TABLES

Table 1 INVENTORY OF TUBE WELLS AND BOREHOLES

No.	Name (Owner) / Location	Drilling Year	Depth (m)	Dia. (inch)	SWL (m)	PWL (m)	Q (m^3/d)	Aquifer Geology	Purpose	Drilled by
W-1*	JKR, Kluang	1982	21.3	8	9.1	-	763	SS/1	PW/2	FED/6
W-2	Estate of Moriulle, Labis	1982	131.1	6	6.1	48.8	327	Volcanic	D/3	"
W-3	Senai Air Port, Senai	1984	21.3	-	-	No water	-	Granite	D	"
W-4	Lee Ruber, Tampoi	-	91.4	6	6.1	48.8	273	SS, conglo.	IN/4	"
W-5	Prawn Firm, Tg. Kaharg	1984	106.7	-	-	-	109	SS, LS, cl = 1,000 PPM	D	"
W-6	Honam Estate, "	1981	48.8	6	4.6	24.4	273	SS, shale	D	"
W-7	Kulai Orchad, "	1982	42.7	6	0.9	21.3	131	Tuff	A/5	"
W-8	Unknown, Simpang Renggam	-	121.9	-	-	No water	-	Mudstone	D	PIM/7
W-9	U.M. Pineapple, Johore (GS 190)	1956	67.1	-	-	No water	-	Boulder, gravel	IN	MAL/8
W-10	Senai Rubber, Senai (GS 194)	1956	38.1	-	3.7	-	218	SS	IN	"
W-11	Lee Pineapple, Skudai (GS 195)	1956	17.1	-	-	No water	-	Clay, SS	IN	"
W-12	Lee Pineapple, " (GS 196)	1956	33.5	-	-	No water	-	Clay, gravel	IN	"
W-13	Kulai Village, Kulai (GS 232)	1958	25.9	-	-	No water	-	Clay, granite	D	"
W-14	Kulai Village, " (GS 233)	1958	25.6	-	-	No water	-	Clay, granite	D	"
W-15	Kulai Village, " (GS 234)	1958	27.4	8	2.4	19.8	59	SS	D	"
W-16	Kulai Village, " (GS 235)	1958	22.9	-	-	No water	-	Clay, granite	D	"
W-17	Kulai Village, " (GS 236)	1958	21.0	-	-	No water	-	Clay, granite	D	"
W-18	Senai Village, Senai (GS 237)	1958	30.5	6	4.3	19.5	382	SS, granite	D	"
W-19	Senai Village, " (GS 238)	1958	19.2	-	-	No water	-	Clay, granite	D	"
W-20	Lee Pineapple, Skudai (GS 249)	1956	26.5	-	-	No water	-	Boulder, gravel, sand	IN	"
W-21	Cancraft Malay, Pekari Nanas	1966	49.4	6	4.0	30.8	109	Granite	IN	"
W-22	RESP, Machap, Kluarg	1982	10.7	4	1.5	-	-	Gravel, clay	D	RESP (5/82)
W-23	RESP, Rergan, "	1982	15.8	-	7.6	-	-	Clay, fine sand	D	" (4/82)
W-24	RESP, SP Rengam, "	1983	10.7	6	4.6	-	-	Clay w/sand	D	" (1/83)
W-25	RESP, Kg. Suyong Pinang, KT	1983	8.2	6	3.0	-	-	"	D	" (29/83)
W-26	RESP, Sg. Redan, JB	1984	12.0	4	6.0	-	-	"	D	" (5/84)
W-27	RESP, Kg. Laut Skudai, JB	1984	15.3	4	2.0	-	-	"	D	" (4/84)
W-28	RESP, "	1984	9.8	4	2.4	-	-	"	D	" (3/84)
W-29	RESP, Kg. Bukit Kuching, JB	1984	28.0	3	5.0	-	-	"	D	" (1/84)
W-30	RESP, Kg. Felda Sg. Tiram JB	1983	18.2	3	4.6	-	-	"	D	" (11/83)
W-31	RESP, Kg. Paya, ulu Tiram JB	1983	18.3	3	3.0	-	-	"	D	" (10/83)
W-32	RESP, Kg. Bukit, Kuching JB	1983	21.3	4	4.6	-	-	Sand and gravel	D	" (9/83)
W-33	RESP, Kg. Bukit Batu JB	1983	13.7	3	3.0	-	-	Clay w/sand	D	" (8/83)
W-34	RESP, Kg. Skudai Laut JB	1983	9.8	4	2.4	-	-	"	D	" (4/83)
W-35	RESP, Kg. Besoi, Murni JB	1983	9.1	4	1.2	-	-	"	D	" (2/83)
W-36	RESP, "	1983	12.8	4	1.2	-	-	"	D	" (1/83)
W-37	RESP, Kg. Pok, Tg. Kupang	1982	9.8	3	4.6	-	-	"	D	" (8/82)
W-38	RESP, Sg. Redan, Sg. Tiram	1982	8.5	3	4.3	-	-	"	D	" (6/82)
W-39	RESP, Kg. Air Manis, Sedenak	1982	16.8	3	1.2	-	-	Gravel, clay w/sand	D	" (10/82)
W-40	RESP, Kg. Bukit Batu, Sednak	1982	8.5	3	3.7	-	-	Clay w/sand	D	" (4/82)
W-41	RESP, Kg. Sinarau Baru, Tebrau	1982	9.1	3	4.6	-	-	"	D	" (2/82)
W-42*	Felcra Kg. Sg. Kaharg	1984	30.0	6	-	-	173	SS	D	DID
W-43*	GSD Kg. Baharu Batu Pahat	1982	15.0	6	2.34	-	72	Alluvium	TW	GSD
W-44*	GSD Kg. Assam Bubuk	1982	12.5	8	0.5	11.8	29	"	TW	"
W-45*	GSD Kg. Panchor Risda Estate	1982	20.0	8	1.06	-	240	Fractured granite	TW	"
W-46*	GSD Kg. Tg. Labu Estate	1982	20.0	8	-	No water	-	Weathered granite	TW	"

Note: * : Drilling at outside of study area

/1 : Sandstone, /2 : Test well, /3 : Domestic water use, /4 : Industrial water use

/5 : Agriculture water use, /6 : Federal driller co, /7 : Pacific Industry and Mining

/8 : Malayan Driller co

Table 2 THE SUMMARY OF TUBE WELLS AND BOREHOLES

Unit: $Q = \times 10^6 m^3/yr$

		GSD (MAL)/3	MOH	FED/5	PIM/6	DID	Total	
							Study Area	Outside
Domestic use	No./1	7	246/4	4	1	1/7	258	1
	Q/2	0.16	0.27	0.22	0	0.06	0.65	0.06
Industry use	No.	6	–	1	–	–	7	–
	Q	0.12	–	0.10	–	–	0.22	–
Agriculture use	No.	–	–	2	–	–	2	–
	Q	–	–	0.05	–	–	0.05	–
Test well	No.	4/7	–	1/7	–	–	–	5
	Q	0.12	–	0.28	–	–	–	0.40
Total study area	No.	13	246	7	1	–	267	
	Q	0.28	0.27	0.37	0	–	0.92	
Outside	No.	4	–	1	–	1		6
	Q	0.12	–	0.28	–	0.06		0.46

Note: /1 : No. of WELL
/2 : Quantity of well
/3 : Malayan Driller Co.
/4 : Small tube well
/5 : Federal Driller Co.
/6 : Pacific Industry and Mining Co.
/7 : Drilling at outside of study area.

Table 3 INVENTORY OF RESP WELLS IN STUDY AREA (1976 - 1984)

Unit: No. of well

Year / District	1976	1977	1978	1979	1980	1981	1982	1983	1984	Total
Johor Bahru	6	10	10	33	39	25	10	10	5	148
Kota Tinggi	1	2	6	6	10	5	2	4	8	44
Pontian	0	2	9	6	8	4	0	1	0	30
Kluang*	0	2	0	6	8	1	2	4	1	24
Total	7	16	25	51	64	35	14	19	14	246

Note: * only Mukim Layang Layang, Macam, and Most Part of Rengam.

Table 4 HYDROGEOLOGICAL CLASSIFICATION CHART

Geological Stage			Geological condition: Geology	Geological condition: Lithology	Ground water potential: Type	Class	Description	Well No.
Cenozoic	Quaternary	Holocene	Recent Alluvium Gula Formation (marine deposits), Berunao For. (inland fresh water deposits)	Alluvium, eluvial soils sand dune, peaty clay clay w/sand and gravel	Unconsolidated Aquifer	UC-3 UC-4 UC-5	Moderate-Fair, Sand dune Fair-Poor, thin sand layer very poor, saline water and dominant of clay layer	Dug well
		Pleistocene	Simparg For. (Terrestrial deposits)	Angular quartz sand with rounded quartz Boulder, gravel, sand clay		UC-3	Moderate-Fair, Sand, clay with sand	RESP wells W-30
	Tertiary		Layang Layang For. Pengeli sands mem. Badak shale mem.	Semi consolidated white cream or pale gray arkosic sand with minor argillaceous layers. Dove gray to brown and black clay shale with plant remains.	Consolidated Aquifer	C-2	Moderate-Fair, except shale member	
Mesozoic	Cretaceous		Panti sandstone For. (Tebak For.)	Mainly coarse, cross-bedded quartz sandstone with conglomerate layers. Typically massive, thick-bedded and flat-lying		C-2	Moderate-Fair, except massive hard rock	W-42
	Jurassic							
	Triassic		Gemas For. Blumet For.	Tuffaceous conglomerate sandstone shale and inter-bedded tuffs Granite		C-3	No potential, except cracks in fractured zone No potential, except sandy materials in fractured zone	W-7 W-18
Paleozoic	Permian		Sedili volcanic For. Linggiu For. Mersing Group	Prominent flows andesitic crystal tuffs ignimbrite Mainly calcareous sandstone minor argillaceous strongly folded mainly psammitic low grade metasediments, with some pelitic and acid metavolcanic bands		C-4	No potential	W-3

Source: Refs. 11-17

Table 5 WATER QUALITY DATA OF RESP WELLS

Kg./village	Mukumu	District	pH -	Color (units)	Tur-bidity (units)	TDS (mg/l)	Cl (mg/l)	$KMnO_4$ cons. (mg/l)	Fe (mg/l)	Hard-ness as $CaCO_3$ (mg/l)	Alkali-nity as $CaCO_3$ (mg/l)
1. Sg. Suloh	Peg. Kes Kanan	Batu Pahat	6.3	70	38	230	25	8.95	2.20	62	68
2. Seri Desa	Simpang Rengam	Kluang	6.0	80	150	135	12	0.15	24.00	22	32
3. Pinggir Jaya	Kahang	Kluang	5.1	5	63	40	6	-	0.56	-	2
4. Teminggal	Kahang	Kluang	5.6	5	4	20	5	-	0.36	-	6
5. Melayu Raya		Pontian	4.4	70	48	90	5	5.50	11.20	8	-
6. Sawah Baru	Pekan Nanas	Pontian	5.9	30	30	80	6	0.85	3.20	18	10
7. Tebing Runtoh		Johor Bahru	5.7	20	60	75	7	0.30	0.76	10	14
8. Sinaran Baru	Kesihatan Kanan	Johor Bahru	4.8	5	27	30	4	0.05	0.06	6	-
9. Air Manis	Kesihatan Kanan	Johor Bahru	5.4	5	4	40	13	0.10	0.16	6	-
10. Sg. Dansa	Kesihatan Kanan	Johor Bahru	5.0	10	16	55	21	0.25	0.34	-	8

Source: MOH

Table 6 WATER QUALITY DATA (Main Wells)

No.	Location	Temp. °C	PH	E.C. μS/cm	Na (mg/ℓ)	K (mg/ℓ)	Ca (mg/ℓ)	Mg (mg/ℓ)	HCO_3 (mg/ℓ)	Cℓ (mg/ℓ)	SO_4 (mg/ℓ)	NO_3 (mg/ℓ)	Total Solids (mg/ℓ)	Diss. Solids (mg/ℓ)	Hardness as $CaCO_3$ (mg/ℓ)	Alkalinity as $CaCO_3$ (mg/ℓ)	Color (units)	Turb. (units)
EX 1	GSD Suri Gadin Project*	29	7.1	16,000	1,699	48	379	615	266	7,500	85	3.43	10.9	10.9	3,485	218	10	32
15	"	32	4.2	390	12.7	4.2	8	13	1	28	100	6.17	0.7	0.24	165	1	10	360
15	"	-	7.5	-	-	-	-	-	-	4,850	-	-	-	-	1,475	-	-	-
18	"	29	6.65	1,000	1,253	22.4	324	289	127	3,020	54	2.40	6.72	6.61	2,030	104	10	32
23	"	-	7.0	2,180	255	25	11.4	25	118	430	20	2.06	1.61	1.03	203	97	160	1,400
25	"	-	7.1	-	-	-	-	-	-	8,640	-	-	-	-	2,465	-	-	-
27	"	-	7.6	-	-	-	-	-	-	4,980	-	-	-	-	1,885	-	-	-
28	"	30	7.0	7,000	1,335	66.5	35.8	132	633	3,120	86	0.34	4.88	4.27	763	519	162	600
31	"	29	6.7	26,000	3,294	108	393	675	838	5,130	152	7.54	27.6	17.4	3,878	687	10	280
32	"	29.5	4.8	90	6.6	3.3	2.3	0.95	4	30	2	3.77	0.1	0.09	12	3	5	1
34	"	-	7.1	-	-	-	-	-	-	272	-	-	-	-	110	-	-	-
TWI/1	"	-	7.4	-	57	3.9	10.4	10.5	156	13	43	3	404	306	74	130	20	90
TWII/2	"	-	7.1	1,200	183	10.8	9.4	8.3	342	162	10	3	82	54	62	346	80	160
TWIII	"	-	7.1	700	71	13.8	11.3	20.5	112	111	29	3	540	430	116	94	240	3.2
TWV/3	"	-	5.3	200	1.7	0.6	0.8	0.5	3.7	4	10	3	50	8	4.3	5.1	5	1.3
TWVI	"	-	7.4	-	6.2	1.4	0.9	0.5	19	6	10	4	196	104	28.5	16	20	65
-	Jalan Padang Tembak**	-	5.6	-	-	-	-	-	-	8.5	2.6	-	995	65	20.0	28	10	-
-	Kahang I**	-	4.8	-	-	-	-	-	-	85.2	1.5	-	122	110	21.0	3.6	5	-
TW2	Sri Banang***	-	6.5	30	-	-	-	0.53	-	3	2	-	25	20	6	8	5	-
TW4	Kg. Petani***	-	5.9	180	-	-	-	2.66	-	30	28	-	125	120	17	26	80	-

