APPENDIX VII

ENVIRONMENTAL ANALYSIS

ANNEX A.7.1 ENVIRONMENTAL QUALITY ACT 1974

ENVIRONMENTAL QUALITY (PRESCRIBED ACTIVITIES)
(ENVIRONMENTAL IMPACT ASSESSMENT) ORDER 1987

In exercise of the powers conferred by section 34A of the Environmental Quality Act 1974, the Minister, after consultation with the Environmental Quality Council, makes the following order:

1. This Order may be cited as the Environmental Quality (Prescribed Activities) (Environmental Impact Assessment) Order 1987 and shall come into force on the 1st April 1988.
2. The activities specified in the Schedule are prescribed to be prescribed activities.

SCHEDULE

1. AGRICULTURE
   - (a) Land development schemes covering an area of 500 hectares or more to bring forest land into agricultural production.
   - (b) Agricultural programmes necessitating the resettlement of 100 families or more.
   - (c) Development of agricultural estates covering an area of 500 hectares of more involving changes in type of agricultural use.

2. AIRPORT
   - (a) Construction of airports (having an airstrip of 2,500 meters or longer).
   - (b) Airstrip development in state and national parks.

3. DRAINAGE AND IRRIGATION
   - (a) Construction of dams and man-made lakes and artificial enlargement of lakes with surface areas of 200 hectares or more
   - (b) Drainage of wetland, wildlife habitat or virgin forest covering an area of 100 hectares or more
   - (c) Irrigation schemes covering an area of 5,000 hectares or more

4. LAND RECLAMATION

   Coastal reclamation involving an area of 50 hectares or more.

5. FISHERIES
   - (a) Construction of fishing harbors.

(b) Harbor expansion involving an increase of 50 percent or more in fish landing capacity per annum.

(c) Land based aquaculture projects accompanied by clearing of mangrove swamp forests covering an area of 50 hectares or more.

6. FORESTRY

(a) Conversion of hill forest land to other land use covering an area of 50 hectares or more.

(b) Logging or conversion of forest land to other land use with thc catchment area of reservoirs used for municipal water supply, irrigation or hydro power generation or in areas adjacent to state and national parks and national marine parks.

(c) Logging covering an area of 500 hectares or more.

(d) Conversion of mangrove swamps for industrial, housing or agricultural use covering an area of 50 hectares of more.

(e) Clearing of mangrove swamps on islands adjacent to national marine parks.

7. HOUSING

Housing development covering an area of 50 hectares or more.

8. INDUSTRY

(a) Chemical : Where the production capacity of each product or of combined products is greater than 100 tonnes/day.

(b) Petrochemicals : All sizes

(c) Non-ferrous : Primary smelting : Aluminium - All sizes, Copper - All sizes, Others : Producing 50 tonnes/day and above of product.

(d) Non metallic : Cement - for clinker throughput of 30 tonnes/hour and above. Lime : 100 tonnes/day and above burnt lime rotary kiln or 50 tonnes/day and above vertical kiln.

(e) Iron and steel : Require iron ore as raw materials for production greater than 100 tonnes/day. Or Using scrap iron as raw materials for production greater than 200 tonnes/day.

(f) Shipyards : Dead weight tonnage greater than 5000 tonnes.

(g) Pulp and paper industry - Production capacity greater than 50 tonnes/day.

9. INFRASTRUCTURE

(a) Construction of hospitals with outfall into beachfronts used for recreational purposes.

(b) Industrial estate development for medium or heavy industries covering an area of 50 hectares or more.

(c) Construction of expressways.

(d) Construction of national highways.

(e) Construction of new townships.

10. PORTS

(a) Construction of ports.

(b) Port expansion involving an increase of 50% or more in handling capacity per annum.

11. MINING

(a) Mining of minerals in new areas where the mining lease covers a total area in excess of 250 hectares.

(b) Ore processing including concentrating for aluminium, copper, gold or tantalum.

(c) Sand dredging involving an area of 50 hectares or more.

12. PETROLEUM

(a) Oil and gas fields development

(b) Construction of off-shore and on-shore pipelines in excess of 50 kilometers in length.

(c) Construction of oil and gas separation, processing, handling, and storage facilities.

(d) Construction of oil refineries.

(e) Construction of product depots for the storage of petrol, gas or diesel (excluding service stations) which are located within 3 kilometers or any commercial, industrial or residential areas and which have a combined storage capacity of 60,000 barrels or more.

13. POWER GENERATION AND TRANSMISSION

Dams and hydroelectric power schemes with either or both of the following :

(a) Dams over 15 meters high and ancillary structures covering a total area in excess of 40 meters.

(b) Reservoirs with a surface area in excess of 400 hectares.

14. QUARRIES

Proposed quarrying of aggregate, limestone, silica, quartzite, sandstone, marble and cooperative building stone within 3 kilometers of any existing residential, commercial, or industrial or any area for which a license permit or approval has been granted for residential, commercial or industrial development.

15. RAILWAYS

(a) Construction of new routes

(b) Construction of branch lines

16. TRANSPORTATION

Construction of Mass Rapid Transport projects

17. RESORT AND RECREATIONAL DEVELOPMENT

(a) Construction of coastal resort facilities or hotels with more than 80 rooms.

(b) Hill station resort or hotel development covering an area of 50 hectares or more

(c) Development of tourist or recreational facilities in national parks.

(d) Development of tourist or recreational facilities on islands in surrounding waters which are gazetted as national marine parks.

18. WASTE TREATMENT AND DISPOSAL

(a) Toxic and Hazardous Waste

(i) Construction of incineration plant

(ii) Construction of recovery plant (Off-site)

(iii) Construction of wastewater treatment plant (Off-site)

(iv) Construction of secure and landfill facility

(v) Construction of storage facility(Off-site).

(b) Municipal Solid Waste

(i) Construction of incineration plant

(ii) Construction of composting plant

(iii) Construction of recovery recycling plant

(iv) Construction of incineration plant

(v) Construction of municipal solid waste landfill facility

(c) Municipal Sewage

(i) Construction of wastewater treatment plant

(ii) Construction of marine outfall.

19. Water Supply

(i) Construction of dams or impounding reservoirs covering an area of 200ha or more.

(ii) Groundwater development for industrial, agricultural or urban water supply of greater than 4,500 cubic meters per day.

TABLE A.7.2 STATUS OF RIVER WATER QUALITY IN TERMS OF RIVER WATER QUALITY INDEX, 1991

STATE	WQR	River Name	WQI	Status
PERLIS	1	Perlis	70	S.Polluted
KEDAH	3	Kedah	76	S.Polluted
	4	Merbok	63	S.Polluted
	5	Muda	80	S.Polluted
	6J	Juru	54	*V.Polluted*
	6P	Prai	70	S.Polluted
	7	Jejawi	61	S.Polluted
	8	Kerian	74	S.Polluted
PERAK	9	Kurau	85	**Clean**
	10	Sepetang	87	**Clean**
	11	Bruas	77	S.Polluted
	12	Raja Hitam	79	S.Polluted
	13	Perak	79	S.Polluted
	14	Bernam	75	S.Polluted
SELANGOR	15	Tengi	62	S.Polluted
	16	Selangor	80	S.Polluted
	17	Buloh	59	*V.Polluted*
FEDERAL TERRITORY (KL)	18	Kelang	56	*V.Polluted*
	19	Langat	68	S.Polluted
SELANGOR	20	Sepang	52	*V.Polluted*
NEGERI SEMBILAN	21	Linggi	66	S.Polluted
MELAKA	22	Melaka	62	S.Polluted
	23	Duyong	53	*V.Polluted*
	24	Kesang	75	S.Polluted
JOHOR	25	Muar	75	S.Polluted
	26	Batu Pahat	73	S.Polluted
	27A	Air Baloi	61	S.Polluted
	27B	Benut	70	S.Polluted
	28A	Pontian Kechil	61	S.Polluted
	28B	Pontian Besar	79	S.Polluted
	28C	Skudai	72	S.Polluted
	28D	Tebrau	77	S.Polluted
	29	Johor	73	S.Polluted
	30A	Sedili Besar	82	**Clean**
	30B	Sedili Kechil	81	**Clean**
	31	Mersing	81	**Clean**
PAHANG	32	Endau	73	S.Polluted
	33	Rompin	90	**Clean**
	34	Bebar	73	S.Polluted
	35	Pahang	85	**Clean**
	36	Kuantan	87	**Clean**
	37	Balok	69	S.Polluted
TERENGGANU	38	Kemaman	80	S.Polluted
	39	Chukai	83	**Clean**
	40	Paka	81	**Clean**
	41	Dungun	88	**Clean**
	42	Ibai	50	*V.Polluted*
	43	Terengganu	86	**Clean**
	44	Setiu	86	**Clean**
	46	Besut	77	S.Polluted
KELANTAN	47	Kemasin	74	S.Polluted
	48	Kelantan	78	S.Polluted
	49	Golok	73	S.Polluted

WQR _ Water Quality Region, WQI - Water Quality Index

Source : Environmental Quality Report, 1991

TABLE A.7.3 PROPOSED INTERIM NATIONAL WATER QUALITY STANDARDS FOR MALAYSIA

Parameters	Unit	CLASSES					
		I	IIA	IIB	III#	IV	V
BOD	mg/l	1	3	3	6	12	12
COD	mg/l	10	25	25	50	100	100
Dissolved Oxygen	mg/l	7	5-7	5-7	3-5	3	1
pH		6.5-7.5	6.5-9.0	6.5-9.0	5-9	5-9	-
Color	TUC	15	150	150	-	-	-
Electrical Conductivity	mmhos/cm	1000	1000	-	-	6000	-
Salinity	%	0.5	1	-	-	2	-
Total Dissolved Solids	mg/l	500	1000	-	-	4000	-
Total Suspended Solids	mg/l	25	50	50	150	300	300
Ammoniacal Nitrogen	mg/l	0.1	0.3	0.3	0.9	2.7	2.7
Turbidity	NTU	5	50	50	-	-	-
Faecal Coliform	Counts/100ml	10	100	400	5000	5000	
Total Coliform	Counts/100ml	100	5000	5000	5000	5000	5000

Source : Environmental Quality Report, 1991

Class I : Conservation of natural environment Water Supply I
practically no treatment is necessary.
Fishery I - Very sensitive aquatic species
Class II : Water Supply II - Conventional treatment required
Fishery II- sensitive aquatic species
Class IIB : Recreational use with body contact
Class III : Water Supply III - extensive treatment required
Fishery III - common, of economic value, and tolerant species
Class IV : Irrigation
Class V : None of the above

TABLE A.7.4 MAJOR ENVIRONMENTAL PROBLEMS OF THE SHORT LISTED PROJECTS

COD	NO	NAME OF PROJECT	DISTRICT	MAJOR ENVIRONMENTAL PROBLEM
PR	1	SIMPANG GETI	-	WATER QUALITY, IE
PR	2	PANGGAS SMALL DAM PROJECT	-	WATER QUALITY, IE
PR	4	TASEK MELATI	-	WATER QUALITY, WE
PR	5	PAYA KELUBI MANGO PROJECT	-	NO
PR	6	HUTAN LEMBAH MANGO PROJECT	-	NO
PR	7	TASEK MELATI II	-	NO
KH	3	AMPANGAN PDG SAGA	LANGKAWI	WATER QUALITY
KH	4	KAWASAN PADI KEDAWANG	LANGKAWI	NO
KH	5	KEDAWANG	LANGKAWI	NO
KH	6	P LIBALI BERKELOMPOK	KUBANG PASU	NO
KH	13	KG PDG GELANGGANG	PDG TERAP	NO
KH	14	SKIM JANING	PDG TERAP	NO
KH	15	LUBUK MERBAU	PDG TERAP	NO
KH	16	SEKIM TANDOP BESAR	PDG TERAP	NO
KH	19	KURONG HITAM IRRIGATION SCHEME	PDG TERAP	NO
KH	31	KUBUR PANJANG	PENDANG	FLOODING
KH	32	KG KAYU TIGA	PENDANG	DRAUGHT
KH	34	KG SAWA KECIK	PENDANG	DRAUGHT
KH	35	BK PERAK	PENDANG	DRAUGHT
KH	40	SG AIR JERNIH	KUALA MUDA	NO
KH	41	SG BARU	KUALA MUDA	NO
KH	43	BENDANG DALAM	KUALA MUDA	NO
KH	48	KG BETONG - P DURIAN KELOMPOK	SIK	NO
KH	49	KG KUBANG YOI	SIK	NO
KH	50	KG SELAMAT - P SAYUR + BUAHAN	SIK	NO
PP	1	LUAR BAN PINANG TUNGGAL	S PERAI UTARA	FLOODING
PP	2		S PERAI UTARA	NO
PP	3	TOK BEDU IRRIGATION AREA	S PERAI UTARA	WATER QUALITY, FE
PP	4	KG TOK BEDU, AIR MELINTAS, PMTG BE	S PERAI UTARA	WATER QUALITY, FE
PP	5	PINANG TUNGGAL IRRIGATION AREA (PI	S PERAI UTARA	NO
PP	6	SG JARAK IRRIGATION AREA	S PERAI UTARA	WATER QUALITY, FE
PP	7	BK TCH ALLANG	S PERAI UTARA	NO
PP	8	SG BURUNG	BARAT DAYA	WATER QUALITY, FE
PP	9	SG BURUNG	BARAT DAYA	WATER QUALITY, FLOODING
PP	10	MAK SULONG	S PERAI TENGAH	NO
PP	11	SG KULIM IRRIGATION SCHEME	S PERAI TENGAH	WATER QUALITY, FE
PP	12	SKIM PENGAIRAN SG KULIM	S PERAI TENGAH	NO
PP	13	SKIM PENGAIRAN TASEK SELATAN	S PERAI SELATAN	NO
PK	1	KG TASEK	HULU PERAK	SOIL EROSION,LC
PK	2	PUSAT PERT TANAH TINGGI BK BARING	HULU PERAK	SOIL EROSION,LC,LG
PK	3	INDUSTRI BUAH-BUAHAN	SELAMA	NO
PK	4	BENDANG TEMELONG	HULU PERAK	SOIL EROSION,LC
PK	5	P KELOMPOK BUAH-BUAHAN	LARUT MATANG	NO
PK	6	P KELOMPOK BUAH-BUAHAN/SAYURAN	LARUT MATANG	NO
PK	7	SENOUK CHANGKAT NING	LARUT MATANG	NO
PK	8	P KELOMPOK BUAH-BUAHAN AIR PUTIH	LARUT MATANG	WATER QUALITY,IE
PK	9	BENDANG JENALIK	KUALA KANGSAR	SOIL EROSION,LC,LG
PK	10	BENDANG KG LANEH	KUALA KANGSAR	SOIL EROSION,LC
PK	11	RANC TALIAIR BENDANG SENGGANG	KUALA KANGSAR	SOIL EROSION,LC
PK	12	RANC TALIAIR BENDANG LEMPOR	KUALA KANGSAR	SOIL EROSION,LG
PK	13	RANC TALIAIR PDG RENGAS	KUALA KANGSAR	WATER QUALITY, SE
PK	15	DENDANG A	MANJUNG	-
PK	16	DENDANG B	MANJUNG	-
PK	17	BRUAS & TAMBAHAN	MANJUNG	-
PK	19	KG LALAT BATU 7	HILIR PERAK	FLOODING
PK	20	SG BATANG PDG MATI	HILIR PERAK	NO
PK	21	SG MANIK,IRRIG SCHEME	HILIR PERAK	NO
SG	1	TEBUK BERIHUN	SABAK BERNAM	-
SG	3	SG JANG	HULU SELANGOR	NO
SG	4	BK TAMU	HULU SELANGOR	NO
SG	5	KG KALONG TENGAH	HULU SELANGOR	NO
SG	6	P SAYURAN SG YU	KUALA SELANGOR	NO
SG	8	KUANG	GOMBAK	NO
SG	9	REKREASI SG CHONGKAK	HULU LANGAT	NO
SG	10	KG KANTAN	HULU LANGAT	-
SG	11	KG PASIR	HULU LANGAT	WATER QUALITY, MN
SG	12	MINANG KABAU	HULU LANGAT	WATER SHORTAGE
SG	13	JLN ENAM KAKI 1	HULU LANGAT	-
SG	14	SAPAN BT MINANGKABAU	HULU LANGAT	NO
SG	15	SG JAI BK KEPONG	HULU LANGAT	FLOODING
SG	16	MARDI RESEARCH STATION	KELANG	NO
SG	18	TAMAN PERT MALAYSIA	PETALING	NO
SG	24	P KELOMPOK SAYURAN KG ENDAH	KUALA LANGAT	NO

TABLE A.7.4 MAJOR ENVIRONMENTAL PROBLEMS OF THE SHORT LISTED PROJECTS

COD	NO	NAME OF PROJECT	DISTRICT	MAJOR ENVIRONMENTAL PROBLEM
SG	25	P KELOMPOK KONTAN KG KUNDANG	KUALA LANGAT	NO
NS	1	STESEN MARDI JELEBU	JELEBU	NO
NS	2	BUAH-BUAHAN LANJUT MANIS	KUALA PILAH	NO
NS	3	SRI MENANTI	KUALA PILAH	SOIL EROSION, LG
NS	4	PEMBANGUNAN SAWAH KG. LONDAH	GEMAS	NO
NS	5	REMBAU	REMBAU	NO
NS	6	KELOMPOK KG CHENGKAU ULU	REMBAU	NO
NS	7	KG BK TEMBOK & SG RAYA	PORT DICKSON	WATER QUALITY
NS	8	P TERNAKAN UDANG GALAH	KUALA PILAH	NO
MA	2	ULU SG BULOH	ALOR GAJAH	NO
MA	11	SG UDANOG	MELAKA TENOGAH	WATER QUALITY, DE
MA	14	KANODANOG	MELAKA TENOGAH	WATER QUALITY, SA
MA	15	SOLOK BK META	MELAKA TENOGAH	WATER QUALITY, BW
MA	16	FELCRA BK SEDANOANO	JASINO	WATER QUALITY, SE
JR	3	SAWAH KEBUN BARU	MUAR	NO
JR	8	LDG KELOMPOK KG SRI TIMOR	KLUANG	NO
JR	9	LDG KELOMPOK BT SAMBULAN, YONG P	BATU PAHAT	NO
JR	10	LDG KELOMPOK KANGKAR MERLIMAU	BATU PAHAT	NO
JR	12	TUNJOK LAUT	KOTA TINGGI	NO
JR	14	SG CHEMARAN	KOTA TINGGI	NO
KN	1	JUBAKAR PANTAI	TUMPAT	NO
KN	4	KG BELIAN	TUMPAT	NO
KN	5	LUBOK SELEHONG	TUMPAT	NO
KN	8	BENDANG JELUTONG, KOK LANAS	KOTA BHARU	RIVER EROSION, FLOODING
KN	9	BENDANG BT TINGGI, BK CHINA	KOTA BHARU	RIVER EROSION, FLOODING
KN	10	BENDANG SOKOR, BK CHINA	KOTA BHARU	RIVER EROSION, FLOODING
KN	11	KUBANG TEBAKANG	PASIR MAS	WATER QUALITY
KN	12	BENDANG TASEK BERANGAN	PASIR MAS	NO
KN	13	TASIK PUTERA	PASIR MAS	WATER QUALITY
KN	16	BENDANG PMTG SUNKAI	PASIR PUTEH	NO
KN	24	RANC TALIAIR HILIR SAT 1	MACHANG	NO
KN	26	RANC PENGAIRAN TERASIL	TANAH MERAH	NO
KN	27	RANC PANGAIRAN GUAL IPOH	TANAH MERAH	NO
KN	35	RANC TALIAIR LEPAN AGOR	KUALA KRAI	NO
TR	1	TELABAK IRRIGATION SCHEME	BESUT	SOIL EROSION, LG
TR	3	SKIM TANAMAN PADI MARAS	KUALA TRG	NO
TR	4	P KELOMPOK SAYURAN	KUALA TRG	NO
TR	7	SALIRAN TOK JIRING	KUALA TRG	NO
TR	12	P KELOMPOK SAYURAN	KUALA TRG	NO
TR	14	P KELOMPOK SAYURAN	KUALA TRG	NO
TR	20	SKIM TANAM PADI DURIAN HAJI	MARANG	-
TR	24	P KELOMPOK SAYURAN	MARANG	NO
TR	28	P KELOMPOK SAYURAN	MARANG	NO
TR	34	LEMBAH MARANG II	MARANG	-
TR	38	P KELOMPOK SAYURAN	MARANG	NO
TR	42	P KELOMPOK SAYURAN	HULU TRG	NO
TR	44	P KELOMPOK SAYURAN	HULU TRG	NO
TR	45	P KELOMPOK SAYURAN	HULU TRG	NO
TR	50	KOLAM ABANG	DUNGUN	NO
PH	9	PAYA PAGAR SASAK	LIPIS	WATER QUALITY, SE
PH	11	P.WAU,BETONG & GEMAYAH	MARAN	NO
PH	12	PAYA JELUTUNG	MARAN	WATER LOGGING, FLOODING
PH	13	PAYA NYAK BESAR	MARAN	WATER LOGGING, FLOODING
PH	14	PAYA TING & BESAR KERTAU	MARAN	WATER LOGGING, FLOODING
PH	16	PAYA NYAK KECIL	MARAN	WATER LOGGING, FLOODING
PH	17	PAYA PDG TENGGALA	MARAN	WATER LOGGING, FLOODING
PH	19	PAYA SG LING	MARAN	WATERLOGGING
PH	20	PAYA LANTING	MARAN	WATER LOGGING, FLOODING,WQ
PH	23	PAYA PESAGI	MARAN	WATER LOGGING, FLOODING, SE
PH	24	PAYA KROT	MARAN	NO
PH	25	PAYA LDG	MARAN	WATERLOGGING

