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The Governments of Malaysia & the State of

# Johor tenggara

## 3 water resources

Hunting Technical Services Ltd  
Birds and Partners  
Overseas Development Group  
University of East Anglia  
Shankland Cox Overseas

1971

**THE GOVERNMENT OF MALAYSIA AND THE STATE OF JOHOR**

**JOHOR TENGAH AND TANJONG PENGERANG  
REGIONAL MASTER PLAN**

**SUPPORTING VOLUME 3**

**WATER RESOURCES**

**AUGUST 1971**

**Binnie & Partners • Hunting Technical Services Ltd.  
Overseas Development Group • Shankland Cox Overseas  
University of East Anglia**

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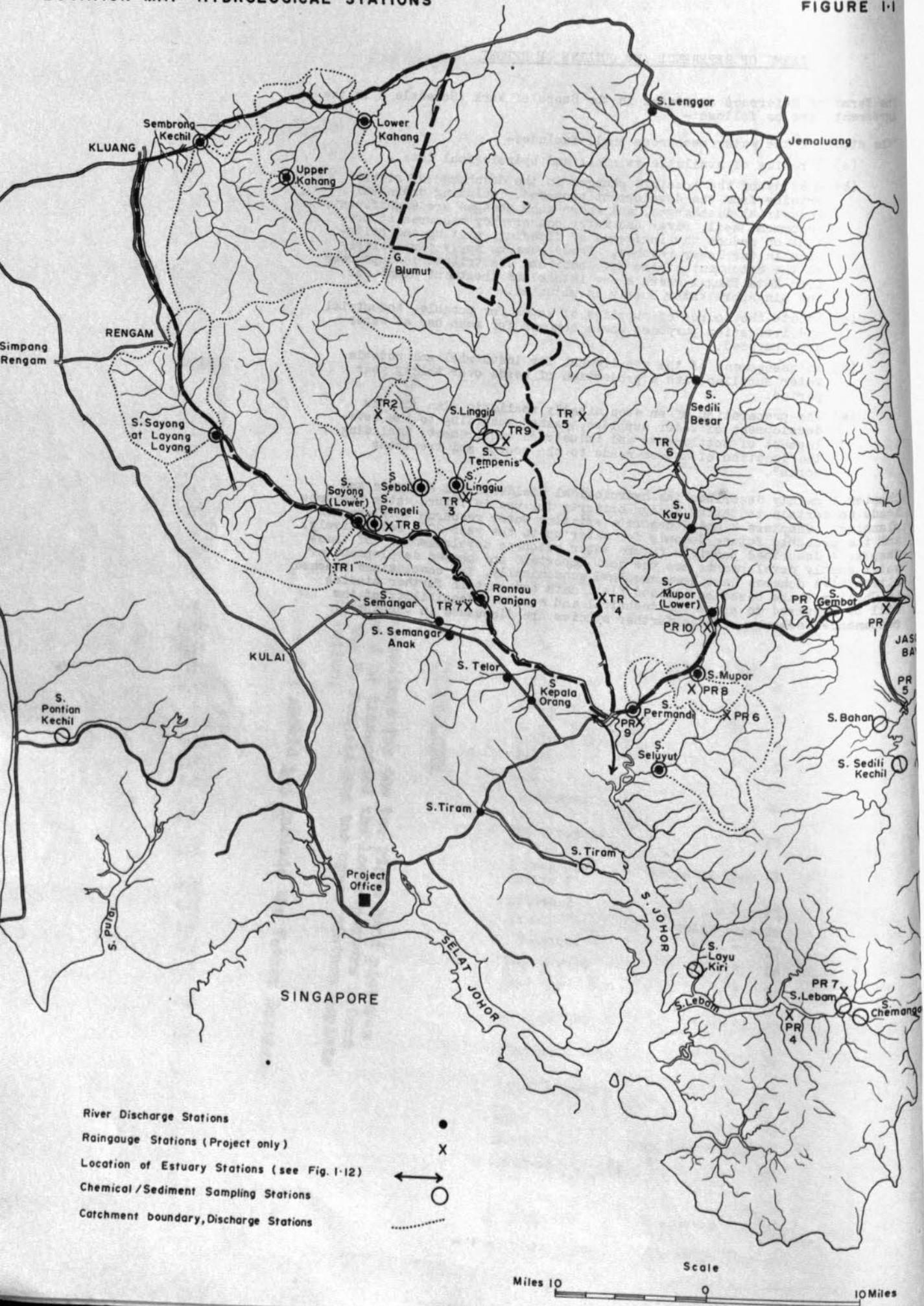
TERMS OF REFERENCE AND OUTLINE OF REPORT

The Terms of Reference as stated in the Scope of Work (Schedule A in the Agreement) are as follows:-

"The study of the water resources shall include:-

- (a) A review of available rainfall and hydrological data.
- (b) A study of the possible changes in the discharge of rivers arising from the development proposed, including urban and industrial discharges, and where such changes are significant, recommend soil, river and water conservancy measures to prevent or reduce the incidence of flooding, silting and pollution in the lower reaches. These remarks apply particularly to the catchment of the Sg. Johor and its tributaries upstream from Kota Tinggi where a new intake and treatment plant for the Singapore Water Supply is situated.
- (c) Locate the source of supplies of water for potable, industrial and irrigation purposes where schemes for such use of water are proposed.
- (d) An assessment of the requirement for industrial and potable water supplies with a projection of needs over thirty year period.
- (e) The preparation of an economically realistic plan for the development of water supplies, phased according to the development of settlements and industrial requirement, including the location of access roads to the source and treatment works".

Chapter 1 mainly describes the hydrological fieldwork and analysis and leads to certain tentative design criteria for use in future water resource planning. Chapters 2 and 3 describe existing water resource developments and the probable future demands for water up to the year 2000 respectively. Chapter 4 described possible future water resource developments; of these water supply developments are the most important and phased development of alternative schemes have been considered economically. The conclusions reached in Chapter 4 are based on limited field data and certain further studies will be required to prove the technical and economic feasibility of the recommended schemes. These further studies are discussed in Chapter 5.



CHAPTER 1  
HYDROLOGY

## 1.1 Introduction

### 1.1.1 Outline of Hydrological Study.

Existing hydrological data were examined in November/December 1969 (R1). By force of circumstances existing river flow data had been collected mainly for specific engineering projects and as such they were of fairly limited use in the determination of the overall changes in river regime characteristics due to large scale land clearance. Examples of this were the records of the S. Sembrong at Brizay Bridge, S. Sembrong Kechil at 4½ mile on the Kluang/Mersing Road, and S. Lenggur at 42nd mile on Kluang/Mersing Road. These three catchments were all between 72 and 80 square miles and were all completely jungle covered. In order to obtain a sufficiently variable range of catchment sizes and cover types, an extensive hydrological network was designed.

This network was established by the Project in December 1969 and January 1970 and was operated and maintained until the end of February 1971 when the Project field work terminated. On 28th February 1971 the entire network and field equipment was officially handed to the Drainage and Irrigation Department (DID) who have now undertaken the continued operation and maintenance of all stations.

The location of field stations is shown on Figure 1.1 and an outline of the more important field activities is shown in bar chart form on Figure 1.2.

### 1.1.2 General Climatology.

A complete description of the climate of the Project Area is contained in Supporting Volume 2 Part I. Aspects of hydrology such as evaporation, temperature, humidity, sunshine and wind speed have been fully discussed in that Volume and this chapter on hydrology deals only with those aspects which have required study as outlined in the Terms of Reference.

No large scale irrigation works are recommended (Supporting Volume 6 Part I) and no field study of evaporation, temperature, humidity sunshine and wind speed was required. Information contained in Supporting Volume 2 was based on existing data.

## 1.2 Hydrological Network

### 1.2.1 Future Staffing Requirements.

It is felt desirable to give guidance on the future staffing that will be required to operate and maintain the hydrological network and to perform the related analysis of data.

Based on Project experience a qualified hydrologist, assistant hydrologist/engineer and four hydrological field assistants, all employed full time, will be required; in addition drivers, labourers and a boatman will be required. During the Project the demand for vehicles per day varied; a requirement of two vehicles per day was common and occasionally four vehicles were required. The local residents engaged by the Project to read instruments daily should be encouraged to continue with the readings.

### 1.2.2 Water Level Recording Stations.

Nine automatic water level recording stations were installed to provide information on river discharges. The locations of these stations, as well as several other spot check stations, and the existing DID station on the S. Johor at Kg. Rantau Panjang is shown on Figure 1.1.

Four automatic water level recorders were also installed on the S. Johor estuary for short periods, to provide necessary information on tidal characteristics.

The measurement of discharge was carried out by current meter and a total of 385 discharge measurements were completed by Project staff up to 28th February 1971. Sufficient measurements were obtained to fully define discharge rating curves to acceptable standards. Two detailed measurements of tidal discharge were also made on the S. Johor at Kota Tinggi, and this involved continuous measurement over periods of approximately 15 hours on both occasions.

River discharge station histories together with summaries of discharge measurements, rating curves, and tabulations of mean daily discharges have been compiled (Appendices A-1 to A-42).

### 1.2.3 Rainfall Stations.

Nineteen rain gauges were installed within and adjacent to the Project Area in order to supplement the coverage provided by the existing DID state network. Prior to this rainfall data were virtually non-existent within the Project Area because of problems with access and regular maintenance. The location of Project rainfall stations is shown on Figure 1.1.

All Project rain gauges were constructed of galvanised iron and were fitted with standard five inch diameter brass rims on the catching funnel. Standard five inch glass measuring cylinders were used.

In areas where access was difficult, the rain gauges were operated either as weekly or monthly storage gauges. Where possible daily readers were employed and if doubt existed as to the quality of the readings, additional storage gauges were installed as a check on the daily readings.

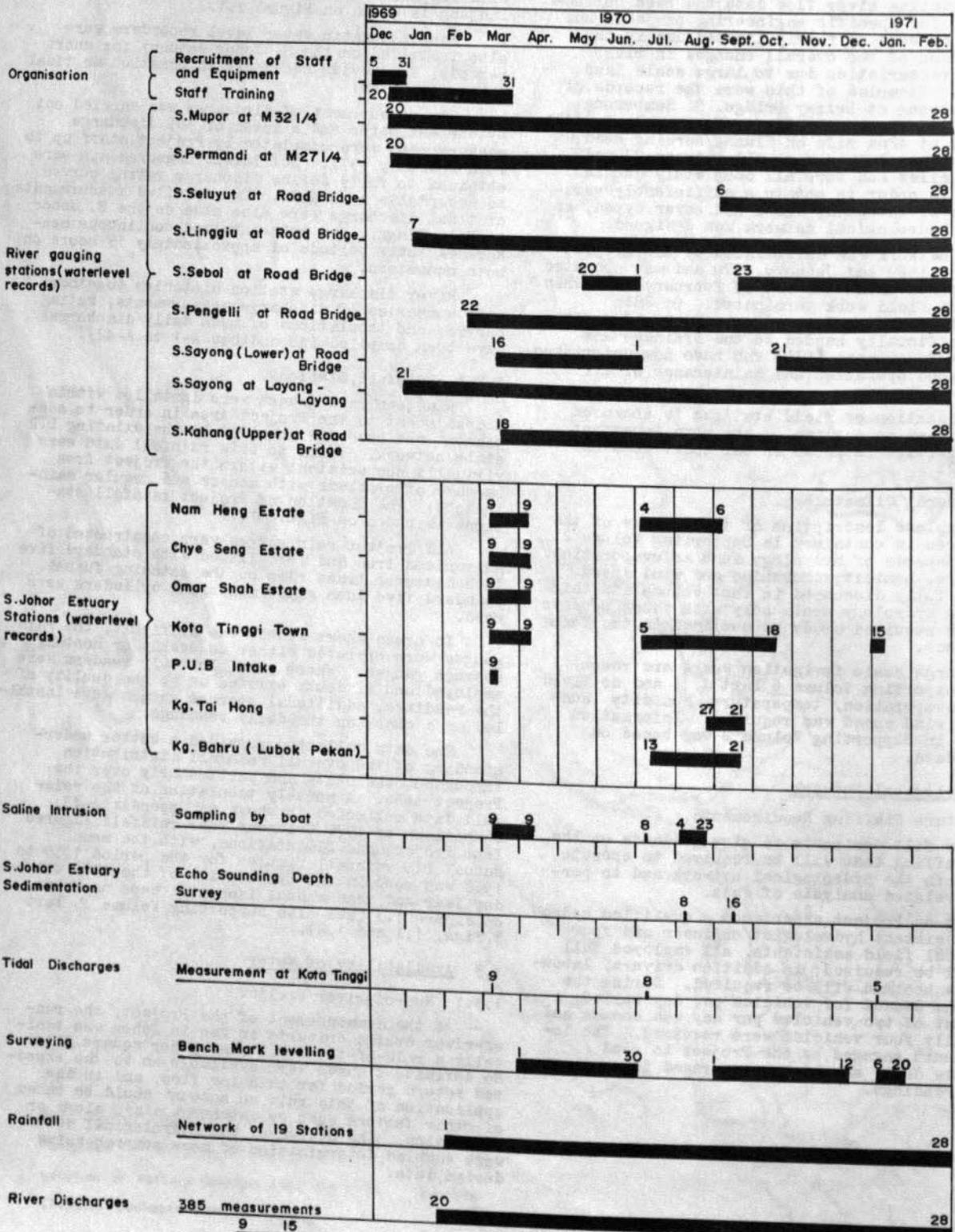
The data collected provided a better understanding of the overall rainfall distribution throughout the State and particularly over the Project Area. A monthly tabulation of the rainfall data collected is shown on Appendix A-43. Comparison of 1970 Calendar Year rainfall figures from Project and DID stations, with the mean annual DID rainfall figures for the period 1950 to 1968 was used in the preparation of the 1970 Calendar Year and mean annual isohyetal maps as shown on Figure 1.3 (see also Supporting Volume 2 Part I Figs. 1.1 and 1.2).