Source: * Ref. 2, Analyses by Geochem. Div. GSD Ipoh (1982)
** Ref. 5, Analyses by consolidated laboratory (M) SDN. BHD. (1983)
*** Ref. 4 (1983)

Note: /1 : W-44 (Table-1), /2 : W-43 (Table-1), /3 : W-45 (Table-1)

Table 7 WHO INTERNATIONAL STANDARDS FOR DRINKING WATER

Substance or Characteristic	Highest Desirable level	Maximum Permissible level
Colour	5 Colour units	50 Colour units
Odour	Unobjectionable	Unobjectionable
Taste	Unobjectionable	Unobjectionable
Turbidity	5 Turbidity units	25 Turbidity units
Total dissolved solids	500 ppm	1,500 ppm
pH Range	7.0 - 8.5	6.5 - 9.2
Total hardness as $CaCO_3$	100 ppm	500 ppm
Boron	1.0 ppm	1.0 ppm
Calcium as Ca	75 ppm	200 ppm
Chloride as Cl	200 ppm	600 ppm
Copper as Cu	0.05 ppm	1.5 ppm
Iron (total) as Fe	0.1 ppm	1.0 ppm
Lead as Pb	Absent	0.1 ppm
Magnesium as Mg	30 ppm	150 ppm
Nitrates & Nitrites as N	Absent	10 ppm
Sulphate as SO_4	200 ppm	400 ppm
Zinc as Zn	5.0 ppm	15.0 ppm
Phenol	0.001 ppm	0.002 ppm
Anionic detergents	0.2 ppm	1.0 ppm
Mineral oil	0.01 ppm	0.3 ppm
Manganese as Mn	0.05 ppm	0.5 ppm

Source: World Health Organisation - Water Quality Criteria (International Drinking Water Standard, WHO 1971)

Table 8 HYDROGEOLOGICAL LAND CLASSIFICATION BY BASIN

Unit: km^2

class / Basin code	Un-Consolidated Aquifer					Consolidated Rocks Aquifer				Total
	1	2	3	4	5	1	2	3	4	
1	0.0	0.0	0.0	0.0	907.2	0.0	0.0	0.0	522.8	1430.0
2	0.0	0.0	208.7	26.2	200.8	0.0	0.0	214.8	359.5	1010.0
3	0.0	0.0	249.8	72.7	277.3	0.0	239.0	0.0	2271.2	3110.0
4	0.0	0.0	38.8	91.0	197.1	0.0	15.2	0.0	1457.9	1800.0
Total	0.0	0.0	497.3	189.9	1582.4	0.0	254.2	214.8	4611.4	7350.0

Table 9 THICKNESS, SPECIFIC YIELD, DEEP PERCOLATION AND PROBABILITY USED FOR POTENTIAL ANALYSIS

Aquifer	class	Average thickness of Aquifer (m)	Average Specific yield (%)	Deep Percoration Ratio (%)	Probability of occurence of Aquifer (%)
Unconsolidated	1	30	17	22	90
"	2	10	15	22	70
"	3	7	13	12	30
"	4	2	10	22	20
Consolidated Rocks	1	15	8	15	50
"	2	10	5	10	20
"	3	5	3	3	10

Table 10 ESTIMATED STORAGE POTENTIAL BY BASIN

Unit: 10^6 m^3

class / Basin code	Un-Consolidated Aquifer		Consolidated Rocks Aquifer		Total
	3	4	2	3	
1	0.000	0.000	0.000	0.000	0.000
2	189.917	5.240	0.000	32.220	227.377
3	227.318	14.540	119.500	0.000	361.358
4	35.308	18.200	7.600	0.000	61.108
Total	452.543	37.980	127.100	32.220	649.843

Table 11 ANNUAL PRECIPITATION

Unit: mm/y

Basin Code	Precipitation
1	2353
2	2435
3	2402
4	2674

Table 12 ESTIMATED GROUNDWATER RECHARGE BY BASIN

Unit: 10^6 m^3/y

Basin Code	Unconsolidated Aquifer 3	Unconsolidated Aquifer 4	Consolidated Rocks Aquifer 2	Consolidated Rocks Aquifer 3	Total
1	0.000	0.000	0.000	0.000	0.000
2	60.982	14.035	0.000	15.691	90.708
3	72.002	38.418	126.297	0.000	236.717
4	12.450	53.534	8.942	0.000	74.926
Total	145.434	105.987	135.239	15.691	402.351

Table 13 PRELIMINARY ESTIMATE OF SAFE YIELD BY BASIN

Unit: 10^6 m^3/y

Basin Code	Unconsolidated Aquifer 3	Unconsolidated Aquifer 4	Consolidated Rocks Aquifer 2	Consolidated Rocks Aquifer 3	Total
1	0.000	0.000	0.000	0.000	0.000
2	18.295	1.048	0.000	1.569	20.912
3	21.601	2.908	23.900	0.000	48.409
4	3.735	3.640	1.520	0.000	8.895
Total	43.631	7.596	25.420	1.569	78.216

Table 14 PRINCIPAL FEATURE AND COST ESTIMATE OF ASSUMED GROUNDWATER SOURCE FACILITIES

Case	UC-3	UC-4	C-2	C-3
Aquifer	Un-Consolidated		Consolidated	
Class	3	4	2	3
Depth of well (m)	50	20	50	50
Pumping discharge: Q (m^3/d)	100	20	150	100
Drawdown (m)	5	5	15	20
Transmissinity: T (m^2/d)	30	5	30	10
Well type	Shallow Tube well		Deep Tube well	
Pump capacity (PS)	1.5	1.5	2	2
Motor capacity (kW)	0.75	0.75	1.5	2.2
Water Source Investment Cost				
1. Wellconstruction (M$$10^3$)	70	40	80	80
2. Submersible pump (M$$10^3$)	6	6	7	9
3. Diesel generator set (M$$10^3$)	9	9	9	11
4. Building (M$$10^3$)	15	15	15	15
5. Quarter (M$$10^3$)	13	13	13	13
6. Land acquisition (M$$10^3$)	13	13	13	13
7. Engineering (M$$10^3$)	6	6	6	6
8. Physical contingency (M$$10^3$)	13	10	14	15
Total (M$$10^3$)	145	112	157	162
O & M Cost				
1. Power generation (M$$10^3$/y)	1.1	1.1	2.2	3.2
2. Chloriation (M$$10^3$/y)	0.7	0.2	1.1	0.7
3. Well cleaning (M$$10^3$/y)	0.7	0.7	0.7	0.7
4. Other cost (M$$10^3$/y)	1.3	1.3	1.3	1.3
Total (M$$10^3$)	3.8	3.3	5.3	5.9

Table 15 ESTIMATED COST STREAM OF ASSUMED GROUNDWATER SOURCE FACILITIES

Unit: M$$10^3$

Year in Order	Capital Cost				O & M Cost			
	Case				Case			
	UC-3	UC-4	C-2	C-3	UC-3	UC-4	C-2	C-3
1	145	112	157	162	-	-	-	-
2-7	-	-	-	-	3.8	3.3	5.3	5.9
8	15	15	16	20	3.8	3.3	5.3	5.9
9-15	-	-	-	-	3.8	3.3	5.3	5.9
16	15	15	16	20	3.8	3.3	5.3	5.9
17-23	-	-	-	-	3.8	3.3	5.3	5.9
24	15	15	16	20	3.8	3.3	5.3	5.9
25	70	40	80	80	3.8	3.3	5.3	5.9
26-31	-	-	-	-	3.8	3.3	5.3	5.9
32	15	15	16	20	3.8	3.3	5.3	5.9
33-39	-	-	-	-	3.8	3.3	5.3	5.9
40	15	15	16	20	3.8	3.3	5.3	5.9
41-47	-	-	-	-	3.8	3.3	5.3	5.9
48	15	15	16	20	3.8	3.3	5.3	5.9
49-50	-	-	-	-	3.8	3.3	5.3	5.9

Table 16 ESTIMATED UNIT COST OF WATER SOURCE

Unit: M$/$m^3$

Discount Rate	Case			
	UC-3	UC-4	C-2	C-3
0.06	0.134	0.540	0.104	0.168
0.08	0.117	0.469	0.090	0.144
0.10	0.106	0.423	0.081	0.129
0.12	0.098	0.391	0.074	0.119
0.14	0.092	0.367	0.070	0.111
0.16	0.088	0.349	0.066	0.105
0.18	0.084	0.334	0.063	0.100
0.20	0.081	0.321	0.061	0.096

FIGURES

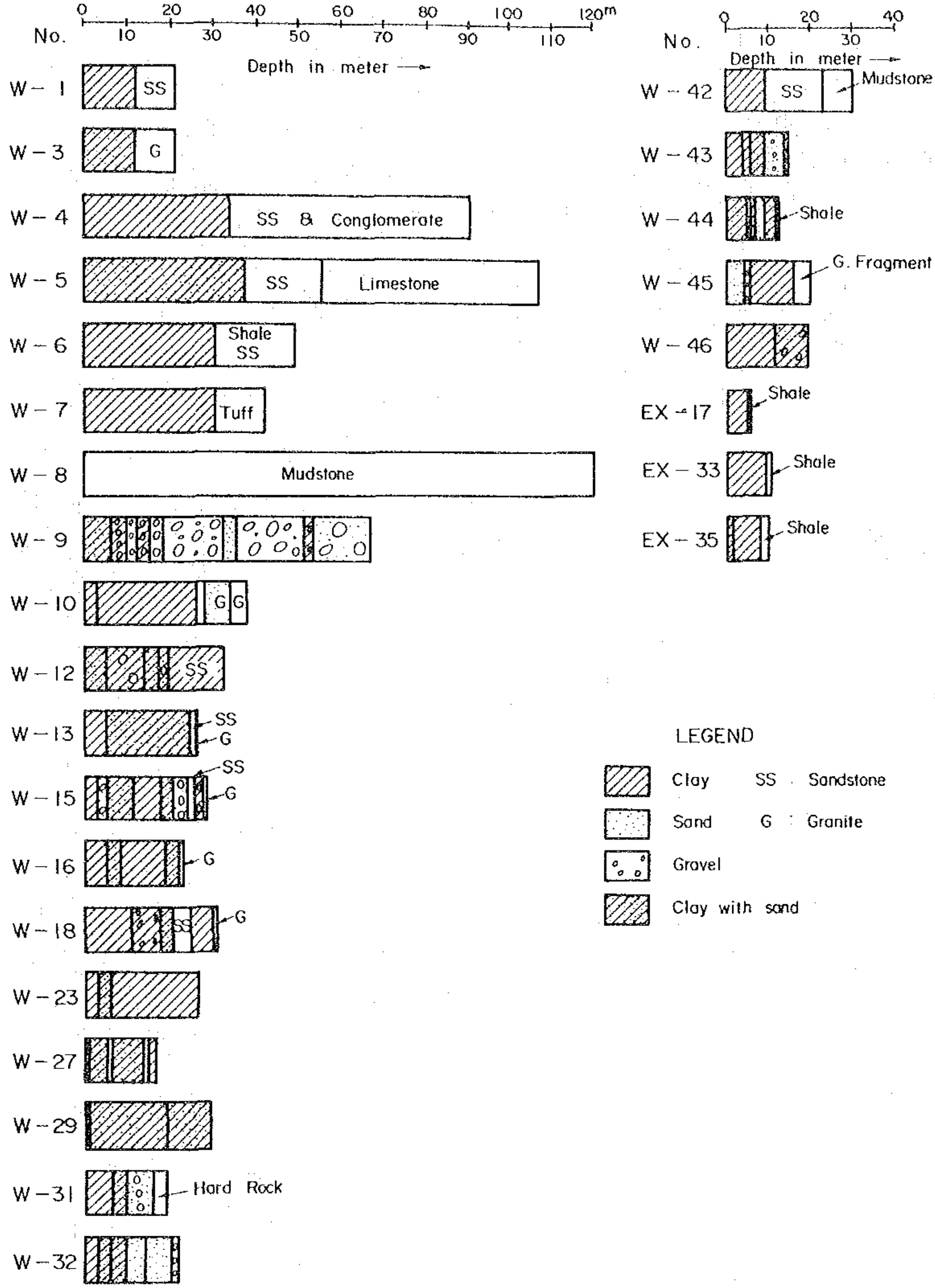

Fig. 1 Summary of Drilling & Geologic Logs

GOVERNMENT OF MALAYSIA
NATIONAL WATER RESOURCES STUDY, MALAYSIA
SOUTH JOHOR
REGIONAL WATER RESOURCES STUDY
JAPAN INTERNATIONAL COOPERATION AGENCY

