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WATER RESOURCES FOR IRRIGATION OF UPLAND CROPS IN SOUTH KELANTAN

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JABATAN PENGAIRAN DAN SALIRAN
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BAHAGIAN PARIT DAN TALIAIR

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SUMMARY

An area totalling about 5500 hectares within the Sg. Rasau – Sg. Yong catchments in South Kelantan has been identified for possible future irrigation development of upland crops.

Water deficits for the area, under upland cropping, were computed from rainfall data using a water balance technique. Expected deficits for 1:5 and 1:10 year recurrence intervals were balanced against corresponding 1:5 and 1:10 year low flow resources available for irrigation. The 1:10 year low flow water resources comprises both surface (9.3 m^3/sec) and groundwater (0.5 m^3/sec) resources. However the low flow of the Sg. Besut (7.6 m^3/sec) has been previously committed, and the low flow of the Sg. Semerak (0.8 m^3/sec) is considered marginal for use because of possible upstream saline migration. The remaining 1.4 m^3/sec is insufficient to meet a 1:5 year water deficit for 5500 hectares of upland crops. Irrigation from low flow resources (0.51 m^3/sec) within the Sg. Rasau could, with careful management, satisfy a 1:5 year water deficit on 1320 hectares of irrigable land within the catchment. To meet a 1:10 year irrigation demand for the 4190 hectares in the Sg. Yong would require an additional 1.21 m^3/sec. Such additional resources could only come from the Sg. Besut.

1. INTRODUCTION

The World Bank Mission has identified an area including approximately 5500 hectares (13,600 acres) of padi land in the Sg. Rasau – Sg. Yong catchments near Pasir Puteh in Kelantan State for possible intensive irrigation development for dry season upland crops.

A water resources study of the area has been completed and the results are presented in this report.

2. DESCRIPTION OF THE PROBLEM

Typical for the whole Kelantan State, the climate for the Sg. Rasau – Sg. Yong district, south of Pasir Puteh, (Fig. 1) is dominated by the north-east monsoon occurring during November to January. The dry season extends from February to June. Rainfall during this period is extremely variable and it is not uncommon to receive little or no rainfall for periods of up to one month.

Rice is transplanted in October, maturing throughout the monsoon season to be harvested in March. Tobacco farming dominates the dry season agriculture with some small areas of maize, groundnuts and water-melons. However the lack of processing facilities compounded by the lack of rainfall and irrigation water in this area limits dry season agriculture to less than 15% of the total padi acreage. Streamflows from the Sg. Yong and Sg. Rasau catchments are available for irrigation and, although insufficient to support a scheme for double crop padi, they could possibly be utilised to increase upland crop production.

3. UPLAND CROPPING PRACTICE

3.1 Tobacco

The growing cycle for tobacco is about 5 months. Seedlings are transplanted into 'keraks' (small coconut fibre or polythene containers) after 3 to 4 weeks, and the 'keraks' transplanted into the field after 7 to 9 weeks from germination at a density of 15,000 to 17,000 plants/ha. (6000 to 7000 plants/acre). Tobacco begins to mature at about 3 months and leaf is picked at 4 to 5 day intervals until about 5 months.

The crop needs ample moisture during the first 3½ months of the growing cycle, but rains occurring at time of harvesting may seriously lower the quality of leaf. Typical of most upland crop varieties, the roots are sensitive to waterlogging and soil aeration is essential.

In Kelantan the tobacco season extends from March to September with peak harvesting in July and August. Green leaf is sold direct to the tobacco companies for curing and processing. Crop yields (Dixon 1971) are variable but average about 930 kg dry leaf/ha (830 lbs/acre). Because of a more intensive labour requirement in comparison to padi, the average farmer limits his area in tobacco to 1000 to 4000 plants about 8 to 20% of the average padi holding. The current practice is to rotate the tobacco crop biennially with fallow land.

3.2 Maize

Seed is sown direct onto the field and begins to mature after about 3½ months; the complete growing cycle totalling 5 months. Maize requires a free draining soil and because of its high nutrient demand, heavy fertiliser (1 tonne/ha) application is necessary. Optimum soil moisture status is critical for this crop just prior to flowering, and a serious water shortage at this time can reduce final yields by up to 50%, compared with a 25% reduction due to moisture stress at earlier or later stages of growth. The labour content required for producing maize is comparatively low.

Because of low yields resulting mainly from lack of water, very little maize is grown at present. Increased production brought about by irrigation could be limited without the introduction of processing plant facilities.

3.3 Groundnuts

Groundnuts can be grown throughout the dry season. Seeds, after treatment, are sown direct into the field and germinate in about 2 weeks. The crop matures after about 4 months and is harvested manually. Regular rainfall is required during the period of vegetative growth, but is harmful while the pods are developing and ripening.

Labour content is quite intensive with regular weeding and moulding required during the growing season to achieve maximum yield. Irrespective of high fertiliser and labour costs, this crop remains economically attractive to the grower. However the lack of an oil processing plant limits production at present.

3.4 Sorghum

Recent tests have demonstrated the agricultural feasibility of this crop for the area. Sorghum has a 4 to 5 month growing cycle and grows well in a variety of soils. Sorghum has the ability to withstand drought conditions, is moderately salt tolerant, and will grow in areas not suitable for maize. Sorghum culture is similar to that required for maize, with the crop requiring optimum soil moisture up to the time of flowering.

The lack of suitable syrup processing facilities limits the introduction of this crop at present.

8,5 Water-melon

Because of distance from major markets, water-melons are grown primarily for local consumption. The crop has very little labour content; seedlings being transplanted to the field after about 3 to 4 weeks and the crop maturing at about 3½ months. Crop yield is very sensitive to soil moisture stress, especially after flowering. Water-melons mature quickly and there is a need to schedule planting to ensure even market distribution throughout the season.

3.6 Soya beans

Soya beans have a growing season of 4 to 5 months and has similar water requirements to other upland crops. In general, most varieties grow best in a humid climate with plenty of rain during the growing season and drier weather throughout the ripening and harvesting season. Soil requirements for soya beans are similar to those of maize. No production trials have yet been conducted to test the suitability of this crop for the area.

4. SOIL MOISTURE STORAGE

4.1 Soils

Soils in the Sg. Rasau – Sg. Yong area are predominantly clays. Some sandy clay loams of granite wash origin in the Sg. Rasau catchment are especially suited to growing tobacco, maize and groundnuts while the heavier clays of the upper Sg. Yong are probably better suited to growing sorghum.

4.2 Water Holding Capacity

Water holding capacity is the difference in moisture content of a soil between field capacity and permanent wilting point, normally expressed in mm depth of water per 100 mm depth of soil profile. Considerable soil moisture is present below the permanent wilting point, but is bonded so tightly by the soil particles that plant roots cannot absorb the water rapidly enough to prevent wilting.

For soils of fine texture; clays and clay loams, the gravitational water is removed slowly by drainage and the field capacity and permanent wilting point are relatively high. These soils usually have a high water holding capacity.

For a particular soil, the permanent wilting point is related to the crop type and for upland crops in clay soils is about 14% soil moisture. Table 1 lists the mean available water holding capacity of soils for selected textural classes.

Table 1 : Water holding capacity of soils

Textural Class	Water holding capacity (mm/100 mm)	
	Above 0.3 m soil depth	Below 0.3 m soil depth
Sand	15	5
Loamy Sand	18	11
Sandy Loam	23	15
Fine loamy sand	21	15
Silt loam	22	15
Clay loam	18	11
Clay	17	11

The utilisation of available soil moisture is determined by the rooting habits of the different plant species, the deeper the rooting system the more water available for plant extraction. Table 2 lists the effective rooting depths for mature upland crops. No data for groundnuts could be established, but because rooting depth is governed largely by the length of growing cycle, the depth for groundnuts is assumed similar to other upland crops.

Table 2 : Effective rooting depths of upland crops

Effective root depth (m)	Crop Type
0.6 – 1.2	Tobacco Maize Sorghum
0.6 - 0.9	Water-melons Soya bean Groundnuts

Assuming an average rooting depth of 0.9 m for all upland crops, then the available water holding capacity for the sandy clay loams of the Sg. Rasau is calculated to be 145 mm and for the clays in the Sg. Yong, 120 mm.

5. RAINFALL RESOURCES

5.1 Mean Monthly Rainfall

Rainfall is recorded daily at Pasir Puteh, Cherang Tuli, Telosan, Jerteh, Kampong Raja and Kampong Cherang Ruku. Table 3 summarises the mean monthly rainfall and standard deviation and the data are plotted in Fig. 2.

Table 3 : Summary of mean monthly rainfall

Station and period of record		Rainfall for month (mm)												Yearly Total
		Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	
Pasir Puteh (1956 – 74)	$\bar{x}$	174	213	261	276	528	593	197	75	84	81	113	125	2720
	s	64	99	115	96	331	330	290	82	90	65	62	47	–
Cherang Tuli (1947 – 74)	$\bar{x}$	204	231	325	322	559	675	296	146	129	100	155	183	3325
	s	84	95	118	116	229	338	257	135	112	77	91	92	–
Telosan 1956 – 74)	$\bar{x}$	179	230	290	327	471	668	285	100	110	92	176	172	3100
	s	60	90	76	139	215	328	298	67	89	57	80	94	–
Jerteh (1946 – 74)	$\bar{x}$	170	227	305	281	542	685	266	129	128	81	144	156	3114
	s	65	64	87	113	259	368	182	119	112	60	71	79	–
Kg. Cherang Ruku (1939 – 74)	$\bar{x}$	102	158	209	268	457	579	200	104	135	73	95	116	2496
	s	61	93	91	109	197	288	324	118	147	66	77	70	–
Kg. Raja (1940 – 74)	$\bar{x}$	132	193	218	292	591	568	231	110	129	74	113	147	2798
	s	63	59	78	132	312	289	157	107	142	60	63	81	–

$\bar{x}$ = mean
s = standard deviation

5.2 Minimum Rainfall for Number of Consecutive Days

Table 4 summarises the recurrence probability of minimum rainfall for a number of consecutive days. For these drought analyses, a rainfall year extended from 1 Jan. to 31 Dec. was used. Daily rainfall totals for 30, 90 and 180 consecutive days were summed successively commencing 1 Jan., 2 Jan., 3 Jan., etc. For each rainfall year the minimum total rainfall for each consecutive day class (i.e. 30, 90 and 180) was extracted. A Gumbel type III extreme value distribution was fitted using a least squares approach to determine the minimum rainfall for each consecutive day class corresponding to return period of 1:2.33, 5, 10 and 50 years (Fig. 3). Results for four rainfall stations: Jerteh, Pasir Puteh, Cherang Tuli and Telosan are presented in Table 4.

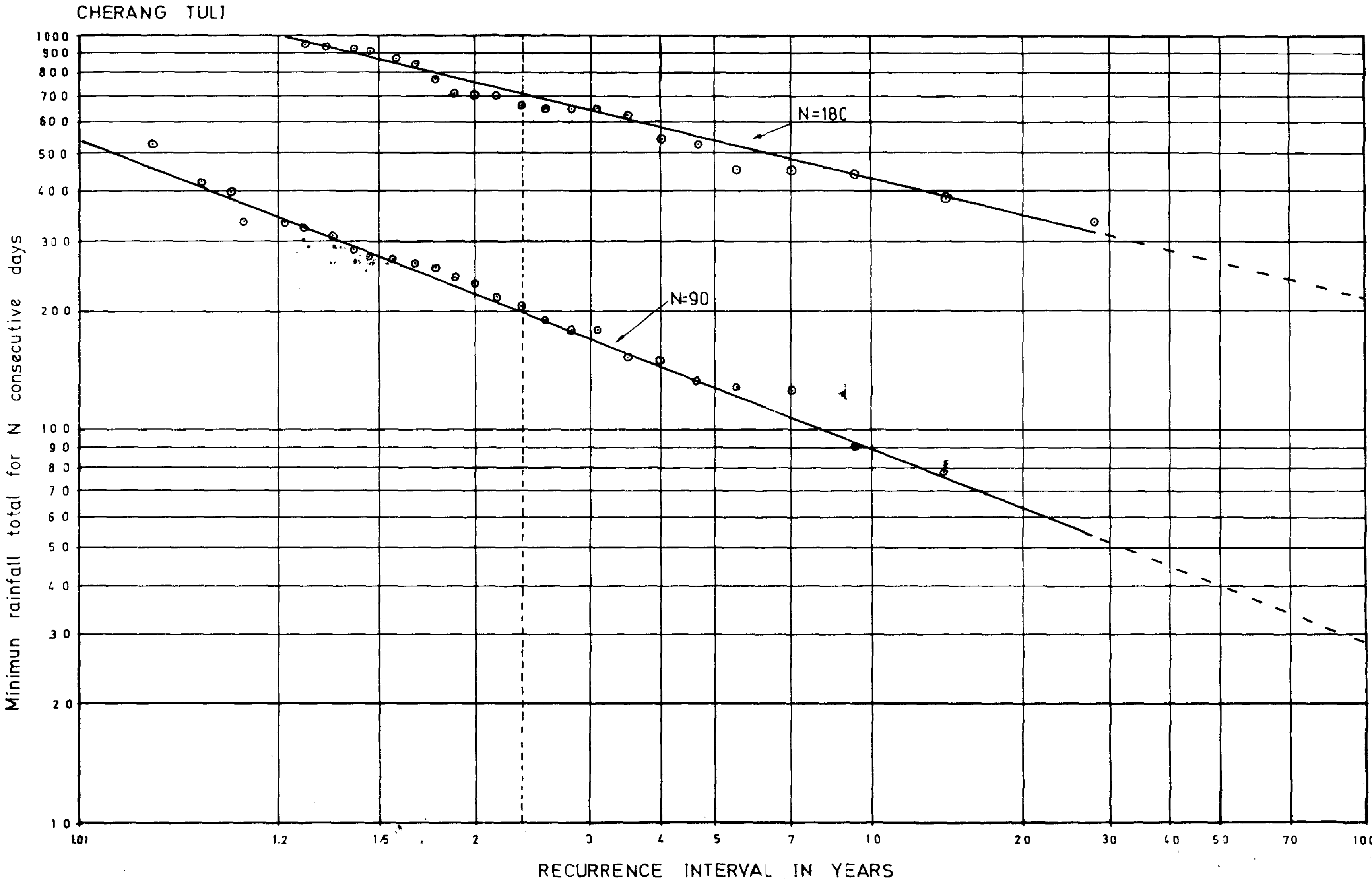


Fig 3: Cherang Tuli : minimun total rainfall for N consecutive days

Table 4 : Recurrence probability of minimum rainfall for 30, 90 and 180 consecutive days

Station	Years of records	Probability 1:T years	Minimum rainfall total (mm) for N Consecutive days		
			N = 30	N = 90	N = 180
Jerteh	26	1:50	0	52	280
		1:10	0	100	420
		1:5	0	130	500
		1:2.33	7	190	640
Pasir Puteh	17	1:50	0	11	120
		1:10	0	37	230
		1:5	0	64	320
		1:2.33	0	125	460
Cherang Tuli	27	1:50	0	40	270
		1:10	0	90	430
		1:5	0	130	550
		1:2.33	1	210	720
Telosan	17	1:50	0	40	260
		1:10	0	90	440
		1:5	0	130	560
		1:2.33	8	210	730

A marked similarity exists between Jerteh, Cherang Tuli, and Telosan frequency data indicating a similar rainfall pattern. Pasir Puteh experiences more prolonged periods of drought for reasons not immediately apparent.

