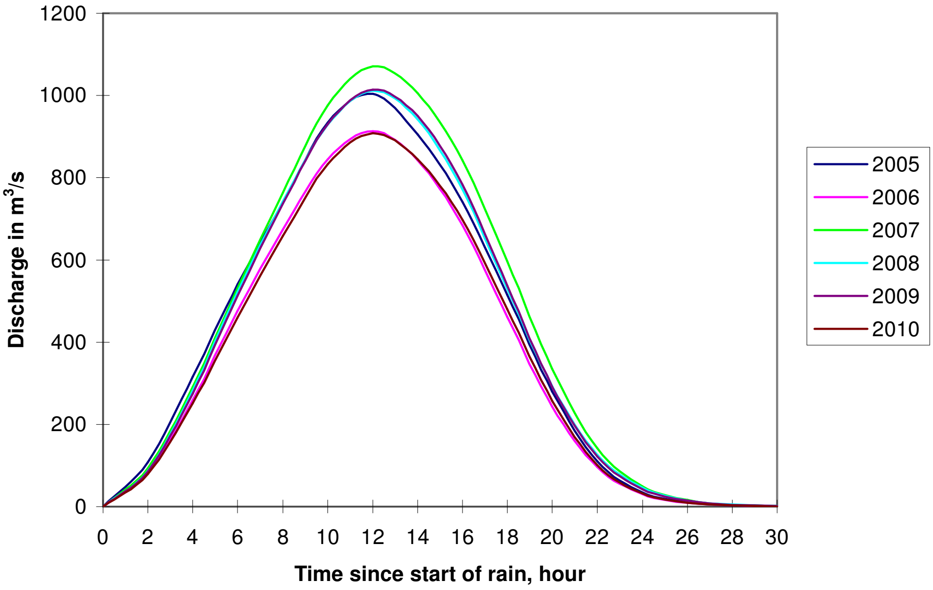


Figure B1.2.14: Sg. Brantian in 20 year.



B1.2.4.9.2 1 in 20 years flood level

HEC 2 was used to estimate the 1 in 20 year flood level for Sg. Kalabakan and Sg. Brantian where survey cross sections are available. No river cross-sections are available for Sg. Kuamut. Results are shown in **Figures B1.2.15** and **B1.2.16**.

Figure B1.2.15: Sg. Kalabakan 20 year flood level phase development

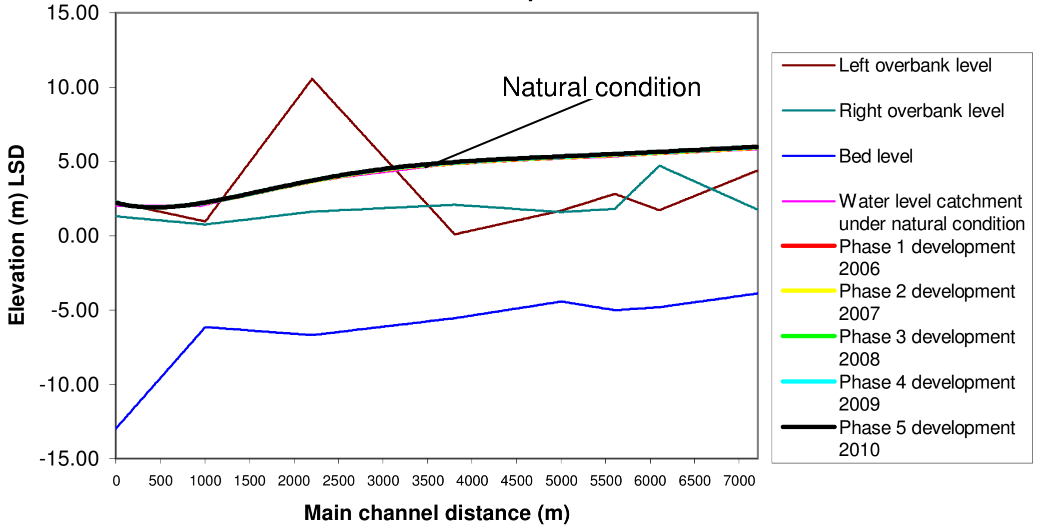
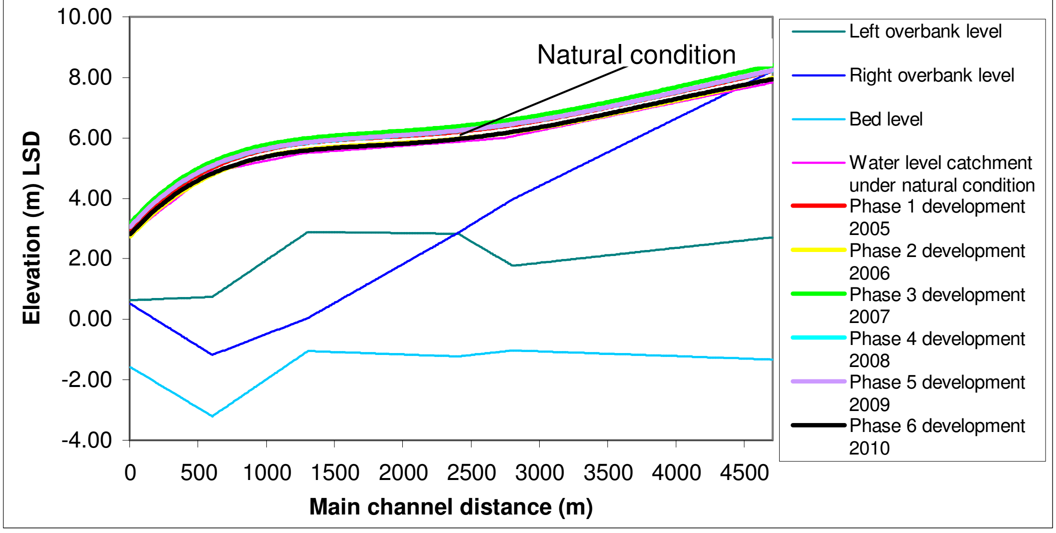


Figure B1.2.16: Sg. Brantian 20 year flood level phase development



Tables B1.17 and **B1.18** summarised the difference in flood levels for phase development and catchments in natural conditions for Sg. Kalabakan and Sg. Brantian. The maximum differences in water level have been reduced as compared to cases where the project area is completely cleared.

Table B1.17: Sg. Kalabakan, maximum difference in flood level for phase development and catchment in natural condition

Phase	Year of development	Maximum difference in flood level for phase development and catchment in natural condition, m
1	2006	0.08
2	2007	0.10
3	2008	0.13
4	2009	0.13
5	2010	0.15

Table B1.18: Sg. Brantian, maximum difference in flood level for phase development and catchment in natural condition

Phase	Year of development	Maximum difference in flood level for phase development and catchment in natural condition, m
1	2005	0.39
2	2006	0.13
3	2007	0.58
4	2008	0.41
5	2009	0.42
6	2010	0.25

B1.2.5 Ambient Air Quality

Since the project site is forested, it is envisaged that air pollution will not be of significance issue. Nevertheless, one sample of Total Suspended Particulates (TSP) level was taken at the nearest settlement to the road expected to be frequently utilized for this proposed Project to gauge the dust levels over 24 hours period. See location in **Figure B1.2.4**. A High Volume Sampler was used for the monitoring.

Table B1.19 shows the location and monitored result.

Table B1.19 Result of the Total Suspended Particulate Monitoring (24 hours)

Point	Date	Region, Location and GPS Coordinates	Weather Condition	TSP ($\mu g/m^3$)	Recommended Malaysian Air Quality Guidelines ($\mu g/m^3$)
A1	24th – 25th Nov 2004	Luasong Forestry Centre (Entrance) N4° 35'24" E117° 22' 10"	Fine during day and drizzle at night	50.2	260

From the results, the TSP levels in these areas are within the Recommended Malaysian Air Quality Guidelines value of 260 $\mu g/m^3$. The Laboratory result of the Total Suspended Particulates is attached at the end of **Annex B1.7**.

B1.2.6 Noise Pollution

As mentioned above, the site is forested and hence noise pollution would not be significant. Nevertheless, noise monitoring was carried out at the same location at the Luasong Forestry Centre (Entrance). This location is selected as general representative of settlement areas closest to the road frequently traveled by vehicles.

Both day and night measurements were taken at this location (see **Figure B1.2.4)** using docimeter. The noise is measures for an hour taking the high, low and average intensities. Based on sites observation, most of the noise is from the on-going logging activities which contributed vehicular movement and minotiry of it is from the natural environment, e.g. birds twittering and whistling, insect bustling and wind blowing.

Table B1.20 : Result of the Noise Monitoring (24 hours)

Point	Date	Region, Location and GPS Coordinates	Noise (day) dB(A)	WHO Std	Noise (Night) dB(A)	WHO Std
N1	25th Nov 2004	Luasong Forestry Centre (Entrance) N4° 35'24" E117° 22' 10"	65.7	55	52.9	45

From the result (refer **Table B1.20**), it is noted that noise levels within the site especially near to the human settlements are above the World Health Organization Standard for Luasong Forestry Centre.

B1.3 BIOLOGICAL ENVIRONMENT

B1.3.1 Wildlife Fauna Ecology

B1.3.1.1 Introduction

When the SEIA for the ITP was conducted in 2001 (SEIA 2002), thorough ground and aerial surveys were conducted. Additional wildlife data was derived from the various research and faunal inventories. See ground and aerial survey routes in **Figures A1.3** and **A1.4**. The impact on wildlife has been studied in depth and documented, including mitigations. Several recommendations have also been outlined. The Project has since been abandoned.

Most of the areas involved in this SEIA are within the SEIA 2002. Thus the SEIA conducted for wildlife in SEIA 2002 is relevant. However, there has been a need to undertake another faunal survey to ascertain the present situation. Instead of acacia, the new crop in this Project is the establishment of about 80,000 ha oil palm plantation. The proposed wildlife corridor linking Maliau Basin to Danum Valley in SEIA 2002, however, is not affected.

B1.3.1.2 Methodology

In line with the requirement of this SEIA 2004 an assessment has been made on the population estimate and impact of wildlife on the Project. The following activities were undertaken:

A ground road survey was conducted on 23rd November 2004 covering the following coupes: BW12/02, BW14/01, BW12/05, BW5/02, BW2/02, BW12/04, BW12/03, BW10/02, BW10/03, BW10/01, BW12/01, BW6/01, BW5/01, BW4/01, BW2/01 and the Kuamut river buffer zone. See **Figure A1.3**.

A ground road survey was conducted on 24th November 2004 covering the following coupes: BW1/98, BW3/01, BW3/98, BW1/01, BW4/98, BW1/99, BW1/00, BW2/99, BW5/98, BW4/00(A), BW4/98, BW5/99, BW3/99, BW5/00, 3/00, BW2/00/I and the Brantian-Tatulit VJR. See **Figure A1.3**.

A ground road survey was conducted on 25th November 2004 covering the following coupes: BW11/01, BW11/02, BW11/00, BW9/01, BW9/03, BW9/02, BW9/99, BW9/00, Mud volcano sites, BW2/00/II, BW10/00 and BW4/00/II. See **Figure A1.3**.

A 1.5-KM transect was made through the Ulu Napagon VJR on 25th November 2004 to check on the presence of wildlife. The transect is located as per GPS readings – N4°

52.581' & E117° 28.471' to N4° 54.441' & E117° 18.591'. See approximate location in **Figure B1.3.1**.

A 1.6 KM transect was made through the Brantian-Tatulit VJR on 26th November 2004 to check on the presence of wildlife. The transect is located as per GPS readings – N4° 38.679' & E117° 32.825' to N4° 37.608' & E117° 33.640'. See approximate location in **Figure B1.3.1**.

An aerial survey was conducted on 28th November 2004 over the proposed project site.

B1.3.1.3 Findings

The road survey on 23rd November 2004 revealed the presence of elephant along the main road from Luasong Forestry Centre to Kuamut river in the north. About a dozen elephant comprising a bull, four females and calves were seen grazing along the Kuamut river. These animals are using the Kuamut river buffer zone. Elephant dung was found in the Ulu Nagapon VJR and BW2/99. According to the workers in BW2/00/II, elephants were roaming this area some months ago, prior to the clearing of the jungle.

During the road survey on 24th November 2004 a male barking deer was seen at BW1/00. An eagle was hovering over her nest perched on a tall tree in B1/00. Elephant dung, a black hornbill and a king cobra were observed along the road in BW2/99. Four orangutan nests about a week old were found along the road in BW5/98, close to the northern part of Brantian-Tatulit VJR. Along the road and Brantian river, a mouse deer hoof prints were seen.

The road survey on 25th November 2004 concentrated on the southern part of the proposed project site. No wildlife of significance was observed. No elephants were reported for many months including at the mud volcano. A wild pig was seen at BW10/00 when the survey moved to the southern coupes of Benta Wawasan I.

The ground survey on 25th November 2004 through the Ulu Nagapon VJR has shown a low fauna density and diversity. Hoof prints of wild pigs, tembadau and sambar deer were the few but common findings. Gibbon calls were heard but no orangutans were detected. Old elephant dung was seen.

The ground survey through the Brantian-Tatulit VJR on 26th November 2004 revealed very low number of animals. Three orangutan nests were seen and some hoof prints of sambar deer and wild pigs. No evidence of tembadau was seen. No proboscis monkeys were observed along the parts of the Brantian river surveyed.

Based on documents from the YS Group and confirmed through site inspection, 68% of the proposed project site is undergoing logging, re-logging or salvaging operation. Another 22% is cleared for acacia plantation, which will be converted into oil palm. Thus, there were very few animals or their evidence encountered in Benta Wawasan I and IIC. The elephants for example are roaming about the Kuamut river buffer zone in the north, Ulu Napagon VJR and the main wildlife corridor linking Maliau Basin to Danum Valley conservation areas. Findings from the previous SEIA 2001 have shown that the elephants use the proposed Project site extensively including the Brantian-Tatulit VJR and Mud Volcano. The orangutan nests were now mostly seen in Brantian-Tatulit VJR and its periphery.

The aerial survey on 28th November 2004 revealed that the forest cover of Brantian-Tatulit VJR and Ulu Nagapon VJR is intact. There is still forest connection between Brantian-Tatulit VJR to the forest beyond BW4/00(A) but logging on the steep ridges is on-going.

Large dirt roads are cutting across this ridge. The Ulu Nagapon VJR has a good forest cover which becomes thinner as it spreads towards Maliau and Kuamut. The proposed major wildlife corridor in SEIA 2001 is still intact although selective logging has occurred sporadically.

Logging camps appeared like a small human settlements. There are children, cats, dogs and chickens in the camps. Some workers are keeping hunting dogs.

Security gates are not properly manned. No registration and search of vehicles were conducted at the gate.

Signboards warning against hunting in the area are placed on the road side but have become hidden by tall grasses.