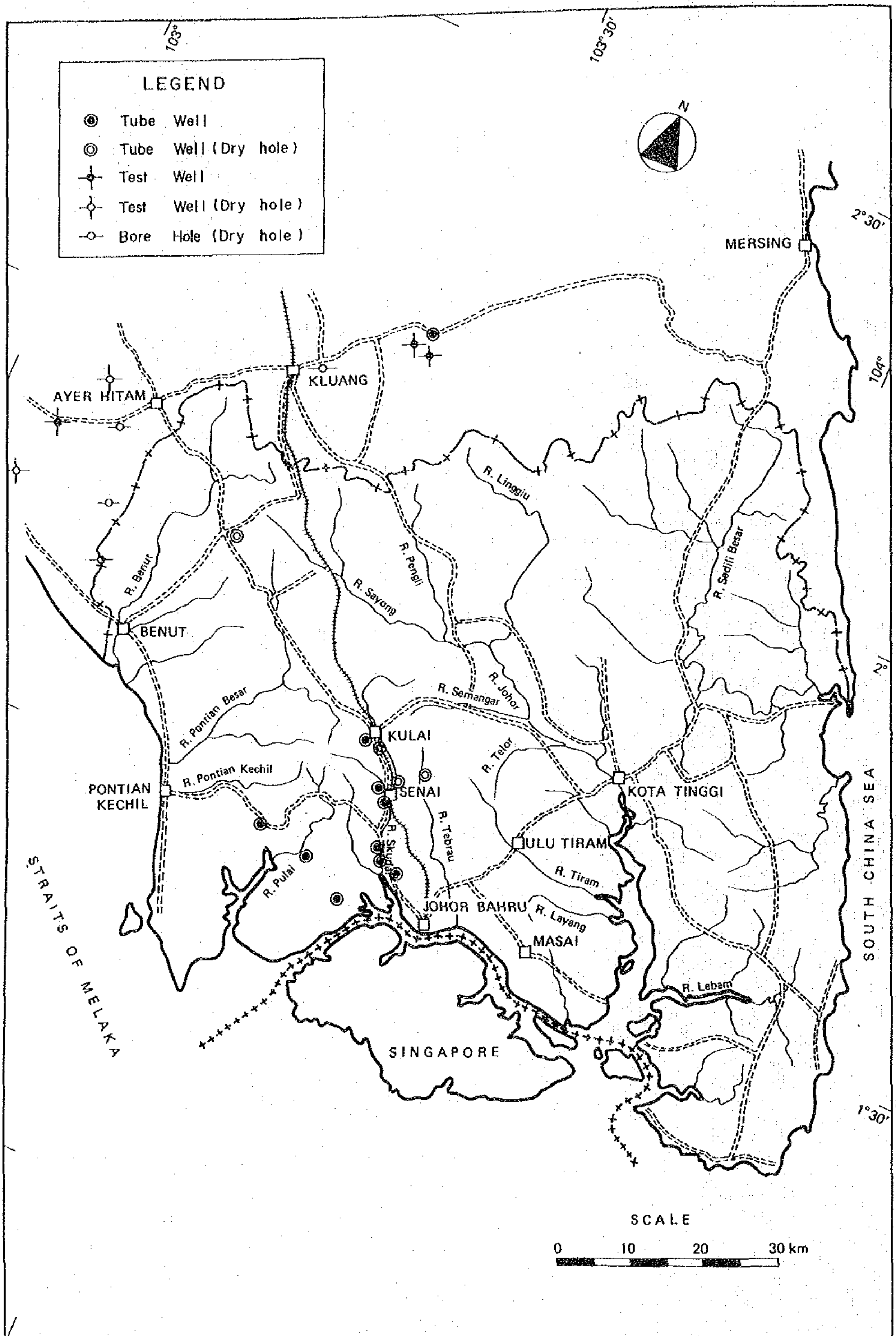

Fig. 2 Location Map of Tubewells and Boreholes

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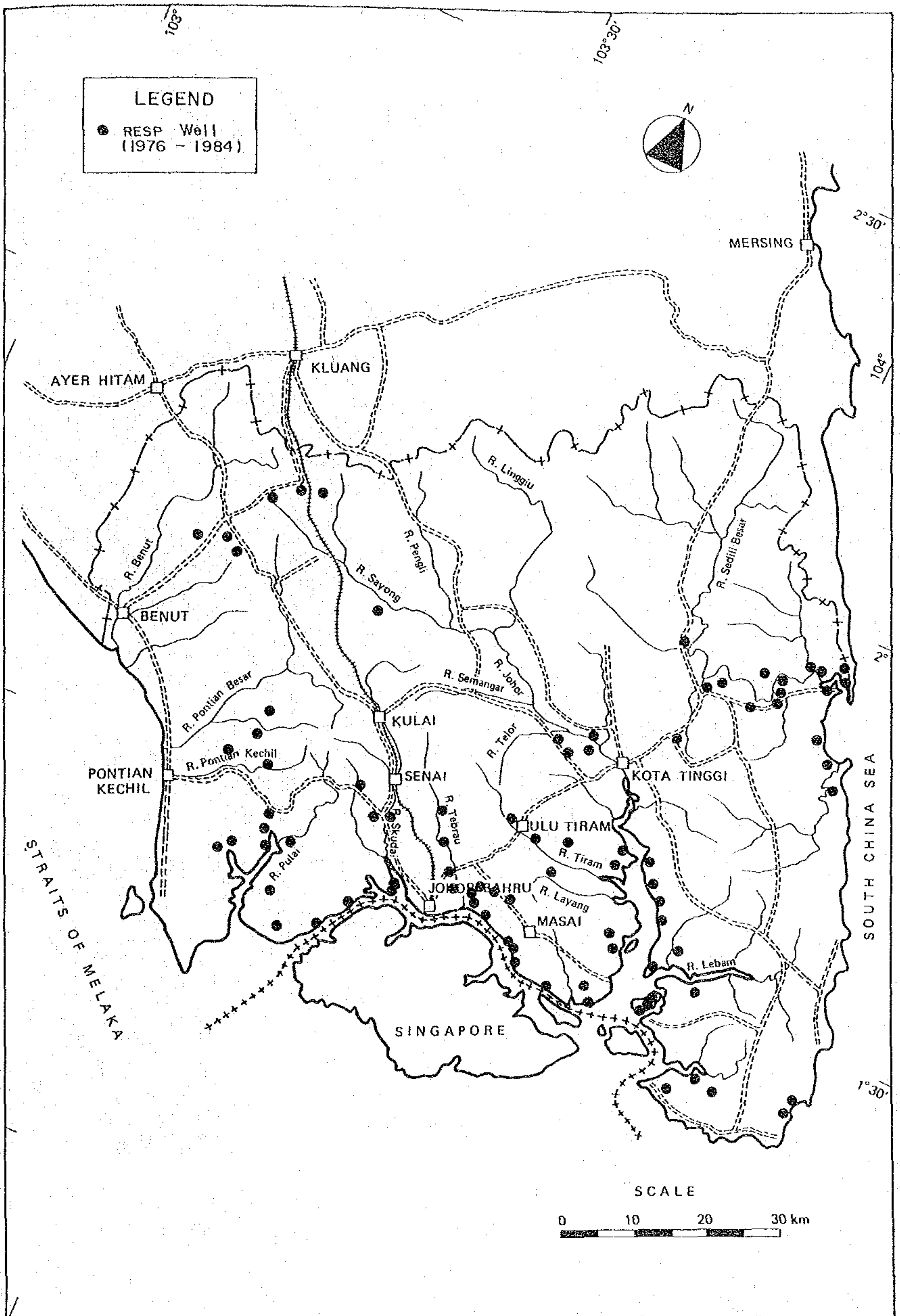

Fig. 3 Location Map of RESP Wells

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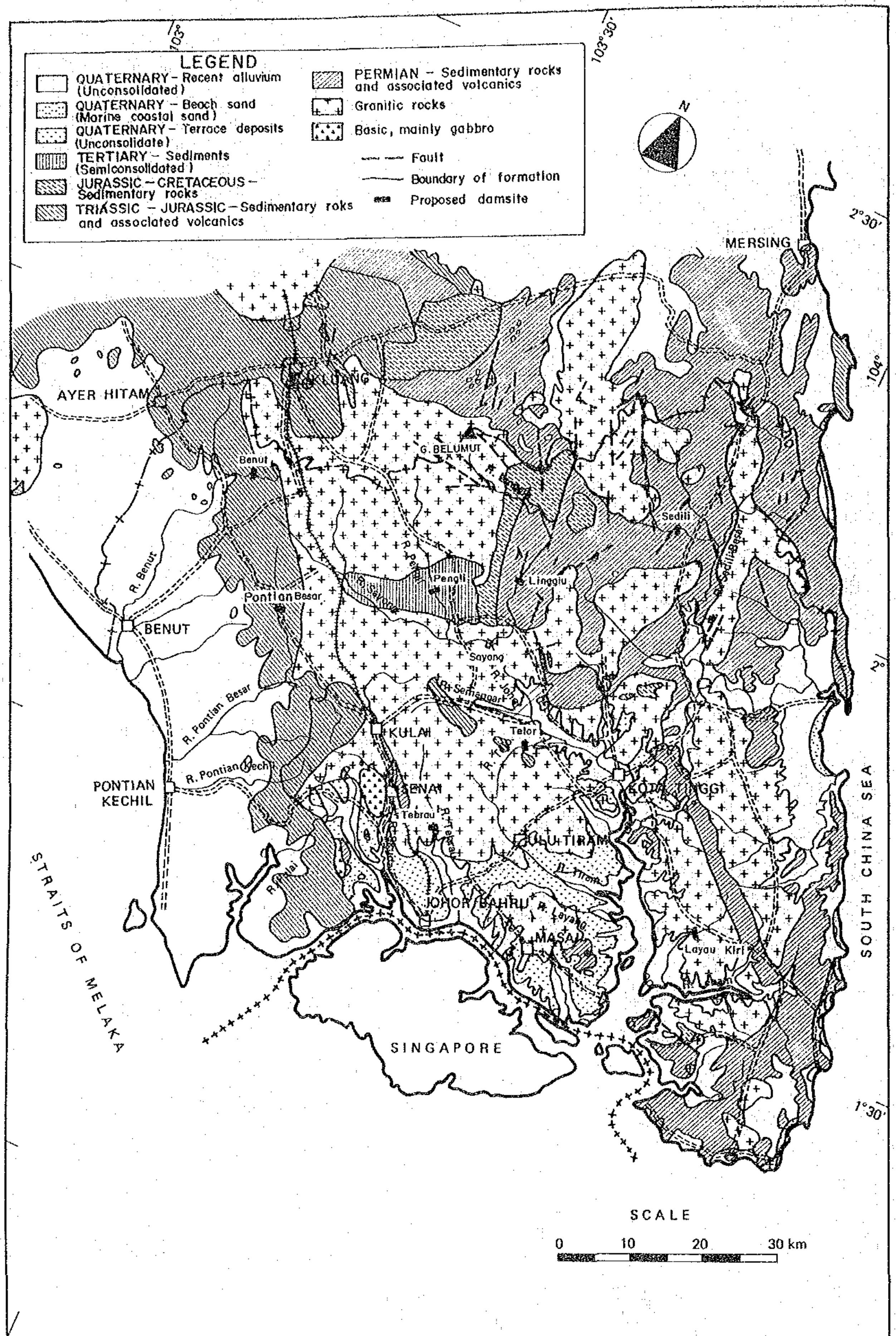

Fig. 4 Geological Map of the Region

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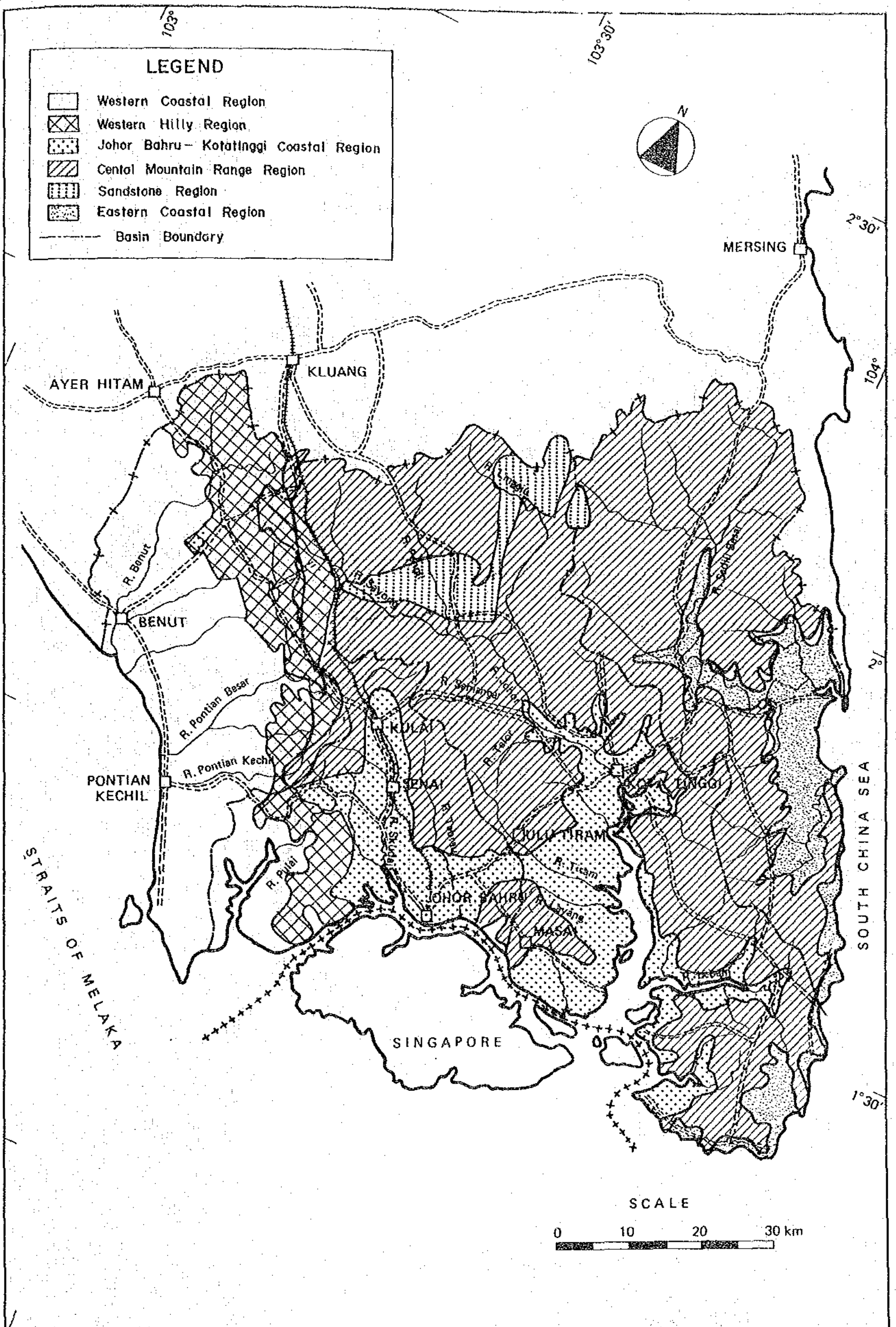