## 1.3 Availability of Water

### 1.3.1 Run-of-river Yields.

At the commencement of the Project, the run-of-river design criteria in use in Johor was basically a rule-of-thumb 0.2 cusecs per square mile. No definite figures were available as to the expected return period for this low flow, and in the application of this rule no account could be taken of other factors such as catchment size, slope or vegetation. The design of the hydrological network enabled determination of more comprehensive design data.

SUMMARY OF PROJECT HYDROLOGICAL FIELD ACTIVITIES FROM 5-12-69 TO 28-2-7

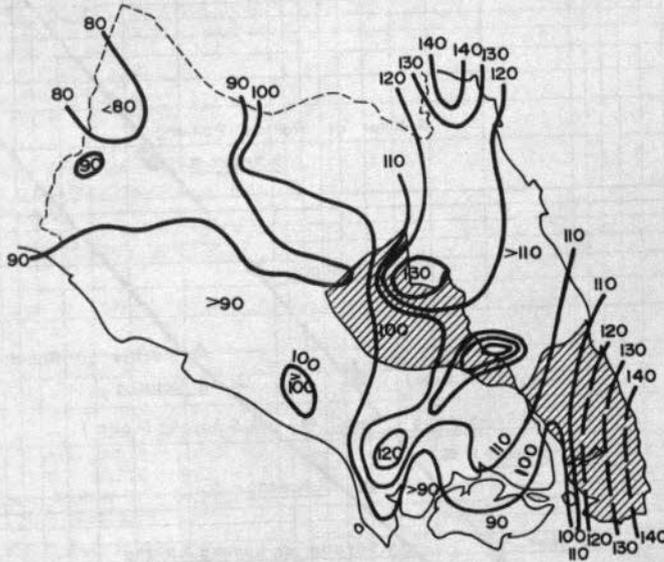


█ - indicates activity commenced on 9th. of the month indicated and finished on 15th of the month indicated.

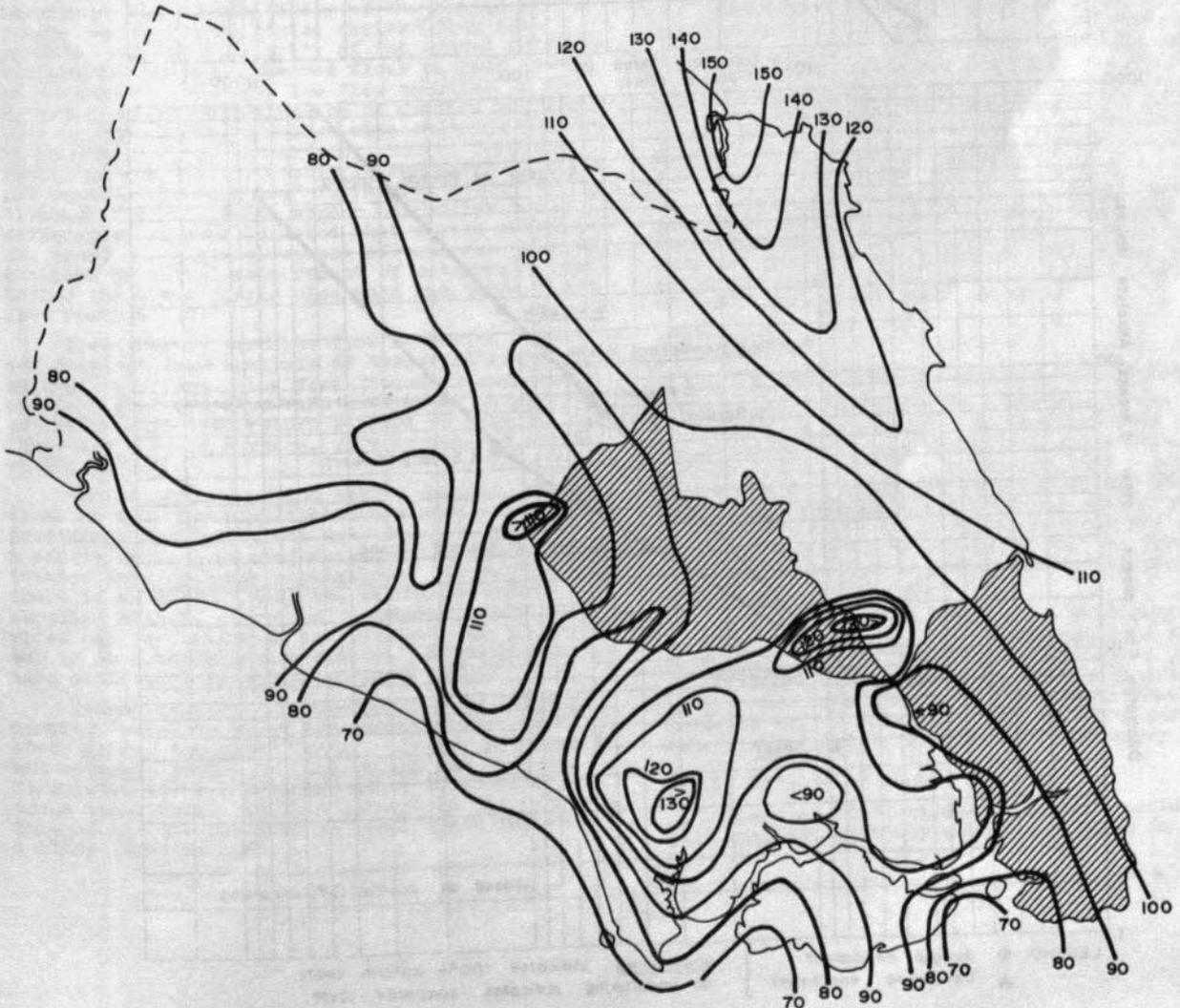
JOHOR STATE

ISOHYETAL MAPS - 1970 CALENDAR YEAR AND MEAN ANNUAL RAINFALL

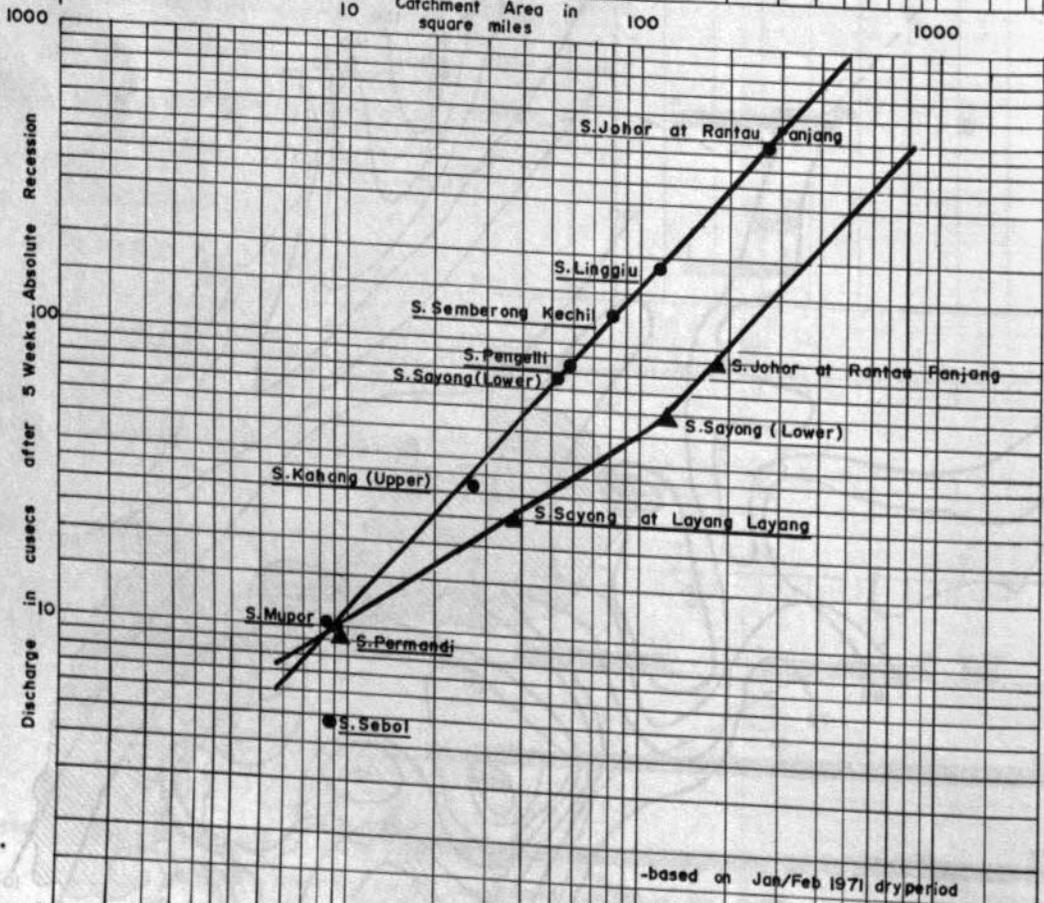
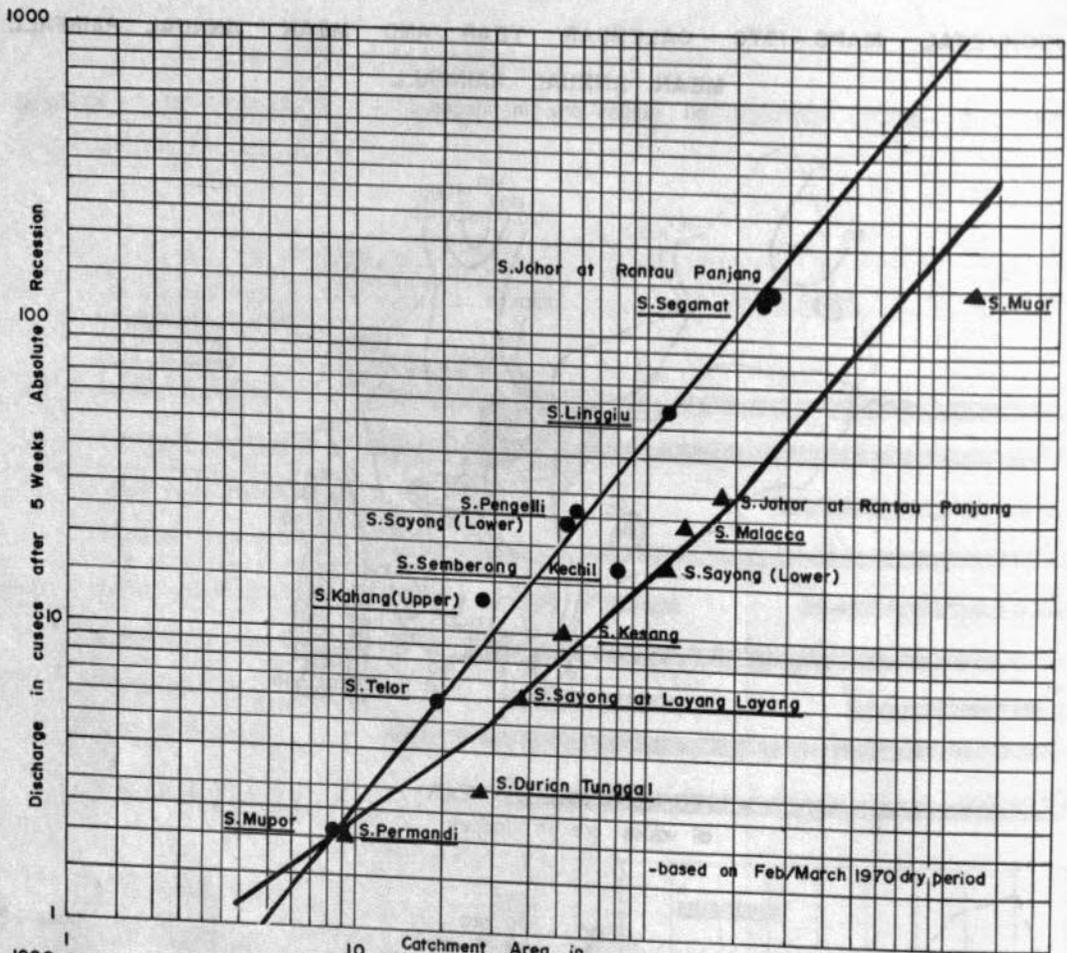
MEAN ANNUAL RAINFALL  
all values are in inches