Note : Data with lines drawn accross indicates the short listed projects dropped by the states

DE - Domestic Effluent, IE - Industrial Effluent, FE - Farm Effluent, SA - Salinity, BW - Brackish Water, SE - Sediments, WE- Weeds, GE - General, LG - Logging, LC - Land Clearing

TABLE A.7.5 LIST OF DID MONITORING STATIONS FOR WATER QUALITY AND SUSPENDED SEDIMENT

State	Water Quality Station			Suspended Sediment Station		
	P.S	S.S	River Name/ Station Name	P.S	S.S	River Name/ Station Name
Perlis					*4*	*Sg. Jemeh at Titi Tampang* *Sg. Tasoh at Titi Baru* *Sg. Arau at Ldg. Tebu Felda* *Sg. Perlarit at Wang Mu*
Kedah	1		Sg. Muda at Jam. Syed Omar	1		Sg. Muda at Jam. Syed Omar
Pualau Pinang	0			0		
Perak	5	*11*	Sg. Kinta at Weir G. Tg. Tualang Sg. Perak at Jam. Iskandar Sg. Plus at Kg. Lintang Sg. Kurau at Pondok Tanjung Sg. Krian at Selama *Sg. Slim at Slim River* *Sg. Sungkai at Sungkai* *Sg. Bidor at Malayan Bidor Bhd.* *Sg. Btg. Padang at Tg. Keramat* *Sg. Cenderiang at Bt. 32 Jln. Tapah* *Sg. Kampar at Kg. Lanjut* *Sg. Raia at Keramat Pulai* *Sg. Pari at Jln. Silibin Ipoh* *Sg. Kurau at Bt. 14 Jln. Taiping* *Sg. Ijok at Titi Ijok* *Sg. Rui at Jam. Jln. Raya*	5	*9*	Sg. Kinta at Weir G. Tg. Tualang Sg. Perak at Jam. Iskandar Sg. Plus at Kg. Lintang Sg. Kurau at Pondok Tanjung Sg. Krian at Selama *Sg. Slim at Slim River* *Sg. Sungkai at Sungkai* *Sg. Bidor at Malayan Bidor Bhd.* *Sg. Btg. Padang at Tg. Keramat* *Sg. Cenderiang at Bt. 32 Jln. Tapah* *Sg. Raia at Keramat Pulai* *Sg. Pari at Jln. Silibin Ipoh* *Sg. Kurau at Bt. 14 Jln. Taiping* *Sg. Rui at Jam. Jln. Raya*
Selangor	3	*3*	Sg. Lui at Kg. Lui Sg. Selangor at Rantau Panjang Sg. Bernam at Jam. SKC *Sg. Langat at Kg. Sg. Rincing* *Sg. Selangor at Rasa* *Sg. Bernam at Tanjong Malim*	4	*4*	Sg. Langat at Dengkil Sg. Lui at Kg. Lui Sg. Selangor at Rantau Panjang Sg. Bernam at Jam. SKC *Sg. Langat at Kg. Sg. Rincing* *Sg. Semenyih at Kg. Sg. Rincing* *Sg. Selangor at Rasa* *Sg. Bernam at Tanjong Malim*
Wilayah Persekutan	5	*0*	Sg. Klang at Jam. Sulaiman Sg. Kombak at Jln. Tun Razak Sg. Batu at Sentul Sg. Klang at Lrg. Kwan Seng Sg. Anak Keroh at Taman Kepong	5	*0*	Sg. Klang at Jam. Sulaiman Sg. Kombak at Jln. Tun Razak Sg. Batu at Sentul Sg. Klang at Lrg. Kwan Seng Sg. Anak Keroh at Taman Kepong
Negeri Sembilan	2	*1*	Sg. Muar at Bt. 57 Jln. Gemas- Rompin Sg. Kepis at Jam. Kayu Lama *Sg. Linggi at Jam. Jln. Persekutan*	3	*0*	Sg. Linggi at Jam. Jln. Persekutan Sg. Muar at Bt. 57 Jln. Gemas- Rompin Sg. Kepis at Jam. Kayu Lama
Melaka	1	*1*	Sg. Melaka at Pantai Belimbing *Sg. Kesang at Chin Chin*	1	*1*	Sg. Melaka at Pantai Belimbing *Sg. Kesang at Chin Chin*
Johor	5	*5*	Sg. Parit Madirono at Weir Sg. Johor at Rantau Panjang Sg. Sembrong at Kuala Sg. Tamok Sg. Muar at Buloh Kasap Sg. Endau at Kuala Jemakah *Sg. Linggui at Ran. Tanah Jengli* *Sg. Sayong at Jam. Johor Tenggara* *Sg. Bekok at Bt. 77 Jln. Yong Peng/Labis* *Sg. Lenggor at Bt. 42, Kualang/Mersing* *Sg. Segamat at Segamat*	4	*3*	Sg. Parit Madirono at Weir Sg. Johor at Rantau Panjang Sg. Sembrong at Kuala Sg. Tamok Sg. Muar at Buloh Kasap *Sg. Linggui at Ran. Tanah Jengli* *Sg. Bekok at Bt. 77 Jln. Yong Peng/Labis* *Sg. Lenggor at Bt. 42, Kualang/Mersing*
Kelantan	4	*4*	Sg. Lebir at Kg. Tualang Sg. Kelantan at Jam. Guillemard Sg. Golok at Kg. Jenob Sg. Nenggiri at Jam. Bertam *Sg. Golok at Rantau Panjang* *Sg. Pergau at Batu Lembu* *Sg. Lanas at Air Lanas* *Sg. Galas at Dabong*	4	*5*	Sg. Galas at Dabong Sg. Kelantan at Jam. Guillemard Sg. Golok at Kg. Jenob Sg. Golok at Rantau Panjang *Sg. Nenggiri at Jam. Bertam* *Sg. Lebir at Kg. Tualang* *Sg. Pergau at Batu Lembu* *Sg. Sokor at Kg. Tegawan* *Sg. Lanas at Air Lanas*

TABLE A.7.5 LIST OF DID MONITORING STATIONS FOR WATER QUALITY AND SUSPENDED SEDIMENT

State	Water Quality Station			Suspended Sediment Station		
	P.S	*S.S*	River Name/ Station Name	P.S	*S.S*	River Name/ Station Name
Terengganu	4	*0*	Sg. Cherul at Ban Ho Sg. Kemaman at Rantau Panjang Sg. Dangun at Jam. Jeram Kenyir Sg. Chalok at Jam. Jalok	5	*0*	Sg. Cherul at Ban Ho Sg. Kemaman at Rantau Panjang Sg. Dangun at Jam. Jeram Kenyir Sg. Chalok at Jam. Jalok
Pahang	13	*3*	Sg. Rompin at Jam. Kuantan/Segamat Sg. Bera at Stn. Hutan Kemayan Sg. Triang at Jam. Keretapi Sg. Pahang at Temerloh Sg. Jengka at Jam. Kg. Awah Sg. Pahang at Lubok Paku Sg. Kuantan at Bukit Kenau Sg. Lipis at Benta Sg. Pahang at Sg. Yap Sg. Jelai at Jeram Bungor Sg. Tembeling at Kg. Merting Sg. Tekam at Lembangan Ujian A Sg. Tekam at Lembangan Ujian B Sg. Tekam at Lembangan Ujian C *Sg. Mentiga at Jam. Cini* *Sg. Lepar at Jam. Gelugur* *Sg. Tembeling at Kg. Merting*	11	*11*	Sg. Rompin at Jam. Kuantan/Segamat Sg. Bera at Stn. Hutan Kemayan Sg. Triang at Jam. Keretapi Sg. Pahang at Temerloh Sg. Pahang at Lubok Paku Sg. Kuantan at Bukit Kenau Sg. Lipis at Benta Sg. Pahang at Sg. Yap Sg. Jelai at Jeram Bungor Sg. Tembeling at Kg. Merting *Sg. Keratong at Jam.Bahau Keratong* *Sg. Serting at Jam. Padang Gudang* *Sg. Tenaglir at Jam. Jln Raya* *Sg. Keshar at Jam. Lama* *Sg. Benus at Hutan Lipur Lentang* *Sg. Mentiga at Jam. Cini* *Sg. Bentong at Jam. Kuala Marong* *Sg. Jengka at Jam. Kg. Awah* *Sg. Lepar at Jam. Gelugur* *Sg. Jelai at Kuala Medang* *Sg. Kechau at Kg. Dusun*
Total	43	*28*		43	*37*	

P.S - Principal Station   *S.S - Secondary Station*

TABLE A.7.6 SUMMARY OF ENVIRONMENTAL IMPACTS FOR SMALL RESERVOIR DEVELOPMENT FOR THE STATES IN PENINSULAR MALAYSIA BASED ON THE PRELIMINARY ASSESSMENT MATRIX

NUMBER OF PROJECTS

ENVIRONMENTAL COMPONENTS	PERLIS					KEDAH					PAULA PINANG					PERAK				
	0	1	2	3	4	0	1	2	3	4	0	1	2	3	4	0	1	2	3	4
I. PHYSICOCHEMICAL																				
1. LAND																				
(i) Change of Land use (Devastation or desertification)	5					15		1		1	8					9	3			
(ii) Soil Erosion	5					15	1	1			8					11	1			
(iii) Soil Salinization	5					16	1				8					12				
(iv) Deterioration of soil fertility	5					17					8					9	3			
(v) Others	5					17					8					12				
2. SURFACE WATER																				
(i) Water Balance					5					17	8					11	1			
(ii) Flooding	3				2	15	2				7		1			10	1	1		
(iii) Soil sedimentation	4				1	15		2			5	2		1		9	3			
(iv) Water Quality	4				1	15		2			7			1		9	3			
(v) Drainage Pattern	3				2	17					7	1				11	1			
(vi) Change in Existing Use	4				1	16				1	8					8	4			
(vii) Others	5				0	17					8					12				
3. GROUNDWATER																				
(i) Change in groundwater hydrology	5					17					8					2	10			
(ii) Water Quality	5					17					8					12				
(iii) Change in Existing Use	5					17					8					11	1			
(iv) Others	5					17					8					12				
4. ATMOSPHERE																				
(i) Atmospheric pollution	4				1	17					8					11	1			
(ii) Others	5					17					8					12				
5. NOISE																				
(i) Noise Pollution	5					17					8					12				
(ii) Others	5					17					8					12				
II. BIOLOGICAL																				
6. SPECIES AND POPULATIONS																				
(i) Terrestrial Vegetation	4				1	17					8					10	2			
(ii) Terrestrial Wildlife	5					17					8					10	1	1		
(iii) Other Terrestrial Fauna	5					17					8					10	2			
(iv) Aquatic/Marine Flora	5					17					7		1			11	1			
(v) Fish	5					17					5		1		2	10	2			
(vi) Other Aquatic/Marine Fauna	5					17					8					11	1			
7. HABITATS AND COMMUNITIES																				
(i) Terrestrial Habitats	5					17					8					11	1			
(ii) Terrestrial Communities	5					17					8					10	2			
(iii) Aquatic, Estuarine, Marine Habitats	5					17					8					11	1			
(iv) Aquatic, Estuarine, Marine Communities	5					17					8					11	1			
(v) Others	5					17					8					12				
III. HUMAN																				
8. HEALTH AND SAFETY																				
(i) Physical Safety	5					17					8					12				
(ii) Psychological Well-Being	5					15				2	8					11	1			
(iii) Outbreak of Diseases	5					17					7		1			11	1			
(iv) Others	5					17					8					12				
9. SOCIAL AND ECONOMIC																				
(i) Employment	1				4	3				14	8					9		3		
(ii) Housing	4				1	8				9	8					11	1			
(iii) Change in Way of Life	2				3	2				15	8					9	1	2		
(iv) Involuntary Settlement	5					17					8					9	3			
(v) Population Increase	4				1	16				1	8					8	3	1		
(vi) Others	5					17					8					12				
10. AESTHETIC AND CULTURAL																				
(i) Impacts on the Community					5					17	6				2	9	2	1		
(ii) Conflicts amoung communities	5					17					8					11	1			
(iii) Historic and Cultural Assets	5					17					8					12				
(iv) Others	5					17					6				2	12				

ENVIRONMENTAL COMPONENTS	SELANGOR					N. SEMBILAN					MELAKA					JOHOR				
	0	1	2	3	4	0	1	2	3	4	0	1	2	3	4	0	1	2	3	4
I. PHYSICOCHEMICAL																				
1. LAND																				
(i) Change of Land use (Devastation or desertification)	17					5					4					6				
(ii) Soil Erosion	15	2				4	1				4					6				
(iii) Soil Salinization	16	1				5					4					6				
(iv) Deterioration of soil fertility	16	1				4	1				4					5		1		
(v) Others	17					5					4					6				
2. SURFACE WATER																				
(i) Water Balance	14	3				4	1				4					6				
(ii) Flooding	14	2	1				5				4					6				
(iii) Soil sedimentation	14	2	1			4	1				4					5	1			
(iv) Water Quality	14	3				4		1			4					6				
(v) Drainage Pattern	14	1	2			1	4				4					6				
(vi) Change in Existing Use	14	2		1		5					4					5	1			
(vii) Others	15	2				5					4					6				
3. GROUNDWATER																				
(i) Change in groundwater hydrology	15	2				1				4	4					6				
(ii) Water Quality	15		2			5					4					6				
(iii) Change in Existing Use	15		2			5					4					6				
(iv) Others	17					5					4					6				
4. ATMOSPHERE																				
(i) Atmospheric pollution	16	1				5					4					6				
(ii) Others	17					5					4					6				
5. NOISE																				
(i) Noise Pollution	17					5					4					6				
(ii) Others	17					5					4					6				
II. BIOLOGICAL																				
6. SPECIES AND POPULATIONS																				
(i) Terrestrial Vegetation	16	1				5					4					6				
(ii) Terrestrial Wildlife	16	1				5					4					6				
(iii) Other Terrestrial Fauna	15	2				5					4					6				
(iv) Aquatic/Marine Flora	15	2				5					4					6				
(v) Fish	15	2				5					4					6				
(vi) Other Aquatic/Marine Fauna	17					5					4					6				
7. HABITATS AND COMMUNITIES																				
(i) Terrestrial Habitats	17					5					4					6				
(ii) Terrestrial Communities	17					5					4					6				
(iii) Aquatic, Estuarine, Marine Habitats	17					4	1				4					6				
(iv) Aquatic, Estuarine, Marine Communities	17					4	1				4					6				
(v) Others	17					5					4					6				
III. HUMAN																				
8. HEALTH AND SAFETY																				
(i) Physical Safety	17					5					4					6				
(ii) Psychological Well-Being	17					5					4					6				
(iii) Outbreak of Diseases	17					5					4					6				
(iv) Others	17					5					4					6				
9. SOCIAL AND ECONOMIC																				
(i) Employment	15	1		1		4	1				4					6				
(ii) Housing	15	1		1		1	4				4					6				
(iii) Change in Way of Life	15	2				5					4					6				
(iv) Involuntary Settlement	16	1				5					4					6				
(v) Population Increase	15	2				5					4					6				
(vi) Others	17					5					4					6				
10. AESTHETIC AND CULTURAL																				
(i) Impacts on the Community	15	2				5					4					6				
(ii) Conflicts amoung communities	15	2				1	4				4					6				
(iii) Historic and Cultural Assets	17					5					4					6				
(iv) Others	16	1				5					4					6				