Fig. 5 Ground Water Regions of Study Area

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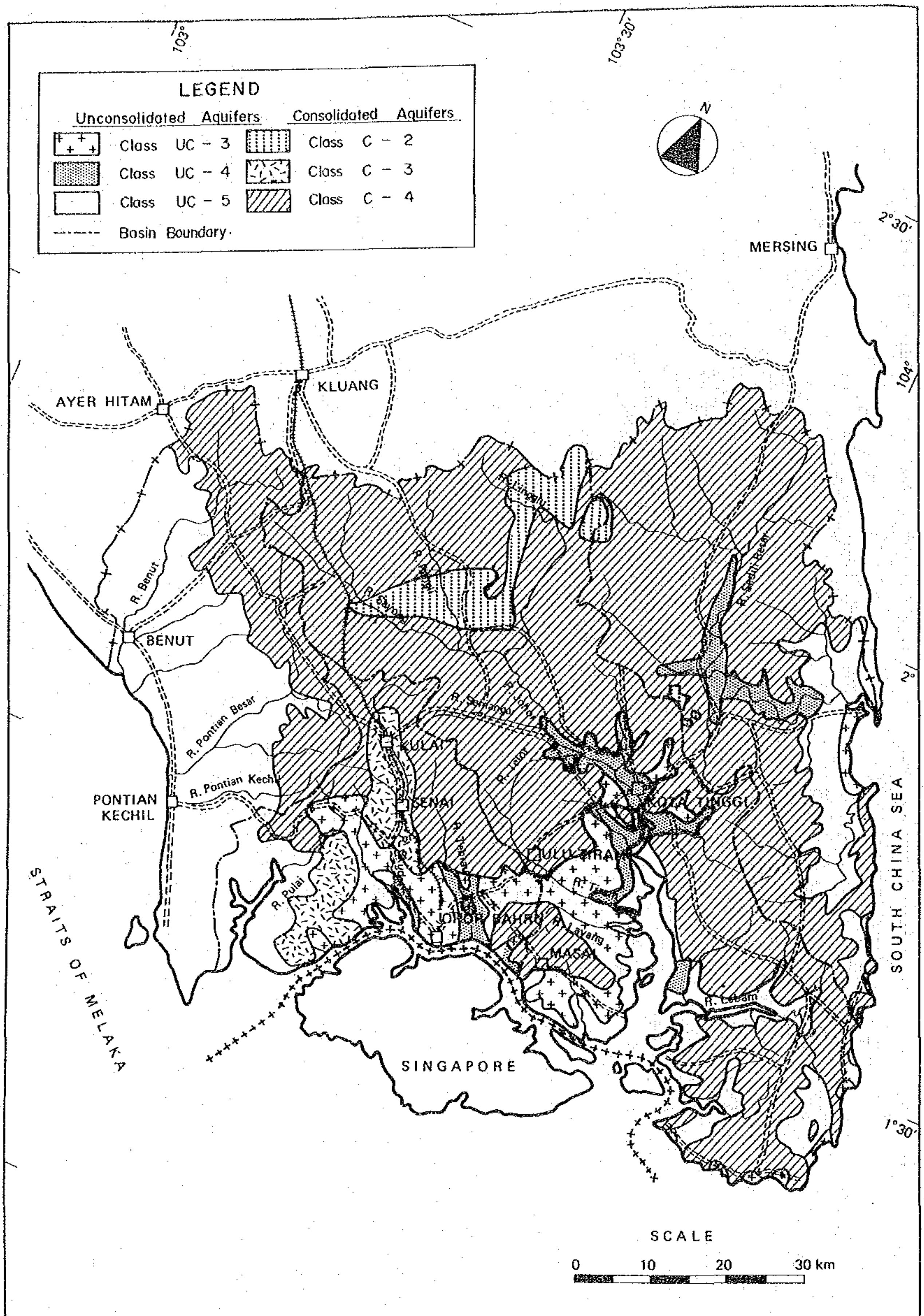

Fig. 6 Classification Map of Ground Water Potential

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ANNEX F
WATER QUALITY

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1. INTRODUCTION

This sectoral report presents a study on the projection of river water quality improvement from 1985 to 2005 in nine river basins in South Johor, Malaysia; namely, Benut, Pontian Besar, Pontian Kechil, Pulai, Skudai, Tebrau, Johor, Sedili Besar, Sedili Kechil, including historical and present conditions of river water quality, the present water quality monitoring systems, development plans for public sewerage systems, and pollution load abatement plans for river water.

Pollutant load abatement plans for river water were projected to keep the river water quality at less than 5 mg/l in BOD concentration for domestic and industrial water supply and less than 10 mg/l in BOD concentration for conservation of river environments.

In this study, the river water quality from 1985 to 2005 is estimated by using the existing and proposed pollution sources. And the improvement of construction of water purification systems for rubber processing factories, palm oil mills, pineapple processing factories, stock farms and public sewerage systems in cities are proposed.

For the purpose of analysis, necessary data were collected with the cooperation and assistance from several agencies under the Government of Malaysia.

2. EXISTING FACILITIES FOR POLLUTION LOAD ABATEMENT

2.1 Sewerage System

At present there is no central sewerage system in the Region. However, there are five forms of sanitary facilities in general use which are explained hereunder; namely, septic tank, pour-flush toilet, pit latrine, bucket system, and direct discharge. The population using these forms of facilities are summarized in Table 1.

<u>Septic Tank System</u>

According to the data of 1980, 455,072 people corresponding to 28% of the total population in the state of Johor use septic tanks for the disposal of raw sewage. The private septic tank system has a tank with a design capacity of 114 l/day/person.

Septic tank systems that are well maintained usually have the following efficiencies: (Ref. 1)

BOD : 45 - 85% removal
SS : 5 - 25% removal

<u>Pour-Flush Toilet</u>

About 47% of the total population in the state of Johor use toilets where excreta and urine are flushed by pouring 2 to 3 liters of water. Wastes are discharged through a pipe to an adjacent solids retention chamber to allow the liquid to percolate into the ground. Sullage is discharged to roadside drains.

<u>Pit Latrine</u>

About 11% of the total population in the state of Johor use pit latrines for waste disposal. Discharge is made directly through an untrapped squatting plate over the pit or retention chamber. Sullage is discharged separately to open drains, so that the operation is similar to that of pour-flush toilets.

Bucket System and Direct Discharge

The bucket system is used by 7.1% of the total population in the state of Johor. Waste from 108,404 people corresponding to 6.8% of the total population is discharged directly to water courses.

2.2 Purification System for Rubber Processing Factories

Raw effluents from natural rubber processing factories have been one of the major sources of water pollution in the Study Area. The characteristics of effluents from factories that process or manufacture various types of rubber are tabulated in Table 2. (Ref. 2)

At present, anaerobic and facultative pond systems are mainly used as the waste water purification systems of rubber processing factories.

2.3 Purification System for Palm Oil Mills

Raw effluents from palm oil processing factories can be generally described as a high viscous brown liquid of high total solids and oil with high BOD_3 and COD values of 24,100 to 28,100 mg/l and 51,200 to 55,300 mg/l, respectively.

The most popular purification system applied in palm oil mills in the Study Area is the anaerobic and facultative ponds system. Table 3 summarizes the BOD, COD, and SS concentrations under different stages of this treatment system. (Ref. 3)

2.4 Purification System for Pineapple Processing Factories

The distinctive characteristics of raw effluents from pineapple processing factories that product canned pineapples are acidic and highly organic. At present, purification systems such as land disposal and anaerobic and facultative ponds are used.

2.5 Purification System for Stock Farms

The number of livestock has been increasing in the state of Johor, therefore, raw effluents from stock farms have become one of the sources of water pollution.

The concentrations of raw effluent are as follows: (Ref. 4)

BOD_3	:	1,900 - 21,600 mg/l
COD	:	4,800 - 39,000 mg/l
SS	:	3,600 - 22,400 mg/l

The most common purification systems used in purifying animal waste are anaerobic ponds, aerobic ponds, oxidation ditches, barrier ditches and biological filtration.

3. HISTORICAL AND PRESENT CONDITIONS OF RIVER WATER QUALITY

3.1 Water Quality

Since 1978, regular river water quality monitoring programs have been carried out partly to assess the existing conditions of public water by the Division of Environment (DOE).

The locations of water quality monitoring stations (WQMS) and the area of water quality control regions (WQCR) in the Region are shown in Fig. 1, and the river water quality monitoring done by the branches of DOE in the regions has been carried out since 1978.

The data gathered from the said monitoring stations consisting of mean, maximum and minimum values of the five selected parameters, i.e., BOD_5, COD, pH, SS and NH_4-N, are tabulated in Table 4 to 9. The explanation of these parameters are in 6.2, Water Quality Projection.

3.1.1 BOD_5

BOD_5 is the most suitable parameter as a primary indicator of organic pollution. Distribution of mean BOD_5 levels on six rivers whose data since 1978 were obtained from WQMS are shown in Fig. 2.

An acceptable United Kingdom (UK) water classification formulated by D.Balfour and Sons (Ref. 5) is based on BOD_5 as follows:

BOD_5	Classification
0 - 4 mg/l	Clean
4 - 8 mg/l	Mildly Polluted
8 - 12 mg/l	Moderately Polluted
More than 12 mg/l	Grossly Polluted

If this BOD_5 classification is applied to the data in Tables 4 to 9, it can be said that some portions of the Skudai, Tebrau, and Johor rivers have become moderately or grossly polluted during the period from 1980 to 1983 as shown in Table 10.

3.1.2 Suspended solids (SS)

Suspended solids (SS) in the Region mainly caused by the operation of rubber processing factories. The distribution of mean SS levels from 1978 to 1983 are shown in Fig. 3.

The concentration of SS can be classified as follows: (Ref. 6)

SS	Classification
0 - 50 mg/l	Class A
50 - 100 mg/l	Class B
100 - 150 mg/l	Class C
More than 150 mg/l	Class D

If this SS classification is applied to the data in Tables 4 to 9, it can be said that some portions of the Benut, Pontian Besar and Johor rivers have become polluted up to Class D as shown in Table 11.

3.1.3 Ammoniacal Nitrogen (NH_4-N)

Ammoniacal Nitrogen (NH_4-N) in the Region mainly caused by the discharge of untreated or partially treated sewage and animal wastes. The distribution of mean NH_4-N levels from 1978 to 1983 are shown in Fig. 4.

According to the standard of water quality in Japan, the concentration of NH_4-N can be classified as follows:

NH_4-N	Classification
0 - 0.1 mg/l	Mildly Polluted
0.1 - 0.5 mg/l	Moderately Polluted
More than 0.5 mg/l	Grossly Polluted

If this NH_4-N classification is applied to the data in Tables 4 to 9, it can be said that most of the portions of all the rivers in the Region are moderately or grossly polluted. Especially, the middle reach of Skudai river and Johor river and the down reach of Tebrau river are grossly polluted in 1983, as shown in Fig. 4.

3.1.4 Other pollutants

The distribution of mean COD and pH levels in the Region during the period from 1978 to 1983 are as shown in Fig. 5 and Fig. 6, respectively.

3.1.5 Water quality condition of each river

The monitoring stations on each river are listed in Tables 12 and 13. By using five parameters, i.e., BOD_5, COD, pH, SS and NH_4-N, water quality conditions in the Benut, Pontian Besar, Pontian Kechil, Pulai, Skudai, Tebrau, Johor, Sedili Besar, and Sedili Kechil rivers are explained as follows:

(1) Benut River

The mean BOD_5 levels at three WQMSs were in the range of 1.4 to 1.6 mg/l in 1981, 2.1 to 3.2 mg/l in 1982, and 1.9 to 2.8 mg/l in 1983. The river water has become polluted since 1982. Especially, WQMS NO.1832604 representing the upper reach at 39.77 river km had recorded higher levels in 1982 and 1983 compared with the down reach, as shown in Fig. 2.

It is considered that the pineapple processing factory which discharges acidic and highly organic waste water near that WQMS has been contributing to the high BOD_5 level.

The SS levels at the down reach are higher than the levels at the upper reach, as shown in Fig. 3.

(2) Pontian Besar River

The mean BOD_5 levels at two WQMSs were in the range of 0.6 to 0.9 mg/l in 1981, 1.8 to 2.2 mg/l in 1982, and 1.2 to 1.4 mg/l in 1983. The mean NH_4-N levels from 1981 to 1983 were in the range of 0.22 to 0.51 mg/l at the down reach of WQMS No.1534604 and 0.09 to 0.24 mg/l at the upper reach of WQMS No.1734614, as shown in Fig. 4.

The level of NH_4-N at the down reach is higher than that at the upper reach, although the BOD_5 level is not so high in the down reach compared with that of the upper reach. It is considered that the stock farms near those WQMS have contributed to the NH_4-N level.

The level of SS at the down reach has become polluted since 1982.

(3) Pontian Kechil River

The mean BOD_5 level at WQMS No.1534603 was 0.6 mg/l in 1981, 0.8 mg/l in 1982 and 0.6 mg/l in 1983. At the same station, the mean NH_4-N level was 0.04 mg/l in 1981, 0.09 mg/l in 1982 and 0.17 mg/l in 1983.

It seems that Pontian Kechil River is not polluted at present.

(4) Pulai River

There is no water quality monitoring station in Pulai River. Therefore, the pollution level cannot be obtained. The DOE has palnned a monitoring station for water quality in Pulai River in 1985.

(5) Skudai River

Skudai River is the most polluted river in the Region. There are many cities, towns and factories as the pollution sources, such as Kulai, Senai, and Skudai.

The mean BOD_5 level from 1978 to 1983 was in the range of 0.7 to 2.0 mg/l at the upper reach, 2.2 to 5.7 mg/l at the middle reach, and 0.8 to 2.4 mg/l at the down reach. NH_4-N level was in the range of 0.08 to 0.23 mg/l at the upper reach, 0.54 to 1.58 mg/l at the middle reach, and 0.11 to 0.54 mg/l at the down reach. These are shown in Figs. 2 and 6.

The levels of BOD_5 and NH_4-N show that the middle reach is much more polluted than the upper and down reaches. It is considered that the domestic waste water from towns, and the effluent water from factories have been polluting the Skudai River.

(6) Tebrau River

Tebrau River is one of the pulluted rivers in the Region. The mean BOD_5 levels at three WQMSs were in the range of 0.8 to 9.7 mg/l in 1982 and 0.8 to 2.4 mg/l in 1983.

The SS levels were in the range of 13 to 30 mg/l in 1982 and 43 to 115 mg/l in 1983. The NH_4-N levels were in the range of 0.08 to 0.19 mg/l in 1982 and 0.11 to 0.85 mg/l in 1983. The levels of SS and NH_4-N in 1983 were higher than the levels in 1982.

The main pollution sources in the Tebrau River basin are considered as one rubber processing factory and one palm oil mill.

(7) Johor River

The Johor River water is polluted by domestic waste water and effluent water from rubber processing factories and palm oil mills.

The mean BOD_5 and NH_4-N levels at the upper reach from 1980 to 1983 were in the range of 0.7 to 1.3 mg/l in BOD and 0.05 to 0.6 mg/l in NH_4-N; at the down reach, they were 0.9 to 1.4 mg/l in BOD_5 and about 0.1 mg/l in NH_4-N. While, the mean BOD_5 and NH_4-N levels at the middle reach which is situated between WQMS No.1834609 and WQMS No.1737606 were in the range of 1.7 to 3.0 mg/l in BOD_5 and 0.6 to 2.5 mg/l in NH_4-N.

The middle reach of Johor River is polluted, same as the Skudai River middle reach.

(8) Sedili Besar River

Sedili Besar River is not so polluted because there are only a few pollution sources. The mean BOD_5 levels of three WQMSs show less than 1.2 mg/l in 1982 and 1983.

(9) Sedili Kechil River

There is no water quality monitoring station in Sedili Kechil River. The river is clean because there are few pollution sources.

3.2 Pollution Sources and Their Locations

Major industrial towns, rubber processing factories, palm oil mills, pineapple processing factories and stock farms are considered as the main pollution sources of river water in the Region.

The location of existing pollution sources are as shown in Figs. 7 and 8, and the inventories including data on existing effluent treatment facilities are in Table 14 for rubber processing factories, Table 15 for palm oil mills, Table 16 for pineapple processing factories and Table 17 for stock farms.