1970 CALENDAR YEAR  
all values are in inches



FLOW RECESSION CHARACTERISTICS OF JUNGLE COVERED AND DEVELOPED CATCHMENT



LEGEND: ● Jungle catchment  
 ▲ Developed catchment  
 } underlining indicates 100% uniform cover  
 no underlining indicates composite cover.

Long records of river discharge were not available on catchments with a suitable range of sizes and vegetation covers to enable straight forward frequency analysis of actual low flows to be carried out. Low flow measurements made at the three stations mentioned in Section 1.1 showed considerable scatter due solely to inherent on site field measurement difficulties. Hence the analysis of low flows was based on a detailed examination of flow recession characteristics combined with a frequency analysis of dry period lengths as determined from the extensive rainfall data available.

Flow recession data for the February 1970 dry period was examined at all Project and DID stations. Considerable difference was observed in the low flow characteristics of jungle covered catchments compared to catchments developed with Rubber and for Oil Palm.

The first indication of these results was presented to the Government in June 1970, and later all characteristics such as slope, geology and catchment shape were examined in detail. In spite of some notable differences in these characteristics between the various catchments, indications are that if the flows of all catchments were adjusted to constant slope, geology and catchment shape, then perhaps greater difference would be observed between the low flows of jungle and developed catchments (see Section 1.9).

Flow recessions analysed after the January 1971 floods show remarkable similarity to the results obtained from the February 1970 recessions. Comparison of the flow recession values five weeks after the peak discharge is shown in Figure 1.4. The fact that the January 1971 curves show higher discharge than the February 1970 curves is due solely to the much higher initial discharge at the start of the January 1971 recessions. Of most importance is the similarity of the shapes of the jungle and developed curves derived from both periods, and the similarity of the actual relative differences between observed flows on both types of catchment. The very low flow recorded on the S. Sebol may be an indication of surface runoff loss to groundwater although with only one point it is difficult to be certain. The S. Sembrong Kechil gave a similar result in Feb/March 1970 and yet behaved "as expected" in Jan/Feb 1971. Although Figure 3.4 may appear to confirm these differences it must be noted that strict scientific proof of jungle clearance effects can only be obtained by actual measurement of catchments both before and after jungle clearance has taken place (see Section 1.9).

Frequency of probable flow recession times was obtained from analysis of twelve selected rainfall stations. Low flow frequency was then obtained from the recession analysis. Design run-of-river flows, for return periods of once in 10 years and once in 5 years, were derived as shown on Figure 1.5.

The occurrence of the severe drought conditions in 1971 has highlighted the advisability of providing, for infrequent use, some storage (as a safety factor) in conjunction with run-of-river intakes serving large populations. Without storage there is no control over the amount by which supplies must be restricted. Where storage is provided the imposition of restrictions can be carried out in an orderly manner without seriously disrupting activities dependent on the supply.

Safety factors are incorporated in all engineering design to allow for contingencies over and above normal design criteria. However a workable and economic policy in this regard can only be formulated after a detailed study of possible extreme conditions. In this connection the present drought in 1971 provides an ideal basis for such a study (Section 1.9).

### 1.3.2 Direct Supply Storage Yields.

The possibility of extending the seven year record on the S. Johor at Kg. Rantau Panjang was examined on a computer. Five different mathematical models were constructed using monthly rainfall and runoff figures and allowances for antecedent moisture conditions and runoff in the preceding months. The models were unable to reproduce historic monthly flows. A similar model based on daily values, would give far better correspondence with historic conditions. Such a model would have required the handling of a much greater amount of data and time did not allow for it to be produced. Therefore storage/yield analysis was based on the transposition of existing data from other catchments in West Malaysia.

Transposition of these data was assisted by the knowledge of catchment behaviour obtained from the low flow analysis (Section 1.3.1). Particular mention should be made of the use made of the flow characteristics of jungle and developed catchments in testing the validity of certain assumptions made in the extension of the yield data to cover storage requirements on developed catchments. The derived storage yield relationships are shown on Figure 1.6 and yields are quoted for a design return period of once in 30 years.

There are indications that the average runoff from a jungle catchment will increase by perhaps 10 percent when the catchment is cleared of jungle and developed with Rubber/Oil Palm. However this increase in average runoff will most likely only become available for use when regulation in excess of approximately 2½ cusecs/square mile is achieved. Below this order of regulation yield requirements can be expected to decrease as a result of jungle clearance.

### 1.3.3 Groundwater Potential.

Although a study of groundwater was specifically excluded from the Terms of Reference, a brief study was included for the sake of completeness in the Water Resources investigations. An engineering geologist has examined existing bore hole information and geological maps and has carried out a brief field inspection (Appendix D). The most promising areas for future groundwater investigations are shown on the Figures in this Appendix.

A gauging station was installed on the S. Sebol catchment which is almost entirely composed of Pantli Sandstone. However the short records available have not provided any definite indications of groundwater and further data would be required before definite statements could be made.

## 1.4 Flooding.

### 1.4.1 December 1969 and January 1971 floods.

Two notable floods occurred during the period of field investigations. In December 1969 a major flood occurred before the hydrological network was properly established. In January 1971 a lesser flood occurred which was recorded on all Project Stations. Limited information was available for the December 1969 flood event; however the large volume of information collected for the January 1971 flood enabled accurate assessments of both events to be prepared.

A summary of the information available is shown in Table 1.1 and the flood hydrographs on the S. Johor and its major tributaries are shown graphically on Figure 1.7. Generally the flooding in January 1971 was less severe in South Johor than in December 1969. However in the northern parts of Johor, flood levels were higher in January 1971.

### 1.4.2 Effects of Jungle Clearance.

There are indications that peak discharges will increase markedly when a catchment is cleared

RUN OF RIVER DESIGN YIELDS

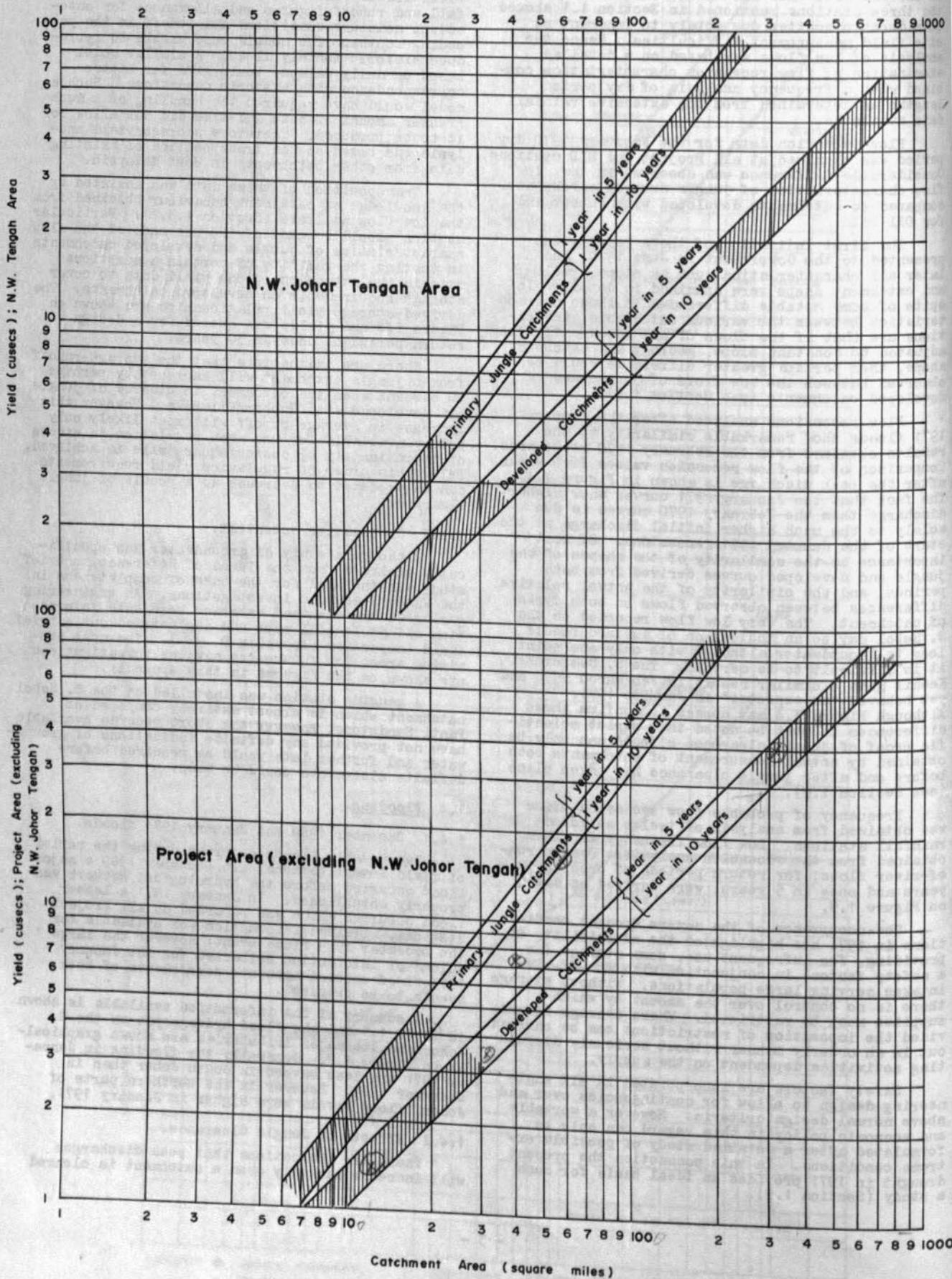
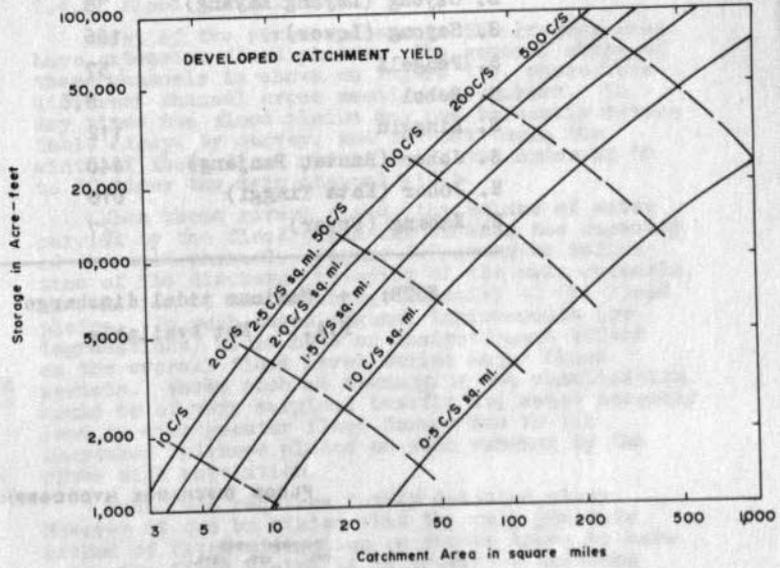
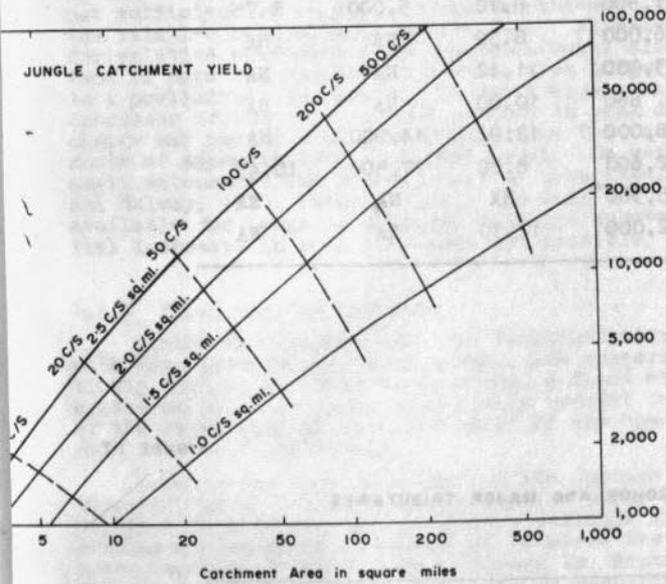