In summary, the ground surveys indicated very low presence of wildlife in the proposed project site. The only wildlife of significance that is found within the Project site is the orangutans, in BW5/98 but very few nests were noticed. Outside the Project site, they are found in the Brantian-Tatulit VJR. The elephants are reported and observed to confine to the forested areas in the north and western part, and outside the project site. They have not been reported at the mud volcano/ salt lick area in Benta Wawasan IIC.

Some photos showing the findings from the fauna survey are presented in **Figure B1.3.1**.

B1.3.2 Aquatic Ecology

B1.3.2.1 General

An ichthyological survey was conducted along the major tributaries, rivers, estuaries and coastal area that is likely to be affected by the proposed development. See locations in **Figure B1.2.4**.

Observations were targeted at major species which are used as indicators representing each ecological niche. Sampling covered the upper reaches of the rivers in the tributary, the middle portions of the major rivers, estuary zone and the immediate coastal zone. The results of these surveys are tabulated and summarized in **Table B1.21**.

B1.3.2.2 Methodology

The whole area under this study was divided into 3 zones:

a) The upper tributary consisting of streams which are less than one meter in water depth and do not exceed a width of 5 meters.

b) The river which constitute the main water causeway and flow out to the sea of varying depth and width.

c) The estuarine area which consist of areas of the river where the water is saline and is affected by the tidal flows up to the coastal area in the bay.

Various methods were used for surveying the areas:

a) In these shallow streams mainly cast nets were used. At each sampling station 10 - 20 casts were carried out over a length of 100 meters of the stream at 5 - 20 meters intervals. The catch was landed, selected to species, counted, photographed then preserved for gut analysis in the laboratory.

b) Cast nets, gill nets, fish traps and hook and line were all used in these river locations. The cast net was used along the banks where the same 20 cast were carried out. The gill net was stretch across the river at an angle and left for a period of 2 hours periodically being checked for fish. The upper river area for 100 meter was also thrashed with a pole to scare the fish into the gill net. Traps belonging to the local fishing population were raised with their permission and the catches counted. The catches by locals using hook and line in the areas surveyed were also taken into account.

c) Using a trawler, 9 trawls were conducted in the estuarine area. Each trawl was for a period of one hour. The catch was landed, selected, weighted, and counted.

The specifications of the sampling equipments are as follows:

i. Cast nets: Three types of cast nets were used

   a) ¾" mesh size with a spread of 12 feet.

   b) 1" mesh size with a spread of 18 feet.

   c) 2 " mesh size with a spread of 24 feet.

ii. Gill nets: Two types of gillnets were used

   a) 1" mesh size, 7 feet width and 300 feet long.

   b) 2.5" mesh, 12 feet width and 300 feet long.

iii. Local bamboo fish traps were used called "bubu".

B 1.3.2.3 Findings

a) Even as it is now the rivers are unable to support the increasing demand for fish as food. As the human population grows in the area the impact is going to be even worse coupled with the loss of fishing habitats. Mitigation measures should include an awareness program for the workers and families on the importance of certain fishing practices and for maintaining sustainable fishing methods such as using the right nets with proper mesh size, no destructive fishing methods and why in the long run it is counter beneficial.

b) The clearing of the forest should be carried out in such a fashion that it does not completely destroy the recruitment cycle of a river system. One method is to alternate the clearing over a period of say one year between the upper tributaries and the mid river area. This would allow for the recruitment of new fishes into each area yearly and prevent a die off at any one time. Such measure may not be necessary if other mitigation measures to prevent the destruction of existing habitats are strictly enforced.

Table B1.21 The Methodology and Samplings locations of Aquatic Survey during January 2001

Station	Location & Geographical Positioning	Description of the site and Methodology Employed
1	Tributary of Sg.	Upstream, shore vegetation is disturbed dipterocarp forest with both up and downstream recently disturbed (within one

Station	Location & Geographical Positioning	Description of the site and Methodology Employed
	Kuamut (North) 04° 58' 12" N 117° 09' 10" E	year), banks are fairly steep with vines and shrubs. Stream is shallow (max. depth 1 m.) and 5 m. at widest. Bottom is gravel and pebbles with sandy banks at corners, stream is 70 – 90% shaded and water is turbid with silt with gently flowing water. Cast nets of ½ " and 1 inch mesh were used for sampling. Length of sampling 100 meters of the stream with 15 casts.
2	Tributary of Kuamut River (North) 04° 59' 26" N. 117° 15' 21" E	Upstream, shore vegetation is disturbed dipterocarp forest with both up and downstream recently disturbed (within one year), banks are gently sloping on one side but steep on the other with vines and shrubs. Stream is shallow (max. depth 1.5 m.) and 15 m. at widest. Bottom is gravel and pebbles with sandy banks at corners, stream is exposed with little shade and water is slightly turbid with silt with gently flowing water. Cast nets of ½ " and 1 inch mesh were used for sampling. Length of sampling 100 meters of the stream with 15 cast.  Photo A1: Part of the Kuamut River showing good riparian along the banks. Water is slow flowing and turbid
3	Tributary of Kuamut River (North) 04° 55' 13" N. 117° 11' 30" E.	Upstream, shore vegetation is secondary growth dipterocarp forest with both up and downstream recently disturbed (within three year), banks are fairly steep exposed rock faces with vines and ferns. Stream is shallow (max. depth 2 m.) and 8 m. at widest . Bottom is boulders, gravel and pebbles, stream is 30 – 50% shaded and water is turbid with silt with swift flowing water. Boulders are mostly covered with algae. Cast nets of ½ " and 1 inch mesh were used for sampling. Length of sampling 100 meters of the stream with 15 cast.
4	Tributary of Kuamut River (North) 04° 54' 05" N. 117° 18' 23" E.	Mid-stream, shore vegetation, banks are gently sloping into stream with creepers, ferns and small shrubs up to the edge of the stream. Stream is shallow (max. depth 1 m.) and 15 m. at widest . Bottom is boulders, gravel and pebbles with sandy pockets, stream is fully exposed to sunlight and water is turbid with silt with rapids. Cast nets of ½ " and 1 inch mesh were used for sampling. Length of sampling 100 meters of the stream with 15 cast.

Station	Location & Geographical Positioning	Description of the site and Methodology Employed
5	Tributary of Kuamut River (North) 04° 53' 14" N. 117° 16' 04" E	Upstream, shore vegetation creepers, vines, ferns and small shrubs up to the water edge, banks are fairly gently slopes. Stream is shallow (max. depth 1 m.) and 7 m. at widest . Bottom is gravel and pebbles with sandy banks at corners, stream is exposed and water is turbid with silt with swift flowing water. Cast nets of ½ " and 1 inch mesh were used for sampling. Length of sampling 100 meters of the stream with 15 cast.
6	Kuamut River 04° 53' 48" N. 117° 12' 45" E.	Main river at the steel bridge, bank are steep with grass and creepers up to the water edge. River is deep and width estimated at 50 m. Bottom is sandy. Depth not measured. Water was turbid with silt and fairly fast flowing due to recent rainfall. Sampling was by hook and line which was done by the local inhabitants.  Photo 2A: Kuamut River, turbid, fairly fast flowing. Sedimentation seen along the banks.
7	Tributary of Imbak River 04° 50' 48" N. 117° 18' 05" E.	Small stream with severe bank erosion caused by former logging removing all plants right to the river's edge. Shallow stream about 2 meters in width. Water was very turbid and flowing rather sluggishly. Cast nets of ½ " and 1 inch mesh were used for sampling. Length of sampling 100 meters of the stream with 12 cast.
8	Tributary of Imbak River 04° 50' 52" N. 117° 17' 45" E.	Small stream with severe bank erosion caused by former logging removing all plants right to the river's edge. Shallow stream about 2 meters in width. Water was very turbid with a fairly fast flowing stream. Evidence of heavy sedimentation almost covering all the rocks at the river bottom. Cast nets of ½ " and 1 inch mesh were used for sampling. Length of sampling 100 meters of the stream with 13 cast.
9	Stream flowing into Imbak River 04° 51' 52" N. 117° 18' 24" E.	A large stream which flows into the Imbak River, the stream is heavily silted with turbid fairly fast flowing water. The banks have a good riparian reserve near the road area however there are evidence that further up and down stream of the sampling area were exposed river banks. Cast nets of ½ " and 1 inch mesh were used for sampling.

Station	Location & Geographical Positioning	Description of the site and Methodology Employed
		Length of sampling 100 meters of the stream with 15 cast.  PHOTO 2B: Imbak River tributary which has had the riparian vegetation completely removed but now planted with other plants. The river is shallow and all boulders covered with sediments and water is very turbid.
10	Imbak River 04° 48' 33" N. 117° 21' 18" E.	The river had a width of about 20 m. and the water depth was up to 2 meters and had turbid fast flowing water. There were good trees over shading the river offering a good habitat for fishes and other aquatic organisms. Good riparian vegetation was seen as this area of the river was probably left during the logging period a few years ago. Cast nets of ½ " and 1 inch mesh were used for sampling. Length of sampling 100 meters of the stream with 15 cast.
11	Tributary of Brantian River 04° 32' 17" N. 117° 30' 06" E.	Upstream, shore vegetation consist of grass and vines which have grown after clear felling for planting of mono species trees. Banks are fairly steep with vines and shrubs. Stream is shallow (max. depth 1 m.) and 3 m. at widest . Bottom is gravel and pebbles with sandy banks at corners, stream is fully exposed and water is turbid with silt with gently flowing water. Algae covered stones. Cast nets of ½ " and 1 inch mesh were used for sampling. Length of sampling 100 meters of the stream with 15 cast.  Photo 2D: Tributary of Imbak River showing wood derbies in the river and bank erosion. Water is fairly clear and fast flowing.

Station	Location & Geographical Positioning	Description of the site and Methodology Employed
12	Tributary of Brantian River 04° 40' 19" N. 117° 27' 36" E.	River width is about 3 meters with shallow fairly fast following turbid water. The river had a lot of wood debris form fallen trees and branches. Sedimentation was also quite severe. Along the banks was evidence of clearing right up to the edge of the river as planted soft wood was seen along the banks. Cast nets of ½ " and 1 inch mesh were used for sampling. Length of sampling 100 meters of the stream with 12 cast.
13	Stream of Brantian River 04° 38' 49" N. 117° 28' 02" E.	The width of the river was between 4 -6 meters with a water depth of between 0.5 to 1 meter at the center of the stream. The water was fairly turbid and fast flowing. The river bed was rocky with sandy bottom interspaced between the rocks and at bens of the stream. An area with good river cover from overhanging trees. Good catch of fishes in the area. Cast nets of ½ " and 1 inch mesh were used for sampling. Length of sampling 100 meters of the stream with 15 cast.
14	Brantian River 04° 32' 19" N. 117° 29' 59" E.	Downstream, shore vegetation small trees, shrubs and vines,banks are fairly steep. River is deep and 35 m. at widest . Bottom is sandy , fully exposed, water is turbid with silt and flowing gently. Hook and lines fishing by local residents.
15	Tributary of Kalabakan River (South) 04° 30' 19" N. 117° 16' 17" E.	Upstream, shore vegetation secondary dipterocarp forest on both sides, area was logged more then 10 years ago. Banks are fairly steep with vines, ferns and grass and shrubs. Few trees with vascular roots protruding into the river. Stream is shallow (max. depth 1 m.) and 5 m. at widest . Bottom is boulders, gravel and pebbles, stream is 50 – 70% shaded and water is clear and swift flowing. Cast nets of ½ " and 1 inch mesh were used for sampling. Length of sampling 100 meters of the stream with 15 cast.
16	Tributary of Kalabakan River (South) 04° 29' 11" N. 117° 16' 22" E.	Upstream, shore vegetation is secondary dipterocarp forest logged more then 10 years ago. Banks are fairly steep with vines, ferns and shrubs. Stream is shallow (max. depth 1 m.) and 5 m. at widest. Bottom is boulders, gravel and pebbles, stream is 70 – 90% shaded and water is clear with swiftly flowing water. Cast nets of ½ " and 1 inch mesh were used for sampling. Length of sampling 100 meters of the stream with 15 cast.
17	Tributary of Kuamut River (South) 04° 31' 22" N. 117° 13' 11" E.	Upstream, shore vegetation is undisturbed dipterocarp forest, banks are fairly steep with vines and shrubs. Stream is shallow (max. depth 0.5 m.) and 3 m. at widest . Bottom is boulders, gravel and pebbles, stream is 70 – 90% shaded and water is clear swift flowing water. Cast nets of ½ " and 1 inch mesh were used for sampling. Length of sampling 100 meters of the stream with 15 cast.
18	Tributary of Kuamut River (South)	Upstream, shore vegetation dipterocarp forest with vascular roots protruding into water, banks are fairly steep with vines and shrubs. Stream is shallow (max. depth 0.5 m.) and 5 m.

Station	Location & Geographical Positioning	Description of the site and Methodology Employed
	04° 32' 23" N. 117° 01' 21" E.	at widest . Bottom is boulders, gravel and pebbles with sandy banks at corners, stream is 30 – 50% shaded and water is clear with swift flowing water. Cast nets of ½ " and 1 inch mesh were used for sampling. Length of sampling 100 meters of the stream with 15 cast.
19	Tributary of Kuamut River (South) 04° 32' 24" N. 117° 03' 24" E.	Upstream, shore vegetation is disturbed dipterocarp forest with banks gently sloping and covered with vines, grasses and shrubs. Stream is shallow (max. depth 0.5 m.) and 3 m. at widest . Bottom is boulders, gravel and pebbles, stream is 70 – 90% shaded and water is clear with fairly swift flowing water. This area is a highly disturbed area as it is behind a logging camp compound. The river is constantly used by residence for washing and bathing. Household waste water flow untreated into the stream slightly downstream. Cast nets of ½ " and 1 inch mesh were used for sampling. Length of sampling 100 meters of the stream with 15 cast.  Photo 1: Unsorted catches of freshwater Fish
20	Tributary of Kalabakan River (Mid) 04° 37' 32" N. 117° 12' 09" E.	Midstream, shore vegetation are vines, ferns and grass, banks are fairly steep. Stream is fairly deep (max. depth 3 m.) and 25 m. at widest. Bottom is sandy with boulders and pebbles exposed at edges and along wider areas, stream is completely exposed and water is turbid with silt with fairly rapid flowing water. Cast nets of ½, 1 and 2 inch mesh were used for sampling. Length of sampling 300 meters of the stream with 30 cast. 1" mesh size gill net spanning the width of the river.
21	Tributary of Kalabakan River 04° 38' 05" N. 117° 09' 03" E.	Upstream, shore vegetation shrubs and vines, banks are fairly steep with vines and ferns. Stream is shallow (max. depth 1 m.) and 5 m. at widest. Bottom is gravel and pebbles with sandy banks at corners, stream is 70 – 90% shaded and water is turbid with silt with gently flowing water. Cast nets of ½ " and 1 inch mesh were used for sampling. Length of sampling 100 meters of the stream with 15 cast.