3.2.1 Major/industrial town

There are five major/industrial towns; Pontian Kechil, Kulai, Johor Bahru, Kota Tinggi and Pasir Gudang. Among these towns, the waste waters of Kulai and Kota Tinggi are being discharged into the river, while treated or untreated waste water from the vicinity of Pontian Kechil, Johor Bahru, and Pasir Cudang are being discharged into the river mouth or the sea directly.

3.2.2 Rubber processing factory

There are 20 rubber processing factories in the Region. There is one factory each in the Pontian Besar, Pontian Kechil, Pulai, Tebrau and Johor river basins, seven in the Skudai river basin. The waste water from eight factories are discharged into the river mouth or other basins.

Among these twenty factories, 17 factories have the purification systems such as anaerobic and facultative ponds or biological ponds.

3.2.3 Palm oil mill

There are 25 palm oil mills in the Region. There is one palm oil mill each in the Benut, Pontian, Kechil and Tebrau river basins, two each in the Pontian Besar, Sedili Besar river basins, four in the Skudai river basin, nine in the Johor river basin. The waste water from five palm oil mills are discharged into the river mouth or other basins.

Among the above-mentioned 25 factories, 13 palm oil mills have the purification system such as anaerobic and facultative ponds and nine have the land disposal system.

In future, one palm oil mill in each Benut, Pontian Besar, Pontian Kechil, Sedili Besar and Sedili Kechil river basin are scheduled to be provided.

3.2.4 Pineapple processing factory

There are four pineapple processing factories in the Region. There is one pineapple processing factory in each Benut and Pontian Besar river basin, and two in the Skudai river basin. These four factories have the purification system such as anaerobic and facultative ponds or land disposal system.

In future, one factory in the Pontian Besar river basin, and two in the Pontian Kechil river basin will be proposed.

3.2.5 Stock farm

In the state of Johor, the number of livestocks in stockfarms has increased. It assumed that the livestock production will grow with the annual average rate of 2.3% during the period from 1980 to 1990, and 1.7% from 1990 to 2005. According to the data of 1982, the stock farms which have more than 1000 heads in 2005 are picked up.

There are two farms in each Benut, Pontian Besar and Purai river basin, one farm in each Betrau and Johor, Sedili Besar river basin, 21 farms in the Pontian Kechil river basin, and four in the Skudai river basins.

The simple purification system is the most common system used by the stock farm in the Region. (Ref. 4)

3.3 Major Pollutants on Each Pollution Source

The major pollutants in domestic waste water are BOD, COD, SS, and Ammoniacal nitrogen. Industrial waste water contain various kinds of pollutants, but BOD, COD, SS, oil and grease, N and P are the major pollustants. (Ref. 7)

In the effluent water of rubber factories, the concentrations of BOD, COD, total solids, SS, and dissolved solids are very high. (Ref. 8)

In the palm oil mill waste water, the concentrations of BOD, COD, and SS are very high. (Ref. 9, 10)

The waste water in the pineapple processing factories has acidic and highly organic characteristics. Therefore, the concentrations of BOD and COD are very high and the value of pH is very low.

The major pollutants of stock farm effluent water are BOD, COD, and SS. (Ref. 4)

4. PRESENT MONITORING SYSTEM OF WATER QUALITY

4.1 Water Quality Monitoring Stations and Their Locations

The water quality sampling and analyzing system has been initiated by DOE since 1978.

The number of water quality monitoring stations (WQMS) in water quality control regions (WQCR) are shown in Table 18. The monitoring stations on each river are listed in Tables 12 and 13, and the location of these stations are shown in Fig. 1.

The present monitoring stations are mainly located on the downstream near the water quality pollution sources, e.g., rubber processing factories, palm oil mills, and pineapple processing factories.

4.2 Water Quality Parameters and Frequency of Sampling

Natural water is principally used for irrigation, power generation, domestic and industrial water supply, waste disposal, transportation, recreation, environmental conservation, fishing, bathing and propagation of aquatic life.

Water quality requirements are most demanded for domestic water supply, less so for water used in recreation and propagation of aquatic life, and least so for water used in the industries and agricultural irrigation.

Water quality parameters vary in accordance with the abovementioned four sectors of water use. Water quality parameters which are generally analysed in laboratories in order to know the state of river water quality are pH, BOD_5, COD, Ammoniacal Nitrogen, Nitrate Nitrogen, Total Nitrogen, Chloride, Fluoride, Suspended Solids, Dissolved Solids, Arsenic (As), Boron (B), Calcium (Ca), Total Chromium (Cr), Lead (Pb), Magnesium (Mg) and Mercury (Hg).

Sampling frequencies from 1978 to 1983 which have been executed by the branch of DOE in Johor Bahru are as shown in Table 19.

Quantitative analysis of all river water quality samples in the Study Area is carried out by the laboratory under the Department of Chemistry in Johor Bahru.

5. DEVELOPMENT PLAN FOR PUBLIC SEWERAGE SYSTEM

5.1 General Description of Public Sewerage System in the State of Johor

There are three sewerage system projects planned in the Region under the Fourth Malaysia Plan (4MP). The project areas are Johor Bahru Town, Skudai Valley and Pasir Gudang Corridor.

The general conditions of the above-said sewerage development plans are as described below. (Ref. 1)

(1) The development period according to the Master Plan is divided into three stages; 1980 to 1990 (Phase I), 1991 to 2000 (Phase II), and 2001 to 2010 (Phase III).

(2) The estimated population in the respective areas by year are as follows:

Estimated Served Population

	1990	2000	2010
Johor Bahru Town	53,100	131,070	324,235
Skudai Valley	20,175	87,890	282,650
Pasir Gudang Corridor	4,200	16,160	16,160

(3) The projections for future water demand of the areas indicate a growth ratio of 2% per annum. Therefore, the estimated domestic waste water volume per capita for the various planning stages are forecasted as 140 (l/head) in 1980, 170 (l/head) in 1990, 200 (l/head) in 2000, and 250 (l/head) in 2010.

(4) The standard concentrations of effluent water from sewage treatment systems are projected to be 50 mg/l in BOD_5 and 100 mg/l in SS.

5.2 Johor Bahru Town

Two treatment sites are proposed, one is in the west of the Sungai Skudai estuary (West Site) and another in the east of the Sungai Tebrau estuary (East Site).

Although treatment system by aerated ponds is proposed for ultimate flows at the West Site, facultative maturation pond system is initially recommended. The construction cost and operation and maintenance (O & M) cost are as shown in Tables 20 and 21.

5.3 Skudai Valley

Three local treatment sites have been selected and proposed for the urban area of Kulai, Senai and Skudai.

Treatment by facultative aerated and maturation system has been proposed for Kulai and Senai, and for Skudai site, facultative aerated system is proposed.

The construction cost and operation and maintenance cost are as shown in Tables 20 and 21.

5.4 Pasir Gudang Corridor

Masai site has been proposed for the construction of treatment facilities, and the treatment method by facultative maturation system is planned. The construction cost and operation and maintenance cost are as shown in Tables 20 and 21.

6. PROJECTION OF WATER QUALITY

6.1 General

The pollutant load and water quality of rivers by basin were projected based on the projection of D & I water demand. Now, the major pollution sources are four cities/towns, rural area of five districts, 20 rubber processing factories, 25 palm oil mills, four pineapple processing factories and the many stock farms in the Region. Five palm oil mills and three pineapple processing factories are proposed, and some of the cities/towns will become pollution sources with the increase of its population. These pollutant sources are classified into ten categories as follows:

(1) Urban domestic sewerage
(2) Urban domestic non-sewerage
(3) Rural domestic
(4) Urban manufacturing sewerage
(5) Urban manufacturing non-sewerage
(6) Rural manufacturing
(7) Palm oil mill
(8) Rubber processing
(9) Pineapple processing
(10) Animal husbandry

Each category has its own values in net unit pollutant load, discharge ratio, runoff ratio and infiltration ratio. These assumed values are listed in Tables 22 to 25. The composition of the above pollution sources is illustrated in Fig. 9.

In order to know the organic water pollution level in rivers, BOD_5 was selected among the five parameters of BOD, SS, DO, pH and NH_4-N.

6.2 Water Quality Projection

6.2.1 Methodology

The water quality of the rivers was projected for nine basins in the Region. Water quality was calculated by the following order:

(1) Pollutant Load from Pollution Source (PLS) = Customer Demand (CD) x Discharge Ratio (R-Ratio) x Net Unit Pollutant Load (NUPL)

(2) Pollutant Load Inflow to River (PLR) = (PLS x Runoff Ratio (R-Ratio) x (1 + Infiltration Ratio (I-Ratio)

(3) Pollutant Load at Some Point (PLSP) = PLR x Residual Purification Ratio (RP-Ratio)

(4) Water Quality at Some Point (WQ) = CD x D-Ratio x NUPL x R-Ratio x (1 + I-Ratio) x RP-Ratio/Maintenance Flow at Some Point

Water Quality was calculated by return point of polluted waste water in basin. The water quality projection flow-chart is given in Fig. 10, and the calculation of water quality was carried out based on the following assumptions:

(1) Hydraulic discharge used for water quality projection is the basin discharge in 1977 which is the driest year between 1961 and 1980;

(2) When the river water is abstracted at intake, pollutant load of the river is decreased. The decreased load is expressed as (Abstracted Volume x Water Quality);

(3) Urban domestic and manufacturing waste water in the coastal area is discharged not into the river, but into the sea directly after treatment;

(4) A part of the abstracted water from a river is reduced by (SC-CD)/2;

(5) The effluent from pollution sources is discharged at the return point; and

(6) I-Ratio of groundwater into sewer pipe in city/town having public sewerage system is 20% of the average daily treatment.

6.2.2 Net unit pollution load (NUPL)

In order to know the water pollution levels in a river, five parameters such as pH, BOD, SS, DO and NH_4-N will be used. Of these parameters, BOD is the most suitable parameter to know the organic pollution level of river water. The reason is described hereunder.

The river water is, first of all, polluted organically because of the direct discharge of domestic waste water. Then, industrial effluent containing heavy metals and chemical materials pollutes the river water chemically, but industrial effluent with heavy metals should not be discharged to the body of water without treatment. Therefore, heavy metals are not suitable parameters to know man-made pollution of river water.

Rivers have the self purification mechanism which purifies organic pollution. This mechanism is caused by the fact that aerobic bacteria in river water transforms organic matters to inorganic matters using dissolved oxygen. The volume of dissolved oxygen used by aerobic bacteria is BOD.

For the above reasons, BOD load was used in the study as pollutant load.

Data of NUPL of sewerage, urban, rural, manufacturing, processing and stock farm are available in Malaysia. (Ref. 10)

NUPL was estimated based on several reports (Ref. 11, 12, 13 & 14), assuming that the purification measures remain at the present level of BOD concentration until 2005.

6.2.3 Discharge ratio (D-Ratio)

Water consumers use clean water and then discharge polluted water into the drainage, river or sea directly. D-Ratio is the ratio of consumer water demand and discharged water. D-Ratio of domestic consumer were determined based on the Malaysia data. D-Ratio by pollution source is as shown in Table 22.

In manufacturing, D-Ratio was determined with consideration of recyclic water use development. In palm oil mills and rubber processing factories, the land disposal system is assumed to be progressively applied.

D-Ratio of palm oil mills and rubber processing factories are determined with consideration of land disposal development and outflow of 10% of pollutant load from land disposal area.

6.2.4 Runoff ratio (R-Ratio)

The ratio of the reduction in discharged pollutant load, which is the ratio before and after discharged pollutants reach a river, is called the runoff ratio.

R-Ratio is about 0.1 in rural areas but increases with the progress of urbanization. For a discharge channel made of concrete, R-Ratio rises to nearly 1.0.

R-Ratio by pollution source is as shown in Table 22.

6.2.5 Infiltration ratio (I-Ratio)

The infiltration ratio in the existing sewerage systems in the region is equivalent to about 25% to 30% of the average flow. Since existing systems are constructed with rigid cement joints, it is to be expected that, with provision of flexible watertight joints in the future, the infiltration ratio will be about 20% of the average daily flow. (Ref. 13, 15, 16 & 17). I-Ratio is assumed to be 20% in the study.

6.2.6 Residual purification ratio (RP-Ratio)

Pollutant load in a river reduces by deposition, adsorption, biological decomposition, and so on. The ratio of reduced pollutant load by these mechanisms to the original pollutant load is called the residual purification ratio. In other words, RP-Ratio is the ratio of pollution load of the upperstream and the downstream.

RP-Ratio has a figure in the range of 0 to 1 by condition of water quality, water velocity, water discharge, water depth and riverbed of a river basin. The relationship between RP-Ratio and water quality is closed. RP-Ratio is about 0.7 in a river with clean water and RP-Ratio rises to nearly 1.0 in a river with polluted water.

6.2.7 River maintenance flow

The river maintenance flow used for water quality projection is the 99% runoff estimated by means of frequency study using the recorded data between 1962 and 1983 except for the Johor river. For the Johor river the specific discharge of 0.15 $m^3/s/100\ km^2$, the recorded minimum discharge, was adopted as the river maintenance flow.

6.2.8 Projection of water quality

Water quality of 9 basins, i.e., the Benut river basin, the Pontian Besar river basin, the Pontian Kechil river basin, the Pulai river basin, the Skudai river basin, the Tebrau river basin, the Johor river basin, the Sedili Besar river basin and the Sedili Kechil river basin was projected. Water demand projection of rubber factories, palm oil mills and pineapple factories are as shown in Tables 26 to 28. Further, domestic and industrial water demand projection are as shown in Tables 29 to 30. Projection of stock farms is as shown in Table 31. Projected BOD load and BOD concentration by basin in 1995 and 2005 are as shown in Table 32. Total BOD load from pollution sources in the Region will be 35.4 ton/d in 1995 and 61.9 ton/d in 2005, respectively.

It is assumed that waste water from 4 cities mentioned hereunder out of 17 cities is discharged to the sea directly because these 4 cities are located near the sea coast. These 4 cities are Johor Bahru, Masai & P.G., Bander Penawan and Pontian Kechil.

BOD load into main stream will be 13.1 ton/d in 1995 and 25.4 ton/d in 2005, respectively. Composition of BOD load into river is as shown in

Table 33. In 1995, urban domestic and urban industry will be the biggest pollution sources and those BOD load will be 9.5 ton/d being equivalent to 73% of the total BOD load of 13.1 ton/d. In 2005, the biggest pollution sources will be also urban domestic and urban industry and those BOD load will be 21.5 ton/d being equivalent to 85% of the total BOD load of 25.4 ton/d.

Projected maximum and minimum BOD concentration by basin are as shown in Table 32. The highest BOD concentration, 43 mg/l in 1995 and 68 mg/l in 2005, was projected for the Skudai river basin because of the non-treated effluent from urban area, rubber factories and palm oil mills. Distribution of BOD concentration along the rivers of 5 basins is illustrated as in Figs. 11 to 13. These 5 basins are the Benut river basin, the Pontian Besar river basin, the Skudai river basin, the Tebrau river basin and the Johor river basin.