The worst drought on record occurred during January to April 1968 when no rainfall was recorded at Cherang Tuli over a 96 day period. For the same period Jerteh and Pasir Puteh recorded totals of 11 and 9 mm respectively. From Fig. 3, a 1:100 year minimum total rainfall for 90 consecutive days is about 30 mm for Cherang Tuli and thus it is apparent that the 1968 drought was an extremely rare event and possibly the most prolonged drought ever experienced in this district.

Another notable drought occurred the following year from February to May when only 18 mm was recorded at Jerteh over a 90 day period. This drought tended to be limited to the Sg. Besut region; the gauges in the Pasir Puteh area recording more than 70 mm for the same period.

6. WATER DEFICIT

6.1 Consumptive water use of upland crops

Actual crop evapotranspiration depends primarily on prevailing climate conditions and soil moisture availability, and to a lesser extent, on crop density and soil nutrient status. The ratio of bare soil to plant cover can be extremely variable, not only between plant species but from crop to crop of the same species. Additionally, evaporation from bare soil varies with soil type, the location of the groundwater table relative to surface level and the degree of cultivation of the soil.

A number of authors (Isrealson 1945, Ven Te Chow 1964, Penman 1963) have reviewed experimental results for consumptive use by various crops. Results tend to be rather variable and are lacking for crops grown under tropical climate conditions. The translation of results from one climate situation to another can, at best, only provide an approximation. Such a seasonal estimate, using the Penman procedure is given in Table 5 and is based on monthly average climate data shown in Table 6.

Table 5 : Approximate seasonal consumptive use of upland crops for Kelantan based on Penman Procedure.

Crop	Length and period of growing season	Approx. seasonal consumptive Use (mm total)
Tobacco	5 months (April–Aug.)	640
Maize	5 months (April–Aug.)	700
Sorghum	5 months (April–Aug.)	680
Groundnuts	4 months (April–July)	480
Water-melon	4 months (April–July)	530
Soya Bean	5 months (April–Aug.)	650
Rice	5 months (Nov.–Mar.)	660*
Rice	5 months (May–Sept.)	790*

*Consumptive use estimate does not include infiltration losses. Rates of infiltration are closely related to the development of the impervious plough sole, and infiltration loss rates in excess of 15 mm/day (2200 mm for season) are not uncommon.

Mean monthly potential evapotranspiration (Table 6) for mature upland crops were calculated using the Penman procedure and assuming an albedo of 0.18 for all months. This albedo is considered to be a minimum for mature upland crops and thus the calculated evapotranspiration rates are maximised for each month.

Table 6: : Mean monthly climate and potential evapotranspiration (PE) data for Kota Bharu (1964 – 74)

	Month												Year
	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	
Air Temperature °C	27.2	26.8	26.8	26.6	25.9	25.6	25.6	26.2	26.8	27.8	27.9	27.4	26.7
Rel. Humidity %	81.0	81.9	82.5	84.2	86.9	85.4	81.1	80.0	79.4	79.8	80.3	80.8	81.9
Sunshine hrs/day	6.8	7.1	6.8	5.9	4.6	4.3	7.1	8.1	8.4	9.0	7.7	7.0	6.9
Wind velocity m/sec (at 15m height)	1.5	1.6	1.6	1.6	1.7	2.7	2.7	2.6	2.2	2.1	1.7	1.6	2.0
Monthly P.E. mm for upland crops	138	141	141	129	109	109	133	154	163	168	151	139	1676

6.2 Water balance model

The water balance model used to evaluate soil water deficits is based on the Thornthwaite (1955) procedure and is described by Teh (1975).

The model uses daily rainfall data and after subtraction of a daily evaporation component and balancing the soil moisture store, sums the daily water deficits to obtain a monthly total. Critical parameters in the model are daily potential evapotranspiration and available water holding capacity for the particular soil/crop combination.

For this problem a water holding capacity of 150 mm was adopted and daily potential evapotranspiration was assumed equal to the monthly total (Table 6) divided by the number of days in the month.

6.3 Water Deficit

Total monthly water deficits were calculated for the period of rainfall records observed at Pasir Puteh, Jerteh, Cherang Tuli and Telosan. Assuming a normal distribution a water deficit probability table was prepared and is summarised in Table 7.

Results for the upland crop season, March to September, are shown plotted in Fig. 2. For all stations maximum water deficit occurs during March and April. In theory the water deficit for any month cannot exceed the total monthly potential evapotranspiration given in Table 6. The Pasir Puteh plot shows 1% (1:100 yrs) probability values for March and April exceeding 163 and 168 mm respectively. This apparent error is related to the relatively short period of record (17 years).

Table 7 : Water deficit probability table for Pasir Puteh, Jerteh, Cherang Tuli and Telosan rainfall stations

Pasir Puteh (17 years of rainfall data)

Probability	Monthly water deficit (mm) for											
	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
1 : 2 yr	30	15	9	10	4	5	22	59	89	94	68	44
1 : 5 yr	48	23	16	18	9	9	38	84	118	124	95	66
1 : 10 yr	57	28	20	23	11	12	47	97	134	139	109	77

Jerteh (26 years of rainfall data)

Probability	Monthly water deficit (mm) for											
	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
1 : 2 yr	22	12	9	9	4	4	13	42	65	87	54	30
1 : 5 yr	35	18	15	14	7	6	21	64	93	108	78	45
1 : 10 yr	42	22	17	17	8	8	25	75	107	120	90	53

Cherang Tuli (26 years of rainfall data)

Probability	Monthly water deficit (mm) for											
	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
1 : 2 yr	21	13	9	9	4	4	16	46	64	77	48	30
1 : 5 yr	31	21	16	22	8	8	27	68	92	101	71	46
1 : 10 yr	37	25	19	29	10	10	33	80	106	114	83	55

Telosan (17 years of rainfall data)

Probability	Monthly water deficit (mm) for											
	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
1 : 2 yr	17	11	8	6	3	3	16	45	65	75	44	22
1 : 5 yr	25	19	17	10	6	6	26	65	89	100	70	36
1 : 10 yr	29	23	22	12	7	8	31	76	102	114	84	43

7. SURFACE WATER RESOURCES

7.1 Sungei Besut

Sungei Besut, with a catchment area of 790 km^2 (304 sq. miles) at Jerteh, is the major surface water resource in the district. Except for a period from April 1952 to September 1954, flow records are more or less continuous from April 1946 until June 1970 when observation ceased. A summary of monthly runoff totals is presented in Appendix I. Minimum monthly runoff for each year occurs in general, during June, July or August, whilst runoffs for the months of February and March display the greatest variability.

Dividing the water year into two seasons; a wet season from November to January and a dry season from February to October, mean flow duration curves (Fig. 4) were prepared from daily runoff data.

To analyse further the low flow characteristics of the Sungei Besut the minimum average discharge for 7, 15 and 30 consecutive days were extracted for each calender year. The calendar year was used in preference to water year to provide continuity for drought periods extending beyond 30 June annually. Results are shown in Table 8. The lowest minimum average discharge for all consecutive day classes occurred during the 1969 drought.

A Gumbel type III extreme value distribution was fitted using a least squares technique. This type of distribution has been widely used in previous studies and has proved a satisfactory model for analysing low flow sequences (Matalas 1963, Joseph 1970). Due to the abnormally severe droughts in 1968 and 1969, the corresponding low flow data whilst ranked according to the standard procedure was not included in calculating the line of best fit. Fig. 5 shows a plot of the data for 30 consecutive days, together with lines of best fit for all three classes.

Table 8 : Sg. Besut : Minimum average discharge (m^3/sec) at Jerteh for a number of consecutive days

Year	Minimum average discharge (m^3/sec) for N consecutive days					
	N = 7 days		N = 15 days		N = 30 days	
	q	Date (1)	q	Date	q	Date
1946	13.4	25/7	14.4	17/7	16.6	2/7
1947	12.8	1/9	14.1	27/7	15.5	12/7
1948	13.0	26/6	13.7	23/6	14.6	21/6
1949	10.9	5/7	11.4	27/6	12.0	12/6
1950	12.3	31/7	12.5	25/7	13.4	20/7
1955	13.3	27/7	14.4	17/9	16.5	7/7
1956	7.2	19/8	8.1	11/8	9.5	28/7
1957	11.2	16/8	12.9	13/8	13.7	30/7
1958	9.3	25/7	9.5	20/7	10.2	6/7
1959	8.1	17/4	8.9	13/4	9.9	10/4
1960	9.6	14/10	9.9	8/10	10.6	21/6
1961	7.2	5/8	7.6	29/6	8.3	25/6
1962	12.7	23/4	13.4	27/5	14.9	19/4
1963	11.6	20/6	12.3	14/6	13.2	16/6
1964	14.1	30/6	14.7	1/7	15.6	16/6
1965	8.0	21/7	9.2	21/7	10.7	10/7
1966	13.5	4/9	17.0	31/8	18.3	12/8
1967	10.9	10/6	11.5	2/6	11.9	1/6
1968	5.3	3/4	5.6	5/4	6.3	1/4
1969	4.4	5/5	4.6	3/5	5.2	3/5

(1) Date = commencement date of consecutive day period.