Station	Location & Geographical Positioning	Description of the site and Methodology Employed
22	Kalabakan River (Mid) 04° 37' 32" N. 117° 12' 09" E	Midstream, shore vegetation are small trees, vines, ferns and grass, banks are fairly steep. Stream is fairly deep (max. depth 3 m.) and 40 m. at widest. Bottom is boulders and pebbles with sand banks in the corners, stream is completely exposed and water is turbid with silt with rapid flowing water. Cast nets of ½ , 1 and 2 inch mesh were used for sampling. Length of sampling 300 meters of the stream with 30 cast. 1" mesh size gill net spanning the width of the river.
23	Tributary of Kalabakan River (Mid) 04° 37' 32" N. 117° 12' 09" E.	Midstream, shore vegetation are small trees, vines, ferns and grass, banks are gently sloping. Stream is fairly deep (max. depth 3 m.) and 30 m. at widest. Bottom is boulders and pebbles and water is turbid with silt with fairly rapid flowing water. Cast nets of ½ , 1 and 2 inch mesh were used for sampling. Length of sampling 300 meters of the stream with 30 cast. 1" mesh size gill net spanning the width of the river.
24	Tributary of Kalabakan River 04° 39' 07" N. 117° 18' 23" E.	Upstream, shore vegetation is disturbed dipterocarp forest, banks are fairly steep with vines and shrubs. Stream is shallow (max. depth 1 m.) and 5 m. at widest. Bottom is gravel and pebbles with sandy banks at corners, stream is 60 – 70% shaded and water is turbid with silt with gently flowing water. Cast nets of ½" and 1 inch mesh were used for sampling. Length of sampling 100 meters of the stream with 15 cast.
25	Tributary of Kalabakan River (North) 04° 36' 13" N. 117° 20' 30" E.	Midstream, shore vegetation are vines, ferns and grass, banks are fairly steep. Stream is fairly deep (max. depth 6 m.) and 30 m. at widest. Bottom is sandy with boulders and pebbles exposed at edges and along wider areas, stream is completely exposed and water is turbid with silt with fairly rapid flowing water. Cast nets of ½, 1 and 2 inch mesh were used for sampling. Length of sampling 300 meters of the stream with 30 cast. 1" mesh size gill net spanning the width of the river.
26	Kalabakan River 04° 28' 36" N. 117° 22' 14" E.	Downstream, shore vegetation is disturbed dipterocarp forest but fairly established secondary growth at present, banks are fairly steep with vines and shrubs. River is deep (max. depth 8 m.) and 35 m. at widest. Bottom is sandy, fully exposed, water is turbid with silt and flowing gently. Hook and lines fishing by local residents.

The survey carried out is not a full representation of all species in the stream concerned, the use of cast and gill nets are confined to fishes of a certain size, the smaller species are not caught in these nets. More destructive methods such as the use of rotenone, chorine or electrical shock will have to be used in order that a complete catch of all species present be caught. However, the species caught even at this level shows the different niches that exist in the different rivers and locations. See findings on species abundance and diversity in **Tables B1.22** and **B1.23** and **Figures B1.3.2** and **B1.3.3**.

The upper reaches of the rivers yield an average of 7 species compared to between 38 – 50 species in Kinabatangan River (Inger & Chin 1962) and 78-96 species in the Tawau River and Binsuluk River (Samat et. al., 1995). Both these survey used rotenone. Many of the species caught by these surveyors were represented by very small fishes of between 5 to 25 mm in total length which for the purpose of this survey was not done as only indicator species were intended to be sampled.

At each of the stations surveyed different composition of species were found but each time the ecological niches in terms of feeding preference complete the food chain, that is herbivores, omnivores and carnivores are all found together in every station. The differences are in the numbers of each group of feeders depending on the location. In areas where the stream is well shaded there are more individuals of omnivores and carnivores as the over hanging branches provide arches over the stream from where crawling insects regularly fall into the stream. The shade also reduces the rate of growth of algae and other aquatic plants thus reducing the presence of herbivores. In areas where the stream is exposed to the sunlight, the herbivores thrive with few of the others.

In areas that are presently being logged or recently logged (between 3-4 years) like the Kuamut Stations the number of fishes per station were generally lower in these areas as compared to stations where logging occurred more than 5 years ago. From the results of Inger and Chin 1962, the number of indicator species in the stations left undisturbed after logging recovers show no significant changes in composition of indicator species. As no other records are available for comparison it could be concluded that given the recruitment capabilities of a stream, if left to recover with no further disturbance the aquatic community could recover within a matter of a few years. The exact composition upon recovery may not be the same as it is dependent on the available candidate for recruitment into the ecosystem but each niche will be filled to complete the food chain.

Near newly logged area where the streams are very turbid, the number of individuals is low compared to similar locations upstream where disturbance is minimal. The turbid conditions are detrimental to the survival of many species since this condition may lead to clogging of the gills of these fishes or to reduction of the available food sources by smothering the rock surfaces and reducing light penetration for vegetative growth. Once the food chain is broken other species will also either migrate to other parts of the stream or die off.

The middle portions of the rivers can be divided into two types. Those which are between 10 to 20 meter wide and have water depths of less then 2 meters and those that are more then 20 meters wide with depths of more then 2 meters. The former (Stations 11, 14, 15, and 16) are well represented in the survey of indicator species showing the complete niches in the food chain and shows a trend of downstream migration of the same species found upstream. This would indicate that the upper reaches of the rivers could be the breeding and nursery ground for many species which migrate downstream as they grow. Upon reaching maturity these fishes would swim back upstream to breed thus completing the recruitment cycle.

In the second type of rivers where only few specimens were caught such as Station 6, 8,19 and 20 these do not truly representative the composition of that area of the river. The rivers were fast flowing, highly turbid and were generally quite deep for proper sampling to be carried out. The nature of these types of rivers does not offer suitable habitats for fishes except in areas where the river bends or physical structures reduce waterflow.

Table B1.22 Distribution of Fresh Water Fishes by Station and Abundance

Fish Species	STATION																									
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Cyclocheilichthys apogon															2	4				2				2		
Glaniopsis hanitschi															7	14	23	13	14	12	5					
Hampala sp.			3	2	5															2	4				2	
Kryptopterus parvanalis						1																				
Leptobarbus hosii	3				2													4		5	7	16	8			
Leptobarbus melanotaenia	2			3	3	1									3	4	2			2	1	1	1	2	2	1
Mastacembelus keithi		1					3		3																	
Mystus nemurus							1		1	2					1											2
Nematabramis everetti	10	42	5	56	16				10	12		5			6	14	18	14		23	48			20		
Ophicephalus sp.													1	2												2
Osteochilus spilurus		1		2	2										2	1		3	5							
Paracrossochilus acerus		1	14	20	21										5		2	8	6	3						
Puntius binotatus															2	8	3	2	7							
Puntius bramoides	1	1		1	2	1		4	2		3				2					3	2	4	1	2	4	
Puntius collingwoodi		2	5	2	3				4						2	3	2	1								
Puntius sealei	3	2	3	1											2	3					2		1			
Puntius sp.	3	3	8	2	1	1	3	3	5	4	8	2	2		6		3	2	1		2	2		2		1
Rasbora sp.	4	2	6	2	12	8	12	4	5	9	12	6			4	12	15	1	3	5	4	6	4	12		
Tilapia mossambica									12																	
Tor douronensis		2		6	7	1										3			4	8	32	7	15		2	2
Trichogaster trichopterus												2	14	6												
No. of Different Species	8	10	7	11	11	6	3	3	9	4	3	4	3	2	13	10	8	9	7	10	10	6	6	5	4	5

Figure B1.3.2 : Freshwater Fish Distribution

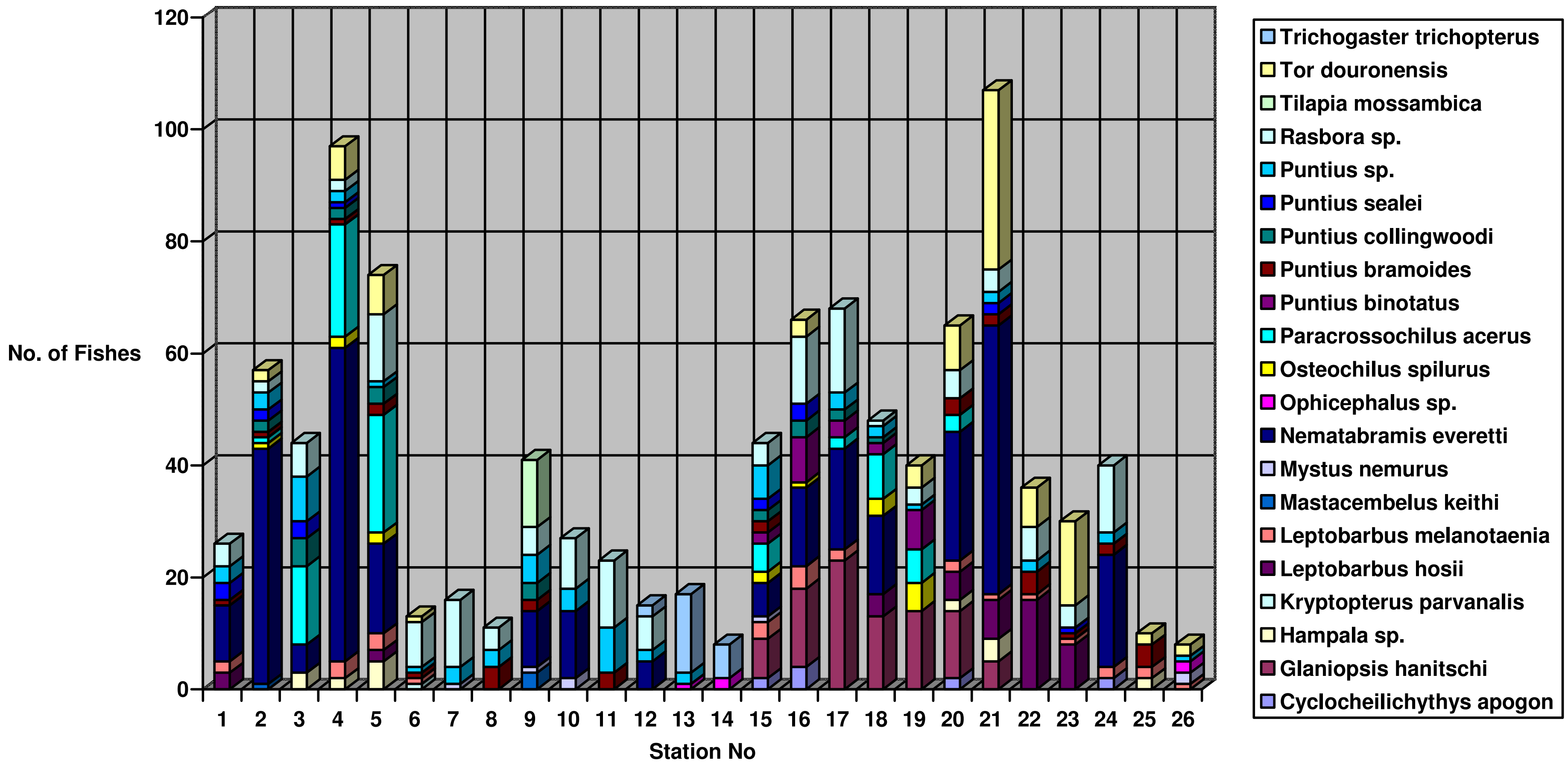


Figure B1.3.3 : Number of Species (Diversity)

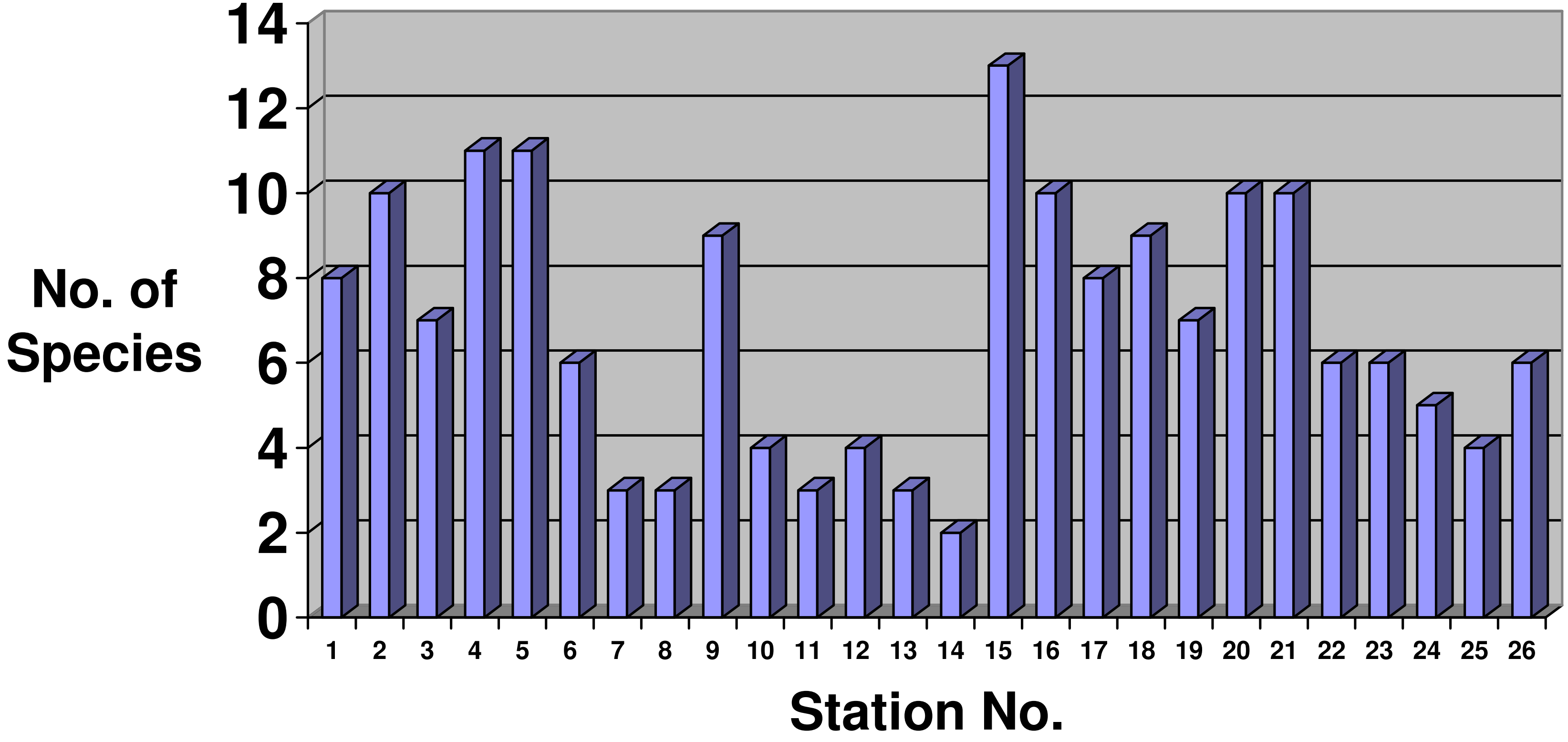


Table B1.23 Distribution of Each Species and Gut Content Examination

FISH SPECIES	DISTRIBUTION	GUT CONTENT
Cyclocheilichythys apogon	Small forest stream 2-5 meters wide, gravel bottom with sandy patches, clear & rapid water.	Unidentified insects both aquatic and terrestrial.
Hampala sp.	Clear fast flowing streams with sand, gravel or rock bottom, none caught in turbid waters.	Unidentified small fishes, insects and other invertebrates fragments.
Kryptopterus parvanalis	Only specimen was fished in turbid water.	Gut empty.
Leptobarbus hosii	Found both in turbid and clear waters of varying bottom conditions. Small upstream & bigger downstream.	Vegetative feeders – pieces of leaves, steam, flowers and a paste like substance could be algae.
Leptobarbus melanotaenia	Found both in turbid and clear waters of varying bottom conditions. Small upstream & bigger downstream.	Vegetative feeders – pieces of leaves, steam, flowers.
Mastacembelus keithi	Only one specimen caught in slightly turbid, gently flowing water, sandy gravel bottom.	Aquatic insects and larvae like nymphs and other insects.
Mystus nemurus	Turbid slow flowing water, large sandy bottom streams	Fragments of crustaceans, terrestrial insects, aquatic insects, small fishes and vegetation.
Nematabramis everetti	Abundant in small streams over silt, gravel and rock bottom both clear and fairly turbid flowing water.	Mainly small terrestrial insects like ants, small beetles and others.
Ophicephalus sp.	Sluggish water flow, larger parts of the river where water is turbid. Sandy bottom.	Whole and fragments of fishes, crabs and some insects.
Osteochilus spilurus	Small clear streams, specimens caught in quiet pools with sandy bottom covered with fallen leaves.	Vegetative paste of green algae, blue green algae, diatoms, vascular plants & insects' parts.