FIGURE 1-6

DIRECT SUPPLY STORAGE YIELDS; FOR 30 YEAR DESIGN RETURN PERIOD

N.W. JOHOR TENGAH



PROJECT AREA EXCLUDING N.W. JOHOR TENGAH

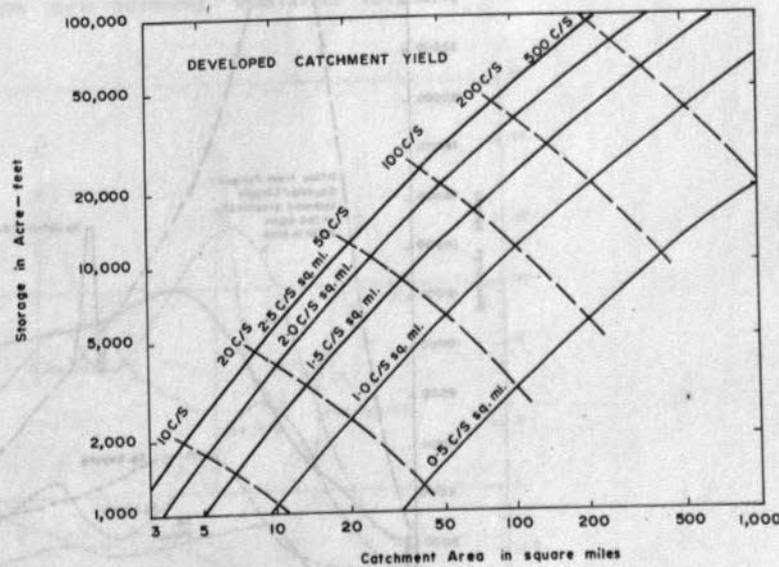
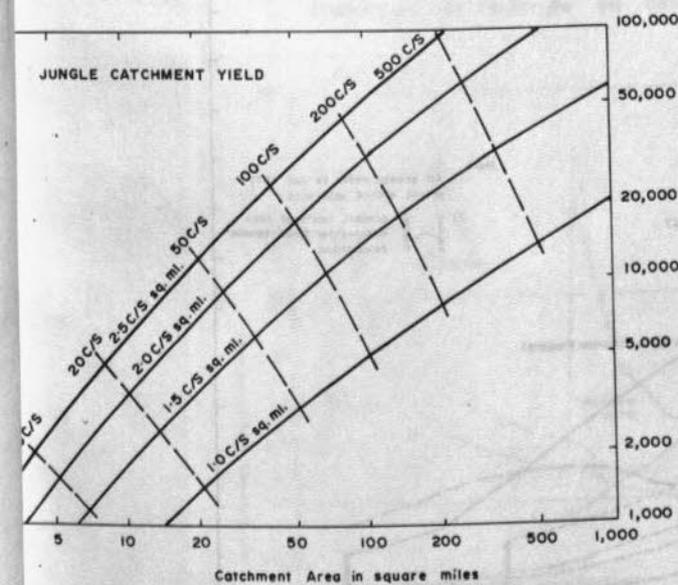


TABLE 1.1

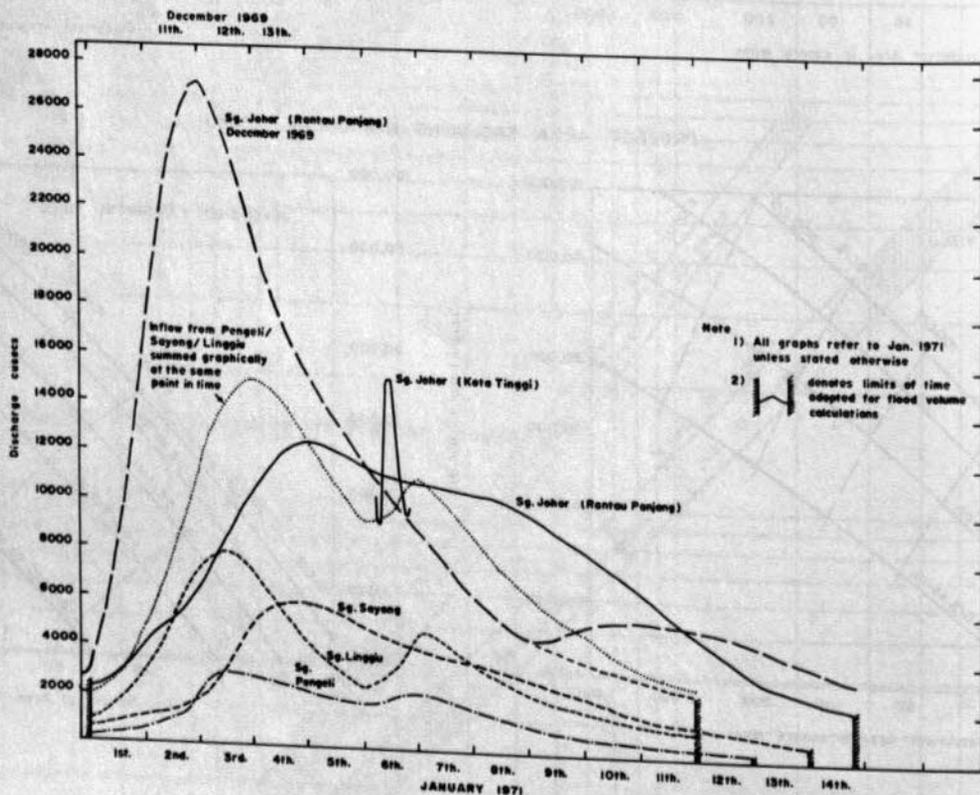
Summary of Flood Information

Station	Catchment Area square miles	Jan. 1971 Flood		Dec. 1969 Flood	
		peak cusecs	Inches runoff	peak cusecs	Inches runoff
S. Mupor	8.4	620	7.63	5,000	9.92
S. Permandi	9.1	1,000	9.86	5,000	12.48
S. Seluyut	23.7	2,000	11.35	NA	NA
S. Sayong (Layang Layang)	38	1,500	8.10	5,000	8.75
S. Sayong (Lower)	166	6,000	8.30	NA	NA
S. Pengeli	57	3,000	11.12	NA	NA
S. Sebol	8.6	660	10.00	NA	NA
S. Linggiu	112	8,000	12.92	14,000	NA
S. Johor (Rantau Panjang)	440	12,600	8.89	27,500	10.43
S. Johor (Kota Tinggi)	610	15,300 <sup>+</sup>	NA	NA	NA
S. Kahang (Upper)	27	2,000	12.10	NA	NA

NOTE: + Maximum tidal discharge  
N.A. - Not Available

FIGURE 1-7

## FLOOD DISCHARGE HYDROGRAPHS, S. JOHOR AND MAJOR TRIBUTARIES



of jungle and developed for agriculture. Two adjacent catchments, one 8.4 square miles of jungle cover (S. Mupor), the other 9.1 square miles developed with Rubber/Oil Palm (S. Permandi) were examined in detail. On the six occasions in twelve months when the run-off on both catchments simultaneously exceeded 10 cusecs/square mile, the peak discharges on the developed catchment were significantly higher than on the jungle covered catchment. Increases in unit peak discharges on these six occasions were 34, 49, 87, 140, 99 and 97 percent. The six hydrographs for each catchment are shown on Figure 1.8.

From field observations it appears unlikely that a substantial part of these increases could be due to rainfall alone. Rainfall coverage was not sufficient to enable a definite statement on the relative rainfalls to be prepared. Allowances for relative catchment slope and size would also tend to make the absolute increases even larger. As a preliminary assessment, it would appear that increases of the order of 100 percent in peak discharge may result from jungle clearance for catchments of approximately 10 square miles. On very small catchments the increase may be less (Hewlett and Helvey, 1970; Nakano, 1967). No data are available for large catchments, although substantial increases in peak discharge are possible.

#### 1.4.3 Flood warning systems.

Within the Project Area the drainage systems, with the exception of the S. Johor, are comparatively small. On these small areas, a flood warning system would be of relatively little benefit because of the short time between the onset of the heavy rain and the flood itself.

However the data collected on the January 1971 flood in the S. Johor catchment and its major tributaries do indicate that perhaps a reliable flood warning system could be developed to serve the lower reaches of the S. Johor between Kg. Rantau Panjang and Kota Tinggi. It should be possible to

implement a scheme using radio telemetry methods whereby flood danger could be forecast 48 hours in advance, and accurate flood levels at Kota Tinggi predicted 24 hours in advance.

There are several factors such as the size and shape of the channels and their bankfull discharge capacity (Fig. 1.10) which indicate that perhaps a significant portion of the S. Johor major floods originate from the S. Linggiu area, however more floods need to be observed and documented before this can be quantitatively clarified. Should this ultimately prove to be the case, then an impounding scheme on the S. Linggiu may well provide a reasonable measure of flood mitigation benefit along the lower reaches of the S. Johor.