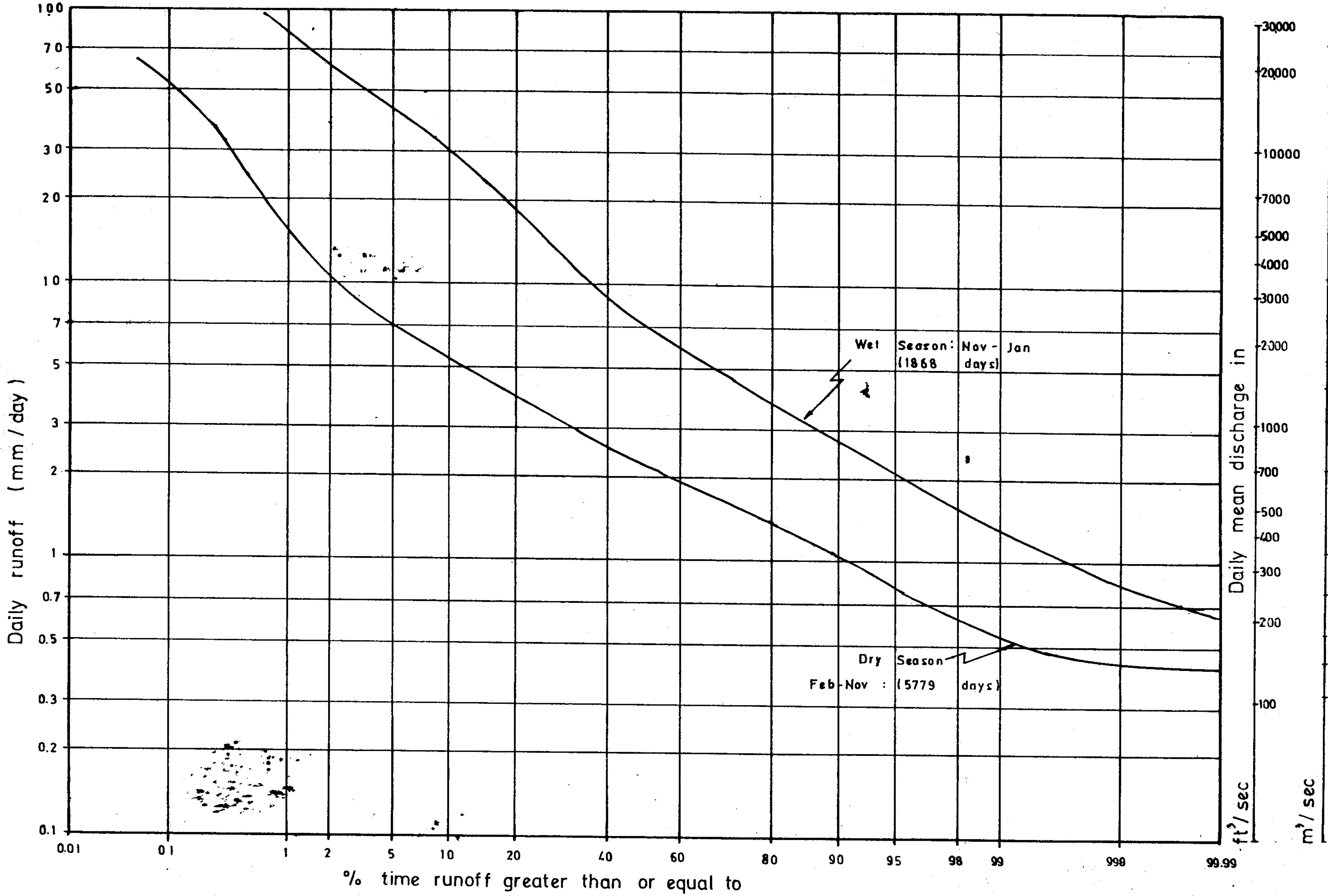


Fig 4: Average flow duration curves for Sg. Besut

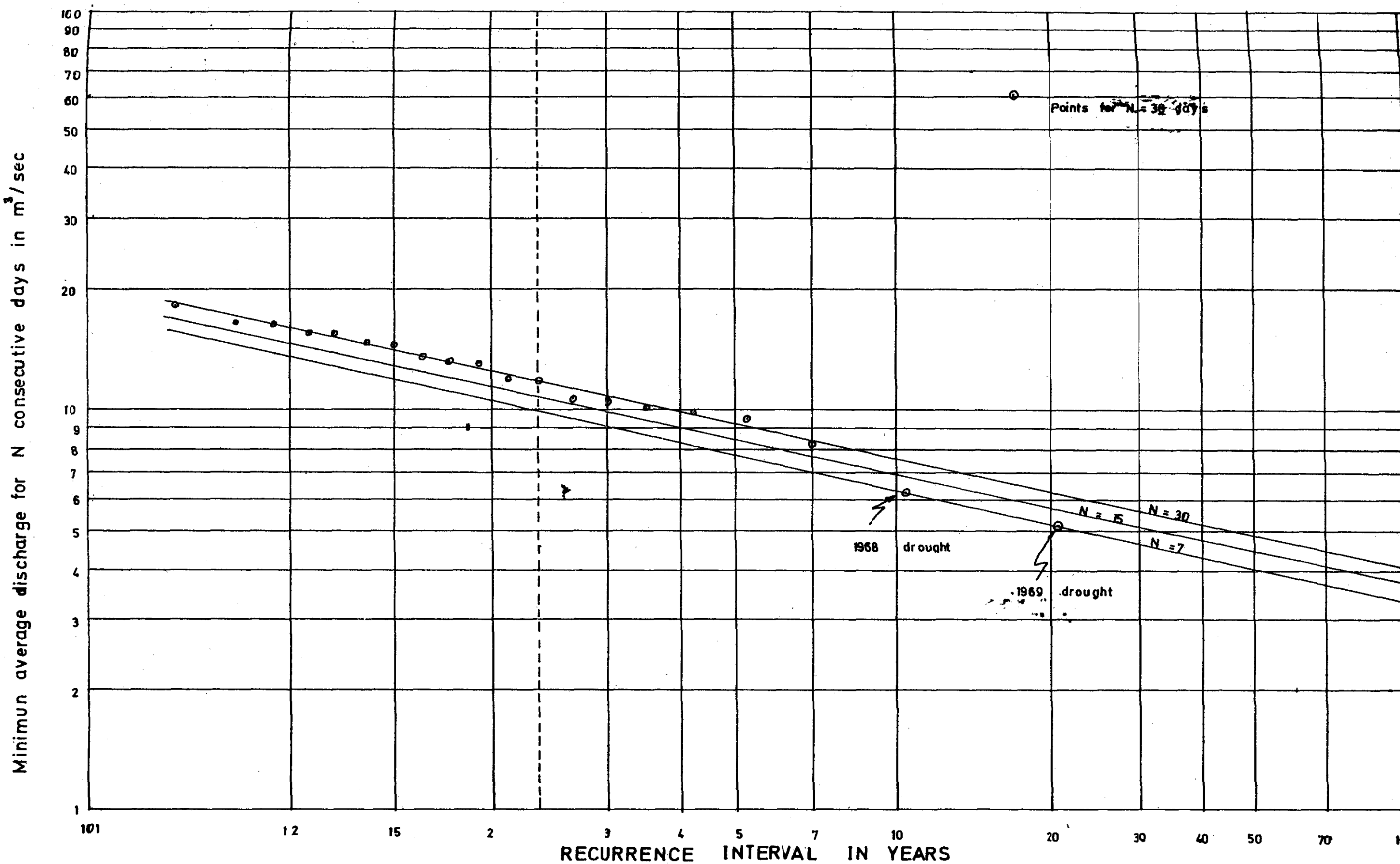


Fig.5 Sg. Besut: Average minimun discharge for number of consecutive days

Table 9 lists the minimum average discharge for 7, 15 and 30 consecutive days for specific recurrence intervals.

Table 9 : Sg. Besut : Minimum average discharge at Jerteh for N consecutive days for specific recurrence intervals

Recurrence intervals 1 : T years	N = 7		N = 15		N = 30	
	q	q_s	q	q_s	q	q_s
1 : 2.33	9.9	12.5	10.9	13.8	11.9	15.1
1 : 5	7.8	9.9	8.5	10.8	9.2	11.6
1 : 10	6.4	8.1	7.0	8.9	7.6	9.6
1 : 50	4.1	5.2	4.5	5.7	4.9	6.2
1 : 100	3.4	4.3	3.7	4.7	4.1	5.2

q = average discharge in $m^3/sec.$
q_s = specific discharge in lit. $sec.^{-1}$ km^{-2}
To convert lit. $sec.^{-1}$ km^{-2} to $cusecs/mile^2$ multiply by 0.0915.

7.1.1. Sungei Pelagat

The Sungei Pelagat controls a catchment area of 57 km^2 (22 sq. miles) and joins the Sg. Besut about 1.6 km upstream from Jerteh.

Whilst some stick gauge water level records exist for a site at Kg. Rawang Panjang, sediment deposition during flood events is responsible for a variable stage discharge relationship. To obtain some estimate of the water resources from this catchment, the specific discharge derived for the Sg. Besut was assumed valid for the Sg. Pelagat. Estimated average monthly discharge and low flows for specific return periods are shown in Tables 10 and 11 respectively.

7.2 Sungei Yong

Above Kg. Bukit Yong this river drains a catchment area of 27.7 km^2 (10.7 sq. miles). The catchment is steep ranging from 15 to 660 m (50 to 2,170 ft.) and drains from granite formations having a dense forest cover.

Flow records at Kg. Bukit Yong date from April 1970 until January 1975 when the recorder and stick gauge were destroyed during the monsoon floods. Appendix 2 summarises monthly runoff data.

Table 10 : Average monthly surface water resources for Pasir Puteh – Besut region

River	Tributary	Site	Area (km^2)	Average monthly discharge in m^3/sec													Remarks
				Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Annual	
Besut		Jerteh (1)	790	15.4	17.5	27.0	33.9	68.8	166.5	111.8	52.3	39.3	21.6	19.9	17.3	49.4	(1) Average monthly discharge from flow records. (2) Excludes flow from Sg. Angga. (3) Average monthly discharge includes losses to ground water; 0.1 to 0.2 m^3/sec. (4) Estimated from P-E (rainfall-evapotranspiration) and adjacent Sg. Kemasin flow records (9 yrs) Accuracy probably not better than ± 20%.
	Angga	Headworks	77	1.49	1.70	2.62	3.29	6.67	16.2	10.8	5.07	3.81	2.10	1.93	1.68	4.79	
	Besut	Rantau Panjang (2)	640	12.5	14.2	21.9	27.5	55.7	135.0	90.5	42.3	31.8	17.4	16.1	14.0	40.0	
	Pelagat	Rawang Panjang	57	1.11	1.26	1.94	2.44	4.95	12.0	8.05	3.77	2.83	1.56	1.43	1.25	3.56	
Yong		Pulau Lima (3)	54	1.04	1.54	1.85	2.00	3.66	8.90	4.01	1.99	1.97	1.23	1.29	1.21	2.57	
	Yong	Bt. Yong (1)	28	0.54	0.80	0.96	1.04	1.90	4.62	2.08	1.03	1.02	0.64	0.67	0.63	1.33	
	Gaal	Gaal	12	0.23	0.34	0.41	0.44	0.83	2.01	0.91	0.44	0.43	0.27	0.28	0.27	0.57	
Rasau		Pasir Puteh	83	1.60	2.37	2.84	3.08	5.63	13.7	6.16	3.06	3.02	1.90	1.99	1.87	3.65	
	Taweh	Taweh	25	0.48	0.72	0.86	0.93	1.70	4.15	1.86	0.92	0.91	0.57	0.60	0.56	1.19	
	Jeram	Jeram	15	0.29	0.43	0.52	0.56	1.03	2.50	1.13	0.56	0.55	0.35	0.36	0.34	0.71	
	Telosan	Gong Kelih	13	0.25	0.38	0.45	0.49	0.89	2.17	0.98	0.48	0.48	0.30	0.31	0.30	0.62	
Semerak		Pasir Puteh (4)	220	3.22	5.45	11.8	14.1	33.0	52.5	16.5	6.22	3.55	1.54	1.24	1.45	12.6	

Table 11 : Average 30 consecutive day low flow for rivers in the Pasir Puteh – Besut region

River	Tributary	Site	Area (km^2)	Average 30 consecutive day low flow m^3/sec for return period 1:T years					Remarks
				1:2.33	1:5	1:10	1:50	1:100	
Besut		Jerteh(1)	790	11.9	9.2	7.6	4.9	4.1	(1) Based on extremal analyses of low flow records.
	Angga	Headworks	77	1.16	0.90	0.74	0.48	0.40	(2) Excludes flow from Sg. Angga.
	Besut	Rantau Panjang(2)	640	9.64	7.45	6.15	3.97	3.32	(3) Accurate estimation difficult because of continual padi usage and accuracy probably not better than ± 30%
	Pelagat	Rawang Panjang	57	0.86	0.66	0.55	0.35	0.30	
Yong		Pulau Lima(3)	54	0.81	0.63	0.52	0.34	0.28	
	Yong	Bt. Yong	28	0.42	0.33	0.27	0.17	0.15	
	Gaal	Gaal(3)	12	0.18	0.14	0.11	0.08	0.06	
Rasau		Pasir Puteh	83	1.25	0.97	0.80	0.52	0.43	
	Taweh	Taweh	25	0.38	0.29	0.24	0.16	0.13	
	Jeram	Jeram	15	0.23	0.17	0.14	0.09	0.08	
	Telosan	Gong Kelih	13	0.20	0.15	0.13	0.08	0.07	
Semerak		Pasir Puteh(3)	220	1.2	1.0	0.8	0.5	0.4	

Except possibly for January, February and March, average monthly runoffs compare favourably with corresponding long term data for the Sg. Besut (Appendix 1). However the flow record is of insufficient length to place too much confidence in the coefficient of variation data. Fig. 6 shows the mean flow duration for the wet season (Nov. to Jan.) and dry season (Feb. to Oct.).

Table 12 shows the minimum average discharge for a specific number of consecutive days. With only three complete years of flow records, extremal low flow analyses were not possible.

Table 12 : Sg. Yong minimum average discharge for N consecutive days (in m^3/sec)

Year	N = 7		N = 15		N = 30	
	q	Date*	q	Date*	q	Date*
1972	0.36	3/6	0.41	21/7	0.45	12/5
1973	0.56	19/7	0.59	22/8	0.66	30/5
1974	0.19	5/10	0.22	16/9	0.23	15/9

*Date of commencement of period.

The Sg. Gaal, a tributary of the Sg. Yong drains a catchment area of 11.8 km^2 above Kg. Gaal and joins the Sg. Yong downstream of Kg. Bt. Yong.

Approximate average monthly discharges for both rivers are included in Table 10, and the average 30 consecutive day low flows are shown in Table 11.

7.3 Sungei Rasau

The Sungei Rasau comprises three major tributaries; Sungei Taweh (24.8 km^2), Sungei Telosan (13.0 km^2) and Sungei Jeram (15.0 km^2).

Catchment geology, vegetation and rainfall are similar to the Sg. Yong, indicating a similarity in mean and low flow characteristics based on specific discharge. Relevant average monthly and low flow data are shown in Tables 10 and 11 respectively.

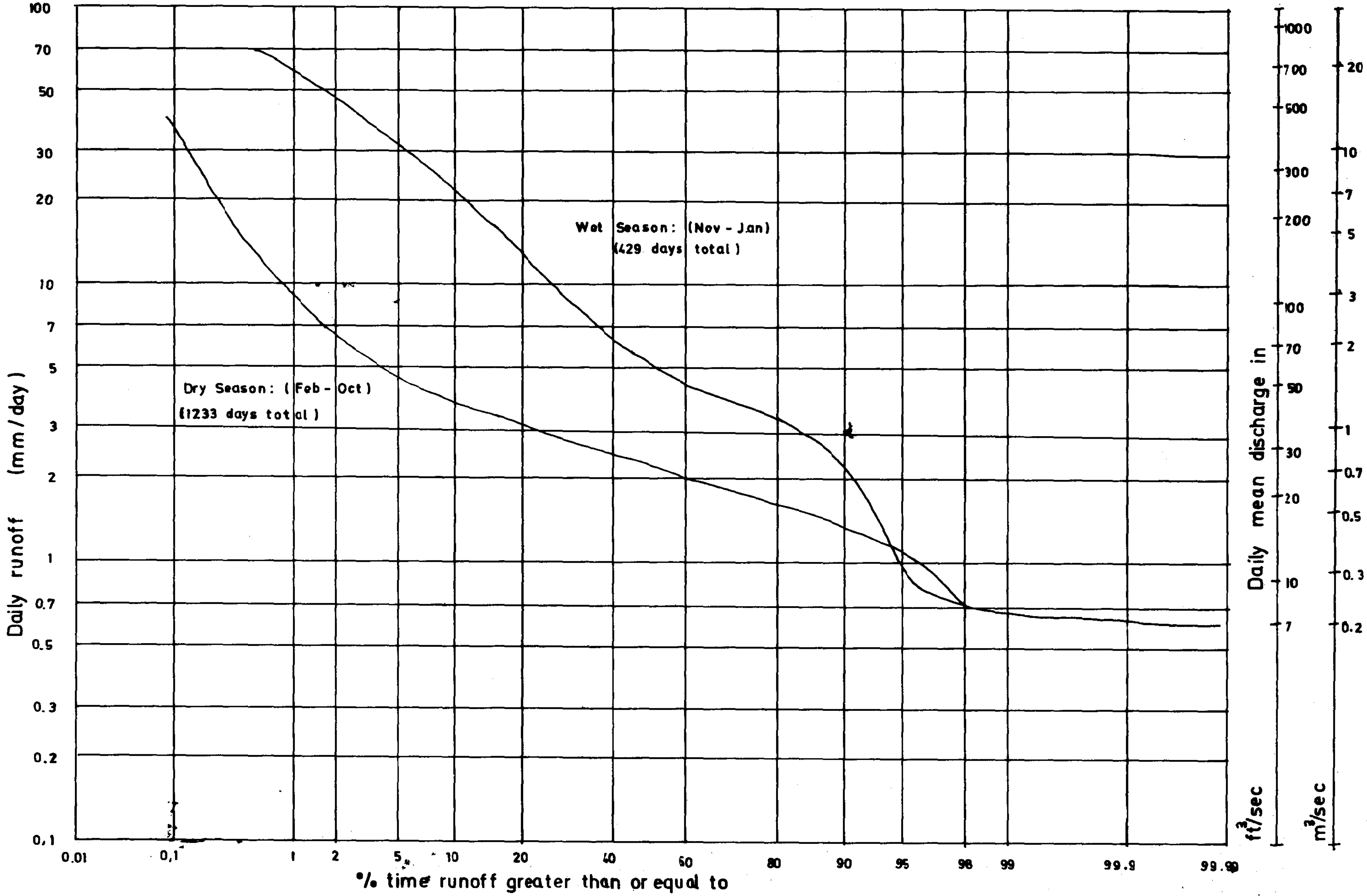


Fig 6: Average flow duration curves for Sg. Yong

7.4 Sungei Semerak

Above Pasir Puteh the Sungei Semerak drains a catchment area of about 220 km² (85 sq. miles) comprising mainly padi land. The river is tidal to Kg. Madang Manis, some 6 km upstream from Pasir Puteh. Tidal range as recorded at Kuala Semerak (½ km from coast) is from 0.0 to 1.22 m and at Pasir Puteh from 0.22 to 1.22 m above mean sea level. Approximate average and low flows are listed in Tables 10 and 11 respectively. It is to be pointed out however that because this river drains extensive padi land much of the water resources from tributaries are channelled continuously to padi production and accurate assessment of actual water resources and current water usage is not possible.