Continue.. Table B1.23 Distribution of Each Species and Gut Content Examination

FISH SPECIES	DISTRIBUTION	GUT CONTENT
Paracrossochilus acerus	Small to medium streams with clear fast flowing water, little shade with gravel to rocky bottom.	Vegetative paste of green algae, blue green algae, diatoms and vascular plants.
Puntius binotatus	Small to medium streams with sandy gravel bottom, both clear and slightly turbid water.	Small insects, fragments of aquatic insects and some plant fragments.
Puntius bramoides	Smaller specimens in small streams to large river where large specimens were caught on sandy or rocky bottom, no preference to clear or turbid water.	Plant and insects for the smaller specimens and smaller fishes, insects, crabs and even snails fragments.
Puntius collingwoodi	Clear to slightly turbid water, fast flowing, sandy to rocky bottom.	Leaves, stems, flowers and grass. Fragments of both aquatic and terrestrial insects
Puntius sealei	Small to medium streams with sandy gravel bottom, both clear and slightly turbid water.	Primarily parts of vascular plants. Fragments of insects.
Puntius sp.	Only in turbid waters with sandy bottom.	Small fruits and flowers.
Tor douronensis	Swift flowing, clear to fairly turbid water rocky bottom for the smaller specimens whereas the larger adults are in deeper pools down river. This fish is highly sorted as food.	Small individuals had insects, crustaceans and plants material. The large specimens had smaller fishes and insects mainly aquatic.
Trichogaster trichopterus	Turbid slow flowing almost sluggish water with silty sandy bottom.	Vegetative paste in gut.

B1.3.3 Flora Ecology

B1.3.3.1 General

The project site had been exposed to different regimes of logging at different times with the exception of the very steep ridges. Owing to these different logging intensities different vegetation types remained. At the heavily logged sites, especially on gentle slopes, most of the big trees had been removed with the dominance of the secondary species of Macaranga gigantea where in some sites these trees form a pure stand. The ridges and steep slopes are sites still with the original vegetation. The flora ecology is already assessed in the previous SEIA (2002). However, due to the continuous change in the environment due to logging, a reassessment is necessary.

B1.3.3.2 Methodology

To assess these different types of habitats and the associated residual vegetation, a ground inspection and aerial survey were conducted. The first was carried out in the last week of November 2004 to all the coupes within the Project Site (see **Figure A1.6**) and this was followed by an aerial survey carried out with a helicopter at 3,000 ft on 29 November 2004 (see **Figure A1.7**). To determine the location of each site inspected GPS readings were recorded (see **Table B1.24**). The survey information was supplemented with harvesting plans, records and information provided by the field staffs of Yayasan Sabah at Luasong Field Centre. Records from the previous two EIAs carried out in the same region in 2001 were also used for reference after being updated (Rakyat Berjaya Sdn. Bhd. 2001; and Innoprise Synergy Sdn. Bhd, Lion Management Sdn. Bhd. & Fuxing Pulp and Paper Co. Ltd, 2002).

The forest within the Project site can be defined mainly as Lowland Mixed Dipterocarp Forest Formation following definition of Ashton (1995) with the exception of the high ridges of G. Nakopan (BW9/00) at 1333m and G. Tampilat at 1083m (BW 9/02) and G. Tembuku at 1021m in Brantian Tatulit VJR, which fall into the Montane Forest. Although generally below the 700m elevation, the project site has many hilly areas with terrains of over 25 degrees in addition to being dissected by many rivers. The steeper slopes are of sandstone outcrops that are characterised by narrow ridges (Williams, Talhar & Wong, 1995). With the many rivers there are the riparian vegetation belts within the project area with their unique set of flora. These variations of habitat types have resulted in specific niches for different plant communities. In addition to these edaphic features, the previous logging history in 1970s and 80s has also created different habitats allowing establishment of specific floristic variations.

Members of the Dipterocarpaceae, which are most important commercially, form the dominant species of this forest type. This is supported by the data collected by the Linear Regeneration Sampling Reports of 1984 to 1991 conducted by the Forestry Division of Innorprise Sendirian Berhad in the project site (Anon. 1989, Anon. 1992). In Kalabakan Forest Reserve, which covers most part of the Project Site, there were 37.1 trees per hectare of advance growth (10<60cm dbh) two to three years after harvesting (Anon, 1992).

Table B1.24 : LOCATIONS VISITED 23 TO 25 NOV 2004 KALABAKAN FR

Location	Longitude	Latitude
23 Nov 2004		
BW 12/02		
Sg. Tiagra		
VJR Ulu Napagan	117^{o} 15.118'	4^{o} 46.567'
BW3/03		
Sg. Kuamut	117^{o} 12.769'	4^{o} 53.831'
Junction to BW5/02	117^{o} 13.132'	4^{o} 51.183'
BW5/02	117^{o} 14.119'	4^{o} 50.511"
BW5/02	117^{o} 14.409'	4^{o} 51.032'
BW2/02	117^{o} 14.842'	4^{o} 51.446'
BW2/02	117^{o} 15.596'	4^{o} 51.404'
Hill top BW2/02	117^{o} 16.659'	4^{o} 51.188'
Bridge over Sg. Imbak	117^{o} 18.407'	4^{o} 51.815'
BW12/04	117^{o} 21.369'	4^{o} 48.494'
24 Nov 2004		
BW 3/01 Sg. Geminchau	117^{o} 26.703'	4^{o} 37.900'
Nursery BW3/01	117^{o} 27.012'	4^{o} 39.858'
Sg. Brantian Buffer	117^{o} 27.926'	4^{o} 41.480'
BW4/98	117^{o} 29.028'	4^{o} 43.761'
BW1/00 log yard	117^{o} 28.526'	4^{o} 45.505'
BW1/00 steep site	117^{o} 28.136'	4^{o} 46.279'
BW1/99	117^{o} 29.450'	4^{o} 44.573'
Turning east to BW5/99	117^{o} 31.634'	4^{o} 43.926'
BW 5/99	117^{o} 32.116	4^{o} 42.389'
Tembakau VJR	117^{o} 31.798'	4^{o} 40.184'
VJR Signpost next BW4/00 B1	117^{o} 31.612'	4^{o} 39.612'
BW4/00 Sg. Brantian	117^{o} 31.221	4^{o} 36.584
Sg. Bara BW3/00	117^{o} 35.720'	4^{o} 39.722'
BW 4/00A	117^{o} 36.403'	4^{o} 40.403'
BW4/99	117^{o} 36.718'	4^{o} 41.101'
BW4/99 Camp site	117^{o} 38.501'	4^{o} 41.110'
BW 5/99	117^{o} 38.497'	4^{o} 41.112'
25 Nov 2004		
BW11/01	117^{o} 22.182'	4^{o} 30.939'
BW11/01	117^{o} 21.849'	4^{o} 31.033'
Gate for BW 11/01	117^{o} 20.680'	4^{o} 30.390'
Bridge across Sg. Kalabakan	117^{o} 18.497'	4^{o} 31.112'
Logging camp BW9/00	117^{o} 16.498'	4^{o} 31.112'
BW9/03	117^{o} 13.180'	4^{o} 31.385'
BW9/03	117^{o} 13.299'	4^{o} 31.696'
BW9/03	117^{o} 13.869'	4^{o} 31.369'
BW 9/01	117^{o} 15.396'	4^{o} 31.427'
BW9/00	117^{o} 15.540'	4^{o} 31.328'
BW9/00	117^{o} 14.078'	4^{o} 29.698'
BW11/01 (gate to YS forest)	117^{o} 21.882'	4^{o} 28.259'
BW2/00(1)	117^{o} 29.618'	4^{o} 23.932'
	117^{o} 12.769'	4^{o} 12.769'

Of the 28.6 trees that were within the Regenerating Sampling List 23.7 or 83% of the trees were from the Dipterorpaceae. In the blocks marked as YT A2/87 and YT 2/87 under the first logging exercise in the 1980s, which are now located within Coupe BW 12/02 in the present harvesting, 77.74% of the total volume of remaining timber trees with diameter over 30cm are from the members of the Dipterocarpaceae (**Table B1.25**). Many residual trees from this family were recorded in the field inventory carried out for the SEIA for the industrial tree plantation project of 2002. Members of the Euphorbiaceae and Leguminosae are also common. A list of the common trees recorded in the SEIA 2002 is in **Table B1.31**.

Table B1.25 : Inventory of residual trees over 30cm diameter in logged over forest BW12/02

Species group	Block no.	
	YT A2/87	**YT 2/87**
Coupe area	1,536 ha	960 ha
Total stand >30cm	31.4 m^3/ha	44.71 m^3/ha
Red seraya (*Shorea leprosula* and *S. smithiana)*	21.90%	17.72%
White seraya (*Parashorea malaanonan* and *P. tomentella)*	14.80%	15.41%
Yellow seraya (*Shorea acuminatissima, S. gibbosa, S. faguetiana* and other *Shorea* with yellow wood)	4.55%	8.17%
Kapur (*Dryobalanops species)*	9.92%	15.48%
Keruing (*Dipterocarpus species)*	12.21%	8.45%
Selangan Batu (Heavy *Hopea species* and heavy and medium density *Shorea species)*	17.52%	5.45%
Melapi (*Shorea bracteolate, S. smingtonii* and other species of *Shorea* having whitish wood)	3.47%	0.43%
Belian	0.19%	0.00%
Binuang	0.00%	0.13%
Nyatoh	0.04%	0.04%
Sepitir	0.46%	1.23%
Kembang	2.59%	0.80%
Merbau	0.27%	0.47%
Other timber species	12.07%	26.20%

Although the Project Area lies mostly within the lowland forest its various topographic features together with the previous logging history have created different habitats allowing specific floristic variation within the Project Area. The different logging regimes determined various harvesting intensities at different terrain types leaving different amount of residual trees. Very intensive logging activities conducted in the 1970s and 80s resulted in massive opening of the forest canopy along gentle slopes and undulating areas resulting in the absence of many commercial trees. Following logging the number of big trees (with diameter above 60cm) remaining within a hectare of Kalabakan Forest Reserve was 19.1 individuals and only 23% were of quality 1 (Anon. 1992). Re-entry logging and fire had further reduced the density of large trees (**Plate A1 in Figure A1.9**). Secondary forest species dominate some of the coupes examples in BW 12/01 (**Plate A1 in Figure A1.9**) and BW2/00(1) (**Plate A1 in Figure A1.9**). Recent logging carried out for the establishment of the proposed industrial tree plantation has further reduced the forested areas.

Owing to the reduced intensity of harvesting along steep ridges, a number of large trees are left behind. In a rich forest on ridges of BW1/00 the volume of trees with diameters above 60cm is given in **Table B1.26**. There is also a good dominance of Dipterocarpaceae in the coupe.

TABLE B1.26 : Net volume per ha by species group in the different forest strata of BW 1/00

Species	Volume per hectare (Trees >60cm dbh)			
	Class 1 460 ha	**Class 2 210 ha**	**Class 3 1210 ha**	**Class 4 210 ha**
Red seraya (*Shorea leprosula & S. smithiana)*	13.34	26.34	22.01	no data
White seraya (*Parashorea malaanonan & P. tomentella)*	4.21	2.89	9.21	no data
Yellow seraya (*S. accuminatissima, S. gibossa, S. faguetiana* and other species of *Shorea* with yellow wood*)*	9.47	4.660	14.64	no data
Oba suluk (*S. pauciflora)*	5.60	0	0	no data
Kapur (*Dryobalanops spp.*)	0	1.19	0	no data
Keruing (*Dipterocarpus spp.)*	0.90	1.71	0	no data
Selangan batu (Heavy *Hopea* and *Shorea spp.* Medium heavy *Shorea*)	2.78	5.28	8.28	no data
Other Dipterocarps	1.2	2.28	0	no data
Merbau (*Intsia palembanica*)	0	1.19	0	no data
Other Non-Dipterocarps	0	1.71	1.71	no data
Fruit trees	0	5.18	6.36	no data

Forest strata classification based on Timber Volume 1995/1996 aerial photographs
Class 1: Low timber stand logged heavily with remnant trees
Class 2: Medium timber stand. Remnant of timber stands in steep terrain
Class 3: Very high timber stand. Steep terrain and high elevation. In this coupe confined to riparian reserve
Class 4: Very low timber stand

Pre re-entry harvesting assessment carried out in 1990s by Inorprise Sdn Bhd. for this coupe showed that 57.9% of the 2,090ha have timber volume of 60 m^3/ha. In BW4/00(A) and BW4/0(B) covering a undulating 13,882 ha, only 4.1% of the area have timber volume of 60 m^3/ha while in the very gentle coupe, BW3/00, the volume of residual trees was very low with nothing above 60 m^3/ha while only 4.7% of its 1,708ha have volume of 20 m^3/ha. The low volume of large trees in some coupes resulted from the dominance of secondary tree species especially Macaranga gigantea which had invaded openings created during harvesting. The large forest fire of Borneo in 1980s further aggravated the situation resulting in pure stands of this species within some coupes. The distribution of these vegetation types is presented in **Figure A1.8**.