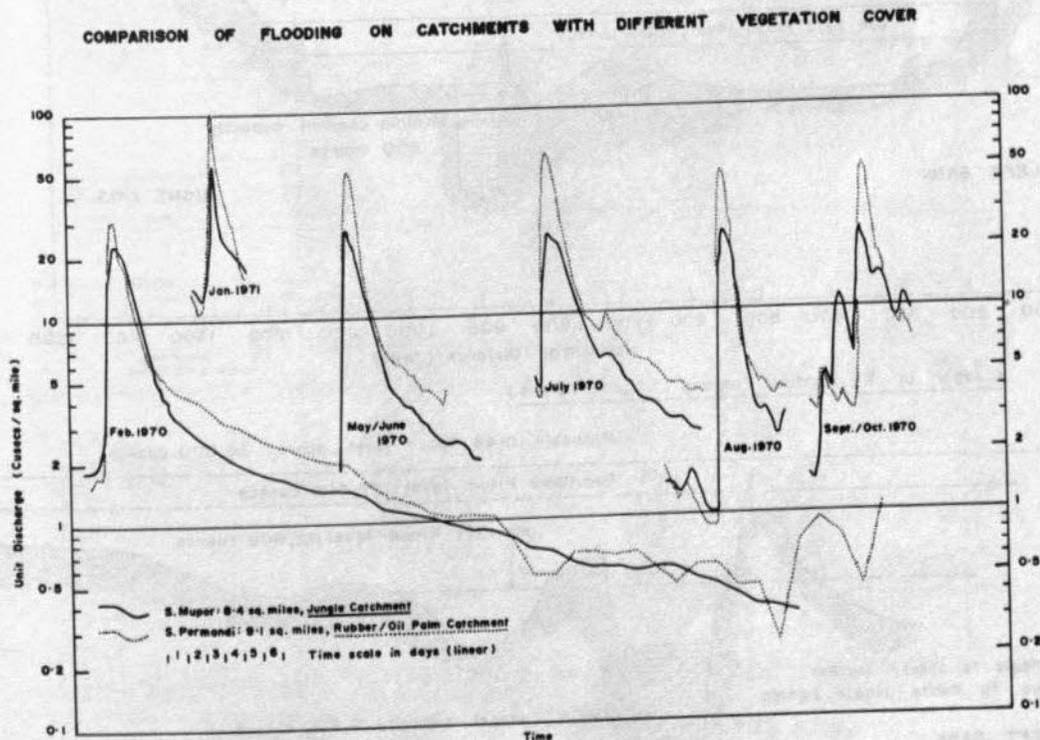
#### 1.4.4 Flood Mitigation.

Most of the river systems in the Project Area have extensive flood plains. The general shape of these channels is shown on Figure 1.9, where four different channel cross sections are shown. In dry times the flood plains may not be easily detectable except by survey, and in most cases the width of these flood plains is of the order of 10 to 30 times the main channel width.

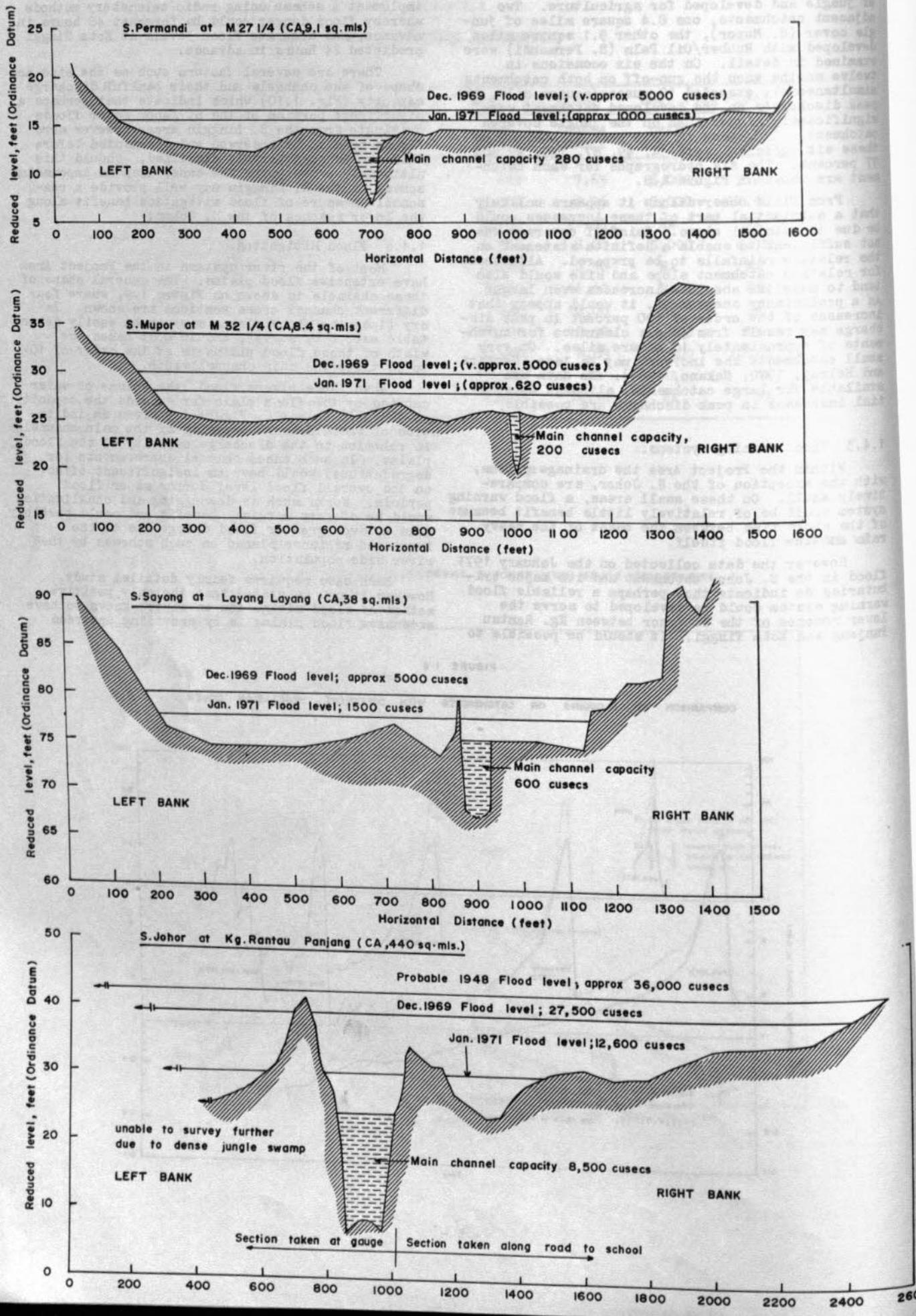
When these rivers flood, the volume of water carried by the flood plain far exceeds the capacity of the main channel. Figure 1.9 gives an indication of the discharge capacity of the main channels in relation to the discharge capacity of the flood plains. In such cases channel improvements (or degradations) would have an insignificant effect on the overall flood level during major flood periods. Works such as desnagging and canalization would be of very marginal benefit and could possibly lead to even greater flood damage due to the increased reliance placed on such schemes by the river side population.

Each case requires fairly detailed study. However it can be stated that the only positive method of flood mitigation on rivers known to have extensive flood plains is by providing upstream

FIGURE 1.8



SELECTED RIVER CROSS-SECTIONS; ILLUSTRATING FLOOD PLAIN CHARACTERISTICS



storage rather than by other localised preventive measures (Section 1.4.5).

#### 1.4.5 Flood Frequencies.

Determination of a design flood frequency diagram applicable to the general Project Area can only be made when longer records are available from different catchment types and sizes.

A plot of known flood peak discharges which have occurred elsewhere in West Malaysia is shown on Figure 1.10, and several broad bands have been drawn to give a preliminary indication of the order of peak discharge which could be expected under various design conditions. Many factors affect the magnitude of the peak discharge at any given location (e.g. the relatively low discharges on the S. Johor at Kg. Rantau Panjang are due to the massive flood plain storage) and the generalised curves on Figure 1.10 should be used only as a guide to obtain an approximate preliminary design figure.

Bankfull discharge would appear to be a very common event and discharges of this order could be expected to occur perhaps several times each year (Fig. 1.10).

#### 1.5 Raw water quality

Samples of raw river water were taken at twenty two locations as shown on Figure 1.1. Ninety four samples were analysed by the Department of Chemistry (Appendices A-44 to A-47).

Samples were normally taken from mid-stream at approximately one foot below the surface. In certain cases samples were taken in the centre of that section of the channel which contained the majority of flowing water. In cases where the water was very shallow, the sample was taken just below the surface, and exposed surface water or stagnant water was not sampled.

All water sampled can be treated to provide potable water. However certain pollutants such as arsenic, oil, mining silt and organic wastes should be controlled in order to prevent their appearance in raw river water (Section 1.7). Water treatment is all a matter of degree - the more pure the raw water then the simpler and less expensive the treatment.

#### 1.6 Sediment Transport

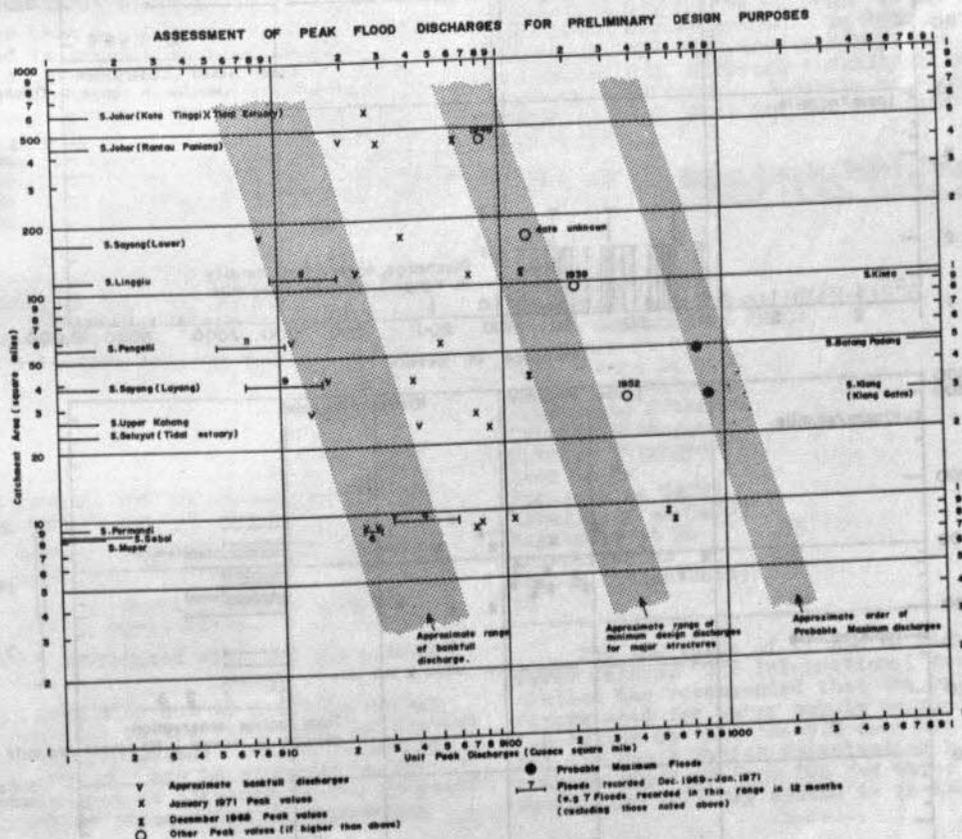
Samples of suspended sediment load were taken at three locations, S. Mupor, S. Permandi and S. Sayong at Layang Layang (Fig. 1.1). These samples were analysed for total solids and solids in suspension by the Department of Chemistry.

All samples were taken using a depth integrating, wading type, hand sampler, type US DH-48 (quarter inch nozzle). The streams were measured on the uniform vertical spacing method, (WMO Flood Control Series No.22; USGS Bulletin No.1181 A). The actual method of sampling was as described in the instructions with the DH-48 sampler.