ENVIRONMENTAL COMPONENTS	KELANTAN					TRENGGANU					PAHANG					PENINSULAR MALAYSIA				
	0	1	2	3	4	0	1	2	3	4	0	1	2	3	4	0	1	2	3	4
I. PHYSICOCHEMICAL																				
1. LAND																				
(i) Change of Land use (Devastation or desertification)	6	1	3		3	15					10				2	100	4	4	0	6
(ii) Soil Erosion	13					15					12					108	5	1	0	0
(iii) Soil Salinization	11		2			15					12					110	2	2	0	0
(iv) Deterioration of soil fertility	11		2			15					12					106	5	3	0	0
(v) Others	13					15					12					114	0	0	0	0
2. SURFACE WATER																				
(i) Water Balance	11		2			15					12					85	5	2	0	22
(ii) Flooding	8	1		1	3	12	2			1	5				7	84	13	3	1	13
(iii) Soil sedimentation	13					15					10				2	98	9	3	1	3
(iv) Water Quality	10	1	2			15					9				3	97	7	5	1	4
(v) Drainage Pattern	7	1	2		3	12	3				3				9	85	11	4	0	14
(vi) Change in Existing Use	11		2			14				1	12					101	7	2	1	3
(vii) Others	13					15					12					112	2	0	0	0
3. GROUNDWATER																				
(i) Change in groundwater hydrology	11		2			15					12					96	12	2	0	4
(ii) Water Quality	11		2			14	1				12					109	1	4	0	0
(iii) Change in Existing Use	10	1	2			15					12					108	2	4	0	0
(iv) Others	13					15					12					114	0	0	0	0
4. ATMOSPHERE																				
(i) Atmospheric pollution	11		2			15					12					109	2	2	0	1
(ii) Others	13					15					12					114	0	0	0	0
5. NOISE																				
(i) Noise Pollution	13					15					12					114	0	0	0	0
(ii) Others	13					15					12					114	0	0	0	0
II. BIOLOGICAL																				
6. SPECIES AND POPULATIONS																				
(i) Terrestrial Vegetation	12	1				15					12					109	4	0	0	1
(ii) Terrestrial Wildlife	13					15					12					111	2	1	0	0
(iii) Other Terrestrial Fauna	13					15					12					110	4	0	0	0
(iv) Aquatic/Marine Flora	13					15					12					110	3	1	0	0
(v) Fish	13					15					10				2	105	4	1	0	4
(vi) Other Aquatic/Marine Fauna	13					15					12					113	1	0	0	0
7. HABITATS AND COMMUNITIES																				
(i) Terrestrial Habitats	13					15					12					113	1	0	0	0
(ii) Terrestrial Communities	12		1			15					12					111	2	1	0	0
(iii) Aquatic, Estuarine, Marine Habitats	12		1			15					12					111	2	1	0	0
(iv) Aquatic, Estuarine, Marine Communities	12		1			15					12					111	2	1	0	0
(v) Others	13					15					12					114	0	0	0	0
III. HUMAN																				
8. HEALTH AND SAFETY																				
(i) Physical Safety	13					15					12					114	0	0	0	0
(ii) Psychological Well-Being	12	1				15					12					110	2	0	0	2
(iii) Outbreak of Diseases	13					15					10	2				110	3	1	0	0
(iv) Others	13					15					12					114	0	0	0	0
9. SOCIAL AND ECONOMIC																				
(i) Employment	7	1	2		3	15					12					84	3	5	1	21
(ii) Housing	10				3	15					12					94	6	0	1	13
(iii) Change in Way of Life	6	1	3		3	15					12					84	4	5	0	21
(iv) Involuntary Settlement	8	1	1		3	15					12					105	5	1	0	3
(v) Population Increase	7	1	2		3	14				1	12					99	6	3	0	6
(vi) Others	13					15					12					114	0	0	0	0
10. AESTHETIC AND CULTURAL																				
(i) Impacts on the Community	10		3			15					10				2	80	4	4	0	26
(ii) Conflicts amoung communities	13					15					12					107	7	0	0	0
(iii) Historic and Cultural Assets	13					15					12					114	0	0	0	0
(iv) Others	13					15					12					111	1	0	0	2

0 - No Impact, 1 - Potentially significant adverse environmental impact for which a design solution has been identified
2 - Adverse environmental impact that is potentially significant but insufficient information has been obtained to make a reliable prediction (Significant Unknown Impact)
3 - Residual and significant adverse environmental impact (Significant Known but Unsolvable Impact), 4 - Significant environmental enhancement (Useful for environmental development)

ANNEX II

METEOROLOGY AND HYDROLOGY

ANNEX II
METEOROLOGY AND HYDROLOGY

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1. INTRODUCTION

The main context of this small reservoir development study is the water resources development, of which necessity is closely related with difficulties of water management and/or water shortage at the boundaries of irrigated areas or isolated small areas without proper irrigation facilities.

Hydrological conditions were identified, i.e. short-listed agricultural areas were investigated and categorized in order to select pilot projects for the small reservoir development, and to carry out the feasibility study.

During the Phase I study which was commenced in August 1993 and finished in March 1994, including two field study periods, i) identification, ii) categorization, and iii) selection of the pilot projects for the feasibility study were done.

During the Phase II study from May to December 1994, the feasibility study of the five selected sites, namely, i) Simpang Geti and Tasik Melati in Perlis, ii) Kedawan in Langkawi, Kedah, iii) Bukit Sedanan in Melaka, iv) Kelompok Kangkar Merlimau in Johor, and v) Pasir Nering in Terengganu were carried out.

In Chapter 2 of this Annex II under "Meteorology and Hydrology", hydrological conditions of the whole Peninsular Malaysia are described, and the procedures of identification, categorization and selection of the projects are explained. Hydrological analyses were done based on the 37 Thiessen polygons aiming at categorizing and selecting pilot projects. In Chapter 3, detailed hydrological analyses on i) water availability, ii) flood and iii) sediment transport were done for the selected five projects.

The guideline for hydrological evaluation was formulated based on the river basins consisting of 41 basins and 27 sub-basins. The polygon rainfall was transposed to those basins and the basin-wise water availability was evaluated using water balance models.

2. IDENTIFICATION AND SELECTION OF THE PROJECTS

2.1 Meteo-Hydrological Conditions in Peninsular Malaysia

(1) Climate and seasons in Peninsular Malaysia

The characteristics of the climate of Malaysia are uniform temperature, high humidity and ample rainfall, which arise mainly from the maritime exposure of the country.

Though the wind over the country is generally light and variable, there are, however, some uniform periodic changes in the wind flow patterns. Based on these changes, four seasons are distinguished, namely, the southwest monsoon, northeast monsoon and two shorter inter-monsoon seasons.

The southwest monsoon is usually established in the later half of May or early June and ends in September. The prevailing wind flow is generally southwesterly and light.

The northeast monsoon usually commences in early November and ends in March. During this season, steady easterly or northeasterly winds prevail. The more severely affected areas are the east coast states.

(2) Meteorological features of Peninsular Malaysia

Temperature

Being an equatorial country, Malaysia has uniform temperature through out the year. The annual variation is less than 2 °C except for the east coast areas which are often affected by cold surges originating from Siberia during the northeast monsoon. Even there, the annual variation is below 3 °C. Mean yearly temperature (1991) ranges from 25 °C to 32 °C depending on the location.

Relative humidity

The mean monthly relative humidity falls within 70 % to 90 %, varying from place to place and from month to month. It is observed that the minimum relative humidity is normally found in the months of January and February except for the east coast states of Kelantan and Terengganu which have the minimum in March. The maximum is however generally found in the month of November.

Sunshine

Being a maritime country close to the equator, Malaysia naturally has abundant sunshine and thus solar radiation. However, it is extremely rare to have a full day with completely clear sky even in periods of severe drought. The cloud cover cuts off a substantial amount of sunshine and thus solar radiation. On average, Malaysia receives about 6 hours of sunshine per day.

Evaporation

Among all the factors affecting the rate of evaporation, cloudiness and temperature are the most important factors which are inter-related. A cloudy day has less sunshine and thus less solar radiation, which gives lower temperature.

An examination of evaporation data shows that the cloudy or rainy months are the months with lower evaporation rates while the dry months are the months with higher rates. In 1991, mean daily evaporation in Peninsular Malaysia ranged from the lowest of 2.6 mm per day (Senai) in November to the highest of 6.5 mm per day (Gajah Mati) in February. For highland areas such as Cameron Highlands where the air temperature is substantially lower, the evaporation rate is proportionally lower too. While lowland areas have annual average evaporation rates of 4 to 5 mm per day, Cameron Highlands has a rate of 2.5 mm per day.

Malaysian Meteorological Services (MMS) has 21 principal stations over the Peninsula (Fig. II.1) recording air pressure, temperature, relative humidity, cloud cover, rainfall, wind, sunshine hours and evaporation. The summary of data recorded is shown in Table II.1.

(3) Rainfall

The seasonal variation of rainfall in Peninsular Malaysia is of three main types.

i) Over the east coast districts, November, December and January are the months with maximum rainfall, while June and July are the driest months in most districts.

ii) Over the rest of the Peninsula with the exception of the southwest coastal area, the monthly rainfall pattern shows two periods of maximum rainfall separated by two periods of minimum rainfall. The primary maximum generally occurs in October - November while the secondary maximum generally occurs in April - May. Over the northwestern region, the primary minimum occurs in January - February with the secondary minimum in June -July while elsewhere the primary minimum occurs in June - July with the secondary minimum in February.

iii) The rainfall pattern over the southwest coastal area is much affected by early morning "Sumatras" from May to August, with the result that the double maxima and minima patterns are no longer discernible. October and November are the months with the maximum rainfall, and February is the month with the minimum rainfall. The March - April - May maximum and the June - July minimum are absent or indistinct.

In this study, the Peninsula was primarily divided into 37 Thiessen polygons for categorization on hydrology (Fig. II.2). Mean monthly polygon rainfall is shown in Table II.2 with seasons, names of stations and durations of observations. Based on long-term rainfall records, the 80 % reliable rainfall which is generally used for the irrigation planning was estimated on monthly and yearly basis. Iwai method (see Annex IIa) was used for this analysis. Table II.3 shows the estimated reliable rainfalls and rainy/dry seasons based on the estimated reliable rainfall. The yearly total of reliable monthly rainfalls shows the least in Kuala Klawang (Polygon 16) and the most in Taipin (Polygon 8). Perlis and south western parts of the Peninsula, i.e., western Selangor, Negeri Sembilan, Melaka, northwest Johor and inland of Pahang, receive less reliable rainfall.

These polygon rainfalls were also transposed to river basins which were established by "National Water Resources Study Malaysia (JICA 1982)". The basins consist of 41 basins and 27 sub-basins as shown in Fig. II.3. The basin-wise mean monthly rainfall and 80 % reliable monthly rainfall were summarized in Table II.4 and Table II.5.

2.2 Constraints for the Development

From the viewpoint of hydrological circumstances for an irrigation project, it can be said that Malaysia has a lot of advantages. Particularly in rainfall, annual rainfall exceeds 2,000 mm except in Perlis, Melaka, part of Negeri Sembilan and Pahang. The total precipitation is considered to be mostly sufficient for irrigating the main crop, paddy, and upland crops in the second season.

Major irrigation development projects have been implemented as "Granary Areas" and/or "Mini (Secondary) Granary Areas", of which paddy rice production has already met the target of self-sufficient rate stated in "The National Agricultural Policy (1992-2010)"*1.

However, on the other hand, irrigation development for high-value upland crops such as vegetables and orchards has fallen behind. In general, the holding sizes of these upland areas are small. Taking into consideration the labor shortage which has been pointed out to be one of the most serious constraints for agriculture in Malaysia, improvement for a modernized, in other words, mechanized irrigation system is indispensable. However, it is rather difficult to use the existing paddy irrigation system for the intensive upland crop cultivation, which requires minute water management. The high-value upland crops are mostly cultivated on commercial or private basis, and irrigation facilities have also been provided by their own efforts, resulting in difficulties in coordination and control of water use, viz., water management.

Different from the inundating irrigation for paddy, upland crops are mostly irrigated by linear (furrow) or pin-point irrigation methods (drip, micro spray, etc.), resulting in their lower unit irrigation requirements. However, a proper water management, namely, a right-on-time operation of irrigation facilities for an equal and due water supply, is very difficult to be achieved in practice.

In these points of view, development of independent small irrigation systems with own water sources, namely small reservoirs, is considered to take a great part in further improvement of irrigated agriculture in Malaysia.

2.3 Identification and Screening of the Potential Sites

For identifying potential sites for the small reservoir development, Questionnaire I was prepared to clarify general features of the areas. Regarding hydrology, water shortage condition was confirmed in this questionnaire. Based on the collected answers, nearly 140 potential sites were short listed out of 266 sites.

Footnotes

*1/ 65 % of the demand. Published by the Ministry of Agriculture, 1993

Questionnaire II-B, "Meteorology and Hydrology", were prepared and delivered for those short-listed sites to get further information on meteorology and hydrology. The questions consisted of: i) meteo-hydrological observations, ii) related rivers and their conditions, iii) recent droughts and floods, iv) seasons, and v) rainfall and surface water resources. Several questions related to hydrological conditions such as water shortage, proposed cropping area, catchment area, etc., were included in other sections of the Questionnaire II. The answers were compiled into a database for: i) categorization and selection of projects for the feasibility study, and ii) providing basic information on each area. The database was formed by using Lotus 123, and all the data are available in output formats (tables).

2.4 Categorization of the Project Sites

(1) Hydrological evaluation

Based on the above-mentioned information, hydrological conditions were evaluated. Factors selected and procedures dopted in the evaluation are explained in the following.

a. Depth of rainfall

In terms of the potential of regional water resources without specific locations of projects (catchment areas), water availability can be expressed by depth of rainfall. The depth of available surface water is determined by quantity of rainfall, evaporation and deep percolation into the ground. Out of these, the most dominant factor for the water availability is rainfall which varies substantially depending on location and season. Thus, the rainfall distribution was evaluated in terms of yearly total of monthly reliable rainfall and its variance in a year. The evaluation was done based on the Thiessen polygons (Fig. II.2). The procedures of evaluation are described in the following.

i) Yearly total of monthly rainfall with 80 % reliability

A quantitative evaluation of rainfall was done by estimating monthly rainfall with 80 % reliability which is generally used for an irrigation planning. The reliable rainfall was calculated by Iwai method*2 for 37 polygon rainfall by month. The rainfall records were provided by DID and their recording periods are long enough.

According to the estimated yearly total of monthly reliable rainfall, scores (Re) from 1 (lowest) to 5 (highest) were assigned for each basin (37 basins). The criterion was as follows:

Footnotes

*2/ See Annex IIa.

Score (Re)	Range
1	less than 1000 mm
2	1000 to 1200 mm
3	1200 to 1400 mm
4	1400 to 1600 mm
5	more than 1600 mm

ii) Standard deviation of monthly rainfalls

The standard deviation explains the variance of data. The lower the value is, the smaller the variance is. The standard deviation of monthly rainfalls through out a year also shows their variation during the year.

According to the standard deviation, scores (Rd) from 1 (lowest) to 5 (highest) were determined for each basin (37 polygons). The criterion was as follows:

Score (Rd)	Range of Standard Deviation
1	more than 80
2	65 to 80
3	50 to 65
4	35 to 50
5	less than 35

Based on the scores Re and Rd, an integrated evaluation was done.

Considering crop cultivation, the uniformity of water distribution through out the year or seasons should be prior to the absolute quantity of available water. In this meaning, some weight was given to the quantitative score (Re). After some trials for the weight, scores on hydrological condition (lowest 1 to highest 10) were determined by using the following the formula.

$$\text{Total Score} = (3 \times Re + Rd) / 2$$

The scores are shown in Table II.6.

b. Run-off to the proposed reservoirs

According to the rain-depth evaluation by polygon, volumetric water availability was evaluated based on certain catchment areas. Even though a project is located in a preferable hydrological conditions with abundant and consistent rainfall, it might not get enough water in case that an imbalance in catchment and irrigation area exists. Considering this, water balance of the estimated run-off and the water demand was examined for each project.

The run-off to the proposed reservoir was estimated by multiplying: i) depth of reliable rainfall to the catchment, ii) catchment area, and iii) run-off coefficient.

(2) Categorization of project sites

The purposes of the categorization of projects are: i) to clarify potential of a project for small reservoir development, ii) to select pilot projects for the feasibility study, and iii) to understand the parameters to be analysed, and selection and evaluation procedures for candidate projects.

Following factors were examined for the categorization of the short-listed projects.

i) Water shortage
ii) General hydrological condition (polygon-wise rainfall depth)
iii) Estimated run-off
iv) Estimated gross irrigation requirement
v) Proposed area

a. Water shortage

Water shortage situation was investigated by the questionnaire survey. The seriousness of the water shortage was evaluated subjectively by owners of the projects indicating by scores of 1 (no water shortage) to 5 (the severest). This factor was used for the screening of projects for short listing. The projects with score of 3 or more were categorized as the "projects which require water source development". In Table II.7, these projects have "O" in the column of "Water shortage", while others have "X".

b. General hydrological condition

According to the score for the depth of reliable rainfall in a certain polygon, the projects were categorized. The projects with higher scores are considered to have preferable hydrological conditions. In this study, the projects with the score of less than 7 were categorized as the "projects with more necessity for water source development". In Table II.7, these projects have "O" in the column of "General hydrological condition", while others have "X".

c. Water availability

The scale of a water source development is determined by the quantity of available water from the source and the proposed irrigation area. However, at the initial stage of planning when dimensions of a reservoir are not fixed, it is difficult to estimate the irrigable area by a detailed water balance study.

As a simplified measure, the run-off to the reservoir was compared with the gross irrigation requirement which was estimated using some assumptions; i) crop water requirement, ii) irrigation efficiency, and iii) effective rainfall. It should be noted that these assumptions were made not for the design or planning but for categorization only

The annual crop water requirement was assumed at 1500 mm based on the average evapo-transpiration rate in Subang (1200 mm/year) estimated in "Estimating Potential Evaporation Using the Penman Procedure, *Hydrological Procedure No. 17, DID* " and the mean annual crop coefficient of 1.2. Irrigation efficiency was assumed at 70 % considering a small irrigation area. Effective rainfall was assumed at 60 % of the reliable rainfall. The available surface water was assumed at 70 % (defined as "run-off coefficient") of the reliable rainfall.

Example : PR1, Simpang Geti (Perlis)

Catchment area	: 3 km^2 *3
Proposed area	: 70 ha
Net water requirement	: 1500 mm
Yearly total reliable rainfall	: 922 mm (Polygon 1, Table II.3)

Estimated run-off = 3 km^2 x 922 mm x 0.70 (run-off coefficient)
= 194 ha m *4

Gross water requirement = (1500 mm - 922 mm x 0.6) x 70 ha / 0.70
= 94.7 ha m < 194 ha m [OK]

If the estimated run-off was bigger than the gross irrigation water requirement, "O" was given in the column of the "water availability". Detailed water balance study was done for the pilot projects with optimization studies of proposed reservoirs (Annex III "Irrigation and Drainage").

2.5 Selection of the Project Sites

According to the above-mentioned three factors (hydrological condition, water shortage, water availability) and size of the proposed area, recommendable projects for further study were selected. The range of the proposed area selected is 30 ha to 400 ha.

If a project had four "O"s, it was automatically selected. If some special conditions are found for the project, it was also selected with some "X"s. The special conditions considered were: island, a good example of each type of reservoir, priority by States, and the government policy. These conditions were all discussed with DID and other related agencies.

Footnotes

*3/ This "catchment" is regarded as the residual catchment of which surface water is available for this project area..

*4/ "ha m (hectare meter)" is a unit of volume which is equivalent to 10,000 cubic meter.

3. FEASIBILITY STUDY OF THE PILOT PROJECTS

3.1 Present Condition of the Project Areas

3.1.1 PR1,4 Simpang Geti, Tasik Melati, Perlis

(1) Climate and rainfall

The project areas are situated in one of the driest areas in the Peninsula. Many of water resource difficulties in this area are brought by this dry condition. The Malaysian Meteorological Services (MMS) operates one principal station in Perlis, i.e. Chuping (station number, 48604), of which average climatic variables (1975 - 1992) are shown in Table II.8.