8. GROUNDWATER RESOURCES

8.1 Introduction

Throughout the alluvial plains of the Sg. Yong and Sg. Rasau catchments there are an estimated 500 private wells ranging in depth from 1.5 to 10 m, and used primarily for domestic water supply. Drawoff from each well is less than 0.45 m^3/day (100 gpd), varying with the number of households relying on the well. The wells are hand dug and the majority are lined to depth with concrete cylinder sections, 760 mm (2' 6'') dia. Construction is usually carried out during the dry season, the ultimate depth being determined by the groundwater table prevailing at that time.

8.2 Lithology

Fig. 7 shows drillhole location and generalised graphic log for 15 investigation holes (76 mm dia) drilled throughout the area.

The occurrence and movement of groundwater in the Sg. Rasau catchment appears to be limited. Maximum depth of sediments is probably not greater than the 24 m (79 ft) observed at drillhole 2. The lithological section given in Fig. 8 (subject to confirmation by a pending Geological Survey report) would indicate the existence of two aquifers separated by a leaky clay aquitard; about 6 m thick. The upper aquifer occurs as a sand lens 2-3 m thick, whilst the lower aquifer is confined in a depression in the underlying basement granite, with a maximum thickness of about 9 m. Both aquifers are restricted in area by nearby outcropping basement granite. The lower aquifer is approximately rectangular; 2 km wide by 4 km long, giving an aquifer volume of about 24 x 10^6 cubic metres.

Groundwater occurrence is considerably more extensive in the Sg. Yong area. Permeable granite sand and gravel outwash formations appear to be continuous, increasing in thickness towards the north-east. The aquifer is unconfined and extends beyond the boundaries of the study area to the coast. Two lithological sections are given in Fig. 8 (subject to confirmation by geological survey report). Whilst unconfirmed by a deep drillhole, logs of shallow private wells (max depth 5.2 m) and exposed bedrock in the Sg. Besut at Jerteh would indicate the aquifer is bounded in the south east as shown in Fig. 7. The volume of aquifer contained within the area (53 km^2) bounded by drillhole 8, drillhole 11, Bt. Peteri and Sg. Semerak is approximately 900 x 10^6 cubic metres.

8.3 Groundwater movement and aquifer recharge

8.3.1 Seasonal water-table fluctuations

Water-table maps corresponding to average dry and wet seasons are shown in Fig. 9. In general the water-table conforms to the surface topography, the slope of the table ranging from 0.55% for the upper Telosan to 0.10% in the lower Sg. Yong.

8.3.2 Aquifer recharge from rainfall

Recharge to the groundwater system is predominantly from rainfall. During the monsoon season the aquifer is completely recharged, the water-table being at (or above) ground surface level throughout the padi areas. Fig. 7 shows the response of the water-table to rainfall.

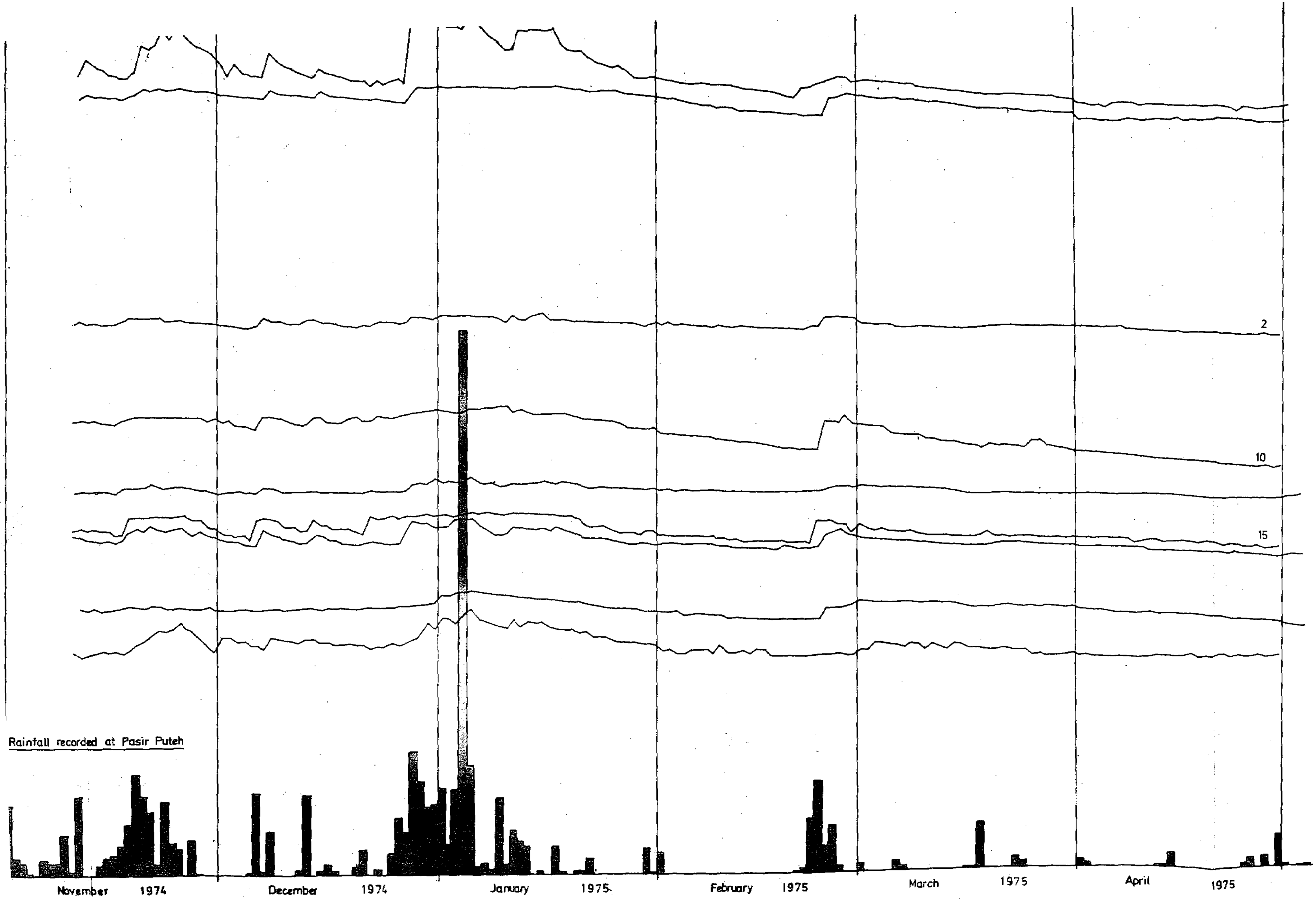
In the upper Telosan region the water-table at well 32 (Refer Fig. 9) is influenced significantly by rainfall. On 27 Dec. 1974 a rise of 2.4 m in 24 hours was recorded following 175 mm of rainfall. This recharged the water-table almost to ground surface level in the area and subsequent heavy rainfall events on 28, 29 and 30 Dec. 1974 did little but maintain the fully charged condition. Response to rainfall is not exhibited to the same degree in well 35 and wells 2 and 27 in the central Rasau region. Wells 10, 15 and 21 in the Sg. Yong region are influenced by rainfall events whilst well 24 shows no response. Wells in the Kg. Gaal, Gong Datok Nering area of the lower Rasau are dug into clay with very low infiltration capacity.

8.3.3 Aquifer recharge from streamflow

A series of streamflow gaugings on rivers and streams throughout the area have shown that no major losses from the Sg. Yong or Sg. Rasau to the groundwater system occurs. However a study of the specific discharge data does indicate the existence of small streamflow losses; less than 200 l/sec from both the Sg. Yong and the Sg. Rasau. Recharge from the Sg. Semerak below Pasir Puteh cannot be excluded. Being tidal and slow flowing, losses to the groundwater system are extremely difficult to detect and measure.

8.3.4 Tidal Influences

Surface level at well 19 at Kg. Sungei Petai is only 2.09 m above mean sea level. The minimum ground water level since automatic recording started in



ig10: Aquifer response for the Sungei Yong/Rasau remon.

Nov. 1974 is 0.93 m R.L. (on 23/2/75); within the tidal range of the nearby Sg. Semerak (0.11 to 1.22 m R.L.). No water-table fluctuations attributable to tidal movement have been observed (see Fig. 10).

8.4 Aquifer storage and transmissibility

Table 13 summarises transmissibility and storage data, obtained from pump tests. For location of pump test wells refer to Fig. 1. Private wells, because of their concrete cylinder casing were found to be most inefficient and the pump test results for these wells serve only to indicate the general magnitude of transmissibility.

Table 13 : Summary of transmissibility and storage data

Well No.	Locality	Well depth m	Producing formation	Transmissibility m^2/day	Storage Coefficient
WP(1)	Teratak Batu	6	recent alluvial sands	200 – 500	0.01–0.06
35*	Gong Genor	3.5	Clay loam	20 – 30	(3)
38*	Taweh	4.2	clay loam	20 – 30(2)	(3)
47*	Merbol	9.2	clay	less than 5	(3)
40*	Gong Datok	6.0	clay	less than 10	(3)
14*	Alor Selising	4.0	sand	200 – 300(2)	(3)
No.14	Sg. Petai	19.0	sand/gravel	370	0.3

(1) Results from a well point system comprising 40 well points (38 mm dia) spaced along a perimeter of a 200 ft. x 42 ft. (61m x 12.8m) rectangle, all points feeding into a common line and pump.

(2) Well does not penetrate total acquifer depth range and transmissibility is possibly underestimated.

(3) Insufficient data to calculate storage coefficient.

* denotes private well.

Aquifer permeability is likely to be variable in the Sg. Rasau with higher transmissibility (more than 100 m^2/day) confined to some shallow deposits of recent alluvial material alongside the existing river channel, and possibly the wells penetrating the deep aquifers in the central Rasau area. Transmissibility is known to be low (less than 10 m^2/day) in the Kg. Merbol, Gaal, Gong Datok area, where existing wells are dug into a heavy organic clay layer overlying basement sandstone shale. These wells (some deeper than 9 m) are capable of sustaining drawoff sufficient only for domestic supply.

Aquifer permeability in the Sg. Yong is likely to be less variable with transmissibility exceeding 300 m^2/day where the depth of permeable sands exceeds 20 metres. Figs. 11 and 12 shows the casing details, location of observation drillholes and analyses for the main test well No. 14 drilled at Sungei Petai.

Pump testing at a rate of 120 m^3/hr started at 1130 a.m. on 19 July 1975 and continued for a period of 172 hours (7.2 days) except for three pump stoppages resulting from power failure; between 104.25 – 106.75, 140.1 – 140.4 and 153.7 – 155.1 hours from commencement of pumping. Drawdown was measured in observation wells at 0.18, 10, 15, 22, 32, 45, 70, 100 and 145 metres respectively from the main pump well. Time drawdown data conformed to standard water table aquifer, fully penetrating wells and constant discharge type curves. Fig. 12 shows plotted data for observation wells at 0.18, 10, 32 and 100m. A similar analytical procedure was used for the remaining observation stations.

Average transmissibility computed from all observation well data was 370 m^2/day. Assuming an aquifer thickness of 20 metres gives a permeability at 18.5 m/day (0.21 x 10^{-3} m/sec). Average long term coefficient of storage is about 0.3. The unconfined aquifer displays typical delayed gravity drainage characteristics, the average delay index being about 300 min. The aquifer comprises stratified medium to fine alluvial medium to fine alluvial granite sands (particles less than 2 mm dia.) interspersed with 1–2 metres of coarser material.

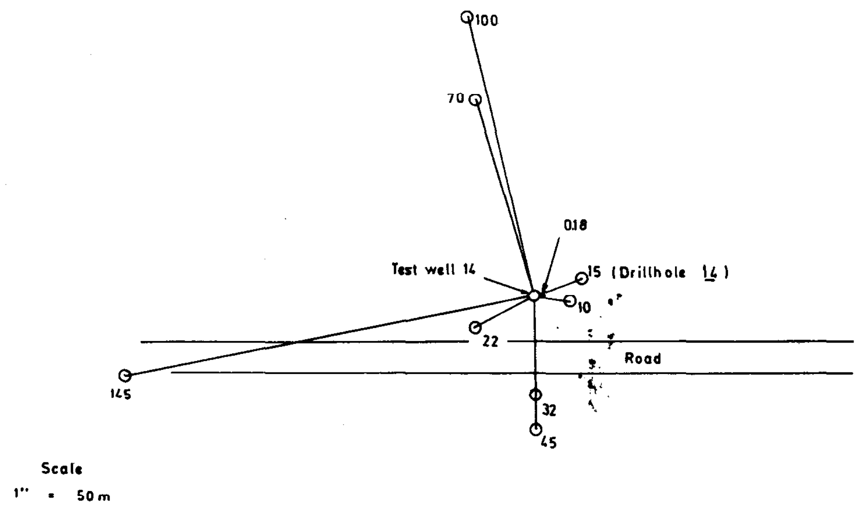
8.5 Aquifer potential

With a lower aquifer volume of only 24 x 10^6 cubic metres, aquifer potential within the Sg. Rasau is obviously limited. Assuming a transmissibility of 50 m^2/day and a storage coefficient of 0.1, the maximum sustained yield from the lower aquifer would be about 15 l/sec (200 gpm); at best, sufficient only for a domestic water supply scheme. Further investigation would be required if this were to be seriously considered.