The Project Area is divided into two main blocks of the Kalabakan and G. Rara Forest Reserves. The bigger block is in the east which will be under the management of Benta Wawasan Plantation I, Benta Wawasan Plantation II, Benta Wawasan Plantation III and Yayasan-Melaka JV. The smaller block is located in the south-west which is to be managed by Ratus Awansari Sdn. Bhd. JV. There are 43 coupes in the eastern block stretching from the main Tawau-Luasong main road at the south and Sg. Kuamut in the north with Sabah Softwoods Berhad plantation on the east. This portion is also the first site to be converted into Industrial Tree Plantation with planting of Acacia mangium beginning 2001. The other block has 8 coupes stretching north and south of the main Kalabakan-Keningau road. It is bordered at the north-west by INNEKIA project with Luasong Forestry Project to the north and Sabah Softwoods at the east. Both these blocks proposed for the project were harvested under the North Borneo Company mainly during mid 1970s to mid 1980s (**Table B1.27**).

Table B1.27 : Logging history of some of the coupes within the project area

Coupe No.	Area (ha)	Originally logged
BW1/98	1,615	1975
BW2/98	1,875	1975
BW3/98	1,560	1975
BW4/98	2,885	1984
BW 5/98	1,445	1983
BW2/00	5,462	mid 1970s
BW3/00	1,708	mid 1970s
BW4/00(A)	7,302	1978
BW4/00(B)	6,580	1975
BW5/00	1,763	mid 1970s
BW9/00	4,803	1988, 1989, 1991 & 1993
BW10/00	2,865	mid 1970s
BW11/00	2,500	1984
BW1/00	2,090	Part in 1980s
BW1/01	1,213	mid 1970s
BW2/01	4,208	mid 1970s
BW3/01	1,907	mid 1970s
BW9/01	5,000	1985
BW11/01	2,500	1983

Within the project area there are coupes that have been cleared of all original vegetation and some were planted. In the first block, 12 coupes had been cleared of vegetation and 7 had been established with Acacia mangium trees (**Table B1.28**).

Table B1.28 : Coupes that have been planted with *Acacia mangium* or cleared of all vegetation

Coupe No.	Area (ha)	Existing condition
BW1/98	1,615	Established with *Acacia mangium*
BW1/99	2,230	Established with *Acacia mangium*
BW2/98	1,875	Established with *Acacia mangium*
BW2/00(II)	2,410	All vegetation cleared
BW3/99	1,713	All vegetation cleared
BW3/98	1,560	Established with *Acacia mangium*
BW4/98	2,885	Established with *Acacia mangium*
BW4/00(B1)	3,170	Established with *Acacia mangium*
BW4/99	2,140	All vegetation cleared
BW5/98	2,115	Established with *Acacia mangium*
BW5/99	1,445	All vegetation cleared
BW5/00	1,494	All vegetation cleared
Total	24,652	

Plate A1 in Figure A1.9 shows BW 3/99 where all vegetation had been cleared and an older area in BW1/99 that was cleared in 2002 and planted with Acacia mangium is shown in **Plate A1 in Figure A1.9**.

For the remaining coupes, salvage logging are now in progress within those shown in **Table B1.29**.

Table B1.29: Coupes that are now undergoing salvage logging

Coupe No.	Area (ha)	Existing condition
BW2/99	2,280	Salvage logging in progress
BW9/99	5,306	Salvage logging in progress
BW1/00	1,407	Salvage logging in progress
BW2/00(1)	2,971	Salvage logging in progress
BW4/00(A)	5,772	Salvage logging in progress
BW4/00(BII)	2,537	Salvage logging in progress
BW9/00	4,045	Salvage logging in progress
BW10/00	2,843	Salvage logging in progress
BW11/00	2,011	Salvage logging in progress
BW1/01	1,008	Salvage logging in progress
BW2/01	3,739	Salvage logging in progress
BW3/01	1,804	Salvage logging in progress
BW5/01	1,907	Salvage logging in progress
BW9/01	3,040	Salvage logging in progress
BW14/01	1,079	Salvage logging in progress
BW2/02	534	Salvage logging in progress
BW10/02	1,220	Salvage logging in progress
Total	43,503	

This form of logging is intensive with all trees with diameter of 25cm and above, are removed exposing barren areas and extensive network of roads as seen in BW9/00 (**Plate A1 in Figure A1.9**).

Relogging for trees with diameter above 60cm is now being carried out in another 8 coupes as shown in **Table B1.30**.

Table B1.30 : Coupes that are now being relogged

Coupe No.	Area (ha)	Status
BW5/01	2,096	Relogging in progress
BW10/01	1,533	Relogging in progress
BW11/01	2,140	Relogging in progress
BW9/02	4,784	Relogging in progress
BW11/02	2,121	Relogging in progress
BW12/02	2,993	Relogging in progress
BW9/03	2,305	Relogging in progress
BW10/03	1,820	Relogging in progress
Total	19,492	

There are another 11,695 ha that are waiting to be harvested in the near future.

Table: B1.31 : List of common tree species within the Project Site

Family	Species	Local names	Habitat
Alangiaceae	*Alangium javanicum*	Kondolori	Primary Forest
Anacardiaceae	*Koordersiodendron pinnatum*	Renggu	Primary Forest
Annonaceae	*Polyalthia sumatrana*	Karai putih	Primary Forest

Apocynaceae	*Alstonia angustifolia*	Pulai bukit	Secondary forest
Apocynaceae	*Alstonia angustiloba*	Pulai bukit	Secondary forest
Bombacaceae	*Durio kutejensis*	Durian merah	Primary forest
Burseraceae	*Dacryodes rostrata*	Kedondong	Primary forest
Ctenolophonaceae	*Ctenolophon parvifolius*	Besi besi	Primary forest
Datiscaceae	*Octomeles sumatrana*	Binuang	Riverine forest
Dillenaceae	*Dillenia indica*	Simpoh	Forest edge
Dilleniaceae	*Dillenia suffruticosa*	Simpoh gajah	Secondary forest
Dipterocarpaceae	*Dipterocarps caudiferus*	Keruing putih	Primary forest
Dipterocarpaceae	*Dipterocarpus acutangulus*	Keruing merkah	Primary forest
Dipterocarpaceae	*Dipterocarpus caudiferus*	Keruing putih	Primary forest
Dipterocarpaceae	*Dipterocarpus gracilis*	Keruing kesat	Primary forest
Dipterocarpaceae	*Dipterocarpus kerrii*	Keruing gondol	Primary forest
Dipterocarpaceae	*Dipterocarpus kunstleri*	Keruing rapak	Primary forest
Dipterocarpaceae	*Dipterocrpus oblongifolius*	Keruing neram	Riverine forest
Dipterocarpaceae	*Dryobalanops beccarii*	Kapur merah	Logged over
Dipterocarpaceae	*Dryobalanops keithii*	Kapur gumpait	Primary forest
Dipterocarpaceae	*Dryobalanops lanceolata*	Kapur paji	Primary forest
Dipterocarpaceae	*Hopea beccariana*	Selanan penak	Primary forest
Dipterocarpaceae	*Hopea nervosa*	Selangan jankang	Primary forest
Dipterocarpaceae	*Parashorea malaanonan*	Urut mata daun licin	Primary forest
Dipterocarpaceae	*Parashorea smythesii*	Urut mata batu	Primary forest
Dipterocarpaceae	*Parashorea tomentella*	urut mata beludu	Primary forest
Dipterocarpaceae	*Shorea argentifolia*	Seraya kuning bukit	Primary forest
Dipterocarpaceae	*Shorea dasyphylla*	Seraya batu	Primary forest
Dipterocarpaceae	*Shorea fallax*	Seraya daun kasar	Primary forest rare
Dipterocarpaceae	*Shorea johorensis*	Seraya majau	Primary forest
Dipterocarpaceae	*Shorea laevis*	Selangan batu kumus	Logged over
Dipterocarpaceae	*Shorea laevis*	Selangan batu kumus	Logged over
Dipterocarpaceae	*Shorea leprosula*	Seraya tembaga	Primary forest
Dipterocarpaceae	*Shorea macrophylla*	Kawang jantung	Riverine forest
Dipterocarpaceae	*Shorea mecistopteryx*	Kawang burung	Primary forest
Dipterocarpaceae	*Shorea ovalis*	Seraya kepong	Primary forest
Dipterocarpaceae	*Shorea parvifolia*	Seraya punai	Primary forest
Dipterocarpaceae	*Shorea pauciflora*	Oba suluk	Primary forest
Dipterocarpaceae	*Shorea platyclados*	Seraya bukit	Primary forest
Dipterocarpaceae	*Shorea seminis*	Selayan batu terendak	Primary forest
Dipterocarpaceae	*Shorea smithiana*	Seraya timbau	Primary forest
Dipterocarpaceae	*Vatica dulitensis*	Resak bukit	Primary forest
Ebenaceae	*Diospyros levigata*	Kayu malam	Primary forest
Elaeocarpaceae	*Elaeocarpus stipularis*	Kungkurad	Primary forest
Euphorbiaceae	*Baccaurea macrocarpa*	Tampoi merah	Primary forest
Euphorbiaceae	*Bridelia penangiana*	Obas	Forest edge
Euphorbiaceae	*Cleistanthus megacarpus*	Baubo	Forest edge
Euphorbiaceae	*Endospermum diadenum*	Senduk-senduk mata	Forest edge
Euphorbiaceae	*Glochidion rubrum*	Obah nasi	Secondary forest
Euphorbiaceae	*Homalanthus populneus*	Ludai susu	Secondary forest
Euphorbiaceae	*Macranga gigantea*	Merkubong	Secondary forest
Euphorbiaceae	*Macranga cornifera*	Mahang	Secondary forest

Euphorbiaceae	*Macranga gigantifolia*	Telinga gajah	Secondary forest
Euphorbiaceae	*Macranga hypoleuca*	Sedaman putih	Secondary forest
Euphorbiaceae	*Macranga triloba*	Sedaman putih	Secondary forest
Euphorbiaceae	*Macranga winkleri*	Sedaman rimba	Secondary forest
Euphorbiaceae	*Mallotus caudatus*		Secondary forest
Euphorbiaceae	*Mallotus macrostachyus*	Mallotus daun	Secondary forest
Fagaceae	*Castanopsis densinervia*	Berangan	Primary forest
Fagaceae	*Lithocarpus sp.*	Mempening	Primary forest
Fagaceae	*Lithocarpus gracilis*	Mempening	Primary forest
Fagaceae	*Lithocarpus leckii*		Primary forest
Fagaceae	*Lithocarpus nieuwenhuisii*		Primary forest
Flacourtaceae	*Hydnocarpus borneensis*	Karpus tulang	Primary forest
Flacourtaceae	*Hydnocarpus woodii*	Karpus wood	Primary forest
Flacourtaceae	*Ryparosa nuttetii*	Giewei	Forest edge
Guttiferae	*Mesua macrantha*	Bintanggor batu	Primary forest
Hypericaceae	*Cratoxylum cochinchinense*	Geronggang bogoi	Primary forest
Lauraceae	*Actinodaphne glomerata*	Medang Serai	Primary forest
Lauraceae	*Litsea accidens*	Medang	Primary forest
Lauraceae	*Litsea garciae*	Pengolaban	Primary forest
Lecythidaceae	*Barringtonia lanceolata*	Tampalang	Primary forest
Lecythidaceae	*Barringtonia sarcotheceus*		Primary forest
Leeaceae	*Leea indica*	Mali-mali	Forest edge
Leguminosae	*Caesalpinia sp.*	Climber and abundant	Forest edge
Leguminosae	*Derris sp.*		Primary forest
Leguminosae	*Dialium indum*	Keranji	Primary forest
Leguminosae	*Intsia palembanica*	Merbau	Primary forest
Leguminosae	*Koompassia excelsa*	Mengaris	Primary forest
Leguminosae	*Parkia javanica*	Kupang	Primary forest
Leguminosae	*Saraca declinata*	Gapis	Primary forest
Leguminosae	*Sindora sp.*		Primary forest
Leguminosae	*Sindora irpicina*	Sepetir	Primary forest
Leguminosae	*Sympetalandra borneensis*	Merbau lalat	Primary forest
Loganiaceae	*Fagraea cuspidata*	Todopon puak	Primary forest
Melastomtaceae	*Pternandra cogniauxii*		Primary forest
Meliaceae	*Aglaia ribuoralis*		Primary forest
Moraceae	*Artocarpus anisophyllus*	Terap	Forest edge
Moraceae	*Artocarpus elasticus*	Terap togop	Forest edge
Moraceae	*Artocarpus lanceifolius*		Primary forest
Moraceae	*Ficus racemosa*		Primary forest
Moraceae	*Ficus treubii*		Primary forest
Moraceae	*Ficus uncinata*		Primary forest
Moraceae	*Prainea limpato*		Primary forest
Myristaceae	*Horsfieldia grandis*	Darah darah	Primary forest
Myrtaceae	*Syzygium barringtonia*		Primary forest
Myrtaceae	*Tristaniopsis teponusis*	Pelawan pelawan	Primary forest
Palmae	*Arenga undulatifolia*		Primary forest
Palmae	*Oncosperma horridum*	Bayas	Primary forest
Rhizophoraceae	*Carallia brachiata*	Meransi	Primary forest

Rosaceae	*Peranneri oblongifolia*		Primary forest
Rubiaceae	*Neolamarckia cadamba*	Laran	Forest edge
Rubiaceae	*Neonauclea gigantea*	Bangkal merah	Forest edge
Rubiaceae	*Timonius villamii*		Primary forest
Rutaceae	*Melicope luna-akenda*	Pauh-pauh	Primary forest
Sapindaceae	*Nephelium costatum*		Primary forest
Sapindaceae	*Nephelium cuspidatum*		Primary forest
Sapindaceae	*Nephelium eriopetalum*		Primary forest
Sapindaceae	*Nephelium rambotan-ake*	Meritam	Primary forest
Sapindaceae	*Paranephelium xestophyllum*	Membuakat	Primary forest
Sapindaceae	*Pometia pinnata*	Kasai	Primary forest
Sapindaceae	*Xerospermum laevigatum*		Primary forest
Simaroubaceae	*Eurycoma longifolia*	Pahit-pahit	Primary forest
Simaroubaceae	*Irvingia malayana*	Pauh kijang	Primary forest
Sonneratiaceae	*Duabanga moluccana*	Magas	Secondary forest
Sterculiaceae	*Sterculia cordata*	Kelumpang	Primary forest
Styraceae	*Bruinsmia styracoides*	Tingo-tingo	Primary forest
Symplocaceae	*Symplocos fasciculata*	Jiak	Primary forest
Theaceae	*Adinandra dumosa*	Bawing	Secondary forest
Tiliaceae	*Microcos reticulata*		Primary forest
Ulmaceae	*Gironniera nervosa*	Ampas tebu	Forest edge
Ulmaceae	*Trema orientalis*	Randagong	Secondary forest
Urticaceae	*Dendrocnide elliptica*	Anjarapai	Primary forest
Verbanaceae	*Vitex pubescens*	Kulimpapi	Forest edge and secondary forest

B1.4 OIL PALM AND FOREST PLANTATION OPERATION MANAGEMENT

B1.4.1 Terracing and Anti-erosion Bunds

The advantages of terracing and anti-erosion bunds are as follows:

- Planting steep land increases the danger of serious soil erosion problems occurring. Good terracing helps to avoid this danger.
- In addition to preventing rapid run-off of water in erosion control, terraces tend to conserve water, thus making more water available for the palm. This is of considerable value for overall palm development and yield. Field observations on hilly estates have confirmed this, with palms on poorer soils in ravine flats often being better developed than palms grown on better soils on higher ground but where there is less water.
- Following field planting, good access to palms is necessary for routine work. This is very much easier along terraces than where labour has to travel over uneven ground on undulating terrain. Work output is thus increased and costs lowered.
- In the absence of terracing, much of the value of any applied fertiliser may be lost through run-off.
- For later harvesting, easier access in terraced plantings for bunch cutting and carrying should lead to reduced fruit damage, with resulting good quality oil and associated increased value. It is sometimes the practice for harvesters to roll fruit down slopes in

non-terraced areas, causing much fruit damage and increases in oil acidity and dirt content.