In Perlis, the main season starts in August and ends in November. Nearly 50 % of the annual rainfall is observed during this season while a distinct dry period is observed from January to February*5. Mean annual rainfall at Bukit Temiang, which is the nearest DID rainfall station of Tasik Melati, is 1,817 mm, while that of Ngolang for Simpang Geti is 1,613 mm.*6

Mean number of rainy days in the neighboring area is about 140 days per year*7. In the driest months, i.e. January and February, mean number of rainy days are only two (2) or three (3). They experienced 3.6 dry periods on average (without rainfall for more than 10 days) in a year. The mean maximum dry period was 39 days and the mean duration of dry periods was 22 days.

(2) Catchment characteristics

The catchment area of Lake Tasik Melati is about 6 km^2 which is mostly developed having flat or slightly undulating topography. Swamps are formed on the upstream of the lake without any major incoming flow. The swampy area seems to work as a buffer against floods. The soil cover in the catchment area consists of various types of soils developed over Sub-Recent to Older Alluvium overlying weathered shale saprolite.

The catchment area of the Ngolang headworks for the Sg. Repoh scheme (272 ha) is 55 km^2, of which the upstream part is covered by a broad sugarcane plantation area. The net area currently under sugarcane is 8,502 ha of which the northern part (4,453 ha) is operated by Perlis Plantation Berhad (PPB) while the southern part (4,049 ha) is operated by FELDA. The remaining part of the catchment is also developed and has a flat or undulating topography.

(3) Water sources and water use (Fig. II.4)

The water of Lake Tasik Melati is used not only for tourist activities but also for irrigation. Alor Baroh scheme (232 ha) operated by DID has two intake gates at Tasik Melati

Footnotes

*5/ Based on long-term (1967 - 1990) rainfall records at DID station 6502010, Bkt Temiang.
*6/ Mean value for 1983 to 1990.
*7/ Abi Kg. Bahru(DID No.65010005), 1976-1990

itself with a head canal capacity of 110 l/sec.*8 Bukit Tau scheme which is also being operated by DID has a pump house (designed capacity, Q=133 l/sec)*9 at a near-by pond next to Tasik Melati. This pond is not connected directly to Tasik Melati, but their catchments and groundwater tables seem to be interconnected. The pump can be driven only for one hour or less because of the quick draw-down of the water table, which recovers in one day.

Simpang Geti scheme (105 ha) was designed to receive water from one of the main canals of Sg. Repoh scheme (R2) via two lines of canals (T1, T2) of which total capacity is 360 l/sec. The R2 canal starts from Ngolang headworks on the Sg. Ngolang receiving water at a rate of 580 l/sec from the Timah Tasoh dam through a link canal*10 of Block C*11 just downstream of the intake. Simpang Geti scheme has two water sources, namely, Timah Tasoh dam and Sg. Ngolang river. However, the most serious problem in water sources of Simpang Geti is that the project area is located on the downmost reach of command areas of both the link canal and Sg. Ngolang. It is very easy to guess that Simpang Geti, even after completion of the link canal, will suffer from water shortage during dry periods without proper water management.

The largest water users in the Ngolang river catchment are considered to be the sugarcane plantation of PPB and FELDA. According to the previous estimation*12, the gross irrigation water requirement for the sugarcane in that area is 168 mm from December to April, which is approximately 1.5 times the estimated run-off (114 mm for the same period) from the Sg. Ngolang catchment (refer to sub-section 3.2.6 (1) "Water availability", p22). They also have 265 ponds in the area for the purpose of irrigation, and others with a total storage capacity of 2.8 million cubic meter (MCM)*13.

Several paddy cultivation areas are located in-between the PPB/FELDA area and the Ngolang headworks. They have simple intake structures for irrigation, but DID is not responsible for water supply except Bendang Chuping, which was one of the five new schemes of DID under IADP along with Simpang Geti.

Two river gauge stations are being operated by DID in the catchment of Ngolang Headworks, viz. Sg. Jernih at Titi Tampang (catchment area is 24 km^2) and Sg. Buloh at Kampung Batu Tangkup (catchment area is 16 km^2). The flow during dry season in Sg. Jernih is low but stable because it originates from springs in a lime stone area. On the other hand, Sg. Buloh which is situated on the downstream of the PPB/FELDA area brings very little discharge during dry periods unless it receives intensive rainfall on the upstream.

Footnotes

*8/ The actual canal capacity is 410 l/sec which includes the drainage duty of 300 l/sec. The irrigation duty is 110 l/sec.
*9/ Obtained from drawings provided by DID Perlis.
*10/ Under construction (to be completed at the end of 1994/95 fiscal year)
*11/ Refer to Bengkel Kedah Pengendalian Skim-Skim Yang Mendapat Bekalan Air Daripada Empangan Timah Tasoh, prepared by Ir. Sabri bin Hassan, DID Perlis.
*12/ "Perlis Integrated Area Development Project", Main Report 1983
*13/ "Penggunaan Kolam Takungan dan Sumber Air Bumi Untuk Kolam Serta Bekalan Air Untuk Domestik dan Industri di Felda Chuping", Information from FELDA Chuping to DID (Bil. (67)3130/ 4-2-1 (3) dated 13 th March 1993)

3.1.2 KH4,5 Kawasan Padi, Kedawan, Langkawi, Kedah

(1) Climate and rainfall

Seasons in Langkawi island is dominated by the south-west and north-east monsoons. The former influences weather conditions from April to November when 92 %*14 of annual rainfall occurs causing marked wet seasons. During the latter monsoon, winds tend to dry out passing over the Central Mountain Range and only low rainfall occurs. The annual rainfall amounts to nearly 2,600 mm.

Mean number of rainy days is about 130 days per year. In the driest months, i.e. January and February, mean rnumber of rainy days are only two (2) or three (3). They experienced 4.4 dry periods on average (without rainfall for more than 10 days) in a year. The mean maximum dry period was 41 days and the mean duration of dry period was 22 days.

The island experiences a tropical climate with relatively low variations in temperature and humidity throughout the year. The Malaysian Meteorological Services (MMS) operates one principal station in Langkawi, i.e. Pulau Langkawi International Airport (station number, 48600), of which average climatic variables (1988 - 1992) are shown in Table II.8.

(2) Catchment characteristics

In Langkawi, steep hilly areas are under forest cover but lower slopes have been planted with rubber trees. Lowland areas are used for paddy cultivation. There are no stream flow measurement stations in Langkawi hence no data are available on run-off characteristics except for the results of isolated spot gaugings. However, as most streams have small catchment areas and fall rapidly from the mountains to the sea, their flows tend to cease during the periods of dry weather.

The catchment area for the proposed Bukit Lembu dam is 3.5 km^2 of which the lower half is paddy fields and the upper area is covered by forests with mountainous topography. The run-off up to the flat lowland is rapid, but the floods do not concentrate into certain streams. The paddy fields seem to provide a flood control storage in the area.

The proposed upstream Bukit Lembu reservoir has a catchment area of 0.4 km^2 at the dam site of which the lower catchment is being developed for orchards, while the remainder is covered by forests in mountainous topography. The slope of the catchment is steep, which causes rapid run-off through two small streams.

The catchment area of the proposed Ketapang dam is 0.6 km^2, consisting of similar topography and vegetation cover to that of the upstream Bukit Lembu dam.

(3) Water source and water use

No major stream/river exists in any of the catchments of the proposed dam sites. Overland flow through paddy fields will be collected and stored in the proposed Bukit Lembu

Footnotes

*14/ Based on DID rainfall records at Ulu Melaka (6397112), monthly mean rainfall from 1953 to 1990.

reservoir, while two streams which are considered to be temporary or seasonal are the sources for the upstream Bukit Lembu reservoir, and a stream called Sg. Ketapang is the main source for the Ketapang reservoir. The water from the catchments is being used mostly for rainfed paddy cultivation. No major water use for non-agricultural purpose was confirmed.

3.1.3 MA16 Bukit Sedanan FELCRA, Jasin, Melaka

(1) Climate and rainfall

Melaka state is known as one of the driest states in Peninsular Malaysia, where annual rainfall is no more than 2,000 mm. The mean temperature is quite stable through out the year. Monthly average temperature is 26 to 27 °C, while the average maximum and minimum temperatures are ranged between 30 to 34 °C and 22 to 24 °C, respectively. Relative humidity fluctuates in a day from 52 to 100 %. The rainfall pattern in this area shows two periods of maximum rainfall sandwiched by periods of minimum rainfall. In general, the primary maximum occurs in October - November while the secondary maximum occurs in April - May.

On the other hand, the primary minimum occurs in January - February with the secondary minimum in June - July. The mean annual rainfall at the nearest DID rainfall station*[15] is 1729 mm with the maximum monthly rainfall of 212 mm in November, and the minimum of 90 mm in February. Mean numbers of rainy days is less than 100 days per year*[16]. In the driest months, i.e. January and February, mean numbers of rainy days is only five (5) which is less than half of that in November (10.9 days). They experienced 5.5 dry periods on average (without rainfall for more than 10 days) in a year. The mean maximum dry period is 29.7 days and the mean duration of dry periods is 17.4 days.

The Malaysian Meteorological Services (MMS) operates a principal station in Melaka, i.e. Melaka Airport (station number, 48665), of which average climatic variables (1968 - 1992) are shown in Table II.8.

(2) Catchment characteristics

The catchment areas of the considered reservoirs has been mostly developed for rubber trees and their inter-crops, such as cocoa, pasture, durian, etc. Most of the catchments are hilly with swamps situated in between. Since the soil cover of the catchments has sandy textures, the flood sediment load is considered higher, particularly during the development stage.

(3) Water source and water use

The main stream in/around the project area is the Ayer Mentangor and its tributaries. The primarily proposed reservoir site is located on the Ayer Mentangor itself with a catchment area of 2.35 km^2, while the secondary candidate site is situated on a tributary with a catchment

Footnotes

*15/ Bukit Senggeh, Jasin (DID No.2324032), 1953 -1990

*16/ Melaka Airport (DID No.2222020), 1953-1990 of 0.47 km^2 which is still bigger than that of the existing pond in the area. The water of these two streams is not being used in the project area. Some paddy areas were confirmed on the downstream of the Ayer Mentangor, but farmers have mostly abandoned cultivation because of shortage of water and labor. Only a small-scale vegetable farm (1 ha) is being operated under MIADP on the downstream of the area.

3.1.4 JR16 Kelompok Kangkar Merlimau, DOA, Batu Pahat, Johor

(1) Climate and rainfall

The nearest principal meteorological station operated by MMS is located in Kluang (station number, 48672). According to the records available from 1974 to 1988, the mean temperatures are 24 - 26 °C, while the maximum and the minimum are 29 - 33 °C and 22 - 24 °C, respectively. Mean relative humidity varies from 55 to 100 %. The rainfall distribution in a year (Fig. II.5) shows a similar pattern to Bukit Sedanan, Melaka, but the amount of rainfall in/around this area is more, 2,347 mm per year. *17

Mean rain days in the project area is 140 days per year.*18 In the driest months, i.e. January and February, mean number of rainy days are nine (9) per month. Comparing with the maximum number of rainy days of 15 days in November, the stability of rainfall through out the year in this area could be expected. They experienced 2.6 dry periods on average (without rainfall for more than 10 days) in a year. The mean maximum dry period was 20.4 days and the mean duration of dry periods was 16.0 days.

(2) Catchment characteristics

Parit Kangkar Merlimau, an artificial drain, is running through the project area receiving consistent flows from near-by springs. A notable characteristic of this catchment is its high and stable baseflow in spite of its small catchment area of 1.4 km^2. During the field investigations, it was confirmed that the discharge of the drain is constant even after short dry periods of one week. The minimum discharge measured during the study period was 40 l/sec.*19 According to the farmers living along the drain, the water level in the drain is almost constant through out the year, and seldom had floods in the past.

It is considered that the peat soil layer which covers lowland in the area has a high water holding capacity, sustaining a consistent flow and a flood-free condition.

(3) Water source and water use

There are several springs along a swampy area on the right bank of the drain. This drain and near-by springs are considered to be the main water source for this area. Since this water comes from the springs, the water itself is very clean and clear without any sediment.*20

Footnotes

*17/ Rainfall records at Parit Sulong (DID No.1929064), 1951-1990
*18/ Same data source as *17/
*19/ Based on the records until the end of August 1994.
*20/ Refer to the Annex VI, "Environment".

Farmers are currently taking this water for domestic use. Drinking water is being extracted from a well located on the hill side of the right bank.

3.1.5 TR44 Pasir Nering, Ulu Terengganu, Terengganu

(1) Climate and rainfall

The meteorological condition in Terengganu is largely dominated by the north-east monsoon. The rainfall pattern in the eastern region in which the project area is situated shows a distinct rainy season from November to January and a dry period from February to August. Temperature is quite constant with mean monthly temperature of 25 - 28 °C, maximum temperature of 28 - 32 °C, and the minimum of 22 - 24 °C. The minimum relative humidity is comparatively high due to abundant rainfall.

The mean annual rainfall in the catchment is 3,058 mm*21 which is the highest among the five project areas. Even in dry months, they received precipitation over 140 mm.

(2) Catchment characteristics

The project area is located on the flat undulating land adjacent to Sg. Terengganu, the largest river in Terengganu. The catchment area of Sg. Por has a long and narrow shape of which upstream part is mountainous covered by forests, while that of Sg. Peching is composed of hilly rubber tree areas and a flat lowland expanding on the right bank of Sg. Terengganu. The catchment of Sg. Udang is sandwiched by those of Sg. Peching and Sg. Por with hilly or undulating topography.

(3) Water source and water use

Three rivers are running through the project area, they are; Sg. Peching, Sg. Udang and Sg. Por. The catchment areas of the three rivers at considered dam or intake sites are 4.8 km^2, 18.2 km^2, and 2.4 km^2, respectively. In terms of the location and water availability, Sg. Por is considered to be the best water source. However, floods in this area are very severe, and permanent structures across the river require large spillways against the floods. On the other hand, the proposed crop for this area is 40 ha of roselle, which originates from arid regions and requires less water. Taking these into consideration, Sg. Por is not considered to be a suitable water source for a reservoir.

Paya Kemat*22 pumping scheme is being operated by DID on the upstream of Sg. Por supplying irrigation water for paddy (60 ha) in the main season. Some water is being extracted from Sg. Peching via a pipe lineto Pasir Nering village for domestic purposes.

Footnotes

*21/ Rainfall station Paya Kemat (DID No.5029036), 1956 - 1990

*22/ Paya Kemat pump scheme was completed in 1981. Two diesel pumps (3 cusec x 2, head 4 m) are being operated. Irrigated area on the average (1983 - 1987) is 41 ha. (source "Database of Non-granary Irrigated Areas, DID)

3.2 Hydrological Analysis

3.2.1 Data used

Data for the hydrological analysis were collected from DID and MMS. Rainfall stations were selected by giving priority in the following priority: i) the nearest station to the project area, ii) long-term observation, and iii) complete records without missing data. DID is operating three types of rainfall stations, i.e. manual rainfall stations, automatic rainfall stations and data-logger stations. The manual rainfall stations are operated by DID state staffs, who measure and record 24-hour rainfall usually at 8:00 every morning. The automatic stations are equipped with rain gauges with automatic weekly recorders. By reading the chart, not only daily rainfall but also hourly rainfall can be obtained. The data loggers record the time of occurrence of every 0.5 mm rainfall. One data logger keeps one-month records which are directly extracted and processed by computers. In terms of long-term availability, the manual rainfall stations provide good records without missing data. However, rainfall for certain duration or rainstorm records can not be obtained from them. DID has recently started to replace all the automatic stations with data logger stations.

Ten (10) rainfall stations were finally selected for the five (5) project areas shown as follows.

Project Area		Station No.	Station Name	Duration
PR1	Simpang Geti	6502001	Ldg. Perlis Utara	1975-1087
		6402006	Guar Nangka	1959-1992
		6503001	Perlis Selatan	1974-1992
		6402008	Ngolang	1983-1992
PR4	Tasik Melati	6502010	Bukit Temiang	1967-1992
KH4	Kedawan	6397112	Ulu Melaka	1953-1992
MA16	Bukit Sedanan	2324032	Bukit Senggeh	1953-1992
JR10	Kangkar Merlimau	1929064	Parit Sulong	1951-1992
TR44	Pasir Nering	5029036	Paya Kemat	1956-1992

As for meteorological data, records of MMS principal stations were used because of the coverage of their observation items and their long-term availability, reliability and less climatological difference by location. In particular, wind speed records which are used in the Penman method for estimating evapo-transpiration are observed only at these principal stations.

Streamflow records observed by DID were used for verifying the estimated run-off. DID is carrying out discharge measurements every two weeks for each gauging station. Using these records, rating curves are generated for converting water level readings to discharges. In some rivers where the sediment transport is high and the river beds are quite unstable, this converted discharge does not often represent the actual one, particularly after floods. It is recommended to check the rating curves frequently especially for lower discharges.

Suspended sediment records observed by DID were used for estimating sediment loads of the water source.

3.2.2 Field Observations

(1) Site reconnaissance

From June to the beginning of July 1994, hydrologists for JICA and the local team made the first site visit to the eight project areas to confirm the condition of the areas and to install instruments for hydrological surveys. Prior to the site visit, data sheets and formats were prepared for conducting the investigations effectively. Procedures for the field surveys were explained and instructed to the DID staffs who were directly in charge of field observations during the study period.

(2) Installation of instruments

Instruments for the hydrological observations were selected and installed taking following aspects into consideration; i) the availability of data from existing stations in the vicinity, ii) hydrological characteristics of the areas, and iii) availability of staff for maintenance.

The instruments installed were i) rain gauge (automatic, manual), ii) stick gauge and iii) pressure-bulb for water level observation. Number/type of instruments and observation period/item are shown in Table II.9.

(3) Field observations

In parallel with observations by these instruments, discharge measurement for the water source rivers was done periodically, and the field observation on weather, water level at water sources, presence of rainfall, etc., were recorded in a data sheet, "Site Information on Hydrology".

All the field observations were continued until 17 th of September, 1994 with great cooperation from related agencies, not only DID but also DOA, FELCRA, and the public.

3.2.3 Water Availability

The water availability, in other words, run-off largely depends on rainfall. When it rains, certain amount of precipitation is lost and the remainder goes down as a streamflow.

The soil layer has its own water holding capacity. Only when the stored volume exceeds the capacity, some of the volume is discharged as the run-off. Evaporation and deep percolation are the losses for this storage and run-off.

(1) Procedures used

Water Resources Publication (WRP) No.12, "Average Annual and Monthly Surface Water Resources of Peninsular Malaysia" (1982, DID) provides a method for estimating the run-off on daily basis. The model used in the procedure is given in Fig. II.6a. The model set constants and coefficients based on the comparison of generated run-off with actual run-off for 75 catchments in the Peninsula. The water holding capacity was set at 250 mm.

When the ground receives a precipitation more than the potential evaporation rate, the same rate (as potential rate) will be lost as an evaporation loss, and the remainder will be stored in the soil. On the other hand, when the precipitation is none or less than the potential evaporation rate, certain amount of the soil moisture will be consumed for the evapo-transpiration.