In the lower Sg. Yong, aquifer potential is considerably better. A sample groundwater balance assuming ideal rainfall recharge conditions (i.e. rainfall not lost to evapotranspiration infiltrates direct to groundwater storage) shows that average annual aquifer recharge from rainfall is about 35 l/sec per square kilometre of aquifer area. Within the boundaries described in section 8.2, the aquifer area totals 53 km^2 indicating that the aquifer potential cannot exceed 1850 l/sec (160,000 m^3/day). In practice, because of groundwater drainage (approximately 5000 m^3/day) and aquifer management considerations such a potential could never be realised.

Assuming that aquifer permeability remains constant throughout the permeable aquifer sands, then the transmissibility is proportional to the depth of aquifer sand. If the aquifer were to be managed such that drawdown at the wellhead did not exceed 30% of the penetrated aquifer depth, the following limitations would need to be imposed:–

(a) Layout of observation wells at Sg. Petai.



(b) Casing details for main test well 14

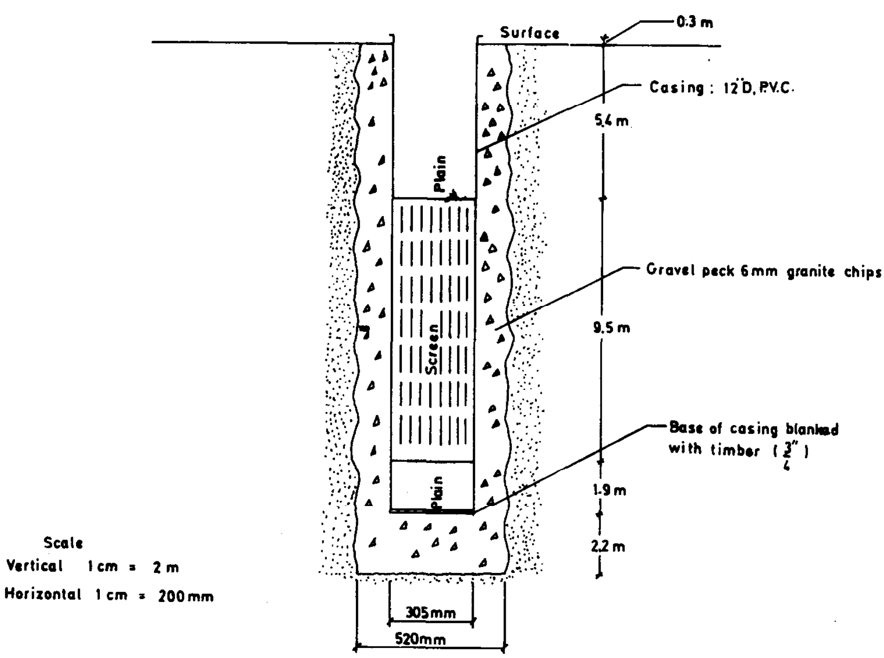


Fig 11: Layout and casing details of test well 14 at Sg Petai

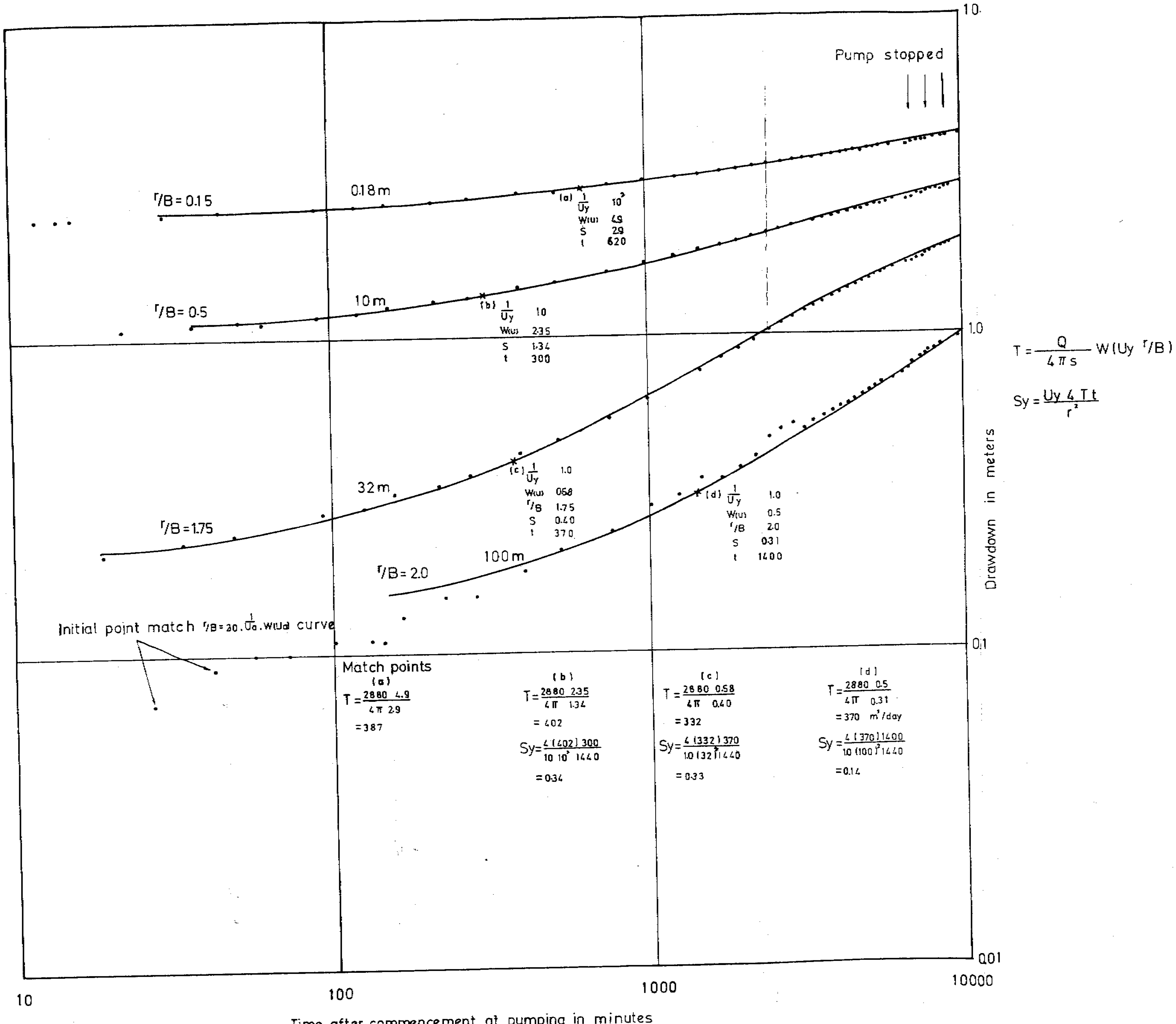


Fig 12: Aquifer analysis for main test well 14 at Sg. Petai

(1) No wells be drilled where aquifer depth is less than 5 metres.

(2) No wells be drilled within 500 m of an areal aquifer boundary (e.g. Bt. Petari).

(3) Where aquifer depth is from 5–15 m, wells should be limited to a flow rate of 500 m^3/day (75 gpm), and spaced not closer than 1000 m apart.

(4) For aquifer depths from 15–30 m, wells limited to 1800 m^3/day and spaced at about 1250 m centres.

(5) For aquifer depths exceeding 30 m, wells limited to 4400 m^3/day (680 gpm) and spaced at 1500 m centres.

Accepting these limitations then the maximum groundwater potential for the Sg. Yong (boundaries given in 8.2) is 43,000 m^3/day (17.5 cusecs). The economics of groundwater drilling and extraction, not considered herein, could further limit the potential.

9.0 WATER QUALITY

9.1 Surface water quality

Table 14 lists water quality data for rivers in the study area.

The chloride data shows that the Sg. Semerak whilst tidal is not saline or brackish at Pasir Puteh. Salinity increases below the confluence with the Sg. Yong – Gali.

Maximum tidal influences in the Sg. Besut extends to just upstream of Kampong Raja, some 2 km below the Kg. Amir site.

9.2 Groundwater quality

Table 15 lists water quality data for groundwater wells in the study area (refer Fig. 1 for locations). Data from samples collected and analysed by Geological Survey are also included.

The location of the saline groundwater wedge is clearly shown by the chloride results obtained from the three PWD drillholes* near Kg. Nangka. Water sampled from 53 m deep in PWD 7 (2.6 km from the coast) was saline, and from 39 m in PWD 8 (3.9 km from coast) the water was brackish. At PWD 9 (5 km from coast) from a depth of 29 m the water was fresh. The main well at Sg. Petai is 9 km inland and there is little danger of saline intrusion resulting from controlled aquifer exploitation.

* drillholes drilled by Geological Survey for PWD survey of groundwater for water supply.

Table 14 : Water quality data for surface water resources

River Site Sampling Date	Rasau Pasir Puteh 26.6.75	Yong Bt. Yong 26.6.75	Besut Amir 26.6.75	Semerak Pasir Puteh 25.6.75	Semarak Pasir Puteh 26.6.75	Semerak Pasir Puteh 25.6.75	Semerak Pasir Puteh 26.6.75
Water level (m)	–	6.90	–	0.30[1]	0.46	0.90	1.07[2]
Discharge[3] (m^3/sec)	2.50	0.85	35	4.5	4.5	4.5	4.5
Sample depth (m)	0.3	0.2	0.2	1.5	1.0	1.0	2.5
pH	7.4	7.1	7.1	6.5	5.6	6.2	6.4
Conductivity (umho/cm)	36	23	24	48	47	55	58
Hardness (mg/1 $CaCO_3$)	10	5	5	10	15	15	15
Total solids (mg/1)	65	55	40	130	120	120	120
Dissolved solids (mg/1)	65	40	40	100	100	95	110
Alkalinity (mg/1 $CaCO_3$)	15	15	25	25	15	15	15
Calcium Ca^{++} (mg/1)	2.8	1.6	2.8	3.6	2.8	2.4	2.8
Magnesium Mg^{++} (mg/1)	0.5	0.5	Nil	0.5	2.2	2.2	1.7
Sodium Na^{+} (mg/1)	4.7	3.4	4.8	4.8	4.8	4.8	5.6
Potassium K^{+} (mg/1)	1.3	1.3	1.1	1.3	1.2	1.2	1.3
Ammonia NH_4^{+} (mg/1)	Nil	Nil	0.01	Nil	0.02	0.02	Nil
Nitrate $NO_3^{=}$ (mg/1)	Nil	0.05	0.05	0.05	0.1	0.05	0.05
Chloride Cl^{-} (mg/1)	7	7	7	9	8	11	13
Sulphate $SO_4^{=}$ (mg/1)	4.5	5	5	6	9	6	8
Silica SO_2 (mg/1)	16.6	16.6	13	14.8	16.6	16.6	18.4
Iron Fe^{+++} (mg/1)	–	–	–	–	–	–	–

NOTES: (1) Low tide level
(2) High tide level

Table 15 : Water quality data for groundwater resources

Well No.	24	15	19	21	$\bar{1}$	$\bar{2}$	$\bar{4}$	$\bar{14}$	$\bar{15}$	PWD 9	PWD 8	PWD 7	Test well No.14	
Sample date (1974/75)	11/11	30/3	30/3	30/3	?/4	?/4	?/4	14/4	14/4	?/4	?/4	?/4	23/6[1]	24/6[2]
Discharge (1/sec)	Nil	Nil	Nil	Nil	Approx. 1–2 1/sec			Approximately 1–2 1/sec					33.3	33.3
pH	6.3	6.6	5.7	6.1	5.9	6.3	6.4	6.0	6.8	5.9	3.9		4.0	4.5
Conductivity (umho/cm)	122	154	188	231	–	–	–	–	–	–	–		212	192
Hardness (mg/1 $CaCO_3$)	30	55	25	35	90	70	70	25	45	25	345		30	25
Total solids (mg/1)	145	120	85	145	120	230	290	320	815	1120	2070		125	130
Dissolved solids (mg/1)	140	100	85	145	–	–	–	–	–	–	–		105	100
Alkalinity (mg/1 $CaCO_3$)	35	60	10	20	35	50	55	20	75	50	Nil		5	15
Calcium Ca^{++} (mg/1)	9.2	23	7.2	8.0	–	–	–	–	–	–	–		9.2	8.4
Magnesium Mg^{++} (mg/1)	1.2	Nil	1.9	4.1	–	–	–	–	–	–	–		1.2	1.5
Sodium Na^{+} (mg/1)	11.6	4.8	16	13	–	–	–	–	–	–	–		8.0	9.5
Potassium K^{+} (mg/1)	2.7	2.4	7.0	11	–	–	–	–	–	–	–		4.3	4.1
Ammonia NH_4^{+} (mg/1)	0.06	Nil	0.06	Nil	–	–	–	–	–	–	–		0.15	0.14
Nitrate $NO_3^{=}$ (mg/1)	0.35	0.1	0.05	2.2	0.1	0.15	0.1	0.05	0.05	Nil	0.35		0.1	0.1
Chloride Cl^{-} (mg/1)	16	8	22	28	10	6	9	19	3	16	900	Saline	11	13
Sulphate $SO_4^{=}$ (mg/1)	5	5	40	14	8	9	6.5	28	20	15	34		60	58
Silica SO_2 (mg/1)	24	13	16	8.4	–	–	–	–	–	–	–		15	15
Iron Fe^{+++}(mg/1)	–	–	–	–	3.2	8.8	8.0	2.6	1.6	3.6	80		–	–

Not Analysed shown –

NOTES: (1) Sampled 1.75 hours after pumping commenced at 0900 hrs 23/6/75; water sample temperature 27.8°C

(2) Sampled 24 hours after pumping commenced at 0900 hrs 23/6/67; water sample temperature 27.8°C

The groundwater has a low sodium absorption ratio (< 1.0). Water with a sodium absorption ratio in excess of 4.0 may be phytotoxic to certain sensitive crops.