- Less fruit is lost, especially loose fruit, from palms planted on terraces.

- Since harvesting is easier on terraces, work output per harvester is increased, so that harvesting costs on terraced land will be lower than in areas straight-planted over slopes. Given a good terrace system, it has been found that harvesting costs on steep land are no higher than those incurred in palms on flatter terrain.

- Mechanised palm-to-palm fruit collection would be extremely difficult to introduce in straight-planted areas of hilly land. It presents little problem on terraces, provided that terrace construction has been sufficiently wide and palm planting not too far forward from the rear of the terrace.

Construction of terraces

The density of contour terraces per hectare, or the lining distance for planting, must be decided before lining for terrace construction starts. The first step in lining for terracing is to peg a base line, usually down the average slope in the area, although there are also arguments for using the steepest slope so that all base line terraces are continuous. If the base line is being pegged for 500 m/ha for erosion and water control terraces, the distance between pegs would be 20m ie. 10,000m divided by 500. For planting terraces the distance would be the nominal lining distance between palms, e.g. for 143 palms/ha this would be 9 m, for 136 palms/ha 9.2 m, and so on. It is worth noting that, for accuracy of lining in terraces, distances should always be measured horizontally. Usually, lines are extended from the base line pegs on contour, using a theodolite or a line of sight level of some sort. An alternative, which is very effective but requires a high level of driver skill, is to use a laser level registering on a receptor on the tractor. This can be particularly useful in thick felled bush. Few slopes are completely regular, consequently the horizontal distance between terraces will become greater as the slope reduces and will close up as it steepens. The aim is to obtain a standard density of terraces per hectare. The general rule is to add an extra terrace if the distance between terraces per hectare. The general rule is to add an extra terrace if the distance between terraces is greater than one-and-one-third times the nominal distance from its neighbour. For example, if the desired stand is 132 palms/ha, the lining distance for 136 palms on a triangular planting pattern is 9.2 m. The general rule is to stop the terrace if it is closer than 6.1 m of the next and add an intermediate terrace, or row of palms, if further than 12.2 m. If this is well done, it will give a reasonably accurate density of terraces but will still create groups of palms up to one-third above and one-third below the desired density, unless a variable lining technique is used. This can be done quite simply by working out a ready-reckoner, based on the desired stand and the actual distance between terraces within the prescribed limits of plus-and minus-two thirds. This is the Violle system, named after the planter who first devised it.

The possibility of manually constructing terraces should not normally be considered, except over very limited areas or where labour costs are very low and those of machinery very high. If mechanised terrace construction cannot be carried out overall but small, localised areas that are exceptionally steep or inaccessible, then the area should not be considered as suitable for oil palm. Terracing is usually done with medium-weight tracked tractors within the Caterpillar D6 to D8 range or equivalent, i.e. 165 to 305 hp, fitted with an angle-blade. The work requires a skilled operator, not only because of the difficulties associated with operations on steep land but also due to the fact that terraces must be level. Outputs vary greatly accordingly to terrain, soil texture, tractor type and operator's experience. A normal output would be 80 to 120 m/h for a 5-m terrace in good working conditions.

Terraces should always be dug on the higher side of the lining pegs and these should represent the edge of the 'hard' or undisturbed soil. The cut should be sloped back into the hill at an angle of about 10° for planting terraces or up to 20° for anti-erosion terraces. For oil palms, planting terraces should be a minimum of 4 m wide to allow proper access to the palms for harvesting, pruning and other field operations (**Figure 1.4.1**).

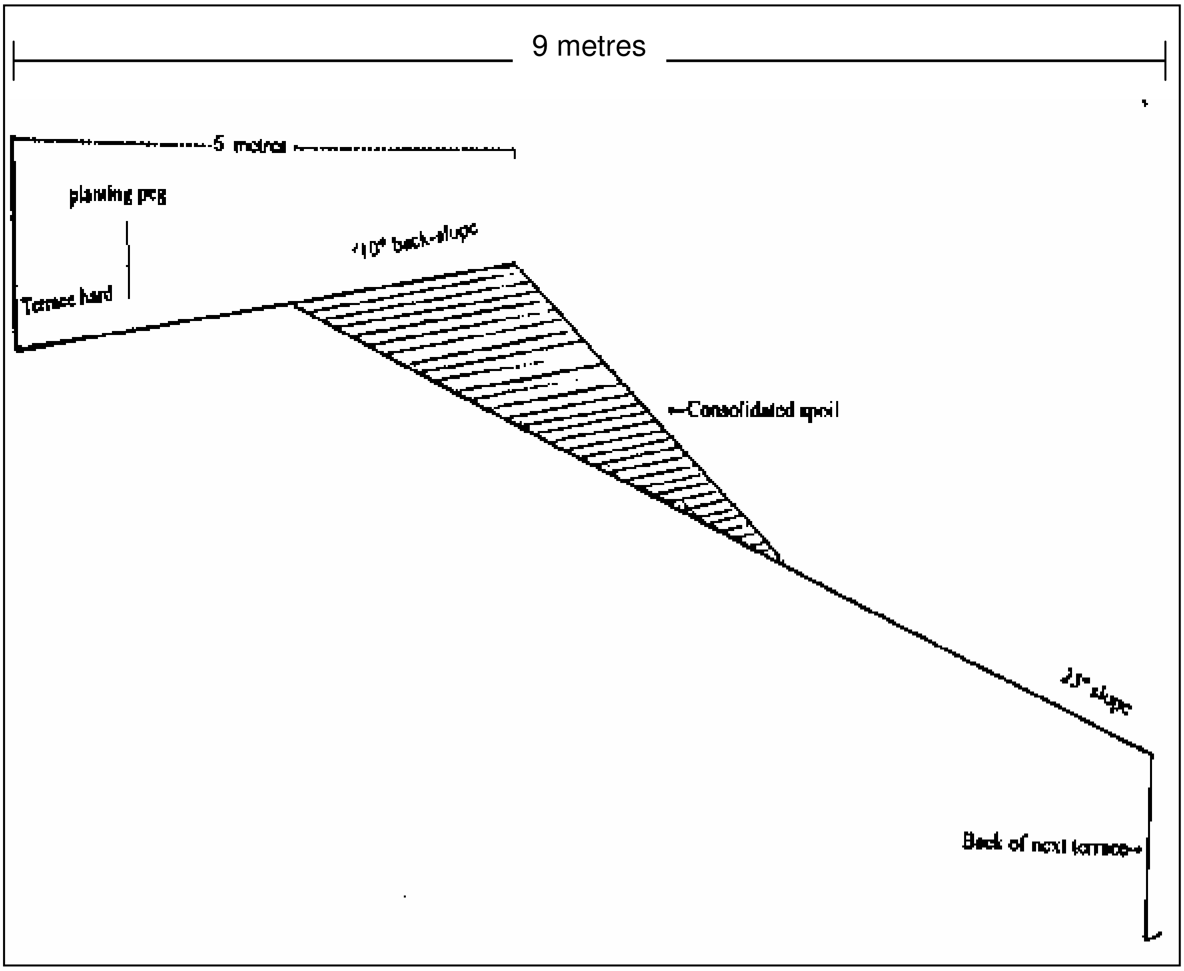


Figure B1.4.1 : Diagram of planting terrace construction

Should mechanised fruit collection be envisaged, then a slightly wider terrace would be of considerable advantage, but would be increasingly difficult or impossible to construct on slopes over 25°. The palm should be planted about 1 m from the rear of the terrace. As it is seldom possible to construct a terrace which is exactly level, it is necessary to prevent water running to the lowest point and spilling over, thus leading to erosion. For this purpose, stop bunds are constructed at intervals of about 10 m and these are level from the lip of the terrace to the back. This can either be done manually or by the tractor during its final pass over the terrace.

As soon as terrace construction is completed, legumes should be sown along the terrace lip to improve soil stability. Creeping legumes, such as Pueraria, Calapogium and Centrosema, are quite suitable and without the management problems associated with the bush species. Once established, Desmodium ovalifolium is good and is moderately shade tolerant. Where terraces and bunds have been well made, there is usually little subsequent maintenance of major proportions required. In the early stages, there should be frequent inspection and repair of any damage at terrace edges or gaps in the bunds after rain. A certain amount of damage and erosion is inevitable until such time as the terrace edge or bund has become firm and overgrown by legume cover or other vegetation. It should be noted that care is required to preserve the vegetation on the edge when later using herbicides for field maintenance. Soil from borrow pits at the back of the terrace can be used to make good any gaps or wash-outs during the life of the planting. These also increase the water holding capacity of the structure.

Construction of anti-erosion bund

The silt pits (see **Figure B1.4.2**) can be made 6 to 7 m long, 0.6 to 0.75 m wide and 0.75 m deep along the contour, with one pit every two to four palms. Occasionally, the bund is erected above the pits, a practice which was once common in Sumatra, but it is preferable to place the excavated soil about 0.5 m from the lower edge of the pit to avoid back-wash. Bunds are constructed manually. Depending on soil conditions and dimensions, one worker can dig and construct 10 to 20 m of bunds daily. Bunds should be maintained at intervals, the frequency depending on need as they silt up or are broken. Temporary bunds can be made on sloping ploughed land with two runs of a plough, turning the furrow down-hill, followed by provision of stops be hand to prevent water running to the lowest point and breaching them. These can be very effective in restraining erosion during the period between completing cultivation and full establishment of a legume cover. Bunds can sometimes be enlarged on slopes to form planting platforms.

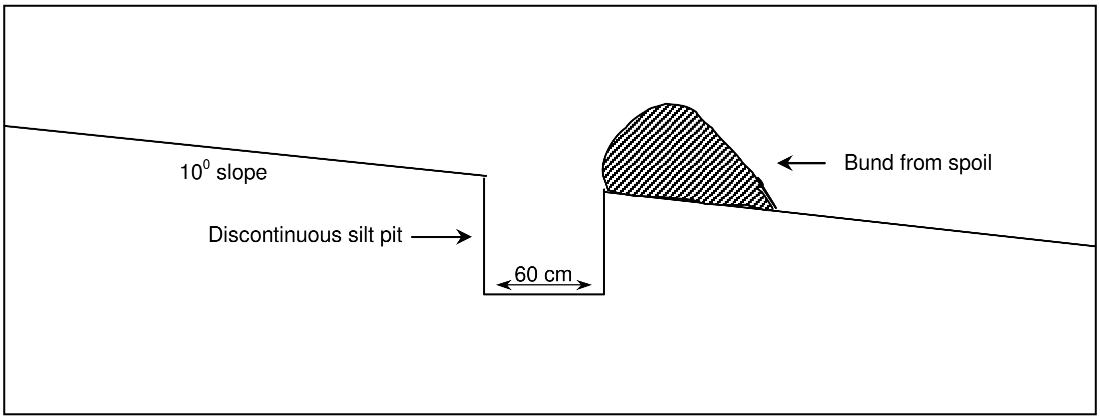


Figure B1.4.2 : Diagram of silt pit and bund construction

B1.4.2 Legume Inter-row Cover

Apart from legumes, few plants significantly improve the soil and palm nutrient status through their cycle of growth death and decay. Non-legumes do contribute organic matter to the soil but very little nitrogen and their decomposition can lead to an adverse carbon : nitrogen ratio and severe problems of nitrogen availability in soils. Legume covers require phosphate application needed for modulation and nitrogen faxation. Endotrophic mycorrhiza of vesicular-arbuscular type found in some legume species enhance phosphorus utilisation present in the soil.

Benefits of a legume inter-row cover

The benefits of inter-row legume covers are both well-proven and widely recognised. They contribute substantial quantities of nitrogen and deposit a soft organic mulch which markedly improves the structure of the top soil. The quantity of nitrogen fixed by leguminous cover crops ranged from 200 to 500 kg/year. In addition other nutrients are recycled and leaching losses are significantly reduced. Release of nutrients from the legume takes place largely over the period 24 to 30 months after field planting the palms which coincides with a period of rapid palm root and frond development. An additional benefit of legumes is obtained from the accelerated rotting of timbers and other crop debris when covered by legumes. This not only releases additional nutrients and humus faster but also improves access for routine maintenance and shortens the period over which such materials become sources of infection for diseases such as basal stem rot disease. Increased soil nitrogen and decreased soil temperature have a strong positive influence on the root development of young palms. For maximum benefit the legume should be established before field planting of palms.

Mucuna bracteata : This is a creeper legume, initially slow developing but becoming very vigorous. Unpalatable to cattle and resistant to pests because of high levels of phenolic compounds. Produces large volumes of biomass which are slower to decompose than most legumes. Such mulch has been claimed to suppress the growth of *Ganoderma* pathogen which is the causal agent for basal stem not disease. It does not seed in the lowland tropics. Good draught and shade tolerance and deep rooting to 2 to 3m. Planted 0.075 kg/ha, as polyplants or planted as cuttings raised in small polybags and keeping them free from competition in a 1m surrounding zone after planting. Requires purifying during the first three months but thereafter, it smothers other species. Monthly weeding of palm circles is needed. After 3 years, 8 to 10 t/ha dry matter are produced. Rock phosphate is needed after 8 and 14 months at 50 and 100 kg/ha respectively.

Establishment

Under Sabah conditions *Mucuna bracteata* is recommended. The sowing rate is 0.12 kg/ha. It is essential to carry out germination test to make sure that it is at least 80%. The seeds are mixed with inoculum at the rate of 10 gm rhizobium compost to 10 kg seed and twice as much natural phosphate fertilizer before sowing. Inoculation will ensure modulation which will enhance nitrogen fixation.

- Sowing is done immediately after strip clearing at the rate of 9 kg / ha. In mechanically windrowed area a line of seed should be drilled as close as possible to the windrow on each side of the stack. In the cleared inter-row, 3 to 5 drills can be made length wise along the row. No drill should be closer than 1.5 m to the planting row.

It is worth while pocketing some seed manually inside the windrow to help obtain a quick cover. Where spraying is required one round before sowing will suffice.