The excess moisture which can not be stored in the soil layer (over 250 mm) is defined as "available water for run-off (AWR)". This excess water (AWR) will be gradually discharged as the run-off. In WRP12, the recession constant (K) was set at 90 %, which means that 10 % of the AWR is to be discharged per day. Then the remaining 90 % will be retained for the run-off of next day. In WRP12, calculations were performed using a FORTRAN programme. Since the FORTRAN is not always user-friendly, especially for a modification, a spread sheet for the "Lotus (release 4)" was developed for this study. A sample output for Bukit Sedanan, Melaka is given in Fig. II.6b.

(2) Discussion on the model

Since this model was calibrated based on the actual run-off in the Peninsula, the total estimated run-off shows a quite reasonable value. However, on the other hand, several points need to be considered in using this model for certain projects, because the estimated short-term run-off (daily or weekly) might not always represent the actual run-off. Particularly for low flow periods, this model often gives "no flow" days as shown in Fig. II.6b. If the proposed water source has a certain baseflow, it is difficult to represent it by this model.

Another point is that this model does not represent a direct run-off by a high-intensity rainfall during dry periods unless the soil moisture reaches 250 mm. Normally, if a high-intensity rainfall occurs, there should be some run-off, but this can not be represented by the original model.

Since this project deals with small catchments, the baseflow and the direct run-off during dry periods are very important factors. Thus the model in WRP No.12 was modified in order to represent the baseflow and direct run-off as mentioned in the following.

(3) Direct Run-off Rate

Three direct run-off rates were temporarily set for this preliminary analysis according to the catchment characteristics. The value of 0.1 was adopted for areas of high run-off rate, such as Terengganu, while 0.01 was adopted for areas with low run-off rate (Melaka) or peat areas (Johor). The value 0.05 was adopted for intermediate areas. For Tasik Melati, this direct run-off rate was not applicable, because its swampy catchment has neither major streams nor the flood concentration.

(4) Baseflow

The baseflow was estimated by the procedure introduced in HP No.12 "Magnitude and Frequency of Low Flows in Peninsular Malaysia". This procedure was developed based on the regional frequency analysis. Four low flow regions were identified, and by using this procedure, design low flows of return periods between 1 and 25 can be estimated. Since the water balance calculation was done for long term by using the actual daily rainfall, the mean annual minimum flow (MAM) was used for the calculation. Table II.10 shows the estimated MAM in depth for each project area.

Along with this calculation, the results of field measurements were also taken into consideration.

As for Johor, Kangkar Merlimau, the baseflow was considered to be much higher than the estimated value due to its catchment characteristics mentioned in the sub-section 3.1.4 (2) in page 12. The observed minimum discharge in July, one of the driest months, was 40 l/sec which is only 10 l/sec less than the annual average run-off.*23 Taking into consideration the previous field observation, the baseflow was set at 20 l/sec or 0.35 mm.

For Terengganu, Pasir Nering, the estimated low flow by HP12 was 0.7 mm which is equivalent to 40 l/sec for Sg. Peching. However, the lowest flow that had been recorded was approximately 20 l/sec (0.35 mm) in January 1994. Taking due consideration, the baseflows for the three rivers were set at 0.35 mm.

For other projects, the estimated low flows (MAM) by HP12 were used comparing with the field observations.

(5) Water availability for the pilot projects

The calculation was done using the modified model as illustrated in Fig. II.7a, and the parameters/data given in Table II.11. Consequently, the baseflow and the direct run-off were represented as shown in Fig. II.7b.

The result of the calculation for each project area is summarized on monthly basis in Table II.12a~f.

(6) Water availability in Peninsular Malaysia

Based on the daily rainfall records between 1982-1992, basin-wise water availability (run-off) was calculated using the modified model.*24.

The baseflow was calculated by using HP12 for the catchment area of 1, 2, 5, 10, 20 km^2 respectively (Table II.13), and the average values were used for the calculation. Direct run-off rates were set according to the annual rainfall data as follows:

Footnotes

*23/ Estimated annual runoff by WRP No.12 (original) is 1,112 mm which is equivalent to 50 l/sec on average for the catchment of 1.4 km^2.

*24/ Rainfall stations used do not always coincide with those of 37 basins used for categorization. In case rainfall records of 1982-1992 are not available, another 10-year records were used.

Annual rainfall	Direct Run-off Rate
less than 2,000 mm	0.01
2,000 to 2,500 mm	0.05
over 2,500 mm	0.10

The nearest MMS principal stations were selected for calculating evapo-transpiration (Table II.14). The results of the calculation are summarized in Table II.15.

3.2.4 Flood

The design of water control structures depends largely on the expected flood discharge. If a streamflow is gauged and the duration and quality of records are adequate, a frequency analysis could be done. However, if such data are not available the designer will have to use some other techniques.

Flood analysis was carried out using several procedures introduced in Hydrological Procedures (HP) by DID. The peak discharge at the proposed dam site was estimated by the rational method given in HP5.*25 Rainstorms within the time of concentration were calculated according to the procedures given in HP1.*26

The rational method generally suggests the run-off coefficients between 0.20 and 1.00 according to the rate of catchment development, vegetation and topography.*27 However in HP5, run-off coefficients given for four (4) regions in the Peninsula are very low ranging from 0.06 to 0.38. This procedure was also modified and revised based on the actual flood conditions in the Peninsula. The actual peak discharge and the time of concentration were compared with the estimated ones in order to represent the design peak discharge properly. After making due discussions, two more procedures for estimating floods were examined, namely HP4*28 and HP11*29. The HP4 being developed for the catchments of more than 20 km^2, it gives lower peak discharges. The dominating factor for HP11 is the "catchment group" which is defined to determine the C_t in the following equation to get the catchment lag.

$$L_g = C_t \times \left(\frac{LL_c}{\sqrt{S}} \right)^n \quad \text{--------------------------------(II.1)}$$

where, L = main stream length from the outlet to the catchment boundary
L_c = main stream length from the outlet to the catchment centroid
S = weighted mean stream slope
C_t, n are constants.

Footnotes

*25/ Rational Method of Flood Estimation for Rural Catchments in Peninsular Malaysia (revised and updated 1989).
*26/ Estimation of the Design Rainstorm in Peninsular Malaysia (revised version 1982)
*27/ "Applied Hydrology", p498, Ven Te Chow *et al*
*28/ Magnitude and Frequency of Floods in Peninsular Malaysia (revised and updated version, 1987)
*29/ Design Flood Hydrograph Estimation for Rural Catchments in Peninsular Malaysia (1976)

	Catchment Type	C_1
Group 1	Whole catchment very steep and covered in virgin jungle.	2.0
Group 2	Upper catchment very steep and jungle covered, lower catchment reaches hilly and covered predominantly with rubber.	4.0
Group 3	Whole catchment undulating with variable vegetation including jungle, rubber and agricultural development.	8.0

For Tasik Melati in Perlis and Bukit Lembu in Langkawi, the "Group 3" was adopted. The "Group 2" was applied for other catchments. The results for the three procedures are shown in Table II.16.

3.2.5 Sediment

(1) General

All rivers transport a certain amount of sediment load, suspended in the flow cross-section or moving along the bed. As they approach the reservoir, the velocity is reduced and the coarser sediment is settled down in the head reaches of the reservoir. The finer sediment is maintained in suspension and gets deposited in the reservoir. This deposition of silt gradually reduces the available storage capacity of the reservoir and is, therefore, an important factor in planning.

To allow for silting, certain percentage of the total storage is usually left unutilized and is called 'dead' storage, the balance being called 'live' or effective storage. The dead storage is seldom more than one fourth of the total, and the reservoir is never allowed to be dropped below this capacity. All the outlets drawing water from the reservoir are provided above the level at which dead storage is available.

Sediment transport depends on the physical properties of the sediment, as well as on the hydraulic characteristics of flow. Among the physical properties, weight, shape and terminal velocity of particles govern directly their movement. All these properties however can be expressed in terms of the size of the sediment; the mean diameter being the most commonly used parameter.

The sediment load consists of two categories ; i) bed load, and ii) suspended load. The bed load is the material in the bottom layers of the flow. The bed load movement of particles takes place by rolling, sliding and hopping, i.e., saltation, depending on the velocity of flow.

With further increase of velocity, smaller-size particles in saltation are thrown in suspension by the transport by the upward component of the turbulent velocity of flow. Thus the transport by suspension is an advanced stage of bed load movement, intensified by eddies with vertical axes. The weight of the particles is supported by the surrounding fluid. The term wash load is often used to designate very minute particles approaching colloidal sizes which always remain in suspension.

(2) Sediment Production Rate

In general, the mean annual sediment production is expressed in the following formula:

$$q_s = KA^n \quad \text{(II.2)}$$

where, q_s : mean annual sediment production (m^3/km^2/year)
A : catchment area (km^2)
K, n : constant

The constant "n" is normally a negative value meaning that the sediment production decreases as the catchment area increases. This is because of the larger sediment storage function and higher percentage of plains in the bigger catchments.

In Japan, -0.7 is used for the constant "n", where in India, -0.2 to -0.5 is applied[30] The arithmetic average of sediment production rates obtained from 1,000 existing measurements in the US. gave a rate of 1,800 m^3/km^2/year for the catchments of less than 25 km^2.

In Malaysia, no long-term sampling of bed load has been done, and only suspended load records at 53 DID hydrological stations are available. The rate of bed load was assumed at 10 to 20 % of the total sediment load*31 in "National Water Resources Study Malaysia, Perlis-Kedah-Pulau Pinang Regional Water Resources Study", and the rate of 20 % was finally adopted for the bed load.

In this study, stations for suspended load measurement were selected in terms of the catchment area (less than 1000 km^2) and the location (near-by the feasibility study sites) as shown in Table II.17. The relationship between the mean annual sediment transport and catchment area is shown in Fig. II.8. The sediment transport was estimated by converting the suspended load transported in tones to the total sediment volume in m^3 assuming that; i) the bed load is 20 % of the total sediment load, and ii) the specific weight of the deposit is 1.0 ton/m^3

Four groups can be found according to the sedimentation rates as follows.

Sedimentation rate	Area
Very high	Part of Selangor (Sg. Batu, Sg. Semenyih), Perak (Sg. Cenderiang), Pahang (Sg. Lepar)
High	Selangor, Lower Pahang river basin Central Perak (Ipoh, Kampar, Tapah)
Low	Perlis, Melaka
Intermediate	Others

Footnotes

*30/ "Engineering Hydrology", R.S. Varshney,1986

*31/ 11 % to 25 % of the suspended load

(3) Sedimentation rate for the proposed water sources

According to catchment areas and groups to which the project areas belong, the sedimentation rates were obtained from Fig. II.8 as shown below;

Project	Water source	Catchment area	Sedimentation rate	
PR1	Simpang Geti	55.00 km^2	≈150 $m^3/km^2/year$	≈8,300 $m^3/year$
PR4	Tasik Melati	5.70 km^2	≈260 $m^3/km^2/year$	≈1,480 $m^3/year$
KH4	Lembu	3.50 km^2	≈300 $m^3/km^2/year$	≈1,050 $m^3/year$
	Upper Lembu	0.34 km^2	≈530 $m^3/km^2/year$	≈180 $m^3/year$
	Ketapang	0.60 km^2	≈460 $m^3/km^2/year$	≈280 $m^3/year$
MA16	Ayer Mentangor	2.35 km^2	≈325 $m^3/km^2/year$	≈760 $m^3/year$
	Durian area	0.47 km^2	≈485 $m^3/km^2/year$	≈230 $m^3/year$
JR10	Kangkar Merlimau	1.40 km^2	≈370 $m^3/km^2/year$	≈520 $m^3/year$
TR44	Sg. Peching	4.85 km^2	≈270 $m^3/km^2/year$	≈1,310 $m^3/year$
	Sg. Por	18.20 km^2	≈190 $m^3/km^2/year$	≈3,560 $m^3/year$
	Sg. Udang	2.40 km^2	≈320 $m^3/km^2/year$	≈770 $m^3/year$

3.2.6 Discussion

(1) Available water

The estimated run-offs at the six water sources in the project areas are summarized below.

UNIT : mm

PROJECT AREA		MONTH 1	2	3	4	5	6	7	8	9	10	11	12	ΣRoff A	ΣRain B	% A/B
PR1	S.GETI	13	8	10	11	22	13	24	29	57	77	104	72	**440**	1529	29%
PR4	T.MELATI	30	11	13	14	28	36	34	46	88	119	137	84	**640**	1745	37%
KH4	KEDAWAN	20	15	19	25	78	118	156	177	245	282	197	72	**1404**	2589	54%
MA16	BKT.SEDANAN	41	16	29	56	64	37	16	21	30	63	106	80	**557**	1718	32%
JR10	K. MERLIMAU	100	68	78	99	111	75	74	78	78	100	139	127	**1127**	2347	48%
TR44	PASIR NERING	283	110	64	41	64	52	61	63	106	154	279	512	**1790**	3089	58%

ΣRoff : Total run-off
ΣRain: Mean annual rainfall for the period of calculation
Framed values : Minimum run-off

From this table, the general hydrological condition of the project areas can be estimated. In terms of the total run-off, the project areas will be evaluated in the descending order as follows:

Terengganu > Kedah > Johor > Melaka > Perlis

However, when the minimum run-off depth is examined closely, the ranking will be changed to:

Johor > Terengganu > Melaka > Kedah >Perlis

If a big reservoir which can store all the run-off in a year is required, Terengganu has the highest potential quantitatively, but in terms of stability, namely, equal distribution of available water, Johor has the best potential.

Following table shows the numbers of rainy days in/around the project areas.

Project area	Rainy days	Number of dry periods *	Mean maximum dry period	Mean dry periods
Perlis	139 days	3.6 nos.	39 days	22 days
Kedah	132 days	4.4 nos.	41 days	22 days
Melaka	95 days	5.5 nos.	30 days	17 days
Johor	140 days	2.6 nos.	20 days	16 days
Terengganu	192 days	2.2 nos.	17 days	14 days

*: "dry period" = period without rainfall for more than 10 days.

Johor has the most desirable rainfall pattern both in terms of quantity and stability, in other words, reliability. Terengganu has a distinct rainy season, in which most of water is lost as excess water, while in dry periods, they also have water shortage problems. Melaka shows the similar run-off depth to that of Perlis. However, the number of rainy days is much less. In this point of view, the necessity and development potential of small reservoirs is high in Melaka. The most serious drawback in irrigation in Perlis is its high development rate of water sources. Almost all the water sources have been developed and used to large extent. Since the water source in Perlis is very limited, the systematic water management and on-farm ponds for off-season would be the main issues in this state. Langkawi is benefited by abundant rainfall and run-off rate, but the concentration of precipitation during the rainy season, and its small catchments are the major constraints for a large-scale water source development.

(2) Run-off volume

The volumes of available water at the proposed dam/intake sites are given in ha·m in the following;

PROJECT AREA		Total Run-off Depth (mm)	Catchment Area (sq.km)	Run-off Volume (ha·m) main	second	others	Total
PR1	S.GETI	440	55.0	1860	233	326	2420
PR4	T.MELATI	640	5.7	270	39	56	365
KH4	KEDAWAN	1404	3.5	340	123	28	491
MA16	BKT.SEDANAN	557	2.4	-	-	-	131
JR10	K. MERLIMAU	1127	1.4	-	-	-	158
TR44	PASIR NERING	1790	4.9	273	212	384	868

NOTE: CROP & SEASON	MAIN	SECOND
S.Geti	Paddy (Aug-Dec)	Tabacco (Jan-Apr)
T.Melati	Paddy (Aug-Dec)	Tabacco (Jan-Apr)
Kedawan	Paddy (Aug-Dec)	Vegetable (May-Jul)
Bkt.Sedanan	Tree crops	
K.Merlimau	Tree crops	
Pasir Nering	Roselle(Jan-Jun)	Roselle(May-Dec)

The most important point here is how to increase the rate of usage of these water sources. Since the capacities of reservoirs for this project are small, it is primarily considered necessary to increase the number of reservoirs themselves. In case of Perlis, the role of small reservoirs should be that of farm ponds which store the irrigation water for one to few times of irrigation.

(3) Floods

The estimated floods by HPs are summarized in the following table.

unit : cumec

Project Area		Hydrological Procedures HP4	HP5 *	HP11
PR4	Tasik Melati	6.9	16.1	15.5
KH4	Bkt.Lembu	5.0	18.4	14.5
	Up Bkt. Lembu	0.8	2.6	4.0
	Ketapang	1.3	3.3	5.8
MA16	Ayer Mentangor	2.5	7.2	12.7
	Durian area	0.8	2.0	3.3
JR10	K. Merlimau	5.2	6.9	10.5
TR44	Sg. Perching	21.4	61.3	43.0
	Sg. Por	71.0	209.8	145.1

Since the HP4 was developed for the catchments bigger than 20 km^2, its results shall not be used for the projects with catchments smaller than 20 km^2. The HP5 uses rather low run-off coefficients (Cf) for dry regions. Accordingly, the estimated values are also low for Melaka and Johor. The dominating factor for the HP11 is the catchment group. Tasik Melati and Bkt.Lembu of which catchments were categorized in Group 3 got lower values comparing with those of the HP5. In case the catchment can not be clearly categorized into these groups, a weighted average by area and group is also applicable.

The specific discharges of the 100 year return period are compared below;

unit : cumec

Project Area		100 year flood (cumec)	HP	Catchment area (km2)	Specific discharge (m3/sec/km2)
PR4	Tasik Melati	16.1	HP5	5.7	2.8
KH4	Bkt.Lembu	18.4	HP5	3.5	5.3
	Up Bkt. Lembu	4.0	HP11	0.4	11.4
	Ketapang	5.8	HP11	0.6	9.7
MA16	Ayer Mentangor	12.7	HP11	2.4	5.4
	Durian area	3.3	HP11	0.5	7.0
JR10	K. Merlimau	10.5	HP11	1.4	7.5
TR44	Sg. Perching	61.3	HP5	4.9	12.6
	Sg. Por	209.8	HP5	18.2	11.5

Note : Maximum values were taken here.

As far as the flood estimate is concerned, we should be conservative enough to take the highest estimated values.

Regarding the "Type A (small dam)" reservoir, probable maximum flood (PMF), which is generally used for determination of design floods, is recommended to be evaluated in case that the scale of dam is comparatively big in terms of dam height (nearly or higher than 10 meter), or influence on the downstream is assumed big.

In this study, the PMFs were estimated for the Ketapang Dam of KH4 Kedawang in Kedah and for the Air Mentangor Dam of MA16 Bkt. Sedanan in Melaka. Probable maximum precipitations (PMP) estimated for the near-by projects of the two project areas were used and the PMFs were calculated as follows:

i) Setting of PMP

PMP is generally estimated based on records of previous floods, meteorological observation records at near-by stations, etc. However, on the other hand, it requires detailed and long-term records, and complicated calculations. In Malaysia, some PMFs have been estimated according to these "calculated PMPs", whereas these PMPs were transposed for PMF estimation in the near-by catchments.