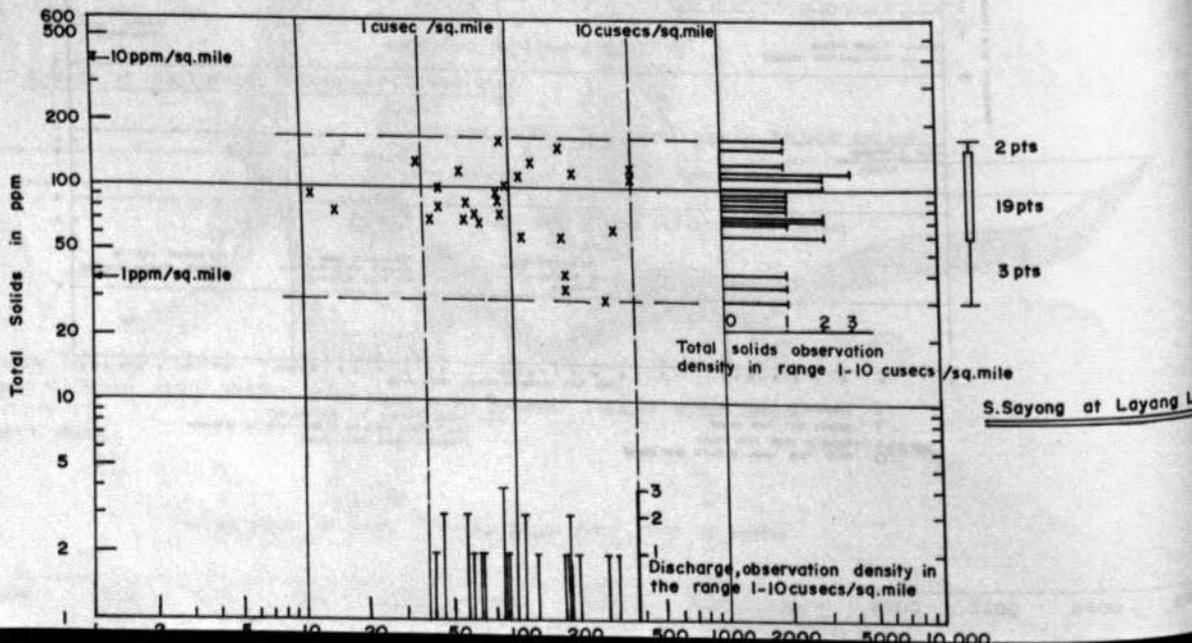
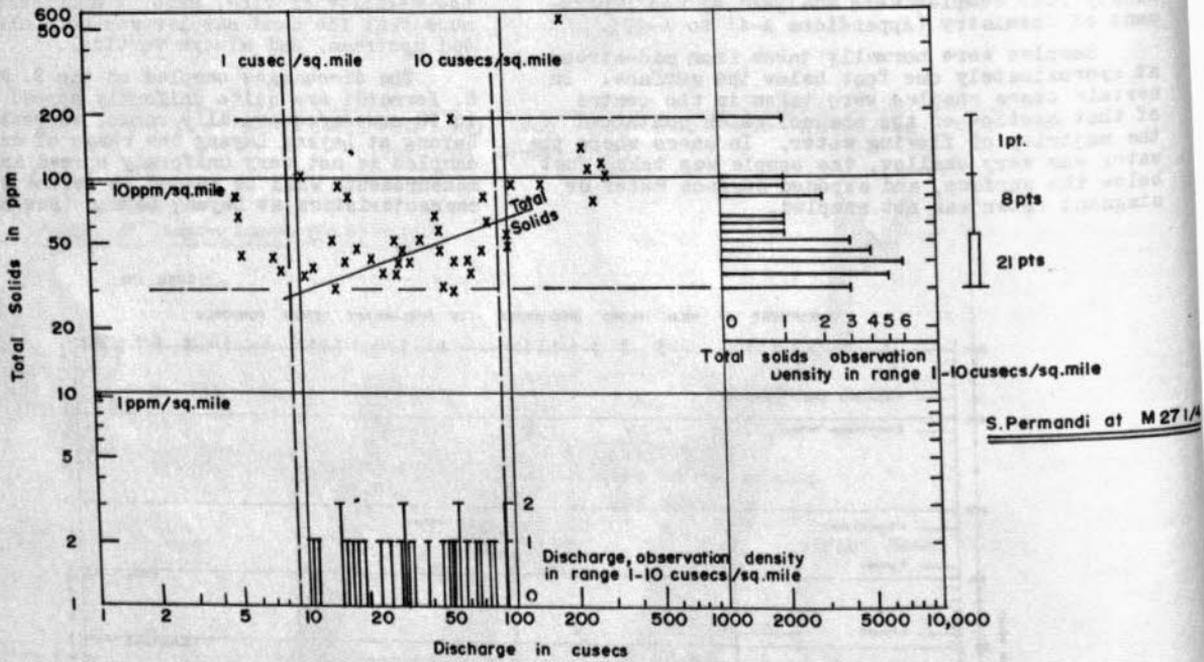
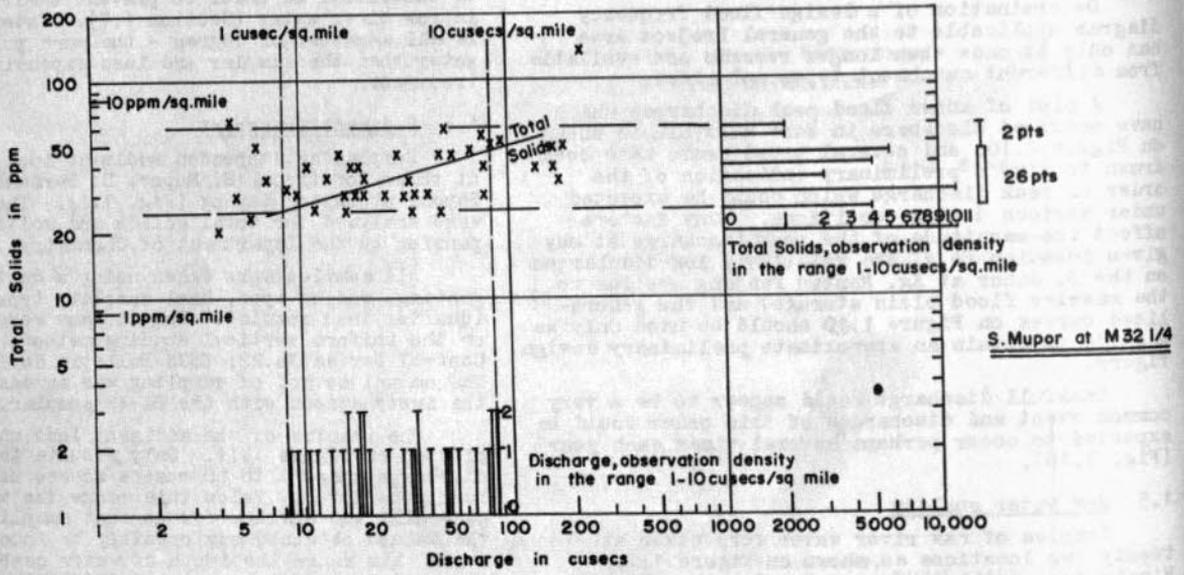
The results of the sediment load analyses are plotted on Figure 1.11. Only results in the water discharge range 1 to 10 cusecs/square mile have been considered. Below this range the water was generally too shallow for correct sampling, and the values obtained may possibly be incorrect. Above this range the depth of water combined with the velocity of flow, made it difficult to be sure that the hand sampler was both always pointed upstream, and always vertical.

The discharges sampled on the S. Mupor and S. Permandi are quite uniformly spread in the 1 to 10 cusecs/square mile range, whereas on the S. Sayong at Layang Layang the range of discharges sampled is not very uniformly spread and more measurements will be needed to define the sediment characteristics at Layang Layang (see Section 1.9).

FIGURE 1-10



SEDIMENT LOAD CHARACTERISTICS



Considerable scatter is evident at all three stations. This is to be expected, as the quantity of sediment carried for any given discharge depends on the intensity of the producing storm and on the prevailing instantaneous catchment conditions. It is also known that generally the sediment discharge hydrograph lags appreciably behind the water discharge hydrograph. At present sufficient numbers of samples and lengths of flow records are not available to justify further analysis apart from the rather generalised statements listed below:-

a) On the S. Mupor (8.4 square mile catchment, jungle covered) there is a tendency for increased sediment concentration with increased discharge. As the discharge increased ten times, the concentration of total solids increased 1.96 times. At the 1970 calendar year mean discharge of 30 cusecs, the concentration of total solids is approximately 35 ppm. This corresponds to a rate of soil erosion from the catchment of 110 tons/square mile/year.

b) On the S. Permandi (9.1 square mile catchment, developed with mature Rubber/Oil Palm) there was a more marked tendency for a general increase in the sediment concentration with increasing discharge. A mean line drawn, ignoring extreme values, indicates that as the discharge increased ten times, the concentration of total solids increased 2.30 times. At the 1970 calendar year mean discharge of 37 cusecs, the concentration of total solids is approximately 45 ppm. This corresponds to a rate of soil erosion from the catchment of 161 tons/square mile/year.

c) On the S. Sayong at Layang Layang (38 square mile catchment, developed with mature Rubber/Oil Palm) the points were too scattered to derive even an approximate line. However, there are definite indications of generally higher sediment concentrations, approaching twice the concentrations on the S. Permandi. Assuming an average value of around 100 ppm, at the 1970 Calendar year mean discharge of 132 cusecs, the corresponding rate of soil erosion from the catchment is 305 tons/square mile/year.

It is clear that a sustained general increase in sediment load is associated with jungle clearance. This investigation was not aimed at determining the exact source of any increased sediment load, but only at the end result. The changes in both the rate of runoff (see Section 1.4.2) and in the composition of the upper soil horizon, and the depth of any overlying leaf mulch would seem to be very significant factors in the increase of sediment load following jungle clearance.

Sediment load is also increased by certain industrial activities such as mining and processing factories. The more notable effects of tin mining on the sediment load in the S. Johor are discussed in the section dealing with Pollution (Section 1.7.4).

## 1.7 Pollution

### 1.7.1 Sources.

The major present and future sources of pollution in river waters are:-

- Trade wastes from agricultural processing factories.
- Insecticides, herbicides and fertilizers used in agriculture.
- Sediment associated with the tin mining industry.

At present pollution due to domestic sewage is not significant due to the fact that the Project Area is very thinly populated. Future pollution due to domestic sewage may be expected to be very small if treatment is provided in the proposed towns and villages as recommended in Supporting

### 1.7.2 Trade wastes from processing factories.

Effluent samples have been taken from Palm Oil and Rubber Factories close to the Project Area. These samples have been analysed by the Department of Chemistry and the results are shown in Table 1.2.