Some of the intakes for domestic and industry water supply are located at the down part of pollution sources. There are four intakes which show higher BOD concentration than 5 mg/l in 1995 or 2005, i.e., (R29) in Pontian Besar river basin, (R31) in Skudai river basin and (R26), (R41) in Johor river basin. Therefore, polluted river water affects the D&I water supply.

7. POLLUTANT LOAD ABATEMENT PLANS FOR RIVER WATER

7.1 General

As the result of the water quality projection in the Study area for 1995 and 2005, Skudai river, upstream of Johor river and down stream of Pontian Besar and Pontian Kechil river will be polluted. Therefore it is necessary to consider the pollutant load abatement from viewpoints of water use and environmental quality in river. The best method for pollutant load abatement is that pollution sources control polluted effluent from sources by themselves.

7.2 Setting of Water Quality Criteria

Water quality standards are of two kinds as follows:

(1) standards for drinking water which pertain to water delivered to consumers after treatment; and

(2) standards for raw water which are classified depending upon the purpose of utilization, i.e., domestic and industrial water supply, fishery, irrigation, bathing and conservation of environment.

International Standards for Drinking Water have been promulgated by the World Health Organization (WHO) as a worldwide guide to the improvement of water quality and treatment. In Malaysia, there are Standards of Bacteriological Qualtiy of Water and Standards for Toxic Substances derived from the WHO Standards and they have been used by relevant agencies.

The Standards for Toxic Substances include Toxicity Limits and Water Quality Criteria for 4 categories, i.e., (i) municipal water supply, (ii) recreation, propagation of fish and other aquatic wildlife, (iii) agricultural irrigation and (iv) industrial water supply. Adopted parameters are 74 in number but they do not include BOD. Standards of raw water in some countries, Holland, U.S.A., U.S.S.R, Philippines and

Japan have adopted several parameters including BOD. Concerning the living environment, river water quality is classified according to water usage, and environmental quality standards values for BOD, DO, SS, pH and Coliform are established for each class. Japanese Standards relating to living environment is as shown in Table 34 and Philippines' water quality criteria is as shown in Table 35 (Refs. 18 & 19). In the Study, BOD is adoped in order to observe the river water quality. Some relationships between BOD concentration in a river and environmental quality, and river water quality standard in some countries are illustrated as in Fig. 14.

As the water quality criteria, two targets for the water pollution abatement are proposed from the viewpoint of environmental quality in the Study. One target is BOD concentration in a river at less than 5 mg/l for the purpose of D&I water supply and another target is BOD concentration in a river at less than 10 mg/l for the conservation of river environment.

7.3 Planning of Treatment Facilities

To reduce BOD concentration to the proposed limit in a river, the improvement of treatment facilities in pollution sources should be conducted.

First of all, the improvement of purification methods in all palm oil mills, rubber factories and pineapple factories is assumed. Improved purification methods are rubber investigation in Palm Oil Research Institute of Malaysia (PORIM) and Rubber Research Institute of Malaysia (RRIM) to attain the limit of BOD concentration for water course discharge from palm oil mills and rubber factories. DOE proposed 50 ppm for the future limit. Present limits for water course discharge in palm oil mills and rubber factories are as shown in Table 36 (Refs. 20 & 21). The limit for watercourse discharge from pineapple factories is assumed to follow the limit of palm oil mills.

If there still remains a river stretch of higher BOD concentration than the proposed limit, the construction of sewerage system in the urban area immediately upstream of the river stretch is assumed.

Urban domestic and manufacturing waste water is collected and treated in public sewerage treatment facilities. BOD concentration in the effluent from a sewerage system is estimated to be 20 mg/l.

No purification measure is assumed for the effluent from rural area and stock farm.

For purification method of effluent from palm oil mills and pineapple factories, anaerobic digestion with extended aeration or land disposal are proposed. As treatment method of effluent from rubber factories, aerobic and facultative pond for SMR and oxidation ditch for Latex Concentrate. The layout of the stabilization pond process, combing facultative pond with maturation pond, is shown in Fig. 15.

For public sewerage system, aerated lagoon process is proposed in the Study. This process is historically developed from stabilization pond. Floating aerator for surface aeration is commonly used to supply the necessary oxygen and arise reduction level of load. Maturation pond is necessary to reduce coliform after treating in the aerated lagoon. The layout of aerated lagoon process is shown in Fig. 16.

7.4 Planning of Pollutant Load Abatement for River Water

As mentioned in 6.2.8, high BOD concentration was projected at the downstream of big pollution sources, i.e., cities/towns. Therefore, it is necessary to plan the treatment facilities in the Benut river basin, the Pontian Besar river basin, the Pontian Kechil river basin, the Skudai river basin, the Tebrau river besin, the Johor river basin and the Sedili Besar river basin.

The public sewerage systems in the urban area to be constructed in 1995 and 2005 by basin are as follows:

Basin Name	City/Town
Pontian Kechil	Pontian Kechil
Skudai	Kulai, Senai
Johor	Bandar Tenggara, Kota Tinggi
-	Johor Bahru, Masai, Pasir Gudang

Johor Bahru, Masai, Pasir Gudang and Pontian Kechil are located in coastal area, therefore the effluent from those cities is discharged to the sea directly. However from the viewpoints of public health and water quality of the sea, public sewerage systems in these cities are proposed.

Renggam and Layang-Layang have been urbanized and the BOD concentrations at the downstream of these areas are presumed to be polluted. Since these areas are located at the upper reach of Sayong dam, the waste water from these areas should be purified as much as possible. With this regard, septic tank and treatment system by soil such as the underground trench are proposed at Layang-Layang and Renggam in order to prevent from the pollution of the water in Johor river.

Outlines of proposed public sewerage system are as shown in Table 37. And effluent volume to be treated in rubber factories, palm oil mills and pineapple factories is as shown in Table 38.

According to the result of the river water quality projection on the assumption of the improvement of purification system in rubber factories, palm oil mills, pineapple factories and the construction of public sewerage system in urban area in 1995 and 2005, BOD concentration of river water will be improved. But at the intake for D&I water supply in the upper stream of Johor river and the Skudai river, there still remains a higher BOD concentration than 5 mg/l in 2005. And at the river mouth in the Pontian Besar river basin and Pontian Kechil river basin, there still remains a higher BOD concentration than 10 mg/l in 2005. BOD load and maximum BOD concentration in 1995 and 2005 by basin with and without project are as shown in Table 39.

8. PLANNING MATERIALS, ECONOMIC BENEFIT AND COST AND MANPOWER REQUIREMENT

8.1 Planning Materials

8.1.1 Construction cost

Construction costs of purification facilities for palm oil mills, rubber factories, pineapple factories and sewerage facilities for urban area composed of sewer, pumping station and treatment facilities are estimated, basing on the data from DOE and the previous studies available, i.e., Butterworth Project. The construction cost of pretreatment facilities for domestic and industrial water supply are estimated using the data of the previous studies available.

Construction cost is estimated in the four categories, i.e. (1) direct construction cost, (2) engineering service & administration, (3) land acquisition, and (4) physical contingency. Engineering service and administration costs are assumed to be 10% of the direct cost. Physical contingency is assumed to be 30% of the total of the above (1) to (3).

For the sewerage facilities, direct construction costs by facilities in reference of the hearing data of Butterworth Project as shown in Table 40 are as follows:

$$C_s = 0.699 \times Q$$
$$C_T = 4.55 + 0.07 \times Q$$

where, C_s: Direct construction cost of sewer, M10^6

C_T: Direct construction cost of treatment facilities, M10^6

Q : Treatment capacity, 10^3 m^3/d

Unit direct construction cost of sewerage facilities per 100 x 10^3 m^3/d of treatment capacity is M$81.5 x 10^6.

Land acquisition cost for sewerage facilities in reference of the hearing data of Butterworth Project as shown in Table 40 are as follows:

$$C_L = 0.112 \times Q$$

where, C_L: Land acquisition cost of treatment facilities, M$\$10^6$

Q : Treatment capacity, 10^3 m^3/d

Unit land acquisition cost of sewerage facilities per 100 x 10^3 m^3/d of treatment capacity is estimated to be M\$11.2 x 10^3.

Construction and land acquisition costs of sewerage facilities are generally born by the public and the private sector. Therefore calculation of costs for sewerage systems was carried out on the following assumptions:

(1) In the existing urban area, cost of house connection pipe is born by the private; and

(2) In the new development urban area, costs of branch sewer and house connection pipe are born by the private.

Cost and share of branch sewer and house connection pipe to total costs of sewerage systems are as shown in Table 41.

For the purification facilities for palm oil mills and pineapple facilities, direct construction costs are M\$3,780/m^3/d of treatment capacity for anaerobic digestion with extended aeration and M\$2,520/m^3/d of treatment capacity for anaerobic digestion with land disposal, respectively.

$$C_{PA} = 3.78 \times Q$$
$$C_{PL} = 2.52 \times Q$$

where, C_{PA}: Direct construction cost of purification facilities with extended aeration, M$\$10^3$

C_{PL}: Direct construction cost of purification facilities with land disposal, M$\$10^3$

Q : Treatment capacity, m^3/d

Unit direct construction cost of purification facilities of palm oil mills and pineapple factories are estimated to be M$3,780/$m^3$/d of treatment capacity.

Purification facilities of palm oil mills and pineapple factories are assumed to be constructed in the factories area, so no land acquisition cost is needed.

For the purification facilities for rubber factories, direct construction costs are M$740/$m^3$/d of treatment capacity for SMR production and M$2,210/$m^3$/d of treatment capacity for Latex concentrate production, respectively.

$$C_{RS} = 0.74 \times Q$$
$$C_{RL} = 2.21 \times Q$$

where, C_{RS}: Direct construction cost of purification facilities for SMR production, M$$10^3$

C_{RL}: Direct construction cost of purification facilities for Latex concentrate production, M$$10^3$

Q : Treatment capacity, m^3/d

Unit direct construction cost of purification facilities of rubber factories is estimated to be M$740 of treatment capacity for SMR production and M$2,210 of treatment capacity for Latex concentrate production.

The raw water for domestic and industrial water supply is treated at the intake point. For the raw water, which BOD concentration is less than 20 mg/l, is treated by the treatment facilities, such as slow sand filtration or rapid sand filtration.

The pretreatment facilities are needed, if the BOD concentration in raw water is more than 20 mg/l. As the pretreatment facilities, the treatment method such as an aerated lagoon process, consist of aerated lagoon or maturation pond, is proposed (Primary treatment). The direct construction cost of the primary treatment facilities are estimated as follows:

$$C_{pre} = 3.94 \times 10^{-6} \times L^{2.9} \times (Q_D + Q_Z)$$

where, C_{pre} : Direct construction cost of primary pretreatment facilities, M10^6

L : Reduction level of pretreatment facilities, %

Q_D : Treatment capacity for domestic water supply, $10^3\ m^3/d$

Q_Z : Treatment capacity for industrial water supply, $10^3\ m^3/d$

Unit direct construction cost of pretreatment facilities are estimated to be M$33.3 x 10^6 per 100 x $10^3\ m^3/d$ of treatment capacity for primary pretreatment facilities as 50% reduction level.

Pretreatment facilities is assumed to be constructed in the treatment plant area, so no land acquisition cost is needed.

Pretreatment capacity to be pretreated in D&I water demand is as shown in Table 42.

The unit construction cost are estimated as shown in Table 43 and summarized below.

Type of Treatment Facility	Unit Construction Cost (M$$10^6$/100 x $10^3\ m^3/d$)
- Public sewerage system	130
- Purification facilities of palm oil mills and pineapple factories with extended aeration system	540
- Purification facilities of palm oil mills and pineapple factories with land disposal	360
- Purification facilities of rubber factories (SMR)	105
- Purification facilities of rubber factories (Latex)	320
- Primary pretreatment facilities as 50% reduction level	48

For the proposed river water pollution abatement, estimated public and private development expenditure for public sewerage system are as shown in Tables 44 and 45. For the proposed improvement of purification in rubber factories, palm oil mills and pineapple factories estimated private development expenditure is as shown in Table 46.

8.1.2 Operation and maintenance cost (O&M cost)

The O&M costs include O&M cost of sewer, pumping station and aerated lagoon process for public sewerage system, O&M cost of ponding process for purification facilities in palm oil mills, rubber factories and pineapple factories and O&M cost of aerated lagoon for primary pretreatment.

Relationship between construction cost and ratio of O&M cost and construction cost by city is shown in Fig. 17. The ratio has the range from 1 to 4%. In the Study, the annual O&M cost is assumed to be 4% of the total construction cost for public sewerage system and 2% of the total construction cost for purification facilities of palm oil mills, rubber factories, pineapple factories and pretreatment facilities.

8.2 Economic Benefit and Cost

Economic benefit for water pollution abatement is assumed to be composed with the sewerage benefit and the saving in pretreatment facility.

The sewerage benefit is the willingness-to-pay by served people and saving in the cost of purification of industrial waste water. It is assumed to be 0.6% of real income of served people and gross value of manufacturing production of served industries in this Study.

Pretreatment facilities are necessary if BOD concentration in raw water is more than 20 mg/l for domestic water supply and industrial water supply. Its cost can be saved, if the proposed water pollution abatement measures reduced BOD concentration in the river across this limit. This saving in cost is counted as a part of water pollution abatement benefit.

Economic cost for water pollution abatement is estimated to be 80% of the financial cost of public sewerage system, purification facilities of palm oil mills, rubber factories, pineapple factories and pretreatment facilities for D&I water supply.

Beneficial and adverse effects of water pollution abatement plants are as shown in Table 47. The length of river stretches where BOD concentration is more than the limit is as shown in Table 48.

8.3 Manpower Requirement

8.3.1 Manpower requirement for construction

Manpower requirement for construction is estimated, basing on the data of Ministry of Local Government and Federal Territory. The staff in the Construction Division of Sewerage Department is composed with four categories as follows:

Staff Category	Number of Staff
Executive Engineer	1
Assistant Engineer	3
Technical Assistant	2
Technician	3
Total	9

In consideration of the above staff-requirement and construction schedule, manpower requirement is estimated for construction schedule of every 50×10^3 m^3/d per year as follows:

Staff Category	Number of Staff	Share (%)
Engineer	2	25
Technical Assistant	2	25
Technician	2	25
Others	2	25
Total	8	100

Estimated manpower requirement for construction by city with public sewerage system are as shown in Tables 49 and 50.