In this study, the "calculated PMPs" for Sg. Malut Dam ("Sg. Malut Dam Project", December 1984) were used for the Ketapang Dam in Kedah, while those for Upper Muar Dam ("Preliminary Engineering Report for Upper Muar Dam", July 1988) were used for the Ayer Mentangor Dam in Melaka. The PMPs by duration are shown below:

Malut Dam (Langkawi, Kedah)		Upper Muar Dam (Melaka)	
Duration	Calculated PMP	Duration	Calculated PMP
1 hour	440 mm	0.5 hour	125 mm
2 hours	600 mm	1.5 hours	225 mm
3 hours	740 mm	2.5 hours	275 mm

ii) Probable maximum rainfall intensity (I_{PMP})

Based on the above-mentioned PMP, probable maximum rainfall intensity during the time of concentration (I_{PMP}) was calculated by interpolation. The results are shown below:

Ketapang Dam (Kedah)		Ayer Mentangor Dam (Melaka)	
time of concentration (t)	I_{PMP}	time of concentration (t)	I_{PMP}
1.27 hours	495 mm	2.17 hours	261 mm

iii) Runoff coefficient (C_{PMF})

In HP5, runoff coefficients for floods are determined by region (1 to 4). Basic runoff coefficients, which represent those of 10 year return period, are multiplied by frequency factors (C_y/C_{10}, derived from Fig. 4 in HP5) to get runoff coefficients for certain return periods (C_{PMF}). However, PMP and PMF do not include sense of return period. In this study, the frequency factors were determined assuming that probability of 1 in 20,000 year recurrence interval is equivalent to that of PMP or PMF. The frequency factors and runoff coefficients for PMF are shown below:

Region	Basic Runoff	Frequency Factor (C_{20000}/C_{10})	Runoff Coefficient for PMF (C_{PMF})	
No. 1	0.130	1.85	0.241	(for Ketapang)
No. 2	0.060	2.02	0.121	
No. 3	0.098	2.28	0.223	(for Ayer Mentangor)
No. 4	0.380	2.37	0.901	

iv) Probable Maximum Flood (PMF)

PMFs were estimated according to the following rational formula:

$$Q_t = 0.278 \times C_t \times I_t \times A$$

where
- Q_t: design flood in cumec (Q_{PMF} for PMF)
- C_t: runoff coefficient (C_{PMF} for PMF)
- I_t: rainfall intensity during the time of concentration in mm/hour (I_{PMF} for PMF)
- A: catchment area

Consequently, PMFs for the Ketapang Dam and the Air Mentangor Dam were estimated at 16.3 m^3/sec and 21.6 m^3/sec, respectively, which both represent upper limits of confidence mentioned in "STEP 4" of HP5.

(4) Sediment

Since the observation records of river sediments are not available particularly for small catchments, the sediment concentration curve (Fig. II.8) should be ascertained and improved through further field observations. It is also recommended to take into consideration the catchment characteristics such as vegetation, soil cover, topography, etc.

The sedimentation in a reservoir varies largely depending on the volume of water which is stored and spilled out. The sediment trap rates of big reservoirs are normally high comparing with small reservoirs. In this point of view, the sedimentation rate is also dominated by the structure of reservoir.

Tables

Table II.1 SUMMARY OF METEOROLOGICAL FEATURES (1/6)

48679 Johor Bahru International Airport (Senai)

Period : 1975-92

Item		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Temperature (°C)	Mean	25.3	25.8	26.1	26.3	26.4	26.4	25.8	25.9	25.7	25.9	25.6	25.3	25.9
	Maximum	30.8	32.1	32.5	32.7	32.3	32.0	31.3	31.4	31.4	31.7	31.0	30.3	31.6
	Minimum	21.7	21.8	22.2	22.8	23.0	22.8	22.3	22.3	22.3	22.5	22.6	22.3	22.4
Relative humidity (%)	Mean	84.5	83.1	85.0	87.1	87.6	86.1	86.8	86.8	86.9	86.9	88.1	87.4	86.4
	Maximum	98.2	98.3	98.6	98.6	98.6	98.4	98.7	98.6	98.7	98.3	98.4	98.3	98.5
	Minimum	63.2	57.7	59.4	61.7	64.2	63.1	64.2	64.0	63.3	62.8	66.1	68.2	63.2
Sunhine hours (hours)	Mean	6.1	6.9	6.2	6.0	5.7	5.9	5.7	5.4	4.7	4.8	4.5	5.1	5.6
Wind speed (m/sec)	Mean	2.4	2.0	1.5	1.0	1.1	1.2	1.3	1.4	1.2	1.2	1.5	2.2	1.5
Evaporation (mm)	Mean	3.6	4.0	3.8	3.6	3.3	3.4	3.3	3.3	3.2	3.2	2.9	3.1	3.4

48672 Kluang

Period : 1974-88

Item		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Temperature (°C)	Mean	25.2	26.0	26.3	26.4	26.5	26.4	25.8	25.9	25.7	25.8	25.5	25.2	25.9
	Maximum	29.8	31.4	32.3	32.5	32.3	31.8	31.1	31.3	31.3	31.6	30.7	29.7	31.3
	Minimum	22.3	22.6	22.9	23.0	23.2	23.0	22.5	22.6	22.4	22.6	22.6	22.5	22.7
Relative humidity (%)	Mean	83.5	82.3	83.3	85.9	86.5	85.8	86.3	86.1	86.6	86.2	87.9	86.6	85.6
	Maximum	95.9	96.4	97.0	98.1	98.1	98.0	98.1	97.9	98.1	98.0	98.4	97.3	97.6
	Minimum	65.3	60.3	59.6	62.5	64.1	64.5	65.3	64.3	64.0	63.5	67.1	69.1	64.1
Sunhine hours (hours)	Mean	6.4	7.1	6.7	6.3	6.4	6.4	6.0	5.8	5.0	5.3	4.9	5.6	6.0
Wind speed (m/sec)	Mean	3.7	3.2	2.2	1.3	1.3	1.5	1.7	1.9	1.5	1.3	1.7	3.0	2.0
Evaporation (mm)	Mean	3.5	3.9	3.7	3.4	3.0	2.9	2.8	2.9	3.0	3.0	2.8	2.9	3.1

48674 Mersing

Period : 1968-92

Item		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Temperature (°C)	Mean	25.9	26.4	26.8	26.8	26.6	26.4	25.8	25.9	25.7	25.9	25.6	25.7	26.1
	Maximum	28.2	29.2	30.4	31.6	31.9	31.4	30.9	31.0	30.9	31.0	29.6	28.2	30.4
	Minimum	23.6	23.7	23.3	23.0	23.1	22.9	22.4	22.4	22.4	22.6	22.7	23.2	22.9
Relative humidity (%)	Mean	81.8	81.2	81.8	84.2	85.6	85.8	86.2	86.2	86.3	86.1	87.2	85.7	84.9
	Maximum	90.6	90.9	93.4	96.4	96.6	96.5	96.8	96.8	96.9	97.0	96.8	94.3	95.2
	Minimum	73.5	71.4	69.2	67.8	67.5	67.5	67.6	67.3	67.0	67.5	72.7	76.3	69.6
Sunhine hours (hours)	Mean	6.1	7.4	7.4	6.9	6.8	6.3	6.1	5.8	5.6	5.6	4.7	4.8	6.1
Wind speed (m/sec)	Mean	5.1	4.6	3.6	2.5	2.5	2.6	2.7	2.7	2.6	2.4	2.7	4.2	3.2
Evaporation (mm)	Mean	4.1	4.8	4.7	4.2	3.8	3.7	3.6	3.8	3.8	3.7	3.1	3.7	3.9

48603 Alor Setar Airport (Kepala Batas)

Period : 1968-92

Item		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Temperature (°C)	Mean	26.8	27.6	27.9	28.0	27.6	27.4	26.8	26.9	26.5	26.5	26.4	26.4	27.1
	Maximum	32.8	34.4	34.5	33.8	32.5	31.9	31.6	31.6	31.1	31.3	31.4	31.4	32.4
	Minimum	21.8	22.3	23.0	23.9	24.3	24.1	23.6	23.6	23.5	23.5	23.2	22.7	23.3
Relative humidity (%)	Mean	72.7	71.4	74.7	79.8	83.9	84.2	84.8	84.5	85.5	86.0	84.3	78.7	80.9
	Maximum	93.3	93.2	94.3	95.5	96.2	96.2	96.6	96.6	96.7	96.7	96.4	94.4	95.5
	Minimum	48.7	43.9	47.4	56.4	65.2	66.4	66.0	65.2	67.1	66.8	64.4	58.7	59.7
Sunhine hours (hours)	Mean	8.6	8.8	8.6	8.4	7.2	6.7	6.8	6.5	5.8	5.8	6.1	7.0	7.2
Wind speed (m/sec)	Mean	1.8	1.6	1.3	1.1	1.0	0.9	1.0	1.1	1.1	1.0	1.0	1.5	1.2
Evaporation (mm)	Mean	5.4	5.9	5.7	5.0	3.9	3.6	3.6	3.7	3.5	3.5	3.4	4.3	4.3

Table II.1 SUMMARY OF METEOROLOGICAL FEATURES (2/6)

48600 Pulau Langkawi International Airport

Period : 1988-92

Item		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Temperature (°C)	Mean	27.8	27.9	28.0	27.9	27.5	27.5	27.0	27.2	26.6	26.6	27.0	27.2	27.4
	Maximum	32.8	33.1	32.8	31.9	30.9	30.9	30.3	30.4	29.9	30.1	30.8	31.4	31.3
	Minimum	24.0	24.0	24.3	24.6	24.8	24.6	24.2	24.6	24.1	24.0	24.2	24.0	24.3
Relative humidity (%)	Mean	72.8	74.4	76.6	82.2	85.0	82.8	81.8	81.4	84.0	84.8	80.2	74.8	80.1
	Maximum	88.8	90.2	92.0	94.0	94.8	93.8	95.8	95.4	96.4	96.2	94.0	89.8	93.4
	Minimum	54.4	54.0	57.0	65.2	70.8	68.4	66.6	67.0	68.6	70.0	64.8	58.6	63.8
Sunhine hours (hours)	Mean	8.9	9.3	9.1	8.4	6.6	6.8	6.3	6.4	5.2	5.8	6.9	8.1	7.3
Wind speed (m/sec)	Mean	3.4	2.7	2.2	1.9	1.6	1.7	1.7	2.3	1.9	1.9	2.4	3.5	2.3
Evaporation (mm)	Mean	7.1	6.6	6.2	5.2	3.6	4.0	3.7	3.9	3.5	3.4	4.5	6.4	4.8

48615 Kota Bharu Airport (Pengkalan Chepa)

Period : 1968-92

Item		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Temperature (°C)	Mean	25.7	26.2	27.0	27.9	28.0	27.6	27.1	27.0	26.8	26.6	26.0	25.8	26.8
	Maximum	29.1	30.2	31.3	32.5	32.8	32.4	32.0	31.9	31.6	31.0	29.5	28.8	31.1
	Minimum	22.5	22.6	23.2	23.9	24.3	23.9	23.5	23.5	23.4	23.4	23.3	23.2	23.4
Relative humidity (%)	Mean	80.2	79.4	79.2	79.3	79.7	80.2	80.9	81.6	82.2	83.4	85.6	82.9	81.2
	Maximum	93.5	94.0	94.6	95.0	94.5	94.7	95.2	95.4	95.5	95.9	96.1	94.0	94.9
	Minimum	66.8	63.8	61.9	60.2	60.5	60.9	61.0	61.8	62.5	65.9	71.9	71.6	64.1
Sunhine hours (hours)	Mean	7.3	8.3	8.6	8.9	8.0	7.1	7.3	7.1	6.8	6.3	5.4	5.5	7.2
Wind speed (m/sec)	Mean	2.6	2.5	2.3	1.9	1.7	1.5	1.5	1.5	1.6	1.7	1.8	2.7	1.9
Evaporation (mm)	Mean	4.5	5.0	5.2	5.5	4.9	4.4	4.6	4.4	4.4	4.2	3.6	3.8	4.5

48616 Kuala Krai

Period : 1985-92

Item		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Temperature (°C)	Mean	24.6	25.7	26.6	27.2	27.0	26.9	26.3	26.2	25.9	25.7	25.1	24.4	26.0
	Maximum	30.2	32.5	33.6	34.8	34.1	33.6	33.1	32.9	32.7	32.3	30.5	29.3	32.4
	Minimum	21.4	21.5	22.4	23.0	23.3	22.9	22.5	22.5	22.4	22.6	22.5	21.8	22.4
Relative humidity (%)	Mean	87.8	83.5	83.1	83.5	85.3	85.5	85.5	86.6	87.3	88.8	90.4	89.9	86.4
	Maximum	99.5	99.4	99.1	99.5	98.9	99.1	99.4	99.0	99.3	99.4	99.6	99.4	99.3
	Minimum	66.0	55.5	54.6	53.9	58.5	59.0	59.6	61.3	61.6	63.1	70.3	71.8	61.3
Sunhine hours (hours)	Mean	4.9	7.1	6.6	7.2	6.2	6.6	6.5	6.0	5.5	4.9	4.2	4.0	5.8
Wind speed (m/sec)	Mean	0.5	0.6	0.6	0.6	0.7	0.7	0.8	0.7	0.8	0.6	0.6	0.6	0.6
Evaporation (mm)	Mean	2.7	3.9	4.2	4.4	4.0	3.9	4.0	3.7	3.7	3.2	2.5	2.3	3.5

48665 Melaka Airport (Batu Berendam)

Period : 1968-92

Item		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Temperature (°C)	Mean	26.4	27.0	27.2	27.2	27.2	27.0	26.6	26.6	26.5	26.6	26.2	26.1	26.7
	Maximum	31.7	33.0	33.0	32.5	32.0	31.6	31.1	31.1	31.1	31.5	31.1	31.0	31.7
	Minimum	22.5	23.0	23.2	23.4	23.5	23.1	22.8	22.7	22.8	23.0	22.9	22.7	23.0
Relative humidity (%)	Mean	78.4	77.4	80.5	84.0	84.7	84.7	84.6	84.8	84.8	84.5	85.7	82.8	83.1
	Maximum	93.9	94.0	95.7	97.6	97.8	98.1	98.1	98.1	98.1	98.0	97.8	96.0	96.9
	Minimum	55.9	52.2	55.6	61.3	64.0	64.0	64.1	64.2	64.0	62.9	64.4	62.1	61.2
Sunhine hours (hours)	Mean	6.7	7.6	7.1	7.0	6.9	6.6	6.7	6.3	5.8	5.9	5.3	5.7	6.4
Wind speed (m/sec)	Mean	2.8	2.7	2.0	1.4	1.2	1.2	1.2	1.2	1.3	1.4	1.6	2.3	1.7
Evaporation (mm)	Mean	5.0	5.5	5.2	4.5	4.1	4.0	3.9	4.0	4.2	4.2	3.8	4.3	4.4

48642 Batu Embun

Period : 1983-92

Item		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Temperature (°C)	Mean	25.3	26.2	26.9	27.4	27.2	26.9	26.4	26.5	26.1	26.2	25.8	25.0	26.3
	Maximum	30.8	32.7	33.5	34.1	33.5	33.2	32.7	32.9	32.5	32.4	31.3	30.0	32.5
	Minimum	21.7	21.9	22.6	23.2	23.3	22.9	22.4	22.5	22.5	22.7	22.7	22.0	22.5
Relative humidity (%)	Mean	86.3	83.0	83.0	83.6	85.1	84.9	85.1	84.7	84.7	84.9	86.7	87.8	85.0
	Maximum	97.9	97.6	97.4	97.6	97.9	97.8	98.0	98.1	98.2	98.2	98.2	98.4	97.9
	Minimum	63.4	56.3	56.4	56.8	60.3	59.7	60.4	58.7	58.7	59.2	64.3	66.3	60.0
Sunhine hours (hours)	Mean	5.7	7.1	7.0	7.2	6.6	6.6	6.5	6.0	5.5	5.4	5.0	4.8	6.1
Wind speed (m/sec)	Mean	0.6	0.5	0.5	0.5	0.4	0.4	0.4	0.5	0.6	0.5	0.5	0.6	0.5
Evaporation (mm)	Mean	2.6	3.4	3.8	3.9	3.5	3.3	3.3	3.3	3.4	3.1	2.7	2.1	3.2

48632 Cameron Highlands (Tanah Rata)

Period : 1984-92

Item		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Temperature (°C)	Mean	17.1	17.7	18.3	18.7	18.7	18.5	17.9	17.9	17.6	17.6	17.6	17.1	17.9
	Maximum	20.9	22.1	22.7	22.9	22.7	22.4	22.0	21.7	21.5	21.5	21.2	20.7	21.9
	Minimum	14.4	14.5	15.1	15.8	15.9	15.5	15.1	15.1	15.1	15.2	15.1	14.8	15.1
Relative humidity (%)	Mean	86.0	86.0	86.4	89.9	90.9	87.6	88.6	89.2	91.0	91.2	91.3	89.6	89.0
	Maximum	96.2	96.8	96.9	97.9	98.1	97.1	97.7	97.8	98.3	98.2	98.1	97.4	97.5
	Minimum	69.9	68.3	68.7	73.7	75.9	72.2	72.9	74.9	77.0	77.6	78.2	75.6	73.7
Sunhine hours (hours)	Mean	5.0	5.8	5.6	5.5	4.6	5.5	5.5	4.7	4.0	3.8	3.7	4.4	4.8
Wind speed (m/sec)	Mean	3.1	2.4	2.3	1.7	1.4	1.6	1.7	1.7	1.9	1.8	2.0	2.9	2.0
Evaporation (mm)	Mean	2.1	2.3	2.5	2.2	2.0	2.2	2.0	2.0	1.8	1.7	1.5	1.8	2.0

48657 Kuantan Airport

Period : 1968-92

Item		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Temperature (°C)	Mean	24.8	25.5	26.2	26.9	27.1	27.0	26.5	26.7	26.3	26.2	25.3	24.7	26.1
	Maximum	29.5	30.8	31.7	32.7	33.0	32.7	32.4	32.5	32.3	31.9	30.2	28.8	31.5
	Minimum	21.6	21.8	22.4	23.0	23.3	23.2	22.7	22.8	22.7	22.8	22.6	22.2	22.6
Relative humidity (%)	Mean	85.1	83.4	83.6	83.8	84.4	83.7	83.6	83.2	84.2	85.6	88.6	88.4	84.8
	Maximum	97.0	97.1	97.6	97.8	97.9	97.8	97.8	97.7	98.0	98.2	98.3	97.7	97.7
	Minimum	65.8	61.6	61.4	60.6	60.6	59.8	59.1	58.2	59.3	61.6	69.0	72.1	62.4
Sunhine hours (hours)	Mean	5.7	6.8	6.9	6.9	6.6	6.4	6.6	6.2	5.8	5.2	4.2	4.3	6.0
Wind speed (m/sec)	Mean	2.8	2.6	2.1	1.6	1.4	1.6	1.8	1.8	1.7	1.4	1.5	2.5	1.9
Evaporation (mm)	Mean	3.2	3.8	4.2	4.1	4.1	3.9	4.0	4.1	4.1	3.7	2.9	2.9	3.8