The low pH (4.0 to 4.5) measured in samples from the main test well is beyond the range of 5.5 to 8.5 desirable for irrigation. In association with a high iron concentration (eg. 2.6 mg/1 at Drillhole 14) continuous irrigation on acid soils over long periods of time may render the soil toxic from soluble quantities of iron. Soils in this area are typical organic soils with pH 4 to 5; with some acid soils (pH 3 to 4) in the lower areas. In this particular case the use of groundwater for irrigation would probably be limited to 1 to 2 months per year with rainfall or surface water resources being utilised for the remainder. It is unlikely that iron toxicity will present any major problem.

10. CURRENT WATER USE

Table 16 summarises current water usage from rivers and groundwater.

Comparing Tables 10 and 16 it is concluded that for at least one in every two years, water resources from the Sg. Angga and Sg. Pelagat are fully committed for irrigation during the period April to August annually. The average annual 30 consecutive day low flows (Table 11) at 1.16 and 0.86 m^3/sec for the Sg. Angga and Sg. Pelagat respectively are only about 50% of the normal demand.

The area irrigated per unit volume of irrigation water varies from 600 ha/cumec (42 acres/cusec) for the Telebah (Sg. Susun) scheme to about 470 ha/cumec (33 acres/cusec) for the Besut and Pelagat schemes. Such a demand rate (ie. 470 ha/cumec) is high by national standards but could result from the padi land soils having a high infiltration loss rate to groundwater storage. Current demand for water resources in the area is such that water losses from current irrigation schemes must be kept minimal.

Table 16 : Current water useage in the Pasir Puteh – Besut region

SURFACE WATER RESOURCES

River	Headworks Location	Water used for	Irrigation			Design capacity (m^3/sec)	Normal demand		Minimum 30 day flow 1:10 yr (m^3 / sec)
			Crop	Area(ha)	Season		m^3/sec	ha/m^3/sec	
Susun	QU : 986215	Irrigation	rice (s)	120	Nov.–Feb.	0.2	0.2	600	0.04
Tabul	QU : 989226	Water supply	–	–	Continuous	?	0.001	–	–
Angga	RQ : 025193	Irrigation	rice (d)	5100	Continuous	3.4	2.3	472	0.74
Besut	RQ : 000274	Irrigation	rice (d)			11.5	8.5		6.15
Pelagat	QU : 980337	Irrigation	rice (d)	490					
			rice (s) and up-land crop	240	Continuous	2.5	1.7	456	0.55
TOTAL WATER COMMITMENT – SG. BESUT				5950	Continuous	17.6	12.7		7.48
Rasau	QU : 913445	Water supply	–	–	20hr/day	?	0.0024		0.80

(d) double crop rice/year
(s) single crop rice/year

GROUNDWATER RESOURCES

Area	No. of wells (Estimated)	Water used for	Estimated drawoff per well (m^3/day)	Total groundwater use (m^3/sec)
Sg. Yong Sg. Rasau	500	domestic supply	0.45	0.002

11. IRRIGATION

11.1 Irrigation design criteria

The primary objective of any irrigation scheme is to provide soil moisture conditions suitable for optimum crop growth. Most varieties of upland crops are susceptible to waterlogging and thus the long established flood irrigation techniques used for padi irrigation may not be suitable for irrigating upland crops. For optimum crop growth the soil moisture within the rooting zone must be maintained above a minimum tolerable level at all times during the growing season. The minimum tolerable level, normally defined as 50% field capacity, represents a boundary soil moisture condition, below which significant inhibition of crop growth results.

Irrigation water may be supplied under either a demand system or roster system. In Malaysia (Heiler 1973) where supplementary rainfall is likely but unpredictable and where the minimum of farmer judgement is preferable, the flexibility of the demand system is superior. The choice of irrigation system is dependant on many factors the more important being:

(1) availability of water,

(2) range at soil moisture tolerances for various crop types,

(3) economics.

Because available water resources are limited, a sprinkler irrigation system is recommended. On-farm irrigation efficiency using a hand shift multi-sprinkler system and well maintained concrete lined canals should approach 80%.

This system consists of a spray line of portable aluminium pipes, each pipe length 6 to 9 m long and fitted with quick action couplers. The spray line is laid on top of the ground and is fitted with medium pressure (35 to 45 psi) rotating sprinklers affixed to riser pipes (suited to crop height) at every second pipe length (12 to 20 m). A pump from a concrete lined irrigation race supplies water to the sprayline, and pumping is continuous for a period sufficient to correct the current soil moisture deficit. The lengths of pipe are moved to a new position, parallel to and 20 mm away from the former position, recoupled and irrigating continued. Normally two shifts per day are required. The maximum irrigation rate is dependant on pump size and length and diameter of sprayline but normally ranges between 10 to 50 mm/hr.

Because of lack of farmer experience in such irrigation techniques, and the relatively high on-farm costs (sprayline pump etc), the purchase and operation of spraylines and pumps is best controlled by a centralised scheme management authority. This ensures efficient irrigation management; essential where the water resources are limited.

Relevant to the design of all irrigation schemes is the degree of security; or the probability that sufficient water cannot be supplied to satisfy soil moisture requirements. To avoid basing the design on extreme climatic seasons a 10% probability is normally acceptable; i.e. there is a probability that for 1 year in 10 years the scheme will not supply sufficient irrigation water to satisfy the corresponding 1:10 yr. water deficit for the area.

In designing a scheme based on surface water resources it must be recognised that a joint probability relationship exists between water deficit and low flow water resources. Whilst a 1:10 year water deficit need not necessarily coincide with a 1 : 10 year low flow, there is a high probability that such a coincidence occurs. A diversion barrage-gravity canal type irrigation scheme has negligible water storage capacity, and such a scheme must be designed on the availability of low flow water resources.

11.2 Irrigation area

The area suitable for irrigation totals approximately 5510 ha (13,615 ac) as shown in Fig. 13 and subdivided as follows in Table 17.

Table 17 : Summary of irrigable areas

Catchment	Location	Area	
		ha	ac.
Sg. Rasau	Telosan – Teratak Batu	376	930
	Lembah – Telipok	154	380
	Kemal – Gaal	186	460
	Jeram – Merbol	367	905
	Chengal Batu	237	585
	Total	1320	3260
Sg. Yong	Kok Jering	497	1230
	Gong Datok	340	840
	Gelong Gajah	332	820
	Tok Kandis	174	430
	Bukit Yong	259	640
	Tok Motong (Trengganu)	121	300
	Ambang-Kemuning-Gong Sepuleh	938	2320
	Pulau Lima	409	1010
	Alor Selising	260	640
	Gong Lapang	520	1285
	Seberang Jerteh	80	200
	Sungei Petai	260	640
	Total	4190	10,355

11.3 Irrigation Potential : Sg. Rasau

The irrigable padi area within the Sg. Rasau catchment suitable for upland crop cultivation totals 1320 ha. Under upland crop production the expected water deficit is represented by the average for Cherang Tuli and Telosan rainfall stations analysed in Table 7. The water deficit must now be balanced against available water resources; in this case solely from low flow surface water resources given in Table 11. The balance, assuming an 80% irrigation efficiency is given in Table 18.

Table 18 : Irrigation balance for 1320 ha in Sg. Rasau

(a) Available resources

30 days low flow resources (m^3/sec) for	1:2.33 yr	1:5 yr	1:10 yr
Sg. Taweh	0.38	0.29	0.24
Sg. Jeram	0.23	0.17	0.14
Sg. Telosan	0.20	0.15	0.13
Total available resources(1)	0.81	0.61	0.51
At 80% irrigation efficiency (m^3/sec)	0.65	0.49	0.41
mm depth/day on 1320 ha	4.25	3.20	2.68
mm/month for 31 day month	132	99	83
mm/month for 30 day month	128	96	81
mm/month for 28 day month	119	90	75

(1) Resources from remaining tributaries are available for Pasir Puteh water supply, and environmental protection.

(b) Irrigation balance

	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Water deficit (mm) for 1:2 yr recurrence	46	65	76	46	26	19	12	9
Water resources (mm) from 1:2.33 yr low flow	119	132	128	132	128	132	132	128
Surplus*/deficit	*	*	*	*	*	*	*	*
Water deficit (mm) for 1:5 yr recurrence	67	91	101	71	41	28	20	17
Water resources (mm) from 1:5 yr low flow	90	99	96	99	96	99	99	96
Surplus*/deficit	*	*	–5	*	*	*	*	*
Water deficit (mm) for 1:10 yr recurrence	78	104	114	84	49	33	24	21
Water resources (mm) from 1:10 yr low flow	75	83	81	83	81	83	83	81
Surplus*/deficit	–3	–21	–33	–1	*	*	*	*

From Table 8 it is notable that the annual 30 day low flow seldom occurs in April and never in February or March. Forest catchments draining granite formations have a characteristically high base flow recession constant in excess of 0.97. The release of water from catchment storage is gradual, with base flow during the dryest months of March and April still depleting the storage recharge received during the monsoon period.

From Table 18 low flow water resources from the Sg. Taweh, Sg. Jeram and Sg. Telosan are capable of satisfying a 1:5 year irrigation demand for 1320 ha. Because of farmer preference, it is highly improbable that the total 1320 ha will be under upland crop at the same time. Planting for off season crops is likely to be spread over the period March to May annually, meaning that peak consumptive use will occur during May to July when the water deficit is on the decline (Table 18b). Thus it is possible that existing resources could, under controlled management, meet a 1:5 year irrigation demand.

11.4 Irrigation Potential : Sg. Yong

The total irrigable area of the Sg. Yong bounded by the Kota Bharu – Trengganu State highway, the Sg. Besut to Bt. Peteri and the Sg. Semerak, is about 4190 ha. The Sg. Pelagat scheme designed to irrigate the Alor Selising and Gong Lapang bendang area (730 ha including 490 ha scheduled for double crop padi irrigation) is currently under construction. This leaves only surface water resources from the Sg. Yong and Sg. Gaal and some groundwater resources in the Sg. Petai area for irrigating the remaining 3460 ha. Some water could be available from the Sg. Semerak subject to further water quality investigations.

In preparing the following irrigation balance (Table 19) the whole irrigable area (including Alor Selising and Gong Lapang) was assumed to be in upland crops. The expected water deficit is given by the average of Jerteh and Pasir Puteh rainfall stations analysed in Table 7. The low flow surface water resources are given in Table 11 and the groundwater resources assumed to be 43,000 m^3/day (see 8.5). The balance assumes an 80% irrigation efficiency as previously defined (see 11.1)

Table 19 : Irrigation balance for 4190 ha in Sg. Yong

(a) Available resources

30 days low flow resources (m^3/sec) for	1:2.33 yr	1:5 yr	1:10 yr
Sg. Yong Sg. Gaal Sg. Pelagat	0.42 0.18 0.86	0.33 0.14 0.66	0.27 0.11 0.55
Total surface resources	1.46	1.13	0.93
Total groundwater resources	0.50	0.50	0.50
Total available resources	1.96	1.63	1.43
At 80% irrigation efficiency (m^3/sec) mm/day on 4190 ha	1.57 3.23	1.30 2.68	1.14 2.35
mm/month for 31 day month mm/month for 30 day month mm/month for 28 day month	100 97 91	83 80 75	73 70 66

(b) Irrigation balance

	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Water deficit (mm) for 1:2 yr recurrence	51	76	91	61	37	26	14	9
Water resources (mm) for 1:2.33 yr low flow	91	100	97	100	97	100	100	97
Surplus*/Deficit	*	*	*	*	*	*	*	*
Water deficit (mm) for 1:5 yr resources	74	106	116	87	56	42	21	16
Water resources (mm) for 1:5 yr low flow	75	83	80	83	80	83	83	80
Surplus*/deficit	*	–23	–36	–4	*	*	*	*
Water deficit (mm) for 1:10 yr recurrence	86	121	130	100	65	50	25	19
Water resources (mm) for 1:10 yr recurrence	66	73	70	73	70	73	73	70
Surplus*/deficit	–20	–48	–60	–27	*	*	*	*

From the table, it is apparent that available water resources are barely sufficient to satisfy an average annual irrigation demand. Without the Sg. Pelagat (38 to 44% of total available resources) irrigation demand would certainly exceed available resources. To satisfy a 60 mm deficit on 4190 ha expected to occur 1:10 years, would require an additional 1.21 m^3/sec (43 cusecs). The 1:10 year, 30 day low flow for the Sg. Semerak has been estimated at 0.8 m^3/sec. Unfortunately pumping from Sg. Semerak at Pasir Puteh would almost certainly create associative upstream saline migration. The only other resource is the Sg. Besut, currently committed to existing irrigation schemes.

Because of increasing irrigation demand there is a need to review the efficiency of existing schemes in the area. The peak consumptive use of rice is about 170 mm/month. With a demand rate of 470 ha/cumec, equivalent to 570 mm/month, the Besut scheme appears to have a high loss rate (70%) either to infiltration or drainage. A 15% saving of water on this scheme could well be utilised towards irrigating the Sg. Yong area.

11.5 Water Resources Planning

Having surveyed the availability of water resources for the Pasir Puteh – Besut region the next stage is preparation of water resources plans, so that resources can be allocated to achieve maximum economic benefit. Some resources need to be retained for environmental protection, including pollution dilution.

No attempt has been made in this report to present a cost benefit analysis with regard to irrigating with surface water resources as compared to groundwater; nor to analyse the cost benefit of irrigating rice compared with upland crops. Such analyses could well influence decisions regarding water resources planning.