TABLE 1.2 Analysis of Factory Effluents  
Palm Oil Factory Effluent (figures expressed in ppm)

Sample No.	Oil	5 Day B.O.D.	Total Solids	Suspended Solids
1	19,800	20,000	54,300	29,200
2	8,380	18,000	126,000	99,400
3	7,500	15,500	75,800	49,600
4	44,930	13,000	70,500	54,400

Rubber Factory Effluent (figures expressed in ppm)

Sample No.	Process	5Day B.O.D.	Total Solids	Suspended Solids
1.	Centrifuge	1,300	905	260
2.	"	2,000	980	590
3.	Crumb and	750	2,440	430
4.	Crepe	1,100	2,160	90

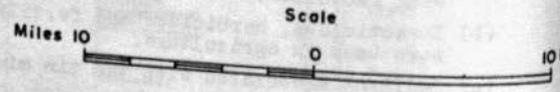
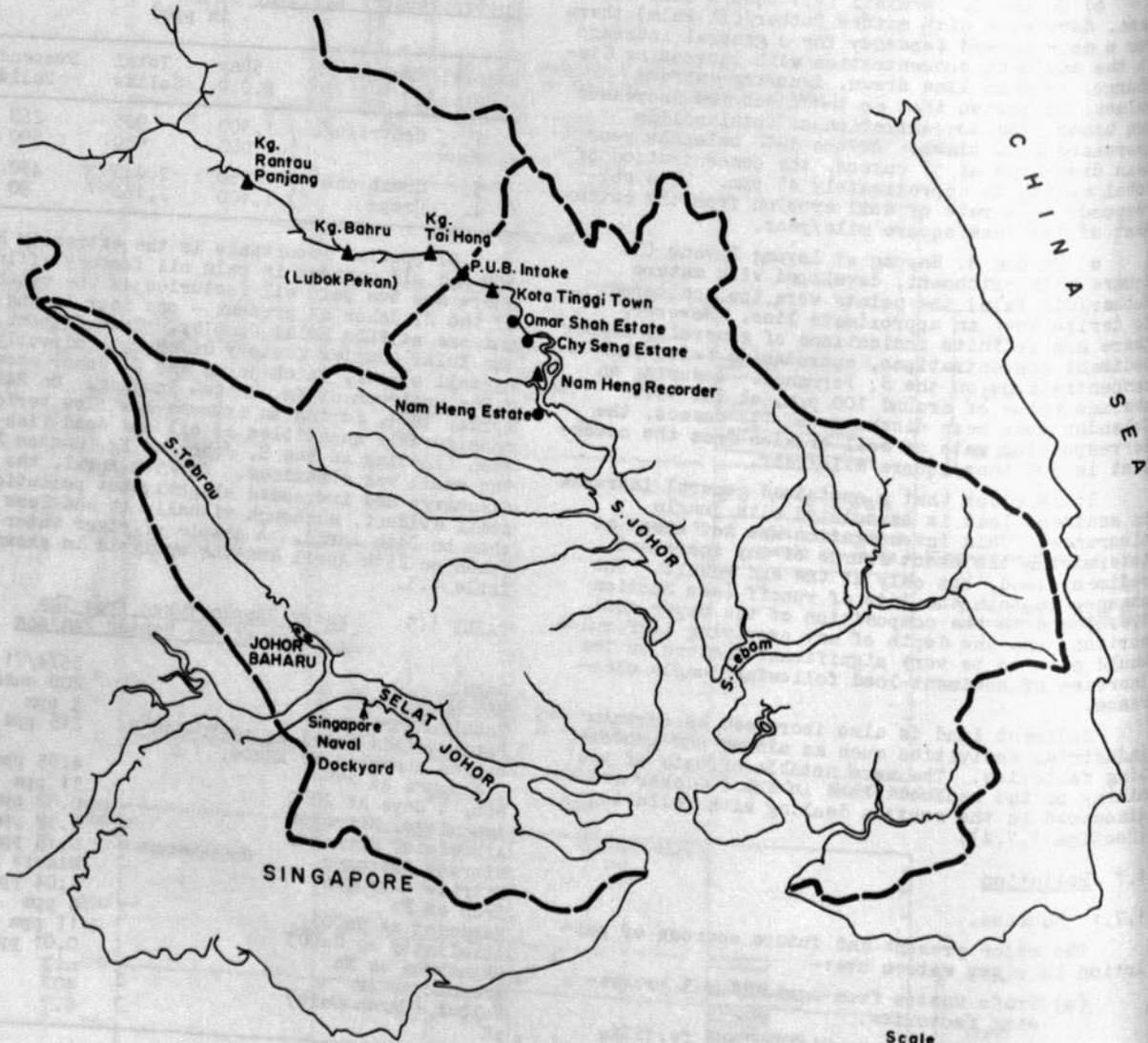
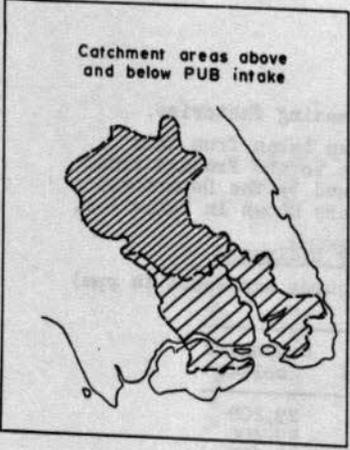
Of special importance is the extremely high BOD and oil content in palm oil factory effluent. There are two palm oil factories in the catchment of the S. Johor at present - one near Layang Layang and one at FLDA Kulai Complex. The effluent from the Kulai Complex factory discharges directly into a small stream, which joins the S. Johor about 2 miles upstream of Kg. Rantau Panjang. On 24th April, 1971, during an extreme low flow period, considerable quantities of oil and dead fish were seen floating in the S. Johor at Kg. Rantau Panjang. The smell was obnoxious. On 25th April, the river discharge had increased slightly but pollution was still evident, although visually it was less acute than on 24th April. A sample of river water was taken on 25th April and the analysis is shown in Table 1.3.

TABLE 1.3 Water Sample Taken From The  
S. Johor at Kg. Rantau Panjang

Date	25/4/71
Discharge	208 cusecs
Total chlorides	3 ppm
Total Solids dried at 105°C-110°C	215 ppm
Oxygen absorbed by KMnO <sub>4</sub> , 4 hours at 27°C	4.65 ppm
BOD, 5 days at 20°C	11 ppm
Ammoniacal Nitrogen	0.02 ppm
Albuminoid Nitrogen	0.38 ppm
Nitrate Nitrogen	0.15 ppm
Nitrite Nitrogen	Minute Trace
Iron as Fe	1.04 ppm
Hardness as CaCO <sub>3</sub>	6 ppm
Alkalinity as CaCO <sub>3</sub>	11 ppm
Magnesium as Mn	0.01 ppm
Arsenic as As	nil
Colour (Hazen Unit)	40
pH	6.7

The BOD value of 11 ppm is high for natural river waters. The International Water Supply Association has recommended that the pollution of rivers used for water supply purposes should be controlled so that the BOD does not exceed 4 ppm, and the World Health Organisation has fixed a maximum limit of 6ppm BOD for water supply sources. During the 1971 dry period it is likely that at

LOCATION MAP - S. JOHOR ESTUARY



- Automatic Recorders ▲
- Manual Readings ●
- Catchment Boundary - - -

times the BOD in the S. Johor has been in excess of 20 ppm.

Effluents from rubber factories also have comparatively high BOD values. In addition, the effluents are acidic and have high Ammoniacal Nitrogen concentration. There is one rubber factory located upstream of Layang Layang which discharges effluent into the headwaters of the S. Johor. Occasional troubles have been experienced in the past at the JKR water supply intake at Layang Layang due to high Ammonia content.

Several new palm oil and rubber factories will be constructed in the Project Area. To prevent future gross pollution of the receiving waters, effluents from these factories should be given treatment at source. The legislation on pollution control, recently passed by Johor State, should be rigidly enforced.

### 1.7.3 Agricultural Pollution.

Thirteen raw water samples, out of a total of 94 analysed, have contained arsenic (Appendices A-44 to A-47). The arsenic occurred at 7 locations, 4 of which are on rivers used as sources of water supply. The maximum concentration detected has been 0.04 ppm. Sampling has been virtually random and it is possible that concentrations higher than 0.04 ppm have occurred.

The source of the arsenic is probably one of the agricultural herbicides containing sodium arsenite which is used for lalang spraying and for girdling of trees under forestry regeneration schemes. The main danger to water supplies arises from accidental spillage or the washing of containers which could cause unexpected high instantaneous concentrations. There are numerous safer and more effective herbicides on the market, even if they are initially more expensive. It is recommended that arsenic herbicides be banned from all water supply catchments.

Although normal water treatment process will remove small concentrations of arsenic the International Standards for Drinking Water (World Health Organisation 1963) sets a maximum allowable limit of 0.05 ppm for communal supply sources. The United States Public Health Drinking Water Standards state that arsenic concentrations greater than 0.05 ppm are grounds for rejection of the supply.

With the exception of arsenic, analysis of samples taken from catchments at present developed and fertilised do not suggest that current fertiliser applications significantly affect the quality of raw water. Future applications in the Project Area are likely to be of the same order and consequently they can be expected to have little effect on water quality. However frequent water samples should be taken in order to confirm this. Careful analysis for dangerously persistent pesticides and herbicides should be carried out at regular intervals - this applies particularly for the protection of food supplies in the form of fish.

### 1.7.4 Tin Mining Pollution.

At present the only tin mines in operation in the Project Area are located on the S. Pelepah and S. Tengkil, (a tributary of the S. Linggiu). Mining is carried out by hydraulic sluicing and considerable quantities of finely divided colloidal matter are passed into the rivers.

On five occasions during 1970 measurements of the suspended sediment load were made simultaneously on the S. Johor, S. Linggiu and S. Sayong at their confluence. The suspended load in the S. Johor on these five occasions was found to be in the range of 200 - 400 tons/day, with the S. Linggiu contributing about 90 percent of the quantity of sediment but approximately only one third of the quantity of water. These high sediment concentrations are

definitely attributable to tin mining operations in the S. Tengkil as the water in the S. Linggiu above its confluence with the S. Tengkil is clear and contains very little sediment.

Finely divided colloidal matter creates problems in water treatment and it is known that difficulties have been experienced at the Public Utilities Board, Singapore (PUB) intake, located just upstream of Kota Tinggi, (A.C. Buck 1969).

Future tin mining operations in the Project Area will not be known until further prospecting, as recommended in Supporting Volume 2 is carried out.

However pollution from tin mining is extensive at present and it would appear that the only way to reduce this pollution is to exercise strict control on the concentration of solids in the mine effluent which is returned to the river. The legal maximum for tin mine effluent concentration is about 11,000 ppm and consideration should be given to substantially reducing this figure.

## 1.8 S. Johor Estuary

### 1.8.1 Engineering Aspects.

The S. Johor tidal estuary (Fig. 1.12) stretches approximately 44 miles from the Johor Straits to between Kg. Semangar and Kg. Bahru (Lubok Pekan). The town of Kota Tinggi and the water supply intake operated by the PUB are the major points of engineering interest in the estuary. Specific problems studied were:-

- a) Saline intrusion, in relation to low river discharges past the PUB intake.
- b) Tidal discharge characteristics, in relation to flooding at Kota Tinggi and saline intrusion at the PUB intake.
- c) Possible siltation occurring downstream of Kota Tinggi, in relation to possible increases in flood incidence to Kota Tinggi.
- d) Water quality at the PUB intake, in relation to upstream tidal discharges occurring at times of low river discharge and high tide.
- e) Navigation upstream of Kota Tinggi, in relation to possible transport requirements.

### 1.8.2 Saline Intrusion.

Direct sampling at times of low river discharge was carried out at several places on the S. Johor between the PUB intake and Nam Heng Estate. Over five hundred samples were collected and these were later analysed by the Department of Chemistry for total chloride concentration.

The results of this analysis were plotted and examined in order to determine quantitatively the relationship between the various tidal factors and the penetration of salt concentrations up the estuary. The finally adopted relationship is shown on Figure 1.13. For design purposes an average annual demand for saline control at the PUB intake by flushing<sup>+</sup> has been taken as 100 mgd. During the periods of extreme high tide instantaneous peak concentrations of the order of 800 ppm total chlorides would occur at high tide, and throughout a 24 hour pumping period the average concentration of total chlorides in the pumped water would most likely be less than 200 ppm.

<sup>+</sup> Flushing means allowing a continuous flow of fresh river water to pass the intake.