48649 Muazam Shah

Period : 1984-92

Item		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Temperature (°C)	Mean	25.4	26.0	26.3	27.0	26.9	26.9	26.3	26.4	26.2	26.2	25.7	25.4	26.2
	Maximum	29.6	31.3	31.9	33.1	33.1	32.9	32.5	32.8	32.6	32.3	30.7	29.4	31.9
	Minimum	22.3	22.1	22.5	23.0	23.2	22.8	22.3	22.3	22.4	22.6	22.7	22.6	22.6
Relative humidity (%)	Mean	83.6	82.2	84.1	84.4	85.6	84.3	84.4	84.0	84.7	85.4	87.1	85.4	84.6
	Maximum	95.9	96.3	97.0	97.2	97.2	97.4	97.7	97.8	97.7	97.7	97.6	96.4	97.2
	Minimum	65.2	59.2	61.6	59.6	62.3	61.2	59.9	58.6	59.1	60.9	67.1	69.1	62.0
Sunhine hours (hours)	Mean	5.8	7.2	6.6	6.8	6.8	7.0	6.9	6.5	6.0	5.5	4.7	4.8	6.2
Wind speed (m/sec)	Mean	2.4	1.9	1.3	0.7	0.7	0.7	0.7	0.8	0.9	0.8	1.0	2.0	1.2
Evaporation (mm)	Mean	3.4	4.1	3.8	3.8	3.5	3.5	3.5	3.7	3.6	3.5	2.8	2.9	3.5

Table II.1 SUMMARY OF METEOROLOGICAL FEATURES (4/6)

48653 Temerloh
Period : 1984-92

Item		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Temperature (°C)	Mean	25.5	26.5	27.1	27.4	27.4	27.2	26.7	26.7	26.4	26.5	26.0	25.4	26.6
	Maximum	30.9	32.8	33.6	34.0	33.7	33.4	33.1	33.3	32.9	32.7	31.6	30.2	32.7
	Minimum	21.9	22.2	22.8	23.5	23.6	23.2	22.7	22.6	22.7	22.9	22.9	22.3	22.8
Relative humidity (%)	Mean	85.0	81.5	81.7	83.7	85.0	84.5	84.4	83.7	85.6	86.0	87.7	87.7	84.7
	Maximum	100.0	99.7	99.9	100.0	100.0	99.9	100.0	99.9	100.0	100.0	99.9	99.9	99.9
	Minimum	48.5	44.1	43.1	46.9	49.7	48.5	47.4	47.1	48.3	49.9	53.2	52.1	48.3
Sunhine hours (hours)	Mean	5.8	6.8	6.6	6.6	6.4	6.3	6.2	6.1	5.4	5.1	4.8	4.8	5.9
Wind speed (m/sec)	Mean	0.6	0.7	0.6	0.5	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.7	0.5
Evaporation (mm)	Mean	3.1	3.8	4.0	3.8	3.6	3.4	3.4	3.5	3.5	3.3	2.9	2.6	3.4

48602 Butterworth Airport
Period : 1985-92

Item		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Temperature (°C)	Mean	27.3	27.7	27.7	28.0	27.8	28.0	27.4	27.3	26.7	26.6	26.6	26.9	27.3
	Maximum	32.3	32.4	32.4	32.3	32.0	32.2	31.7	31.4	30.7	30.7	31.0	31.8	31.7
	Minimum	23.0	23.3	23.6	24.3	24.4	24.2	23.6	23.6	23.5	23.5	23.4	23.1	23.6
Relative humidity (%)	Mean	73.6	75.1	78.8	81.6	82.8	80.4	81.1	81.6	84.4	84.9	82.8	75.9	80.2
	Maximum	90.5	92.1	95.0	95.9	96.0	95.6	95.9	96.1	96.9	97.1	96.0	91.1	94.9
	Minimum	53.3	55.6	59.5	63.8	64.8	62.5	62.3	63.9	67.0	67.5	64.6	56.5	61.8
Sunhine hours (hours)	Mean						data not available							
Wind speed (m/sec)	Mean	1.6	1.7	1.6	1.4	1.3	1.4	1.5	1.5	1.4	1.4	1.4	1.8	1.5
Evaporation (mm)	Mean						data not available							

49601 Penang International Airport (Bayan Lepas)
Period : 1968-92

Item		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Temperature (°C)	Mean	27.2	27.5	27.7	27.8	27.6	27.5	27.0	26.9	26.5	26.5	26.7	27.0	27.2
	Maximum	31.8	32.2	32.2	32.0	31.6	31.5	31.1	31.0	30.5	30.5	30.7	31.2	31.3
	Minimum	23.3	23.6	23.8	24.2	24.2	24.0	23.5	23.5	23.3	23.3	23.4	23.6	23.6
Relative humidity (%)	Mean	73.7	76.1	79.2	82.8	84.2	83.2	83.0	83.9	85.3	85.6	83.1	77.3	81.4
	Maximum	91.4	94.2	96.0	96.9	97.2	97.1	96.9	97.1	97.5	97.4	96.0	92.0	95.8
	Minimum	55.5	56.3	59.6	65.1	66.9	65.4	64.9	65.8	67.9	68.2	65.8	60.4	63.5
Sunhine hours (hours)	Mean	8.2	8.3	8.0	7.5	6.7	6.9	6.7	6.3	5.5	5.6	6.2	7.0	6.9
Wind speed (m/sec)	Mean	2.2	2.0	1.8	1.5	1.4	1.4	1.5	1.5	1.4	1.4	1.7	2.3	1.7
Evaporation (mm)	Mean	5.0	5.0	4.7	4.3	3.8	3.9	3.8	3.7	3.5	3.4	3.6	4.4	4.1

48625 Ipoh Airport
Period : 1968-92

Item		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Temperature (°C)	Mean	26.7	27.1	27.4	27.5	27.5	27.5	27.0	27.1	26.6	26.5	26.2	26.3	27.0
	Maximum	32.9	33.8	33.9	33.6	33.3	33.3	33.0	33.0	32.4	32.3	32.0	32.0	32.9
	Minimum	22.3	22.7	23.2	23.7	23.8	23.4	22.9	23.0	22.9	22.9	22.9	22.6	23.0
Relative humidity (%)	Mean	77.7	77.3	78.4	81.5	81.5	79.0	78.7	79.1	81.5	82.9	83.8	81.9	80.3
	Maximum	94.7	94.6	94.8	95.6	95.7	94.7	94.7	94.9	95.7	96.2	96.5	96.0	95.3
	Minimum	51.4	49.2	51.4	56.4	57.2	54.5	53.7	53.9	56.3	58.0	59.7	57.7	55.0
Sunhine hours (hours)	Mean	7.1	7.5	7.3	7.0	6.6	6.7	6.7	6.1	5.5	5.5	5.5	5.9	6.5
Wind speed (m/sec)	Mean	1.7	1.8	1.7	1.6	1.6	1.6	1.8	1.7	1.7	1.6	1.6	1.6	1.7
Evaporation (mm)	Mean	4.2	4.5	4.6	4.5	4.0	4.1	4.0	4.1	3.8	3.9	3.4	3.7	4.1

Table II.1 SUMMARY OF METEOROLOGICAL FEATURES (5/6)

48620 Sitiawan

Period : 1968-92

Item		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Temperature (°C)	Mean	26.3	26.7	27.1	27.4	27.4	27.3	26.9	26.9	26.5	26.4	26.2	26.1	26.8
	Maximum	31.5	32.2	32.6	32.6	32.5	32.6	32.2	32.2	31.7	31.4	31.1	31.2	32.0
	Minimum	22.3	22.7	23.1	23.6	23.7	23.3	22.8	22.9	22.9	23.0	22.9	22.6	23.0
Relative humidity (%)	Mean	84.1	82.8	83.1	84.3	84.3	83.2	82.7	82.8	84.5	85.6	86.6	85.9	84.2
	Maximum	97.9	97.8	97.8	97.9	97.9	97.6	97.6	97.6	98.0	98.1	98.2	98.1	97.9
	Minimum	61.7	59.8	60.9	63.5	63.3	61.4	60.1	60.4	62.5	64.8	66.3	64.7	62.5
Sunhine hours (hours)	Mean	6.9	7.3	7.1	7.1	6.9	6.9	6.8	6.3	5.7	5.7	5.5	5.9	6.5
Wind speed (m/sec)	Mean	1.2	1.4	1.5	1.4	1.4	1.3	1.4	1.5	1.5	1.5	1.3	1.2	1.4
Evaporation (mm)	Mean	2.6	3.0	3.1	3.0	2.9	2.8	2.9	2.8	2.8	2.7	2.4	2.5	2.8

48604 Chuping

Period : 1968-92

Item		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Temperature (°C)	Mean	26.8	27.6	28.0	27.9	27.4	27.2	26.7	26.7	26.4	26.2	26.1	26.1	26.9
	Maximum	32.9	34.8	34.9	34.2	32.7	32.3	31.8	31.7	31.4	31.5	31.4	31.1	32.6
	Minimum	23.1	23.3	23.8	24.1	24.1	23.9	23.3	23.4	23.4	23.3	23.3	23.1	23.5
Relative humidity (%)	Mean	75.6	73.5	76.7	81.9	86.5	86.3	86.5	86.7	87.8	88.4	86.8	82.0	83.2
	Maximum	97.4	98.5	99.8	99.8	99.9	100.0	99.9	99.9	100.0	100.0	99.9	98.8	99.5
	Minimum	41.1	35.3	35.4	41.6	52.6	52.9	54.1	54.9	56.4	55.2	55.4	51.8	48.9
Sunhine hours (hours)	Mean	8.5	8.7	8.2	7.8	6.8	6.5	6.8	6.6	5.7	5.7	6.0	7.0	7.0
Wind speed (m/sec)	Mean	2.3	2.4	1.6	1.0	0.7	0.7	0.9	0.9	0.9	0.8	1.4	2.1	1.3
Evaporation (mm)	Mean	4.8	5.5	5.1	4.6	3.7	3.2	3.2	3.2	3.1	2.8	2.9	3.4	3.8

48647 Kuala Lumpur International Airport (Subang)

Period : 1968-92

Item		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Temperature (°C)	Mean	26.3	26.7	27.0	27.1	27.3	27.2	26.8	26.8	26.6	26.5	26.2	26.2	26.7
	Maximum	32.0	32.9	33.1	33.0	32.7	32.5	32.1	32.3	31.9	31.9	31.4	31.4	32.3
	Minimum	22.1	22.4	22.9	23.4	23.6	23.2	22.8	22.8	22.8	23.0	23.0	22.6	22.9
Relative humidity (%)	Mean	81.1	80.2	81.2	83.6	83.0	81.5	81.4	80.9	82.9	83.7	85.2	83.9	82.4
	Maximum	97.0	96.6	96.8	97.1	96.5	96.2	96.2	95.9	96.5	96.8	97.2	97.1	96.7
	Minimum	54.0	52.0	53.8	58.4	59.7	58.0	58.1	56.7	58.9	59.6	62.0	59.5	57.6
Sunhine hours (hours)	Mean	6.2	7.0	6.8	6.6	6.6	6.5	6.5	6.2	5.4	5.5	5.1	5.4	6.1
Wind speed (m/sec)	Mean	0.9	1.1	1.1	1.1	1.2	1.2	1.4	1.3	1.3	1.2	1.1	0.9	1.1
Evaporation (mm)	Mean	4.0	4.7	4.9	4.5	4.3	4.2	4.1	4.3	4.1	4.1	3.8	3.7	4.2

48648 Petaling Jaya

Period : 1968-92

Item		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Temperature (°C)	Mean	26.8	27.2	27.5	27.5	27.8	27.8	27.3	27.4	27.0	27.0	26.6	26.6	27.2
	Maximum	32.6	33.3	33.6	33.5	33.2	33.1	32.6	32.8	32.5	32.6	32.0	32.1	32.8
	Minimum	23.0	23.3	23.8	24.1	24.3	24.0	23.6	23.7	23.6	23.6	23.5	23.2	23.6
Relative humidity (%)	Mean	77.7	77.4	78.6	80.8	80.3	77.6	78.2	77.0	80.1	80.9	83.1	80.6	79.3
	Maximum	94.5	94.3	94.7	95.3	94.6	93.4	93.7	92.9	94.4	94.7	95.7	95.1	94.4
	Minimum	52.1	50.8	52.8	56.4	57.9	55.9	56.6	55.2	57.7	58.3	60.6	57.1	55.9
Sunhine hours (hours)	Mean	5.9	6.7	6.4	6.2	6.2	6.1	6.1	6.0	5.3	5.4	4.7	5.2	5.8
Wind speed (m/sec)	Mean	1.0	1.0	1.0	1.0	1.1	1.1	1.2	1.2	1.1	1.2	1.0	0.9	1.1
Evaporation (mm)	Mean	3.3	3.7	3.8	3.6	3.3	3.3	3.1	3.4	3.1	3.2	2.8	2.8	3.3

Table II.1 SUMMARY OF METEOROLOGICAL FEATURES (6/6)

48619 Kuala Terengganu Airport

Period : 1968-92

Item		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Temperature (°C)	Mean	25.3	25.8	26.6	27.2	27.4	27.1	26.6	26.5	26.3	26.2	25.6	25.4	26.3
	Maximum	28.3	29.3	30.5	31.6	32.1	31.8	31.3	31.3	30.9	30.5	29.0	28.1	30.4
	Minimum	22.4	22.5	22.9	23.5	23.7	23.6	23.1	23.1	23.0	23.1	23.0	23.0	23.1
Relative humidity (%)	Mean	83.1	82.7	82.6	83.1	83.6	84.1	84.0	84.6	85.0	86.3	88.2	85.4	84.4
	Maximum	95.4	96.1	96.2	96.7	96.7	96.6	96.5	96.7	97.0	97.4	97.4	95.4	96.5
	Minimum	71.2	69.0	67.3	66.1	65.4	66.1	66.0	66.3	66.8	68.8	74.6	75.0	68.5
Sunhine hours (hours)	Mean	6.6	7.9	8.2	8.6	7.9	7.1	7.2	6.8	6.5	6.1	5.4	4.9	6.9
Wind speed (m/sec)	Mean	3.2	2.9	2.7	2.3	2.3	2.2	2.2	2.2	2.2	2.2	2.5	3.5	2.5
Evaporation (mm)	Mean	3.7	4.2	4.7	4.7	4.4	4.0	4.0	4.0	3.9	3.5	3.1	3.3	4.0

Table II.2 MONTHLY POLYGON RAINFALL AND SEASONS

No.	Location	Station No.	Station Name	Average Monthly Rainfall in mm												
				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1	Perlis	6502003	Tasoh	47	34	90	160	196	133	154	182	237	235	199	105	1770
2	Lankawi	6398121	Sg.Penghulu	23	31	86	165	263	247	293	292	385	333	219	53	2387
3	Kedah north	6105037	Gajah Mati	38	58	133	230	255	180	218	212	324	390	242	107	2376
4	Kedah central	5807067	Sik	46	75	135	238	257	169	207	222	300	378	276	100	2400
5	Kedah south, Perai	5305091	Kulim	116	134	194	298	241	145	188	198	294	408	319	198	2731
6	Pulau Pinang	5402002	Pulau Pinang	51	63	125	211	265	157	218	236	403	388	242	90	2448
7	Perak northeast	4811078	Elphill	106	125	150	211	215	122	145	131	216	297	229	144	2089
8	Perak northwest	4807031	Taipin	279	322	422	505	318	188	224	218	335	489	463	342	4103
9	Perak central east	4311001	Kampar	202	203	287	342	261	158	178	156	262	339	309	263	2961
10	Perak central west	4307041	Sitiawan	159	158	182	219	170	110	111	134	175	275	256	223	2171
11	Perak south	3711160	Ulu Bernam	166	149	198	219	188	111	114	136	191	260	271	229	2231
12	Perak southeast	3717051	Bukit Frazer	212	154	165	232	219	134	120	130	186	276	301	278	2409
13	Selangor west	3313043	Kuala Selangor	149	126	128	162	124	101	106	128	147	222	205	196	1794
14	Selangor central	3117070	Kuala Lumpur	114	213	208	315	228	153	162	159	215	242	267	169	2444
15	Selangor southwest	2615131	Batu Untong	101	86	111	145	188	167	203	196	247	270	257	182	2153
16	N.Sembiran north	2920012	Kuala Klawang	88	96	126	133	113	73	93	73	123	127	199	124	1325
17	N.Sembiran west	2719001	Seremban	78	114	178	192	167	93	131	115	195	218	265	133	1882
18	N.Sembiran east	2724082	Jeram Padang	124	115	167	180	169	103	111	117	152	173	220	179	1811
19	Melaka	2222020	Melaka	82	92	149	195	168	170	170	167	209	216	238	134	1989
20	Johor north	2330009	Melvile	144	119	172	164	136	93	107	119	154	168	195	188	1759
21	Johor northeast	2438185	Mersing	312	143	143	122	144	147	167	167	180	207	359	629	2719
22	Johor central	2033152	Kluang	175	121	178	241	198	139	136	140	193	226	218	244	2205
23	Johor southeast	1839196	Simpang Mawai	265	109	149	166	220	177	179	177	211	227	287	389	2555
24	Johor south	1537114	Johor Bahru	217	185	243	245	216	170	169	190	189	240	258	313	2643
25	Johor southwest	1829001	Batu Pahat	133	141	172	208	167	137	200	168	207	200	243	176	2154
26	Kelantan north	6021061	Pasir Mas	141	69	73	74	151	168	198	231	247	269	507	570	2699
27	Kelantan central	5521050	Kuala Krai	178	95	99	128	169	160	187	201	284	277	360	499	2635
28	Terengganu north	5331048	Kuala Terengganu	117	65	93	93	106	102	113	155	166	269	768	482	2528
29	Terengganu south	4734079	Dungun	139	72	103	113	132	108	140	172	173	241	545	564	2502
30	Pahang north, Kelan	4620045	Merapoh	114	73	123	182	253	184	170	174	270	319	312	295	2467
31	Pahang northeast	4324113	Kuala Tahan	120	72	122	200	223	157	173	165	231	299	229	218	2169
32	Pahang Lipis	4120064	Kuala Lipis	158	113	154	198	223	152	169	181	231	279	297	262	2418
33	Pahang north coast	3833004	Kuantan	342	169	161	137	170	128	144	174	222	226	375	608	2854
34	Pahang central coast	3533102	Pekan	214	91	189	145	141	102	110	129	203	217	322	496	2358
35	Pahang central	3424081	Temerloh	78	94	156	171	138	80	109	121	153	171	180	184	1634
36	Pahang south	2929001	Ldg. Sg. Mengah	147	92	124	158	159	95	110	131	124	17	235	262	1796
37	Pahang south coast	2834180	Chondong	310	156	189	156	131	124	165	169	156	198	397	585	2734

Remarks : Rainfall data were provided by DID.