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APPENDIX 1 : Sg. Besut : Summary of monthly and annual runoffs (mm) recorded at Jerteh for period 1946 – 1970

Water Year	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Annual Total
1945/46	–	–	–	–	–	–	–	–	–	111	131	98	–
46/47	57	92	97	94	273	561	684	359	476	177	114	114	3098
47/48	67	57	75	94	281	1091	–	–	–	124	76	56	–
48/49	56	60	107	116	253	246	106	180	68	43	75	42	1352
49/50	48	62	81	94	338	649	370	283	342	108	119	83	2577
50/51	58	62	92	145	283	260	792	239	119	67	76	–	–
51/52	–	–	–	–	162	428	511	204	114	58	–	–	–
52/53	–	–	–	–	–	–	–	–	–	–	–	–	–
53/54	–	–	–	–	–	–	–	–	–	–	–	–	–
54/55	–	–	–	110	219	834	671	157	83	73	79	62	–
55/56	58	69	65	107	209	281	175	109	149	65	66	44	1397
56/57	37	38	102	186	290	926	339	101	82	75	84	76	2336
57/58	61	56	136	198	162	1214	353	214	100	51	43	46	2634
58/59	35	72	114	95	326	136	146	68	54	34	46	37	1163
59/60	66	80	74	117	–	–	–	–	77	54	50	49	–
60/61	42	46	68	46	217	411	396	61	75	78	59	42	1541
61/62	37	30	52	116	272	792	442	118	140	56	55	59	2169
62/63	61	70	126	102	140	306	487	141	122	67	51	47	1720
63/64	47	72	91	109	235	421	183	378	237	107	77	65	2022
64/65	67	59	101	66	77	224	94	90	64	43	56	54	995
65/66	40	52	104	134	218	1063	735	189	123	77	91	82	2908
66/67	71	71	86	175	64	696	–	–	296	86	64	39	–
67/68	72	73	77	83	361	393	95	35	31	24	31	33	1308
68/69	32	27	88	187	118	408	233	42	24	20	19	22	1220
69/70	38	41	41	45	252	550	413	88	34	40	30	43	1615
$\bar{x}$	52.5	59.5	88.9	115.2	226.2	566.2	380.3	160.8	133.8	71.2	67.8	56.8	1878
s	13.2	16.7	23.5	43.1	81.6	315.0	224.2	100.2	114.0	36.0	28.6	22.7	668
k	0.25	0.28	0.26	0.37	0.36	0.56	0.59	0.62	0.85	0.51	0.42	0.40	0.36
Mean m^3/sec	15.4	17.5	27.0	33.9	68.8	166.5	111.8	52.3	39.3	21.6	19.9	17.3	49.4
Mean ft^3/sec	545	618	954	1196	2427	5877	3948	1848	1389	764	704	609	1745

NOTE: $\bar{X}$ = mean   s = standard deviation   k = coefficient of variation $= \frac{s}{\bar{x}}$

To convert monthly runoff (mm) to monthly mean discharge (cusecs or cumecs) multiply by the following convertion factors:–

No. days in month	Conversion factor (cusecs)	Conversion factor (cumecs)
31	10.38	0.294
30	10.73	0.304
29	11.10	0.314
28	11.49	0.325

APPENDIX 2 : Sg. Yong : Summary of monthly runoff (mm)

Water Year	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Annual Total
69/70										–	83	82	–
70/71	–	83	103	140	144	229	352*	95	184	64	72	51	–
71/72	–	104	–	93	246	500	127	67	51	53	48	47	–
72/73	45	79	124	77	115	519	156	88	84	66	70	65	1488
73/74	68	78	92	171	258	829	169*	111*	76	55	51	52	2010
74/75	44	42	39	25	129	160							
Average Runoff (mm)	52	77	90	101	178	447	201	90	99	60	65	59	1519
Discharge (m^3/sec)	0.54	0.80	0.96	1.04	1.90	4.62	2.08	1.03	1.02	0.64	0.67	0.63	1.33
Discharge (ft^3/sec)	19.0	28.1	34.0	36.9	67.2	163	73.4	36.4	36.2	22.6	23.7	22.3	47.1
Coef. of Var. k	0.26	0.29	0.41	0.56	0.38	0.60	0.51	0.20	0.59	0.21	0.23	0.24	

– monthly flow records incomplete; construction of missing record not possible.

* missing record during part of month. Runoff for period estimated from rainfall and baseflow recession data.

WATER RESOURCES PUBLICATIONS PREVIOUSLY PUBLISHED

1.	Surface Water Resources Map (Provisional) of Peninsular Malaysia (1974)	$5.00
2.	Hydrological Regions of Peninsular Malaysia (1974) ..	$6.00
3.	Sungei Tekam Experimental Basin Annual Report No. 1 for 1973–1974 (1975)	$5.00
4.	Notes on Some Hydrological Effects of Land Use Changes in Peninsular Malaysia (1975)	$5.00
5.	Evaporation in Peninsular Malaysia (1976)	$5.00
6.	Average Annual Surface Water Resources of Peninsular Malaysia (1976)	$5.00
7.	Sungei Lui Representative Basin Report No. 1 for 1971/72 to 1973/74 (1977)	$5.00

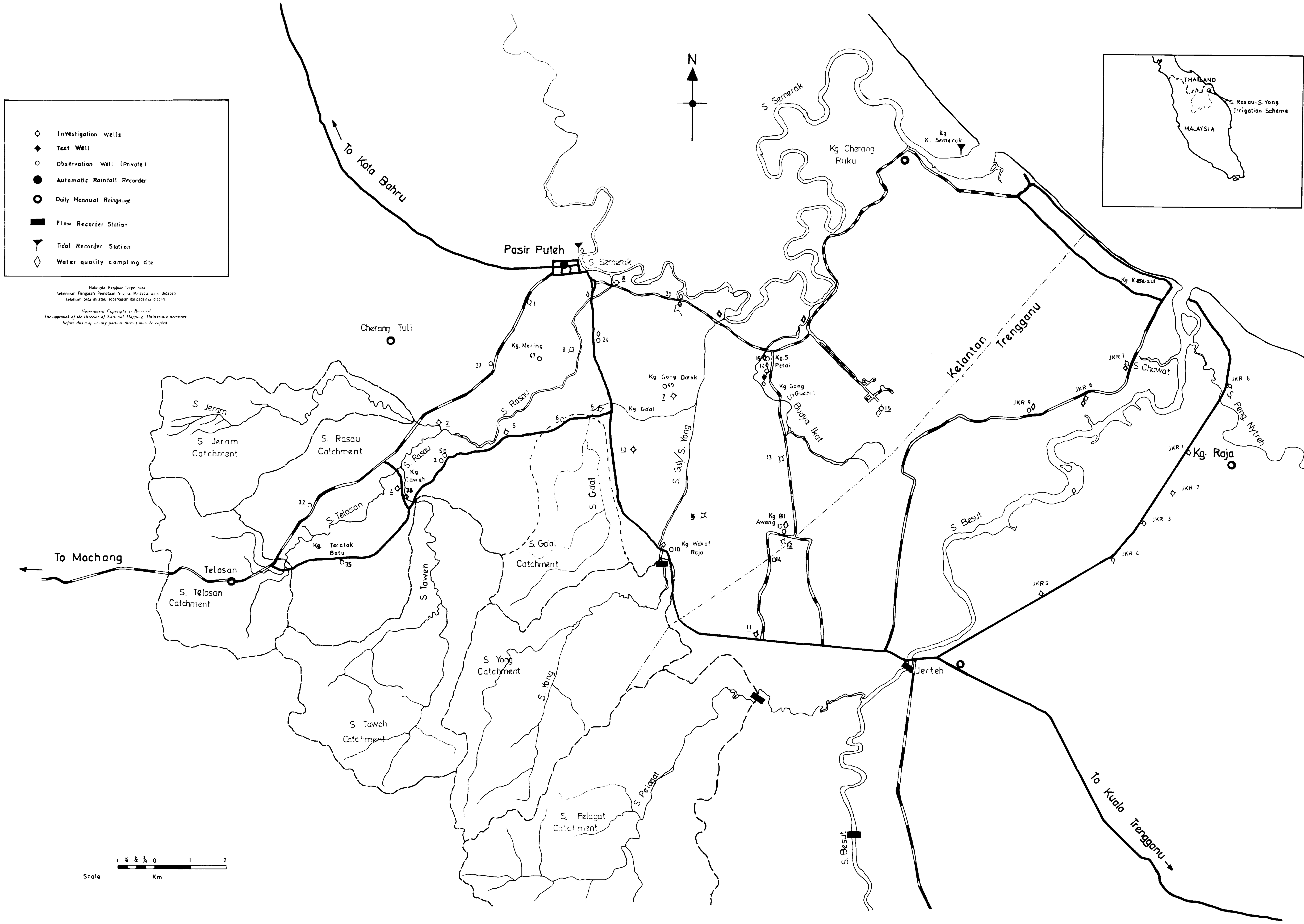
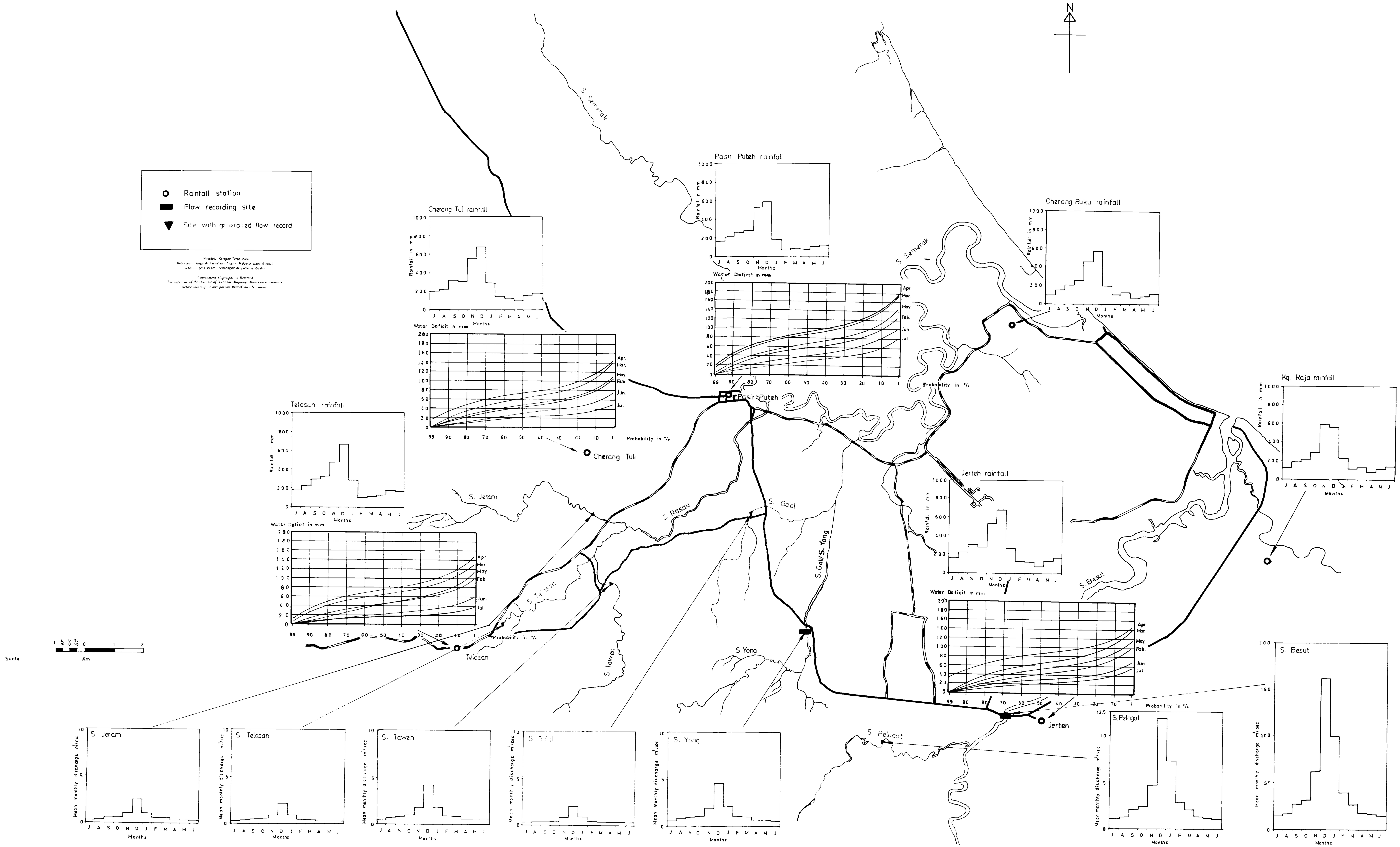


Fig 1: Location map Sg. Rasau-Sg. Yong showing Hydrological Observation Stations

(DID Water Resources Publications No. 8 - "Water Resources for Irrgation of Upland Crops in South Kelantan")

Fig 2 : Water deficit monthly mean rainfall and river discharge

(DID Water Resources Publication No. 8 - "Water Resources for Irrigation of Upland Crops in South Kelantan")