8.3.2 Manpower requirement for O&M

Manpower requirement for O&M is estimated, basing on the data of the staff-requirement of the Operation Division, Sewerage Department, Ministry of Local Government and Federal Territory as well as manpower requirement for construction. The staff in the Operation Division of Sewerage Department is composed with categories as follows:

Staff Category	Number of Staff
Treatment Plant	
- Laboratory Assistants	3
IMG Workers	18
Pumping Stations	
- Mechanical Supervisors	1
IMG Workers	11
- Sewer Inspectors	2
IMG Workers	29
Other Operations	
Works Manager	1
Chemist/Biologist	2
Technical Assistant (Electrical)	1
Supervisors (Works)	1
Assistant Clerk/Typist	2
Technicians (Sampling Meter Reader)	1
Security	3

IMG Workers	22
Driver	1
Total	98

In consideration of the above staff-requirement and staff required in the D&I water supply, manpower requirement is estimated for treatment capacity of every 200 x 10^3 m^3/d as follows:

Staff Category	Number of Staff	Share (%)
Engineer	2	4
Technical Assistant	3	6
Technician	18	38
Others	24	52
Total	47	100

Manpower requirement for O&M by city with public sewerage system are as shown in Tables 49 and 50.

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TABLES

Table 1. POPULATION SERVED BY VARIOUS TYPES OF SANITATION SYSTEMS IN 1980

System	Population Served	Percentage
Central Sewerage System	-	-
Septic Tank	455,072	28.4
Pour-Flush Toilet	751,500	46.9
Pit Latrine	172,835	10.8
Bucket System	113,135	7.1
Direct Discharge	108,404	6.8
Total	1,600,946	

Table 2. PHYSICAL AND CHEMICAL PROPERTIES OF EFFLUENT FROM DIFFERENT TYPES OF RUBBER FACTORIES

(Unit: mg/l except pH)

Type of Factory	pH	Sus-pended Solids	Total Solids	COD	BOD	NH_3-N
Block Rubber	6.3	230	995	1,620	1,140	55
Latex Concentrate	4.2	190	6,035	4,590	2,580	395
RSS	4.9	140	3,745	3,300	2,630	10
Remilling	6.2	350	480	900	740	15

Table 3. CONCENTRATION OF DIFFERENT STAGES OF ANAEROBIC AND FACULTATIVE PONDS

(Unit: mg/l except pH)

Stage	pH	BOD	COD	SS
Raw Effluent	5.0-5.3	24,125-28,125	51,230-55,340	17,680-20,850
After Deoiling	4.0-4.2	27,000-27,125	56,920-67,170	19,910-22,090
Acidification	4.9-5.5	11,125-11,400	16,510-18,480	4,200-4,930
Anaerobic Digestion	7.2-7.4	90-460	1,260-1,820	350-1,120
Facultative Ponding	8.4-8.7	80-160	700-840	80-240

Table 4. POLLUTANT LEVELS OF RIVERS IN 1978

Unit: mg/l except pH

River Name & Basin No.	WQMS No.	No. of Samples	pH			BOD_5			COD			Suspended Solid			Ammoniacal Nitrogen		
			Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min
Benut 23	1632601	1	3.7			1			105			135			.11		
	1833602	1	5.6			1			35			25			.02		
	1833603	1	5.7			1			20			50			.02		
Sekudai 23	1536601	9	6.2	6.7	5.9	1.7	3	1	18.2	30	8.5	35	80	10	.18	.45	.02
	1536602	9	6.2	6.6	5.9	1.9	4	Nil	16.5	30	8.5	59.4	115	25	.19	.46	.01
	1636603	9	6.2	6.7	5.7	1.9	5	1	15.2	25	5	48.1	75	30	.19	.54	.01
	1636601	8	5.9	6.4	3.5	2.1	3	Nil	28.9	130	11.5	23.8	55	5	.47	1.30	.10
	1636605	9	6.1	6.7	5.6	2.5	5	1	15.7	30	5	21.1	50	5	.71	1.70	.20
	1636606	9	6.1	6.5	5.5	2.6	7	1	18.3	35	5	35.6	95	10	.58	1.20	.23
	1635607	9	6.1	6.6	5.6	1.4	4	0	17.9	35	5	50	180	5	.07	.11	.02
	1735608	9	6.0	6.6	5.6	1.4	3	Nil	14.5	30	5	28.8	105	5	.10	.22	.01
Johor 24	1739604	6	6.4	7.4	5.6	1.5	2	1	13.7	22	5	-	-	-	.09	.18	.03
	1738605	6	6.1	6.2	5.7	1.7	3	1	18	25	5	-	-	-	.08	.1	.03
	1737606	6	6.0	5.9	5.7	2	3	1	18.7	30	10	-	-	-	.11	.30	.01
	1835608	5	5.6	6.3	4.3	6.4	23	1	257	1440	12	-	-	-	1.65	7.8	.01
	1834609	6	5.1	6.2	3.9	4.2	14	Nil	30.8	80	10	-	-	-	.66	1.4	.19
	1834610	6	6.4	7.6	5.9	0.7	1	Nil	13.2	20	4	-	-	-	.04	.08	.01

Table 5. POLLUTANT LEVELS OF RIVERS IN 1979

Unit: mg/l except pH

River Name & Basin No.	WQMS No.	No. of Samples	pH			BOD_5			COD			Suspended Solids			Ammoniacal Nitrogen		
			Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min
Benut 23	1632601	9	4.8	5.9	3.8	0.7	2	Nil	107	390	30	108	290	25	.11	.21	.06
	1833602	9	6.2	6.8	5.6	0.9	1	Nil	28.3	50	5	40.6	85	5	.10	.18	.03
Sekudai 23	1536601	9	6.4	6.6	6.0	1.5	2.0	1.0	19	30	5	68	175	5	.18	.50	.07
	1536602	9	6.4	6.6	6.1	1.9	4.0	1.0	20	35	5	79	145	30	.23	.58	.04
	1636603	9	6.4	6.6	6.1	2.0	4	1	15	30	5	64	105	15	.26	.60	.05
	1636601	9	6.4	6.6	6.1	1.8	4.0	1.0	21	40	10	52	115	25	.57	1.90	.02
	1636605	9	6.4	6.6	6.1	3.6	17	0.9	20	45	5	51	90	10	.44	1.50	.10
	1636606	9	6.4	6.7	6.2	2.8	5.6	1.0	27	90	5	76	225	30	.49	1.80	.02
	1635607	9	6.5	6.7	6.2	1.2	2.0	Nil	14.4	30.0	5	46.7	750	15	.07	.19	.03
	1735608	9	6.3	6.8	5.9	1.2	4	Nil	16.7	30	5	29.4	110	5	.09	.22	.04
Johor 24	1739604	9	6.1	6.8	5.5	1.1	2.9	Nil	17.8	30	5	70.6	140	5	.07	.14	.01
	1738605	8	6.1	6.7	5.6	0.9	2	Nil	18.1	30	5	81.9	265	20	.04	.10	.01
	1737606	9	5.9	6.5	4.7	1.6	3.0	0.7	16.7	25.0	5	83.9	170	20	.05	.12	.02
	1835608	9	5.8	6.3	5.4	1.5	3	1	26.7	40	10	84.4	150	20	.36	.79	.01
	1834609	9	5.8	6.4	4.8	2.9	5	0.8	19.4	35	10	63.3	115	20	.20	.58	.01
	1834610	9	6.2	7.0	5.3	0.6	1.0	Nil	10	30	5	28.1	50	10	.04	.11	.01

Table 6. POLLUTANT LEVELS OF RIVERS IN 1980

Unit: mg/l except pH

River Name & Basin No.	WQMS No.	No. of Samples	pH Mean	pH Max	pH Min	BOD$_5$ Mean	BOD$_5$ Max	BOD$_5$ Min	COD Mean	COD Max	COD Min	Suspended Solids Mean	Suspended Solids Max	Suspended Solids Min	Ammoniacal Nitrogen Mean	Ammoniacal Nitrogen Max	Ammoniacal Nitrogen Min
Skudai (5)	1536601	12	6.6	6.8	5.6	1.1	3.4	0.2	16	25	5	35	90	10	0.17	0.26	0.07
	1536602	12	6.3	6.8	5.8	1.4	4.2	0.3	19	45	5	110	755	20	0.25	0.58	0.08
	1635607	12	6.3	6.9	5.7	1.0	2.7	0.2	17	35	5	34	60	20	0.07	0.17	0.01
	1636601	12	6.3	6.9	5.5	1.9	3.6	0.5	14	35	5	136	715	30	0.52	1.40	0.01
	1636603	12	6.4	6.9	5.9	2.3	4.4	0.8	21	55	5	81	290	15	0.35	1.10	0.04
	1636605	12	6.3	7.0	5.9	2.7	4.5	1.2	16	30	5	62	140	15	0.53	1.70	0.05
	1636606	12	6.3	7.0	5.8	2.0	4.1	0.7	19	30	5	46	140	20	0.42	1.10	0.05
	1735608	12	6.1	6.8	5.6	0.7	1.5	0.3	15	30	5	30	100	5	0.13	0.54	0.01
Johor (7)	1638611	11	5.2	6.9	4.4	1031	6200	3.4	2608	18000	15	326	1150	25	3.29	12.0	0.18
	1737604	11	6.1	6.5	5.6	0.9	1.7	Nil	20	65	5	29	130	5	0.12	0.26	0.05
	1737606	11	6.1	6.5	5.5	1.9	4.0	0.6	24	65	5	82	185	45	0.12	0.26	0.05
	1737607	11	6.4	6.8	5.5	0.4	0.9	Nil	19	55	5	33	70	10	0.08	0.14	0.02
	1738605	11	6.0	6.9	5.0	1.1	1.8	0.5	25	70	10	82	225	20	0.12	0.22	0.05
	1834608	11	5.7	6.7	4.4	2.8	10.0	0.8	26	50	5	168	530	50	1.82	6.60	0.19
	1834609	11	5.8	7.1	4.4	2.1	5.6	0.7	24	50	5	85	150	20	1.69	9.60	0.22
	1834610	11	6.2	7.0	5.4	0.7	1.6	Nil	14	50	5	32	75	10	0.06	0.14	0.02
Sedili Besar (8)	1839604	3	6.4	6.7	6.1	0.2	0.4	Nil	27	45	15	42	75	20	0.05	0.14	0.01
	1839605	3	6.6	6.6	6.5	0.3	0.5	Nil	25	55	5	98	140	60	0.07	0.19	0.01
Sedili Besar ( )	1941601	3	7.2	7.5	7.0	0.7	1.0	0.4	418	610	40	45	60	25	0.11	0.24	0.02
	2038608	3	6.7	6.8	6.5	0.4	0.6	0.5	18	40	5	30	55	10	0.05	0.07	0.02
	2038609	3	6.2	6.5	5.6	0.3	0.5	0.1	20	30	5	77	190	15	0.03	0.07	0.01
	2138610	3	6.3	6.5	5.9	0.4	0.5	0.3	22	25	15	20	30	5	0.06	0.12	0.01
	2138611	3	6.2	6.6	5.6	0.6	0.7	0.4	58	140	5	125	325	30	0.11	0.12	0.10

Table 7. POLLUTANT LEVELS OF RIVERS IN 1981

Unit: mg/l except pH

River Name & Basin No.	WQMS No.	No. of Samples	pH			BOD_5			COD			Suspended Solids			Ammoniacal Nitrogen		
			Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min
Benut (1)	1632601	1	-	-	-	1.4	-	-	415	-	-	110	-	-	0.17	-	-
	1833602	1	-	-	-	1.6	-	-	5	-	-	35	-	-	0.43	-	-
	1833603	1	-	-	-	1.6	-	-	5	-	-	35	-	-	0.11	-	-
	1832604	1	-	-	-	1.4	-	-	5	-	-	25	-	-	0.16	-	-
Pontian Besar (2)	1534604	3	6.0	7.5	4.8	0.9	1.4	0.3	600	1690	45	130	225	20	0.22	0.34	0.13
	1534605	2	6.6	7.0	6.1	0.1	0.1	ND	25	35	15	28	50	5	0.10	0.17	0.12
	1734614	3	6.8	7.2	6.5	0.6	0.7	0.3	8.3	10	5	38	60	25	0.09	0.14	0.01
Pontian Kechil (3)	1534603	3	6.3	7.4	5.2	0.6	0.7	0.5	17	30	5	62	145	5	0.04	0.05	0.01
Skudai (5)	1536601	1	6.2	-	-	0.8	-	-	5	-	-	25	-	-	0.12	-	-
	1536602	1	6.1	-	-	1.2	-	-	5	-	-	50	-	-	0.23	-	-
	1636601	3	6.4	6.5	6.4	2.4	3.7	1.0	9	15	2	75	125	30	1.91	2.90	0.43
	1636603	1	6.2	-	-	1.4	-	-	5	-	-	55	-	-	0.19	-	-
	1636605	1	6.3	-	-	2.2	-	-	30	-	-	55	-	-	0.48	-	-
	1636606	1	6.2	-	-	1.9	-	-	15	-	-	30	-	-	0.48	-	-
	1636607	1	6.2	-	-	0.5	-	-	15	-	-	60	-	-	0.05	-	-
	1735608	1	6.0	-	-	1.8	-	-	10	-	-	10	-	-	0.11	-	-
Tebrau (6)	1537609	3	6.7	6.9	6.5	2.1	4.3	0.5	157	395	5	27	45	10	0.49	1.0	0.23
	1537613	3	6.2	7.4	4.7	0.6	1.2	0.3	5	5	5	20	25	15	0.06	0.11	0.01
Johor (7)	1638611	7	6.7	7.4	6.3	298	2040	1.3	605	4060	5	493	3130	30	3.03	16.5	0.19
	1737604	6	6.4	7.0	6.0	1.0	2.2	0.6	12	15	5	48	55	25	0.11	0.18	0.05
	1737606	7	6.4	7.1	5.9	1.7	3.2	0.7	14	45	5	68	145	20	0.08	0.16	0.01
	1737607	7	6.7	7.5	6.0	0.8	3.1	Nil	8	20	3	26	65	10	0.08	0.29	0.01
	1834608	6	6.1	7.0	5.5	2.7	4.3	2.5	38	110	5	107	255	30	1.67	3.60	0.04
	1834609	7	6.0	7.2	5.2	2.8	4.4	1.7	31	100	5	73	230	25	2.48	6.20	0.36
	1834610	7	6.7	7.5	6.1	0.9	2.7	ND	9	30	5	18	25	5	0.08	0.29	0.01