Desmodium ovalifolium is used as leguminous cover for areas with slopes of more than 15° as it is able to control erosion better. It is a low-growing semi-shrubby plant. Not a very successful general legume cover but useful for stabilising drain banks and terrace edges. Fair to good shade tolerance. Slow to establish, but ultimately producing a large biomass. The very small seeds are sown at up to 0.5 kg/ha.

B1.5 SOCIO-ECONOMICS ENVIRONMENT

B1.5.1 Objectives

The analysis for the socio-economics was conducted with the following objectives:

- To produce a basic profile of the communities within the zone of impact.
- To assess the effects on human environment of the potentially adverse impacts arising from the proposed Project including the implications of people from other regions moving into the area during the construction and operation phase of the project and possible effects on water catchments and water supply for communities within and at the surrounding of the Project area.
- To assess the people's perception and acceptance of the proposed Project.
- To provide recommendations to Project Proponent for minimising negative Project impacts.

B1.5.2 Activities Performed

As part of the socio-economic study, a number of activities were carried out. The activities consisted of literature review (including previous SEIA of the area, 2001) and desk study, topographic and land use map analysis to identify affected settlements combined with site visit and fieldwork, including on the ground field observations and interview of affected population. Areas of interest were prioritised based on the location of the Project sites. The focus of the field observations was on areas where risks to human health and the environment were expected, including inhabited areas, drinking water sources and agricultural areas.

Collection of baseline socio-economic data was undertaken for settlements located nearest to the Project sites[B1]. Interviews constitute an important source of information about the environmental and social impacts of the project as well as assisted in baseline data collection and verifying information.

Stakeholders and affected parties raised a number of issues and concerns regarding the proposed project. Issues pertinent to the study are the following:

- Impact of estate workers on the environment.
- Dependency of local villagers on the river and forest resources within and adjacent to the proposed oil palm plantation.
- Influx of foreign workers into the area.
- Safety and security, including concern regarding illegal accesses onto the area, illegal hunting and safety risk to public road-user.
- Pressure on existing infra-structure, facilities and amenities.

[B1] Visit/revisiting of the Project areas including logging area/plantation area, Luasong Forestry Centre (LFC), Kg. Harapan Baru Mukandut now known as Kpg. Fajar Harapan Luasong, some timber camps within the Project area and related infrastructure, settlements and oil palm plantation adjacent to the Project area including Kalabakan, Brantian, FELDA Umas-Umas, Sabah Softwood and related infrastructure.

- Employment opportunities, including the number of jobs to be created by the proposed project and the use of local labour during the construction phase.

B1.5.3 BOD Estimation

The population increase due to the Project will further increase the BOD load.

The increase of BOD estimation was made for the oil palm plantation (OPP), industrial tree plantation (ITP) and natural forest enrichment (NFE). The estimated number of employment is 9,649 for OPP, and 649 for ITP.

For Oil Palm Plantation:

BOD Loading

Total PE	=	9,649					
BOD concentration	=	225	mg/l				
BOD after treatment (standard B)	=	50	mg/l				
BOD after treatment (standard A)	=	20	mg/l				
Sewage discharge per person	=	227	l/d				
Total Sewage Discharge per day	=	227	l/d	x	9,649		
	=	2,190,323	l/d				
a) Amount BOD discharge per day without treatment	=	2,190,323	l/d	x	225	mg/l	
	=	492,822,675	mg/d				
	=	**492.82268**	**kg/d**				
b) Amount BOD discharge after treatment (standard B)	=	2,190,323	mg/d	x	50	mg/l	
	=	109,516,150	mg/d				
	=	**109.51615**	**kg/d**				
c) Amount BOD discharge after treatment (standard A)	=	2,190,323	mg/d	x	20	mg/l	
	=	43,806,460	mg/d				
	=	**43.80646**	**kg/d**				
Assumed River Flowrate	=	2.10E+09	m^3/sec				
Instantaneous increase for (a)	=	492.82268 / 2.1E+09	kg/d / cu-m/sec	x	1 / 86400	sec	
	=	2.716E-12	kg/cu-m				
	=	**2.716E-09**	**mg/l**				
Instantaneous increase for (b)	=	109.51615 / 2.1E+09	kg/d / cu-m/sec	x	1 / 86400	sec	

	=	6.036E-13	kg/cu-m			
	=	**6.036E-10**	**mg/l**			
Instantaneous increase for (c)	=	43.80646 / 2.1E+09	kg/d / cu-m/sec	x	1 / 86400	sec
	=	2.414E-13	kg/cu-m			
	=	**2.414E-10**	**mg/l**			

For Industrial Tree Plantation:

BOD Loading

Total PE	=	649				
BOD concentration	=	225	mg/l			
BOD after treatment (standard B)	=	50	mg/l			
BOD after treatment (standard A)	=	20	mg/l			
Sewage discharge per person	=	227	l/d			
Total Sewage Discharge per day	=	227	l/d	x	649	
	=	147323	l/d			
a) Amount BOD discharge per day without treatment	=	147323	l/d	x	225	mg/l
	=	33147675	mg/d			
	=	**33.147675**	**kg/d**			
b) Amount BOD discharge after treatment (standard B)	=	147323	mg/d x		50	mg/l
	=	7366150	mg/d			
	=	**7.36615**	**kg/d**			
c) Amount BOD discharge after treatment (standard A)	=	147323	mg/d x		20	mg/l
	=	2946460	mg/d			
	=	**2.94646**	**kg/d**			
Assumed River Flowrate	=	2.10E+09	m^3/sec			
Instantaneous increase for (a)	=	33.147675 / 2100000000	kg/d / cu-m/sec	x	1 / 86400	sec
	=	1.82692E-13	kg/cu-m			
	=	**1.82692E-10**	**mg/l**			
Instantaneous increase for (b)	=	7.36615 / 2100000000	kg/d / cu-m/sec	x	1 / 86400	sec

$$= 4.05983E\text{-}14 \quad kg/cu\text{-}m$$

$$= \mathbf{4.05983E\text{-}11 \quad mg/l}$$

$$\text{Instantaneous increase for (c)} = \frac{2.94646 \quad kg/d}{2100000000 \quad cu\text{-}m/sec} \times \frac{1}{86400 \quad sec}$$

$$= 1.62393E\text{-}14 \quad kg/cu\text{-}m$$

$$= \mathbf{1.62393E\text{-}11 \quad mg/l}$$

B1.6 GREEN HOUSE EFFECT

B1.6.1 IPCC Guidelines for National Greenhouse Gas (GHG)

The IPCC Guidelines for National Greenhouse Gas (GHG) Inventories are approved internationally and developed through an international process which has included:

- wide dissemination of drafts and collection of comments from national experts;
- testing of methods through development of preliminary inventories;
- country studies which ensure that methods are tested in a wide variety of national contexts;
- technical and regional workshops;
- informal expert groups convened to recommend improvements on specific aspects of the methodology.

The IPCC Guidelines were first accepted in 1994 and published in 1995. The United Nations Framework Convention on Climate Change Third Conference of Parties, COP3 held in 1997 in Kyoto reaffirmed that the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories should be used as "methodologies for estimating anthropogenic emissions by sources and removals by sinks of greenhouse gases".

The Revised 1996 IPCC Guidelines contain three volumes, each of which provides assistance to the analyst in the preparation of national GHG inventories. As this study only estimates the greenhouse gas emission/uptake of a forest conversion or land use change project, only the second and third volumes are required. These volumes contain step-by-step instructions for calculating emissions of carbon dioxide (CO_2) and methane (CH_4), as well as some other trace gases, from six major emission source categories/activities, including forestry and land use change.

B1.6.2 Methodology

The following methodology was employed to compute the net carbon dioxide balance resulting from activities of the project.

i. The total amount of dry matter in above ground biomass (existing biomass stock) is calculated based on the type of existing forest at the project site, the size of the forest and default values provided by the IPCC document for the type of existing forest.

ii. As the existing forest is cleared, the rate and method of clearing and the disposal method are defined. Based on these information, the rate of carbon released is computed.

iii. As the cleared forest will be replanted with oil palm and industrial trees, the rate of replanting of the oil palm and tree species and the use of the new tree species are defined. Based on these factors, the amount of carbon removed or emitted are computed.

iv. Carbon accumulation by the conservation areas of natural forest is included in the computation of the carbon dioxide balance (natural regeneration of forest).

v. In addition to the above computations which account for above ground carbon stock changes, the emission or uptake by soil from land use change and management practice is also included in the overall carbon stock balance.

vi. Finally the net carbon removed from the atmosphere or emitted into the atmosphere over a period of time (20 years) is computed and this is then converted to the amount of carbon dioxide.

The carbon dioxide inventory for each year for a period of 20 years is computed and presented as well.

B1.6.3 Computation

The amount of carbon emitted into or removed from the atmosphere were computed based on data provided by the project proponent.

In instances where no data was available, default values from the IPCC Guidelines were used in the calculations.

The carbon dioxide balance were computed for a total project area of 109,600 hectares, of which 80,000 hectares will be planted with oil palm and the remaining 29,600 hectares left to regenerate. The following are the conversion and planting schedule used in the carbon dioxide inventory study;

Year	New Oil Palm Area (hectare)	Oil Palm Area (hectare)	Forested Area (hectare)
2004	0	0	109,600
2005	2,500	2,500	107,100
2006	9,000	11,500	98,100
2007	16,300	27,800	81,800
2008	21,800	49,600	60,000
2009	21,900	71,500	38,100
2010	8,500	80,000	29,600
2011	0	80,000	29,600

Information and values which were used in the computation are:

i. Project location: District of Tawau.

ii. Project area: 109,600 hectares.

iii. Present forest type at the Project site: Logged over forest with above ground biomass of 185 tons biomass dry matter per hectare (IPCC, 1996, Workbook, Page 5.14, Table 5-5).

iv. Replanted tree specie: oil palm

v. Annual increment in biomass for oil palm: 6 tons biomass dry matter per hectare per year (Prasad S, et .al.)

vi. Annual average above ground biomass growth by natural regeneration of forest: 9 tons biomass dry matter per hectare per year and 2 tons per hectare per year for matured forest, after 20 years (IPCC, 1996, Workbook, Page 5.22, Table 5-8).

vii. Carbon fraction of biomass dry matter: 0.5 (IPCC, 1996, Workbook, Page 5.5, item No.7)

viii. Computation cycle: 20 years beginning with 2005

ix. Harvest method: Clear felling.

x. Disposal method of wood waste: Zero burning, natural decay.

xi. End use of harvested timber: building materials and disposed in landfills

xii. Carbon dioxide emitted from organic soils converted to agriculture (oil palm) and based on the top 30 cm of soil only (IPCC, 1996, Workbook, Page 5.23). This is because this layer typically has the highest concentration of carbon and greatest response to changes in management and land use.

Harvested wood releases its carbon at rates dependent upon its method of processing and its end-use, waste wood in this case is left to decay and was estimated to oxidise in roughly a decade (IPCC, 1996, Reference Manual, Page 5.31) and in building, the end product of the timber decays in approximately 10 years (IPCC, 1996, Reference Manual, Page 5.17, Box 5, The Fate of Harvested Wood).

The climate at the project site was defined as tropical, moist with short dry season, mean average temperature of above 20 C and annual precipitation between 1000 and 2000 mm. This is based on meteorological data from the Tawau Meteorological Station (IPCC, 1996, Workbook, Page 5.37, Item No. 8).

To account for carbon emitted or removed by the soil due to land use change and management practice, the following data and factors were used;

i. Carbon content under native vegetation for tropical moist with short dry season region and low activity soil: 60 tons carbon/hectare (IPCC, 1996, Workbook, Page 5.26, Table 5-9)

ii. Base factor: 0.6

iii. Tillage factor: 1.0 (reduced tillage)

iv. Input factor: 1.0 (neutral)

The above inputs (ii), (iii) and (iv) are based on factors given in the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Workbook, Page 5.27, Table 5-10. The base factor typically represents changes in soil organic matter associated with conversion of the native vegetation (forest) to agricultural use (oil palm planting). Tillage and input factors account for effects of various management practices of lands in agricultural use.

The results of the analysis are presented in **Section 4.10.3**.

B1.7 LABORATORY REPORTS

The following attached reports are:

1. Water quality analysis report

   Water quality of the area was assessed based on grab samples analyzed in-situ and in an ISO/IEC G25 accredited laboratory.

2. Proposed National Water Quality Standards for Malaysia.
3. Air Quality report
4. Soil Test Report
5. Noise Level Measurement
6. Environmental Quality (Sewage & Industrial Effluents) Regulations 1979

B1.8 HECRAS MODELING DATA

1. Sg. Kalabakan – HECRAS Modeling Data
2. Sg. Brantian – HECRAS Modeling Data

B1.9 ENVIRONMENTAL COST AND BENEFIT

B1.9.1 Assumptions for Oil Palm Plantation Yields and Prices

The two key drivers to plantation segment's earnings are production volume and CPO prices. The production estimate is based on average annual yield per ha for oil palm throughout the life cycle of the palms.

B1.9.2 Overview of Malaysian Palm Oil Industry 2004

The Malaysian oil palm industry recorded an impressive performance in 2004. The industry continued to contribute significantly to the country's economic development and foreign exchange earnings. Export earnings of oil palm products rose to RM 30.41 billion despite facing strong competition from other palm oil producing countries and unfavourable tariff treatment in some markets.

The total oil palm planted area increased by 1.9% or 73,000 hectares to 3.87 million hectares in 2004, mainly in Sabah and Sarawak. Sabah remained the largest oil palm planted state with 1.2 million hectares.

The production of crude palm oil soared to the highest level in the Malaysian oil palm industry's history, increasing by 4.7% or 0.63 million tonnes to 13.98 million tonnes from 13.35 million tonnes in 2003. The increase was mainly attributed to the large expansion in matured areas, as well as improvement in the oil extraction rate from 19.75% in 2003 to 20.03% in 2004. However, the production of crude palm kernel oil was down marginally by 0.1% to 1.64 million tonnes. Likewise, the fresh fruit bunches yield per hectare also declined, by 2.1% to 18.60 tonnes from 18.99 tonnes in 2003 due to the dry period encountered in the early part of 2004, coupled with lower yield from newly replanted areas coming into maturity.

The total exports of oil palm products, constituting palm oil, palm kernel oil, palm kernel cake, oleochemicals and finished products increased marginally by 3.1% to 17.35 million tonnes in 2004 from 16.82 million tonnes in 2003. Total export value showed an increase of 16.0% or RM 4.18 billion to RM 30.41 billion compared to RM 26.23 billion in 2003. Total export revenue for all the oil palm products, however, showed an increase compared to the previous year, with finished products and oleochemicals registering the largest increase of 58.4% and 30.5% respectively. This was due to higher palm oil prices, especially during the first quarter of the year.