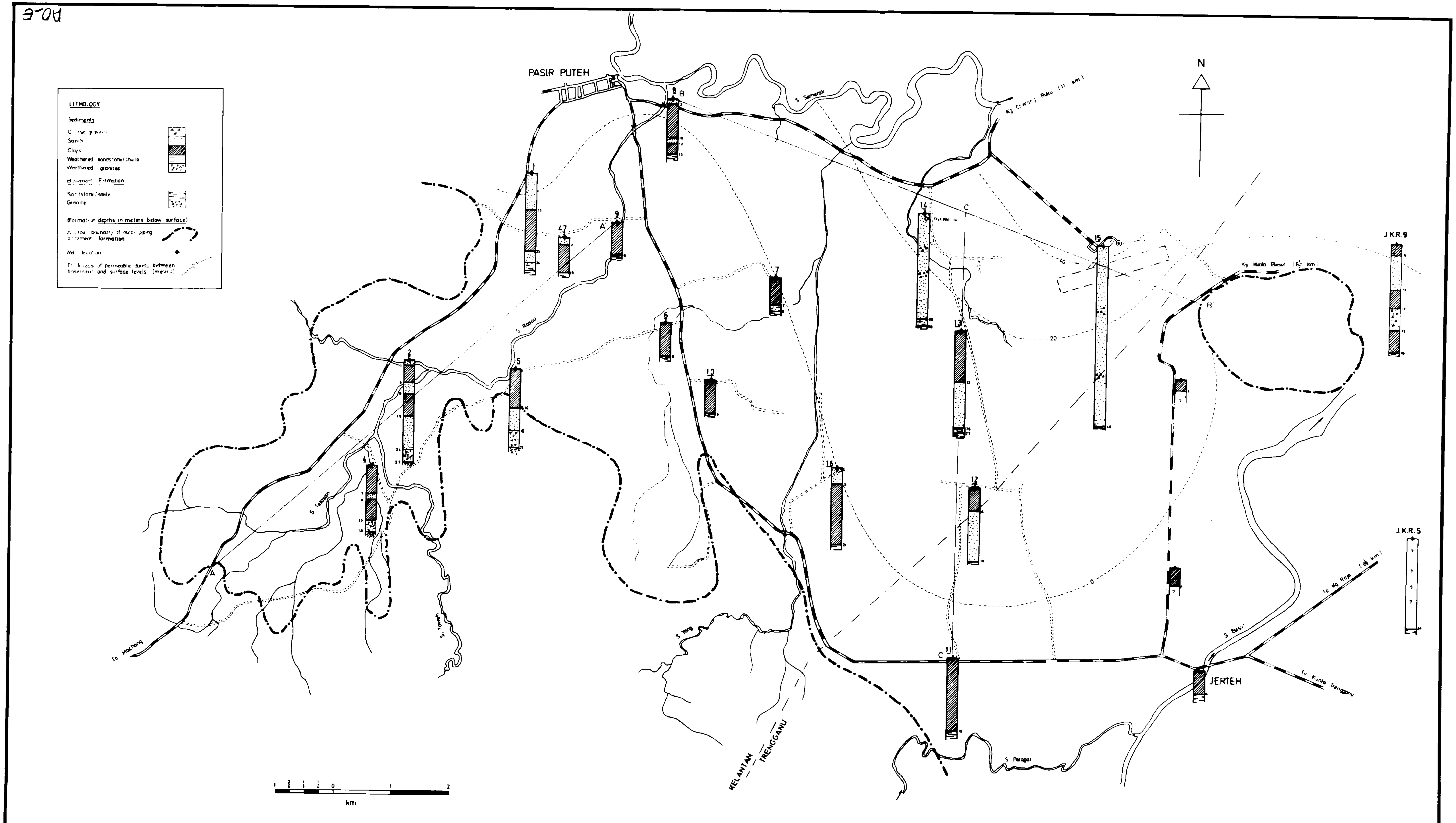


Fig 7 : Location plan and generalised logs for drillholes in Sg. Rasau-Yong area.

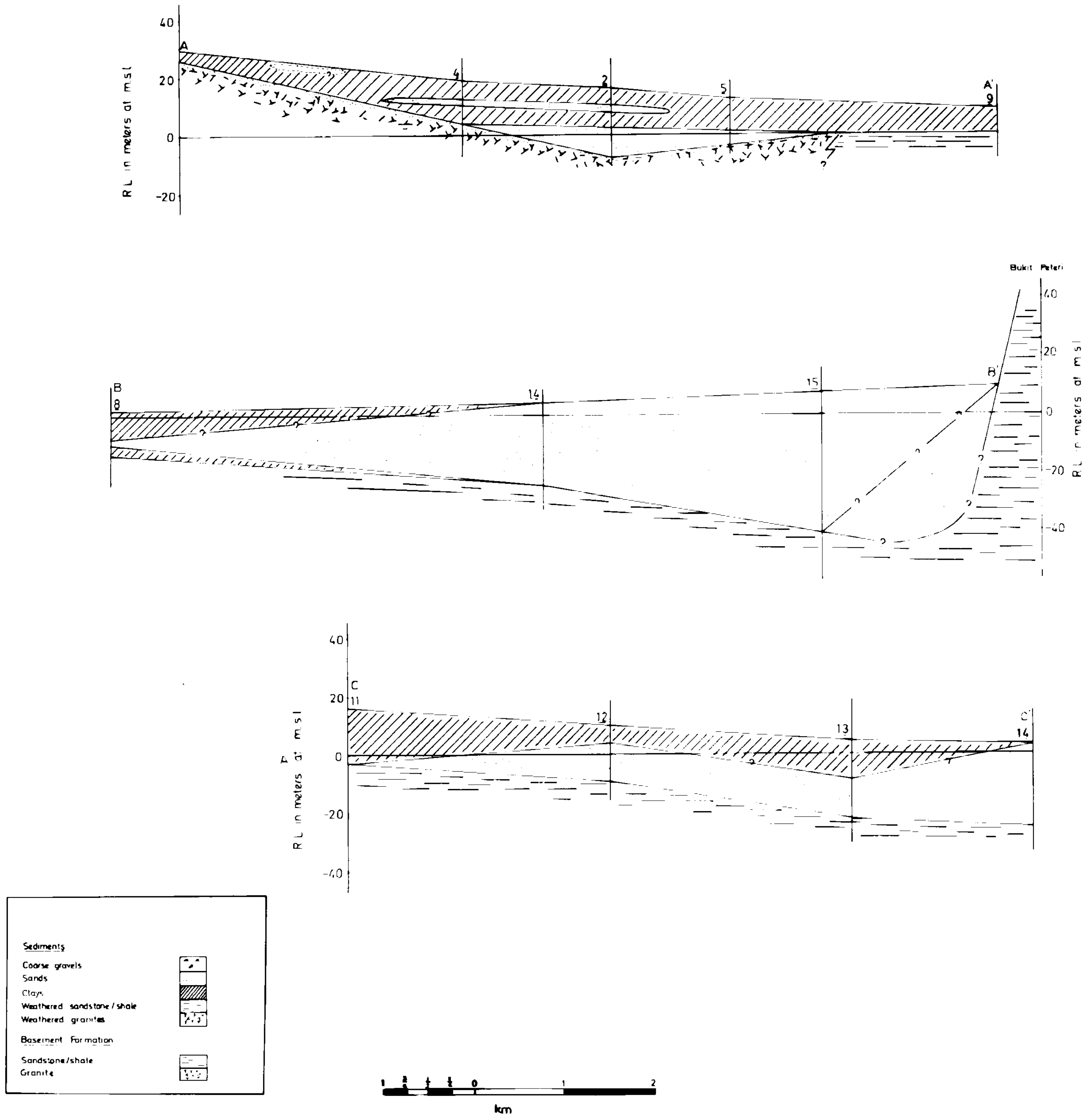


Fig 8: Geological Sections : Sg. Rasau and Sg. Yong.

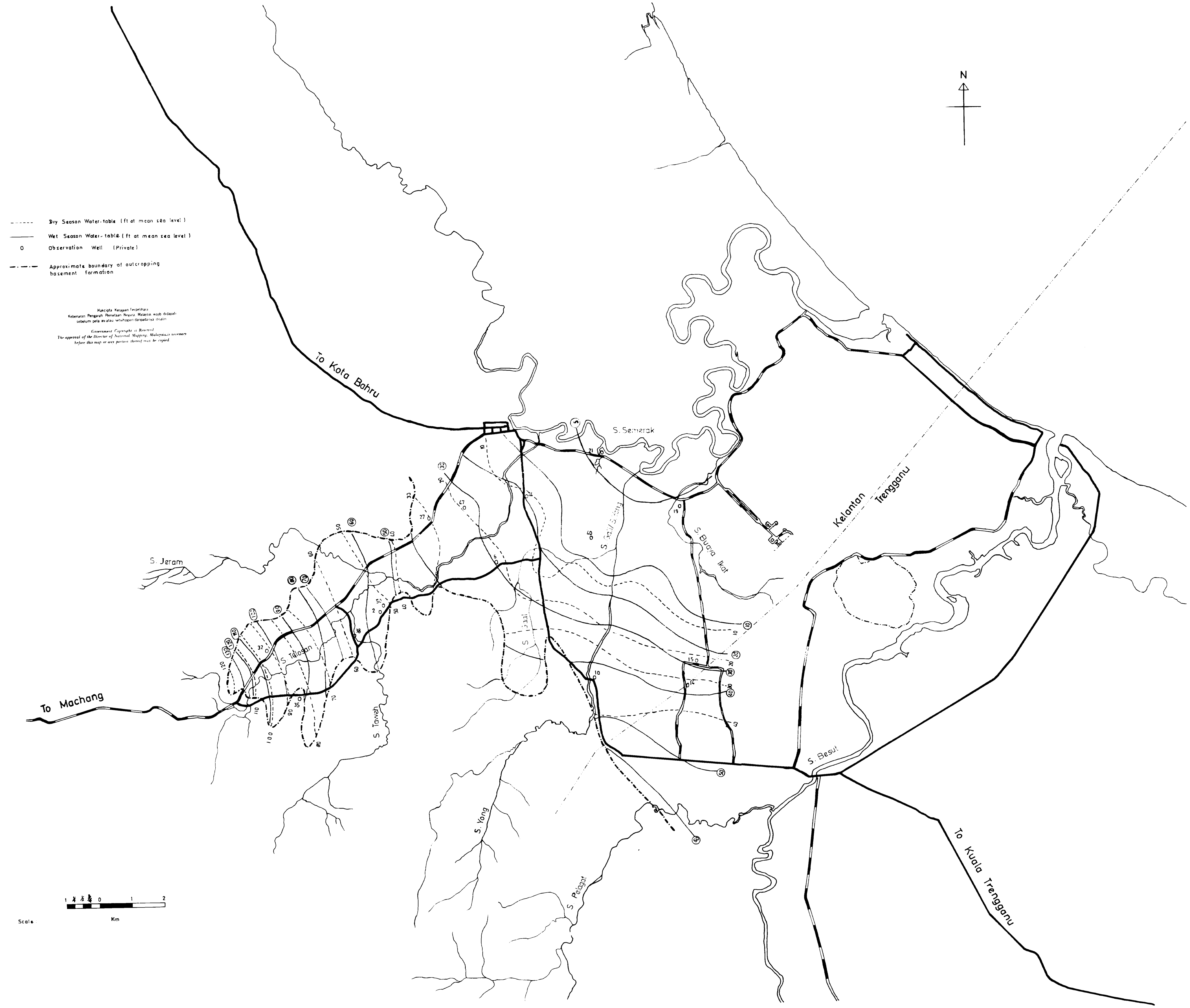


Fig 9 : Water table fluctuation for wet and dry seasons
(DID Water Resources Publication No. 8 - "Water Resources for Irrigation of Upland Crops in South Kelantan")

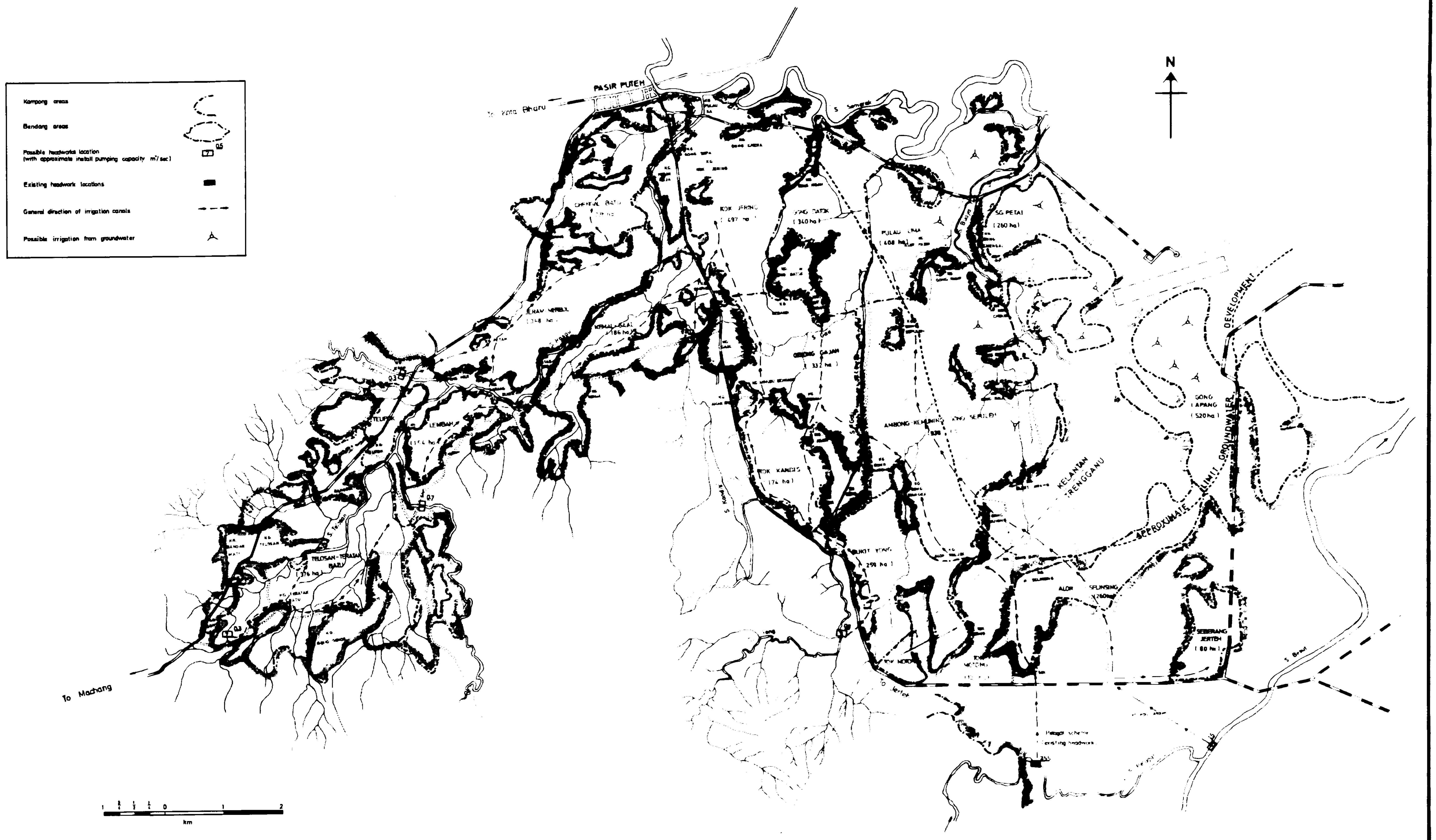


Fig 13 : Location of irrigatable areas : Sg. Rasau - Sg. Yong

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