Table 8 POLLUTANT LEVELS OF RIVERS IN 1982

Unit: mg/l except pH

River Name & Basin No.	WQMS No.	No. of Samples	pH			BOD_5			COD			Suspended Solids			Ammoniacal Nitrogen		
			Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min
Benut (1)	1632601	5	4.9	6.5	4.2	2.1	3.4	1.3	82	135	55	306	1100	20	0.37	1.10	0.04
	1833602	5	5.7	6.9	4.7	2.5	3.4	1.6	17	30	15	41	85	20	0.25	0.58	0.08
	1833603	5	5.5	6.9	4.7	1.8	2.6	1.2	15	25	5	51	65	30	0.19	0.22	0.06
	1832604	5	5.6	6.6	5.0	3.2	4.5	1.5	26	35	15	18	45	5	0.23	0.62	0.06
Pontian Besar (2)	1534604	2	4.7	5.8	3.5	1.8	2.3	1.2	55	60	50	95	145	45	0.36	0.43	0.29
	1534605	2	4.3	4.9	3.7	2.0	3.3	0.7	33	35	30	13	15	10	0.20	0.23	0.17
	1734614	2	5.4	6.2	4.6	2.2	2.8	1.5	18	20	15	30	50	10	0.12	0.12	0.11
Pontian Kechil (3)	1534603	2	4.8	6.1	3.6	0.8	1.5	ND	20	20	20	10	10	10	0.09	0.11	0.06
Skudai (5)	1536601	5	5.5	6.1	4.9	2.4	3.8	1.1	14	35	5	53	125	15	0.45	1.10	0.11
	1536602	5	5.7	6.2	5.2	2.4	4.5	0.2	10	20	5	29	50	15	0.63	1.40	0.13
	1636601	5	5.8	6.5	5.4	2.7	4.3	0.8	14	30	5	56	120	25	1.10	2.90	0.19
	1636603	5	5.8	6.5	5.4	3.0	4.7	1.6	18	35	5	40	80	5	0.88	2.40	0.14
	1636605	5	5.8	6.3	5.5	3.5	5.8	1.6	19	30	10	55	160	15	1.20	3.60	0.29
	1636606	5	5.7	6.2	5.2	3.0	4.8	1.1	16	30	5	36	80	15	0.69	1.60	0.23
	1636607	5	5.8	6.9	5.2	1.4	1.9	1.0	15	50	5	54	95	25	0.13	0.22	0.08
	1735608	5	5.5	6.3	4.9	1.8	2.9	0.4	7	10	5	23	45	5	0.14	0.19	0.10
Tebrau (6)	1537609	2	6.3	7.4	5.2	4.6	7.9	1.2	30	45	15	30	55	5	0.19	0.30	0.07
	1537613	2	5.0	5.4	4.6	9.8	18.0	1.6	10	15	5	13	20	5	0.06	0.08	0.05
	1636612	2	5.1	5.7	4.5	0.8	0.8	0.0	5	5	5	13	15	10	0.08	0.10	0.06
Johor (7)	1638611	5	6.1	7.4	4.6	81.0	312	1.9	232	455	95	889	2770	65	6.18	22.0	1.70
	1737604	5	5.6	6.4	5.1	1.4	2.0	0.8	13	15	10	27	45	5	0.11	0.17	0.06
	1737606	4	5.4	6.3	4.5	3.0	4.8	2.0	13	20	5	25	35	10	0.10	0.13	0.06
	1737607	5	5.8	6.5	5.3	1.1	2.3	ND	11	30	5	31	45	15	0.08	0.13	0.02
	1834608	4	5.2	6.2	4.2	2.5	4.4	0.9	19	30	5	34	55	5	0.69	1.20	0.24
	1834609	5	5.0	6.1	4.2	2.5	5.3	1.5	19	30	5	53	155	10	0.90	1.50	0.34
	1834610	5	4.9	5.6	4.4	1.3	2.8	0.8	9	15	5	49	85	20	0.07	0.18	0.04
Sedili Besar (8)	1839604	1	5.5	-	-	1.1	-	-	5	-	-	5	-	-	0.12	-	-
	1839605	1	5.3	-	-	1.2	-	-	15	-	-	30	-	-	0.60	-	-
	1840602	1	5.3	-	-	0.1	-	-	5	-	-	35	-	-	0.70	-	-
	2038608	1	5.2	-	-	1.2	-	-	10	-	-	25	-	-	0.10	-	-
	2138611	1	5.2	-	-	1.2	-	-	5	-	-	35	-	-	0.50	-	-

Table 9 POLLUTANT LEVELS OF RIVERS IN 1983

Unit: mg/l except pH

River Name & Basin No.	WQMS No.	No. of Samples	pH			BOD_5			COD			Suspended Solids			Ammoniacal Nitrogen		
			Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min
Benut (1)	1632601	8	4.9	6.2	3.1	2.0	3.1	1.4	80	110	40	209	765	35	0.25	0.43	0.12
	1833602	7	5.2	5.8	4.5	1.9	2.7	1.1	23	35	10	92	340	20	0.42	0.96	0.12
	1833603	8	5.5	5.7	5.3	1.1	1.9	0.2	13	25	5	58	175	10	0.22	0.36	0.06
	1832604	7	5.6	5.7	5.5	2.6	5.9	0.7	29	50	10	61	170	5	0.20	0.50	0.06
	1833605	8	5.8	6.5	4.8	2.8	4.5	1.6	22	50	5	43	90	5	0.38	0.84	0.05
Pontian Besar (2)	1534604	4	4.6	5.3	3.9	1.4	2.4	0.7	69	120	35	278	915	50	0.51	1.00	0.26
	1534605	4	4.1	5.2	3.4	0.5	0.7	0.3	57	70	40	36	85	5	0.28	0.41	0.14
	1734614	4	5.3	5.8	4.8	1.2	2.3	0.5	23	25	15	25	40	10	0.24	0.48	0.09
Pontian Kechil (3)	1534603	4	4.2	4.5	3.7	0.6	1.0	0.2	34	45	25	90	290	10	0.17	0.21	0.11
Skudai (5)	1536601	8	6.0	6.9	5.4	1.7	2.6	0.5	13	30	5	44	100	10	0.54	0.84	0.34
	1536602	8	5.9	6.2	5.2	2.3	3.1	1.6	22	85	5	82	270	15	0.61	1.10	0.18
	1636601	8	5.9	6.4	5.5	2.7	3.6	2.0	19	25	10	51	210	5	1.51	3.10	0.45
	1636603	8	5.9	6.4	4.8	2.9	3.9	1.1	21	55	10	56	95	25	0.95	1.70	0.21
	1636605	8	5.9	6.3	5.3	5.7	10.0	3.0	25	40	10	68	130	30	1.58	3.60	0.66
	1636606	8	6.0	6.3	5.5	4.5	9.4	2.4	26	40	5	78	110	30	1.04	2.10	0.41
	1636607	8	5.8	6.2	5.4	1.3	2.4	0.6	12	25	5	52	115	10	0.19	0.36	0.10
	1735608	8	5.8	6.5	5.2	2.0	3.8	0.9	16	25	5	53	120	15	0.23	0.47	0.13
Tebrau (6)	1537609	3	6.0	6.4	5.1	2.4	4.0	0.4	70	120	20	115	300	20	0.85	1.30	0.54
	1537613	4	5.5	5.8	4.6	0.9	1.6	0.5	9	15	5	43	100	10	0.11	0.15	0.05
	1636612	4	5.3	6.0	4.8	0.8	1.7	0.3	10	15	5	51	110	15	0.14	0.27	0.05
Johor (7)	1638601	8	5.4	5.8	4.9	3.8	9.6	1.0	19	30	10	111	315	10	0.34	0.50	0.16
	1637602	8	5.1	5.8	3.0	3.1	7.0	1.1	41	100	10	52	115	20	0.38	1.40	0.06
	1638611	9	5.7	6.6	4.7	6.0	19.0	0.9	72	405	10	53	150	15	0.92	3.60	0.06
	1640601	9	6.1	6.5	5.7	11.4	50	2.5	83	245	15	194	530	35	1.37	3.4	0.08
	1737604	9	5.6	6.0	4.9	1.1	2.1	0.4	17	30	10	18	35	5	0.09	0.22	0.02
	1737606	7	5.8	7.3	4.7	2.2	5.3	0.7	18	35	5	49	70	5	0.15	0.48	0.05
	1737607	5	5.5	6.2	5.2	1.0	1.3	0.6	16	20	10	29	65	5	0.06	0.11	0.04
	1834608	8	5.3	5.7	4.8	1.7	3.0	0.9	14	25	5	44	75	10	0.57	1.80	0.13
	1834609	8	5.4	5.8	4.9	2.3	7.6	0.3	18	35	5	52	115	10	0.73	1.80	0.15
	1834610	8	5.5	6.1	5.2	0.8	1.3	0.2	9	15	5	25	80	10	0.07	0.13	0.04
	1835611	8	5.6	6.0	5.1	4.0	6.5	1.6	23	45	5	64	150	15	0.35	1.30	0.06
	1836601	5	5.6	6.5	5.0	1.7	3.8	0.3	22	45	5	77	100	55	0.30	1.00	0.04
	1836602	5	5.0	5.8	3.6	1.1	1.4	0.7	13	30	5	30	35	25	0.23	0.48	0.07
	1836603	5	5.6	6.0	5.0	0.6	1.0	0.2	8	10	5	14	30	5	0.07	0.11	0.04
	1837604	5	5.5	6.0	5.0	1.4	3.2	0.5	20	30	5	85	165	25	0.16	0.48	0.02
Sedili Besar (8)	1839604	3	4.2	5.0	3.4	0.37	0.9	<0.1	8	10	5	15	25	5	0.09	0.11	0.05
	1839605	3	5.2	5.4	5.0	0.5	0.9	0.1	15	25	5	15	20	10	0.14	0.21	0.08
	1840602	3	3.3	3.5	3.0	0.4	0.9	0.1	13	20	10	15	15	15	0.16	0.26	0.09
	2039606	3	5.1	5.1	5.1	0.7	1.3	0.3	20	30	5	53	60	45	0.15	0.24	0.07
	2038608	3	5.2	5.2	5.1	0.7	1.3	0.4	15	20	10	25	30	20	0.19	0.32	0.11
	2138611	2	4.4	4.4	4.4	0.7	1.0	0.4	8	10	5	5	5	5	0.08	0.11	0.05

Table 10. CLASSIFICATION OF WQMS ACCORDING TO BOD_5 CLASSIFICATION USING MEAN BOD_5

River Name	WQCR No.	1978 No. of WQMS	Cl	Mip	Mop	Gp	1979 No. of WQMS	Cl	Mip	Mop	Gp
Benut	1	3	3	0	0	0	2	2	0	0	0
Pontian Besar	2	-	-	-	-	-	-	-	-	-	-
Pontian Kechil	3	-	-	-	-	-	-	-	-	-	-
Skudai	5	8	8	0	0	0	8	8	0	0	0
Tebrau	6	-	-	-	-	-	-	-	-	-	-
Johor	7	6	4	2	0	0	6	6	0	0	0
Sedili Besar	8	-	-	-	-	-	-	-	-	-	-

River Name	WQCR No.	1980 No. of WQMS	Cl	Mip	Mop	Gp	1981 No. of WQMS	Cl	Mip	Mop	Gp
Benut	1	-	-	-	-	-	4	4	0	0	0
Pontian Besar	2	-	-	-	-	-	3	3	0	0	0
Pontian Kechil	3	-	-	-	-	-	1	1	0	0	0
Skudai	5	8	8	0	0	0	8	8	0	0	0
Tebrau	6	-	-	-	-	-	2	2	0	0	0
Johor	7	8	7	0	0	1	7	6	0	0	1
Sedili Besar	8	7	7	0	0	0	-	-	-	-	-

River Name	WQCR No.	1982 No. of WQMS	Cl	Mip	Mop	Gp	1983 No. of WQMS	Cl	Mip	Mop	Gp
Benut	1	4	4	0	0	0	5	5	0	0	0
Pontian Besar	2	3	3	0	0	0	3	3	0	0	0
Pontian Kechil	3	1	1	0	0	0	1	1	0	0	0
Skudai	5	8	8	0	0	0	8	6	2	0	0
Tebrau	6	3	1	1	1	0	3	3	0	0	0
Johor	7	7	6	0	0	1	15	12	2	1	0
Sedili Besar	8	5	5	0	0	0	6	6	0	0	0

Remarks

Cl :	Clean	0 - 4 mg/l
Mip:	Mildly polluted	4 - 8 mg/l
Mop:	Moderately polluted	8 - 12 mg/l
Gp :	Grossly polluted	> 12 mg/l

Table 11. CLASSIFICATION OF WQMS ACCORDING TO SS
CLASSIFICATION USING MEAN SS

River Name	WQCR No.	1978 No. of WQMS	1978 0-50 mg/l	1978 50-100 mg/l	1978 100-150 mg/l	1978 >150 mg/l	1979 No. of WQMS	1979 0-50 mg/l	1979 50-100 mg/l	1979 100-150 mg/l	1979 >150 mg/l
Benut	1	3	1	1	1	0	2	1	0	1	0
Pontian Besar	2	-	-	-	-	-	-	-	-	-	-
Pontian Kechil	3	-	-	-	-	-	-	-	-	-	-
Sukudai	5	8	6	2	0	0	8	2	6	0	0
Tebrau	6	-	-	-	-	-	-	-	-	-	-
Johor	7	-	-	-	-	-	6	1	5	0	0
Sedili Besar	8	-	-	-	-	-	-	-	-	-	-

River Name	WQCR No.	1980 No. of WQMS	1980 0-50 mg/l	1980 50-100 mg/l	1980 100-150 mg/l	1980 >150 mg/l	1981 No. of WQMS	1981 0-50 mg/l	1981 50-100 mg/l	1981 100-150 mg/l	1981 >150 mg/l
Benut	1	-	-	-	-	-	4	3	0	1	0
Pontian Besar	2	-	-	-	-	-	3	2	0	1	0
Pontian Kechil	3	-	-	-	-	-	1	0	1	0	0
Sukudai	5	8	4	2	2	0	8	3	5	0	0
Tebrau	6	-	-	-	-	-	2	2	0	0	0
Johor	7	8	3	3	0	2	7	3	2	1	1
Sedili Besar	8	7	4	2	1	0	-	-	-	-	-

River Name	WQCR No.	1982 No. of WQMS	1982 0-50 mg/l	1982 50-100 mg/l	1982 100-150 mg/l	1982 >150 mg/l	1983 No. of WQMS	1983 0-50 mg/l	1983 50-100 mg/l	1983 100-150 mg/l	1983 >150 mg/l
Benut	1	4	2	1	0	1	5	1	3	0	1
Pontian Besar	2	3	2	1	0	0	3	2	0	0	1
Pontian Kechil	3	1	1	0	0	0	1	0	1	0	0
Sukudai	5	8	4	4	0	0	8	1	7	0	0
Tebrau	6	3	3	0	0	0	3	1	1	1	0
Johor	7	7	5	1	0	1	15	7	6	1	1
Sedili Besar	8	5	5	0	0	0	6	5	1	0	0