Palm oil export increased by 2.5% to 12.58 million tonnes in 2004 from 12.27 million tonnes in 2003. P.R. of China maintained its position as the biggest market for Malaysian palm oil, with export totalling 2.80 million tonnes. The European Union came in second, accounting for 1.97 million tonnes, followed by Pakistan with 0.95 million tonnes and India 0.94 million tonnes. However, in the case of India, its intake of Malaysian palm oil declined by 41% or 652,584 tonnes mainly attributed to the tariff preference for CPO.

The export of oleochemicals increased from 1.57 million tonnes in 2003 to 1.77 million tonnes in 2004. The major oleochemical products exported were fatty acids (0.77 million tonnes or 43.4% of oleochemicals exports), fatty alcohols (0.33 million tonnes), methyl-esters (0.20 million tonnes), glycerines (0.20 million tonnes) and soap noodles (0.18 million tonnes).

The major markets for oleochemicals were the European Union (0.51 million tonnes), China, P.R (0.25 million tonnes), Japan (0.21 million tonnes) and USA (0.21 million tonnes).

The average prices of oil palm products sustained its upward trend in 2004, influenced mainly by supply tightness, especially during the first half of the year, moderate export growth and strength of soyabean oil prices in the world market. The average CPO price increased by 4.3% to RM1,610. The highest CPO daily traded price was RM 2,030, while the lowest was RM1,380. Subsequently, the average export price for RBD palm oil rose by 3.9% to RM1,676; RBD palm olein up by 3.4% to RM1,752; and RBD palm stearin increased by 9.5% to RM1,532. The average price of palm kernel and crude palm kernel oil performed even better, rising by 45% to RM 1,063 and RM 2,306 respectively owing to supply tightness and higher lauric oil prices in the world market.

The projected slow growth in domestic production and steady export demand is expected to reduce the impact of a slight recovery in world oils and fats supply situation and higher local palm oil carry-over stocks. This is expected to mitigate the pressure on local CPO price in 2005. On the production front, CPO production is projected to increase marginally to 14.24 million tonnes.

B1.9.3 Yield

Palm oil is extracted from the mature fresh fruit bunches (FFBs) of oil palm plantations. One hectare of oil palm yields approximately 20 tonnes FFBs, which when crushed yields 6 tons of oil (including the kernel oil, which is used both for edible and industrial purposes). Crude Palm Oil (CPO), Crude Palmolein, RBD (refined, bleached, deodorized) Palm Oil, RBD Palmolein and Crude Palm Kernel Oil (CPKO) are the various edible forms of palm oil traded in the market. While Oil is the stable derivative (saturated fat, solid at room temperature) of fresh fruit crushed, Olein is relatively unstable (unsaturated fat, liquid at room temperature, but low cholesterol).

B1.9.4 Projected Yield in Project Area

The projected yield in the project area compared to a low, average and high projection scenario for Sabah on average is presented in **Tables B1.33 and B1.34**. The FFB yield in tonnes per ha is estimated to increase gradually to a maximum of 28 Tonnes before declining to 22 tonnes in year 21 to 25. Details are shown in the Tables Section of this chapter.

B1.9.5 Prices

The Kuala Lumpur-based Malaysian Derivatives Exchange (MDEX) could be considered as the 'price maker' of oilseed and edible oils traded World over. This Futures Exchange trades only in CPO.

Prior to the crisis, prospects for the Malaysian oil palm sub-sector looked extremely promising and all three producer groups, particularly the private sector, were expected to rapidly expand for several reasons. First, the CPO production process in Malaysia is highly efficient due to the relatively high yield obtained from trees[B2] and the potential to harvest trees throughout the year. These factors, combined with low imported labour costs, favourable climate and soil conditions, resulted in lower production costs than for other edible oils. Malaysia is, therefore, one of the most cost-efficient countries in the world for the establishment of oil palm plantations (**Table B1.32**).

Table B1.32: Comparison of CPO production costs, 1997

US$ per tonne	Colombia	Côte d'Ivoire	Indonesia	Malaysia	Nigeria	World Average
Establishment	71.2	69.5	64.3	60.7	224.5	72.1
Cultivation	91.2	136.1	72.5	75.7	113.7	79.3
Harvesting/ transport	78.9	33.8	40.2	45.1	90.7	47.3
Milling costs	106.1	105.3	82.6	98.3	130.7	96.6
Kernel milling costs	6.9	7.7	7.2	7.6	8.2	7.5
Kernel oil and meal credits	(58.2)	(54.0)	(60.0)	(61.9)	(65.6)	(61.5)
Total	**296.1**	**298.4**	**206.8**	**225.5**	**502.2**	**241.3**

Source: PT Purimas Sasmita (1998)

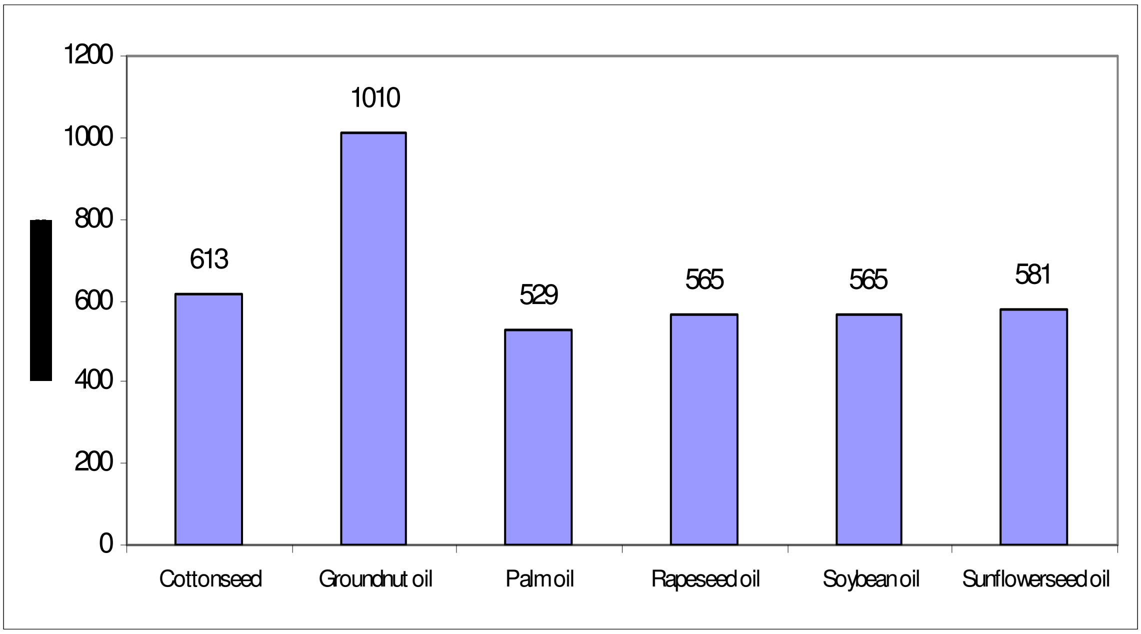
Second, from an investor's perspective, the domestic and international markets for crude palm oil still look promising. Before the economic crisis hit South-East Asia, palm oil was projected to replace soybean oil as the world's most consumed oil by the year 2000[B3]. Growth in global demand for palm oil was attributed to world population growth and rising spending power. There had been an increasing preference for CPO over other edible oils

[B2] In 1997, Malaysia's oil palm trees produced an average of 3.68 3.37 tonnes per hectare. This is slightly higher than the Indonesian average of 3.37 million tonnes per hectare and higher than the world average of 3.21 tonnes per hectare (Oil World, July 1997, p251).

[B3] Danareksa Sekuritas, Plantation Sector Review 1998: 2.

because it was cheaper than other vegetable oils such as soybean and rapeseed oils prior to 1998 (**Figure B1.9.1**).

Figure B1.9.1: Year-end 1997 global vegetable oil price comparison



Source: Oil World, 8 January 1998.

On the international market, the compound average growth rate of palm oil consumption was the highest among vegetable oils and all major categories of oils and fats since 1992. Between 1992 and 1997, global demand for palm oil grew around 7 percent per annum, followed by soybean oil at 5 percent while other vegetable oils grew less than 4 percent per annum (Goldman Sachs 1998: Most of this palm oil was consumed in Asia, primarily by Indonesia, China, India, Malaysia and Pakistan. This is mainly because of the type of food characteristic of the region, which is usually fried.

B1.9.6 Cost Estimate

The cost estimate is divided into development costs and operating costs as well as external costs and benefits. The cost estimate will be prepared for the entire development rather than each individual developer. The development costs and annual recurrent cost will be estimated based on average costs per ha while major capital costs will be based on average cost for a plantation unit of 2,500 ha.

B1.9.7 Development Costs

The development costs related to the establishment of the oil palm plantation are divided into several components and cover one or more years during the establishment. Typical cost elements and timing of the costs are shown below:

Major Development Works (RM)

Description	Year 1	Year 2	Year 3	Year 4
Land preparation:				
Survey and blocking	100			
Felling, clearing, stacking and windrowing	1500			

Description	Year 1	Year 2	Year 3	Year 4
Terracing	600			
Establishment of cover	370			
Infrastructure:				
Agricultural roads	400		380	380
Drains and bridges	390			
Crop Establishment:				
Lining/holing/planting	204			
Oil palm seed costs	680			
Pest and diseases 1)	120			
Contingencies:	150		100	100
Weeding Costs 2)		240	210	180
Fertiliser Programme 3)				
Pests and disease control 4)		200	200	200
Supply of palms		45	25	15
Harvesting / Transportation of FFB 5)			34	32

Notes:

- 1): Year 1 considered development, while following years are considered maintenance
- 2): RM 100 / Ha for year 5 and 6.
- 3): Separate table
- 4): RM 30 / Ha for year 5 and above
- 5): RM 28 in year 5, RM 27 in year 6 and RM 27 in subsequent years

B1.9.8 Recurrent Administrative Costs

General recurrent costs include management services, staff emoluments, welfare and amenities, insurance, upkeep of buildings, vehicle running costs, office expenses and other incidental costs. These costs have been estimated based on present figures for typical average costs per Ha available for Sabah. The salary costs are calculated for a typical phase of 2,500 ha to be RM 576,000 per year or RM 230.40 per Ha per year. The administrative / management costs per ha per year is estimated to be RM 250.

B1.9.9 Capital Costs for Plantation

The capital cost is divided into buildings, estate machinery and vehicles and palm oil mill. These costs have been estimated based on present figures for typical average costs per Ha available for Sabah.

Buildings

Total building costs per 2,500 ha phase is estimated to be RM 1,470,000.

Estate machinery and vehicles

Total costs of estate machinery and vehicles per 2,500 ha phase is estimated to be RM 2,609,000.

B1.9.10 Costs for Palm Oil Mill

The capital cost of a palm oil mill with a capacity of 45 tons / hour is estimated to be RM 18 million, while upgrading of the capacity from 45 to 60 tons / hour is estimated to be RM 8 million.

The buildings and housing for a mill is estimated to be RM 1.765 million while capital cost of water sourcing and treatment is estimated to be RM 0.22 million.

The estimated annual cost of maintenance and upkeep of one mill is estimated to be RM 0.25 million.

The total capital cost and annual maintenance and upkeep cost is calculated based on the approximate number of mills required each year during the study cycle. The economic analysis is based on the assumption that the FFB will be sold directly to other mills throughout the study period and therefore no costs have been included in the analysis.

An alternative analysis could be made which include the investment and annual costs of the palm oil mills. The benefits in this case would change from revenue from FFB to revenue from the revenue from Crude Palm Oil and Palm Kernel.

Table B1.33: Malaysian Statistics, Yield of Fresh Fruit Bunches, Crude Palm Oil and Palm Kernel, 1975 - 2003 (tonnes/hectares)

Year	Fresh Fruit Bunches	Crude Palm Oil	Palm Kernel
1975	17.95	3.66	0.74
1976	16.16	3.48	0.71
1977	16.32	3.54	0.74
1978	16.25	2.95	0.68
1979	17.76	3.65	0.79
1980	18.72	3.78	0.81
1981	19.16	3.76	0.79
1982	19.50	3.83	0.80
1983	17.45	3.43	0.72
1984	21.80	4.25	1.19
1985	22.15	4.33	1.28
1986	22.15	4.41	1.28
1987	17.10	3.39	1.01
1988	17.52	3.47	1.04
1989	19.57	3.88	1.15
1990	18.53	3.64	1.10
1991	17.85	3.48	1.01
1992	17.83	3.43	0.99
1993	20.26	3.78	1.16
1994	18.42	3.43	1.05
1995	18.93	3.50	1.08
1996	18.95	3.55	1.06
1997	19.10	3.63	1.06
1998	15.98	3.02	0.86

1999	19.26	3.58	1.03
2000	18.33	3.46	1.01
2001	19.14	3.66	1.05
2002	17.95	3.58	0.98
2003	18.99	3.75	1.02

Source: Department of Statistics, Malaysia : 1975 - 1986, MPOB : 1987 - 2003

Table B1.34 : Average Oil Yield Hectare for Oil Palm Estates: 2003 (tonnes)

State	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
Johor	0.24	0.22	0.27	0.31	0.32	0.33	0.33	0.34	0.35	0.30	0.26	0.32	3.60
Kedah	0.20	0.25	0.34	0.35	0.37	0.37	0.35	0.31	0.30	0.23	0.18	0.21	3.48
Kelantan	0.19	0.14	0.20	0.27	0.30	0.31	0.31	0.30	0.32	0.29	0.23	0.23	3.10
Malacca	0.29	0.32	0.40	0.44	0.50	0.49	0.46	0.43	0.40	0.36	0.27	0.32	4.65
N. Sembilan	0.22	0.26	0.34	0.36	0.36	0.35	0.36	0.36	0.34	0.28	0.21	0.24	3.68
Pahang	0.20	0.19	0.26	0.30	0.32	0.34	0.36	0.36	0.36	0.31	0.25	0.29	3.53
Penang	0.20	0.25	0.32	0.37	0.41	0.37	0.36	0.29	0.26	0.19	0.18	0.21	3.44
Perak	0.30	0.28	0.33	0.33	0.35	0.37	0.41	0.41	0.38	0.32	0.25	0.34	4.07
Selangor	0.26	0.27	0.33	0.33	0.35	0.35	0.37	0.37	0.36	0.30	0.25	0.30	3.84
Terengganu	0.17	0.14	0.18	0.21	0.22	0.24	0.25	0.26	0.27	0.25	0.19	0.22	2.59
P. Malaysia	0.23	0.22	0.28	0.31	0.32	0.34	0.35	0.35	0.35	0.30	0.25	0.29	3.57
Sabah	0.32	0.25	0.31	0.35	0.39	0.40	0.41	0.44	0.45	0.44	0.42	0.39	4.56
Sarawak	0.21	0.17	0.19	0.19	0.19	0.22	0.25	0.28	0.29	0.26	0.23	0.25	2.75
Sabah/Sarawak	0.29	0.23	0.28	0.31	0.34	0.35	0.36	0.40	0.40	0.38	0.37	0.35	4.05
MALAYSIA	0.25	0.22	0.27	0.30	0.33	0.34	0.35	0.37	0.37	0.33	0.29	0.32	3.75