Note :

(black)	Main rainy season
67	Other rainy season
36	Main dry season
55	Other dry season

Table II.3 80 % RELIABLE MONTHLY RAINFALL BY POLYGON

No.	Location	Station No.	Station Name	80 % Reliable Monthly Rainfall in mm													
				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Ann
1	Perlis	6502003	Tasoh	8	9	29	43	110	80	86	106	157	170	92	33	922	1544
2	Lankawi	6398121	Sg.Penghulu	9	8	31	74	180	153	153	173	257	232	126	20	1416	2077
3	Kedah north	6105037	Gajah Mati	12	12	64	114	155	100	115	127	228	244	122	25	1318	2024
4	Kedah central	5807067	Sik	14	16	61	146	165	100	135	138	210	251	151	56	1443	2070
5	Kedah south, Perai	5305091	Kulim	43	40	109	180	159	87	119	123	195	271	201	73	1600	2440
6	Pulau Pinang	5402002	Pulau Pinang	12	16	35	102	194	80	126	131	261	230	129	20	1334	1916
7	Perak northeast	4811078	Elphill	45	67	87	132	142	73	88	71	150	179	144	85	1263	1856
8	Perak northwest	4807031	Taipin	195	186	296	348	188	98	113	125	205	310	324	195	2583	3761
9	Perak central east	4311001	Kampar	98	36	235	202	161	77	75	55	161	155	173	154	1582	2577
10	Perak central west	4307041	Sitiawan	80	82	89	114	98	45	49	69	103	75	158	146	1107	1976
11	Perak south	3711160	Ulu Bernam	85	61	114	127	118	52	45	73	126	153	183	146	1283	1912
12	Perak southeast	3717051	Bukit Frazer	106	54	88	100	135	69	47	46	89	202	186	166	1289	1937
13	Selangor west	3313043	Kuala Selangor	68	56	57	79	63	45	40	67	98	162	138	63	937	1577
14	Selangor central	3117070	Kuala Lumpur	62	131	133	233	151	85	80	97	139	140	164	90	1505	2216
15	Selangor southwest	2615131	Batu Untong	37	26	48	77	118	86	118	130	145	194	191	96	1268	1898
16	N.Sembiran north	2920012	Kuala Klawang	22	20	45	26	36	13	33	16	74	59	91	32	467	974
17	N.Sembiran west	2719001	Seremban	36	40	89	65	89	24	75	39	98	128	156	66	904	1269
18	N.Sembiran east	2724082	Jeram Padang	46	44	96	92	116	52	60	60	94	104	160	74	996	1557
19	Melaka	2222020	Melaka	24	21	77	108	87	96	107	116	137	142	162	68	1144	1773
20	Johor north	2330009	Melvile	23	27	50	98	80	47	47	68	72	90	144	66	811	1530
21	Johor northeast	2438185	Mersing	76	27	45	49	91	93	119	123	123	143	226	312	1427	2334
22	Johor central	2033152	Kluang	33	43	78	146	123	77	86	80	119	125	129	92	1130	1817
23	Johor southeast	1839196	Simpang Mawai	88	23	68	47	160	132	129	103	139	118	183	157	1346	2006
24	Johor south	1537114	Johor Bahru	78	87	119	156	142	106	95	102	114	156	171	157	1482	2152
25	Johor southwest	1829001	Batu Pahat	52	44	82	116	96	75	119	88	122	133	147	69	1143	1849
26	Kelantan north	6021061	Pasir Mas	44	14	21	17	51	83	129	137	173	175	248	292	1384	2166
27	Kelantan central	5521050	Kuala Krai	50	22	35	43	101	96	129	135	207	191	213	294	1516	2217
28	Terengganu north	5331048	Kuala Terengganu	47	23	27	20	47	65	69	98	96	179	329	291	1291	2284
29	Terengganu south	4734079	Dungun	67	29	35	26	60	75	78	98	99	159	248	334	1306	2166
30	Pahang north, Kelan	4620045	Merapoh	19	14	53	64	147	105	110	72	173	205	173	132	1267	2072
31	Pahang northeast	4324113	Kuala Tahan	27	16	36	99	153	86	105	82	163	183	133	75	1157	1836
32	Pahang Lipis	4120064	Kuala Lipis	77	58	71	105	139	91	81	85	155	157	197	158	1374	2094
33	Pahang north coast	3833004	Kuantan	106	42	47	46	114	82	88	119	155	160	210	313	1480	2342
34	Pahang central coast	3533102	Pekan	52	28	49	52	96	56	49	79	77	133	150	260	1081	2045
35	Pahang central	3424081	Temerloh	20	13	44	100	80	25	40	17	115	112	130	106	800	1356
36	Pahang south	2929001	Ldg. Sg. Mengah	49	19	30	77	114	45	58	48	74	75	145	114	847	1477
37	Pahang south coast	2834180	Chondong	106	25	43	39	67	49	82	90	106	122	242	304	1274	2309

Remarks : Probability analysis was done by using Iwai Method and monthly rainfall records provided by DID.
Total : total of monthly reliable rainfall.
Ann : Reliable yearly rainfall.

Note :

(black)	Main rainy season
67 (shaded)	Other rainy season
36 (bold box)	Main dry season
55 (box)	Other dry season

BN : Basin number (Fig. 2.1)
Tot : Yearly total of 80 % reliable monthly rainfall
Ann : 80 % reliable annual rainfall

Table II.4 MEAN MONTHLY RAINFALL BY RIVER BASIN

unit : mm

Basin	Period	Month Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1	1983-1992	19	47	111	138	177	129	180	182	257	247	169	76	1733
2	1983-1992	12	51	102	212	288	225	359	316	459	409	218	35	2686
3a	1983-1992	18	35	102	172	221	138	270	294	327	258	168	64	2066
3b	1983-1992	18	39	105	162	207	135	243	260	306	255	169	67	1966
3c	1983-1992	18	53	121	187	237	141	263	289	332	289	202	73	2203
3d	1983-1992	18	52	121	186	236	141	263	289	331	287	201	72	2198
4	1983-1992	51	116	175	253	273	156	214	232	324	351	283	121	2549
5a	1983-1992	18	89	161	217	270	147	248	278	340	350	269	91	2478
5b	1983-1992	18	99	172	226	279	149	244	275	342	368	288	97	2557
5c	1983-1992	18	99	172	226	279	149	244	275	342	368	288	97	2557
5d	1983-1992	95	138	180	289	266	166	174	176	299	329	276	153	2540
6	1983-1992	95	138	180	289	266	166	174	176	300	329	276	153	2540
7	1983-1992	58	63	138	221	262	189	256	240	385	365	236	96	2508
8	1983-1992	97	128	167	255	235	148	156	157	272	294	252	144	2305
9	1983-1992	130	102	143	148	123	81	81	85	155	152	181	149	1530
10a	1983-1992	79	123	153	186	242	132	184	190	278	273	280	227	2348
10b	1983-1992	84	143	150	153	207	104	129	138	206	190	188	127	1820
10c	1983-1992	169	210	240	280	244	151	175	160	243	260	296	235	2663
10d	1983-1992	180	211	249	298	253	162	175	160	247	276	329	256	2794
11	1983-1992	147	144	198	239	219	130	115	145	207	232	290	226	2292
12	1983-1992	169	115	141	158	149	74	116	139	180	187	184	221	1833
13	1983-1992	143	123	155	183	179	88	119	141	200	206	206	207	1950
14	1983-1992	169	115	141	158	149	74	116	139	180	187	184	221	1833
15	1983-1992	113	132	205	201	210	86	173	157	263	265	298	214	2317
16	1983-1992	89	97	162	166	216	106	167	142	256	244	263	168	2075
17	1983-1992	83	86	142	153	198	99	150	121	218	205	229	138	1822
18	1983-1992	72	102	164	186	191	90	142	114	183	178	230	128	1779
19	1983-1992	72	102	164	186	191	90	142	114	183	178	230	128	1779
20	1983-1992	78	104	176	236	193	146	153	152	205	186	233	142	2003
21a	1983-1992	122	108	184	141	197	84	129	128	187	163	218	197	1856
21b	1983-1992	152	78	221	173	170	96	125	120	160	172	249	244	1962
22	1983-1992	174	108	240	192	176	102	131	122	168	186	263	231	2094
23	1983-1992	186	115	195	194	207	124	138	123	182	149	186	252	2051
24	1983-1992	233	107	197	205	233	146	153	154	221	178	225	340	2392
25	1983-1992	300	100	196	206	250	167	169	189	259	210	295	474	2815
26	1983-1992	349	110	135	119	146	119	151	159	187	157	409	656	2698
27	1983-1992	244	72	192	152	149	117	133	130	168	161	303	431	2254
28	1983-1992	222	99	172	133	150	86	115	120	148	154	273	386	2058
29	1983-1992	307	112	198	154	121	122	123	114	174	199	472	577	2675
30a	1983-1992	152	115	162	187	224	165	174	155	261	283	306	284	2467
30b	1977-1986	92	90	131	213	228	153	178	140	201	256	238	337	2258
30c	1983-1992	119	119	173	188	205	95	123	138	225	227	240	196	2048
30d	1983-1992	102	99	162	139	196	116	149	118	200	192	221	196	1888
30e	1983-1992	129	102	172	149	192	87	115	124	184	171	214	212	1852
30f	1977-1986	104	91	144	197	203	118	138	99	171	225	209	171	1868
30g	1983-1992	262	106	197	143	119	113	105	108	172	220	499	566	2610
31	1983-1992	180	76	151	106	130	105	100	115	168	151	298	420	1999
32	1983-1992	153	73	125	98	128	105	101	123	190	167	421	487	2172
33	1983-1992	120	69	93	89	124	105	102	134	218	188	573	569	2385
34	1983-1992	120	69	93	89	124	105	102	134	218	188	573	569	2385
35	1983-1992	114	57	108	89	109	109	93	131	206	202	655	534	2408
36a	1977-1986	64	78	96	112	142	115	133	148	193	237	463	471	2252
36b	1983-1992	110	50	117	89	99	111	88	130	199	211	706	512	2421
37	1983-1992	110	50	117	89	99	111	88	130	199	211	706	512	2421
38	1983-1992	155	71	102	135	169	141	212	178	300	271	425	599	2757
39	1983-1992	97	51	98	82	169	177	200	213	271	235	486	608	2687
40a	1977-1986	78	85	108	165	233	158	184	180	256	295	294	333	2368
40b	1983-1992	119	100	139	158	243	156	164	171	287	274	308	309	2429
40c	1983-1992	155	71	102	135	169	141	212	178	300	271	425	599	2757
40d	1983-1992	97	51	98	82	169	177	200	213	271	235	486	608	2687
41	1983-1992	97	51	98	82	169	177	200	213	271	235	486	608	2687

Note : River basin : 41 basins with 27 sub-basins which originate from "National Water Resources Study, Malaysia (JICA 1982)"

	LAND OWNERSHIP						ENVIRONMENTAL PROBLEM: WATER QUALITY								
	G	P	G,P	O	c	TOTAL		DE	IE	FE	SA	BW	SE	MN	WE
PERLIS	6	1				7			2	1					1
KEDAH	17	23	6		1	47	1								
PULAU PINANG	9	1	3			13				5					
PERAK	11	8	2			21		1	2				3		
SELANGOR	19	6				25				1				1	1
N SEMBILAN	5	1		2		8									
MELAKA	7	5	4	2		18	1	2	2		1	1	2	1	
JOHOR	6	6		1	1	14									
KELANTAN	10	20	5			35									
TERENGGANU	12	41				53									
PAHANG	7	15	3			25							10		
TOTAL	109	127	23	5	2	266	2	3	6	7	1	1	15	2	2

	ENVIRONMENTAL PROBLEM: SOIL EROSION			FLOODING	MINIMUM	DRAUGHT	RIVER EROSION	WATER SHORTAGE	WATER LOGGING	c	NO
	LG	LC	UB								
PERLIS											3
KEDAH	3					4					39
PULAU PINANG				1						1	6
PERAK	2	7		1						3	6
SELANGOR								1		12	9
N SEMBILAN	1				1						6
MELAKA				1							8
JOHOR										4	10
KELANTAN		1					3				31
TERENGGANU	2									39	12
PAHANG	1			1					10	3	5
TOTAL	9	8	0	4	1	4	3	1	10	62	135

	REMEDIAL						PRIORITY OF PROJECT						
	IMPROVING	SILT TRAP	FUNDING	NO	c	TOTAL	1	2	3	4	5	c	TOTAL
PERLIS				7		7	1			1	5		7
KEDAH				47		47		3	6	16	13	9	47
PULAU PINANG			1	10	2	13				4	8	1	13
PERAK	7	1	1	9	3	21	1	1	4	8	7		21
SELANGOR				10	15	25		1	3	4	16	1	25
N SEMBILAN				6	2	8		1	2	2	3		8
MELAKA	1			17		18	1	2	3	5	7		18
JOHOR				10	4	14			1		3	10	14
KELANTAN	1			34		35			4	9	22		35
TERENGGANU				12	41	53		4	4	5	39	1	53
PAHANG				20	5	25	3	1	7	12		2	25
TOTAL	9	1	2	182	72	266	6	13	34	66	123	24	266

Notes for LAND OWNERSHIP :
G = Government
P = Private
O = Others
c = blank, to be filled

Notes for WATER QUALITY :
DE = Domestic Effluent
IE = Industrial Effluent
FE = Farm Effluent
SA = Salinity
BW = Brackish Water
SE = Sediments
MN = Mineral
WE = Weeds

Notes for SOIL EROSION :
LG = Logging
LC = Land Clearing
UB = Urbanization

Notes for PRIORITY OF PROJECT :
c = blank, to be filled

HD?5/1 1?MISC/TL-5

Table I-4 WATER SOURCE EVALUATION

BN	Location	Station No.	Station Name	80 % Reliable Monthly Rainfall in mm															Re	Rd	
				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	SD	Ann			
5	Kedah south, Perai	5305091	Kulim	43	40	109	180	159	87	119	123	195	271	201	73	1600	70	2440	5	2	9
24	Johor south	1537114	Johor Bahru	78	87	119	156	142	106	95	102	114	156	171	157	1482	31	2152	4	5	9
8	Perak northwest	4807031	Taipin	195	186	296	348	188	98	113	125	205	310	324	195	2583	85	3761	5	1	8
14	Selangor central	3117070	Kuala Lumpur	62	131	133	233	151	85	80	97	139	140	164	90	1505	47	2216	4	4	8
9	Perak central east	4311001	Kampar	98	36	235	202	161	77	75	55	161	155	173	154	1582	62	2577	4	3	8
33	Pahang north coast	3833004	Kuantan	106	42	47	46	114	82	88	119	155	160	210	313	1480	78	2342	4	2	7
4	Kedah central	5807067	Sik	14	16	61	146	165	100	135	138	210	251	151	56	1443	74	2070	4	2	7
27	Kelantan central	5521050	Kuala Krai	50	22	35	43	101	96	129	135	207	191	213	294	1516	85	2217	4	1	7
21	Johor northeast	2438185	Mersing	76	27	45	49	91	93	119	123	123	143	226	312	1427	80	2334	4	1	7
2	Lankawi	6398121	Sg.Penghulu	9	8	31	74	180	153	153	173	257	232	126	20	1416	88	2077	4	1	7
32	Pahang Lipis	4120064	Kuala Lipis	77	58	71	105	139	91	81	85	155	157	197	158	1374	45	2094	3	4	7
23	Johor southeast	1839196	Simpang Mawai	88	23	68	47	160	132	129	103	139	118	183	157	1346	48	2006	3	4	7
11	Perak south	3711160	Ulu Bernam	85	61	114	127	118	52	45	73	126	153	183	146	1283	44	1912	3	4	7
7	Perak northeast	4811078	Elphill	45	67	87	132	142	73	88	71	150	179	144	85	1263	42	1856	3	4	7
12	Perak southeast	3717051	Bukit Frazer	106	54	88	100	135	69	47	46	89	202	186	166	1289	54	1937	3	3	6
15	Selangor southwest	2615131	Batu Untong	37	26	48	77	118	86	118	130	145	194	191	96	1268	55	1898	3	3	6
30	Pahang north, Kelan	4620045	Merapoh	19	14	53	64	147	105	110	72	173	205	173	132	1267	63	2072	3	3	6
3	Kedah north	6105037	Gajah Mati	12	12	64	114	155	100	115	127	228	244	122	25	1318	76	2024	3	2	6
25	Johor southwest	1829001	Batu Pahat	52	44	82	116	96	75	119	88	122	133	147	69	1143	32	1849	2	5	6
10	Perak central west	4307041	Sitiawan	80	82	89	114	98	45	49	69	103	75	158	146	1107	34	1976	2	5	6
26	Kelantan north	6021061	Pasir Mas	44	14	21	17	51	83	129	137	173	175	248	292	1384	93	2166	3	1	5
6	Pulau Pinang	5402002	Pulau Pinang	12	16	35	102	194	80	126	131	261	230	129	20	1334	84	1916	3	1	5
29	Terengganu south	4734079	Dungun	67	29	35	26	60	75	78	98	99	159	248	334	1306	94	2166	3	1	5
28	Terengganu north	5331048	Kuala Terenggan	47	23	27	20	47	65	69	98	96	179	329	291	1291	105	2284	3	1	5
37	Pahang south coast	2834180	Chondong	106	25	43	39	67	49	82	90	106	122	242	304	1274	85	2309	3	1	5
22	Johor central	2033152	Kluang	33	43	78	146	123	77	86	80	119	125	129	92	1130	35	1817	2	4	5
31	Pahang northeast	4324113	Kuala Tahan	27	16	36	99	153	86	105	82	163	183	133	75	1157	54	1836	2	3	5
34	Pahang central coast	3533102	Pekan	52	28	49	52	96	56	49	79	77	133	150	260	1081	65	2045	2	3	5
19	Melaka	2222020	Melaka	24	21	77	108	87	96	107	116	137	142	162	68	1144	44	1773	2	3	5
18	N.Sembiran east	2724082	Jeram Padang	46	44	96	92	116	52	60	60	94	104	168	74	996	34	1557	1	5	4
20	Johor north	2330009	Melvile	23	27	50	98	80	47	47	68	72	90	144	66	811	34	1530	1	5	4
13	Selangor west	3313043	Kuala Selangor	68	56	57	79	63	45	40	67	98	162	138	63	937	37	1577	1	4	4
17	N.Sembiran west	2719001	Seremban	36	40	89	65	89	24	75	39	98	128	156	66	904	39	1269	1	4	4
36	Pahang south	2929001	Ldg. Sg. Mengah	49	19	30	77	114	45	58	48	74	75	145	114	847	38	1477	1	4	4
35	Pahang central	3424081	Temerloh	20	13	44	100	80	25	40	17	115	112	130	106	800	44	1356	1	4	4
1	Perlis	6502003	Tasoh	8	9	29	43	110	80	86	106	157	170	92	33	922	54	1544	1	3	3
16	N.Sembiran north	2920012	Kuala Klawang	22	20	45	26	36	13	33	16	74	59	91	32	467	24	974	0	5	3

Remarks : Probability analysis was done by Iwai Method using monthly rainfall records provided by DID.

Total Score is...

(3 x Re + Rd) / 2

Note Total : Yearly total of monthly rainfall of 80 % reliability

SD : Standard deviation for monthly rainfall in a year

Ann : Annual rainfall of 80 % reliability

163	Main rainy season
67	Other rainy season
36	Main dry season
55	Other dry season

Re : Scores for total monthly 80% reliable rainfall
- 1 : 500 - 999 mm/year
- 2 : 1000 - 1199 mm/year
- 3 : 1200 - 1399 mm/year
- 4 : 1400 - 1599 mm/year
- 5 : 1600 mm/year <

Rd : Scores for monthly rainfall distribution
- 1 : Standard deviation (SD) over 80
- 2 : Standard deviation (SD) 65 - 80
- 3 : Standard deviation (SD) 50 - 65
- 4 : Standard deviation (SD) 35 - 50
- 5 : Standard deviation (SD) less than 35