TIDAL DISCHARGES ON THE S. JOHOR AT KOTA TINGGI

FIGURE 1-14

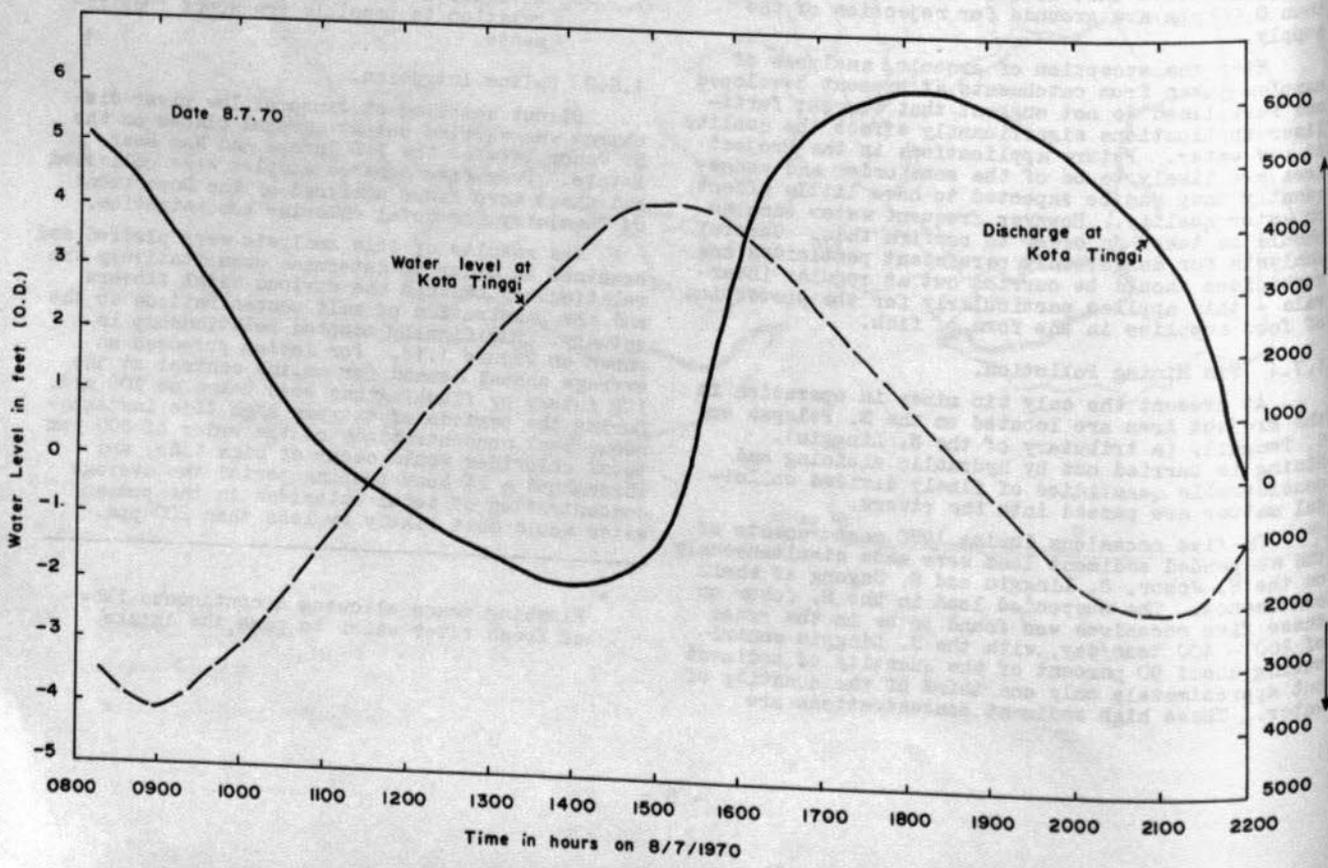
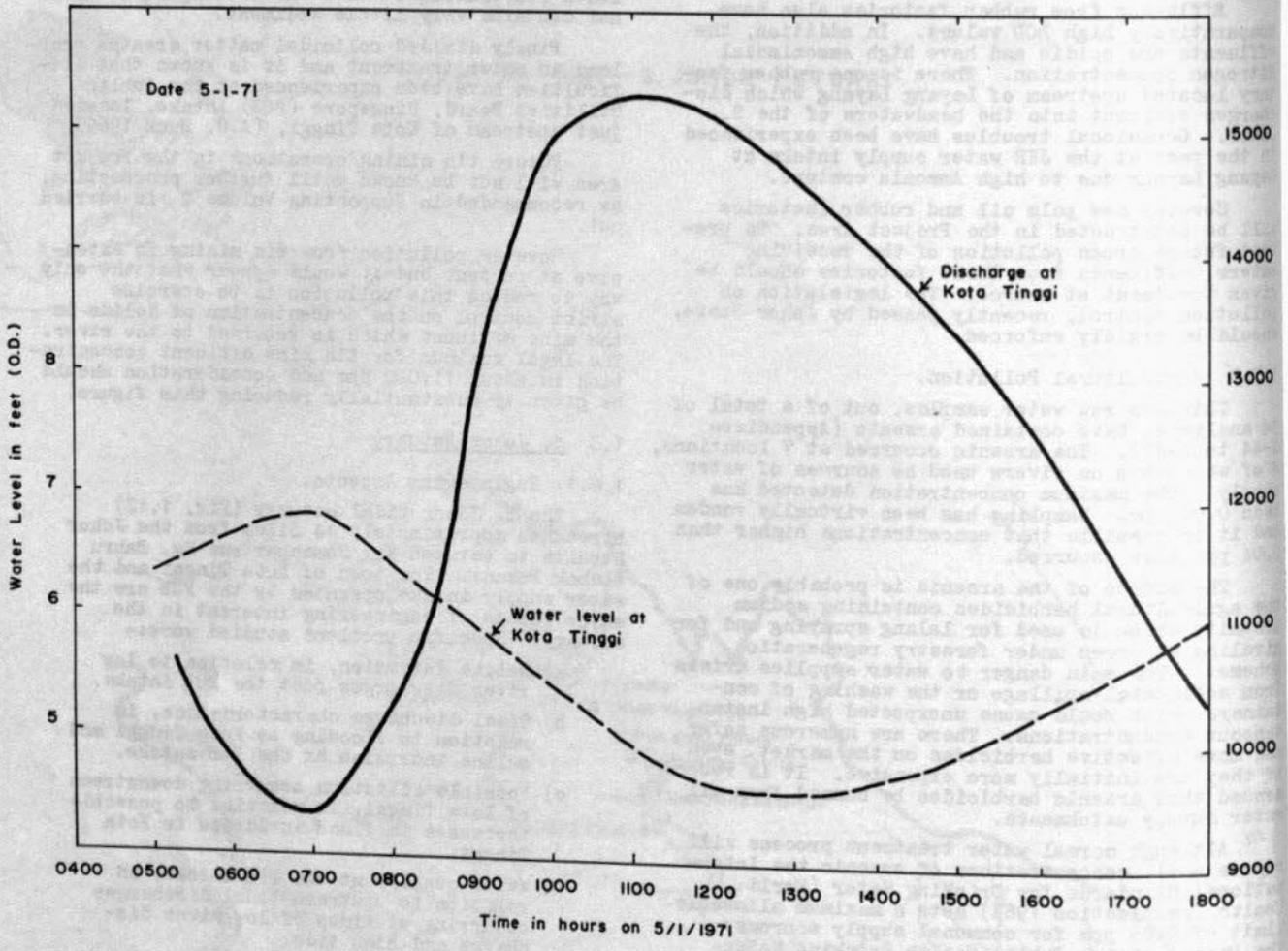
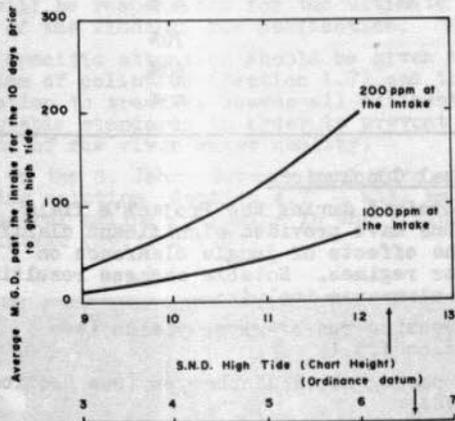


FIGURE 1-13

ESTIMATED PEAK CHLORIDE CONCENTRATIONS AT

THE P.U.B. INTAKE UNDER VARIOUS TIDE AND FLOW CONDITIONS



The corrosive power of saline water is perceptible at about 200 ppm., although the limit of human perception is approximately 800 ppm.

1.8.3 Tidal Discharges.

A detailed tidal discharge measurement was made on the S. Johor at Kota Tinggi bridge on 8th

July 1970 and the results are shown on Figure 1.14. Continuous measurement by bridge crane was used and 1 foot depth velocities and depth-integrated velocities were taken during the period 0700 hours to 2200 hours. Instantaneous discharges were calculated from smoothed area and velocity time curves drawn for each vertical section.

The information gained from this measurement was extremely valuable in both the assessment of peak upstream discharge on 9th March 1970, and of the discharge during the passage of the peak of the January 1971 flood. Tidal discharge in the upstream direction was observed at 7,500 cusecs on 9th March 1970, and it has been estimated that the maximum upstream discharge on that day was approximately 8,000 cusecs (see also Table 1.4 for corresponding water quality). The hydrograph of the January 1971 peak flood passage is shown on Figures 1.14 and 1.

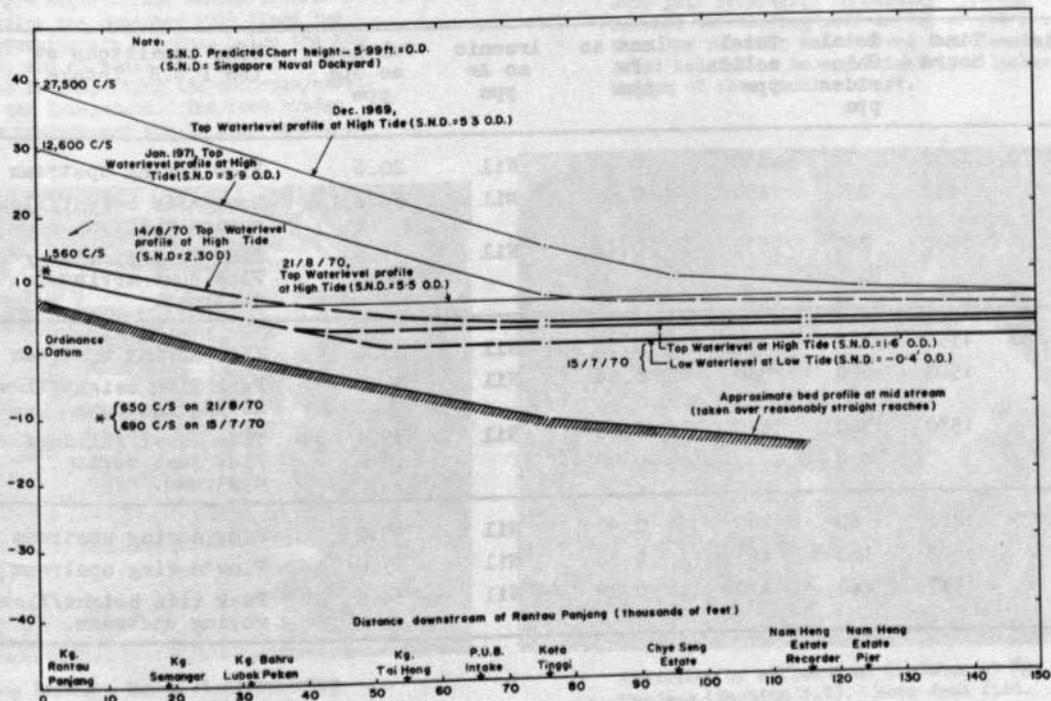
1.8.4 Bed and Water Surface Profiles.

An echo sounding survey was carried out in the S. Johor between Kg. Semangar and Nam Heng Estate. Average centre channel depths taken from straight sections of the river were adjusted back to Ordinance Datum using water level information from automatic recorders installed specifically for this purpose.

No evidence was obtained of any massive or even significant deposition of sediment, and the average bed level (ignoring levels taken on or near sharp bends) is shown on Figure 1.15. The deposition of the largely colloidal sediment load in the S. Johor is governed by the position a particular salt concentration in the sea water. This concentration front moves a great distance up and down the estuary depending on both the natural flow in river and the tidal fluctuations, and even at a sediment load (section 1.7.4) of 400 tons/day, it

FIGURE 1-15

S. JOHOR ESTUARY LONGITUDINAL PROFILES



would be likely that a build up at any specific point would only become detectable over a considerable span of years.

Localised deposition does occur around the entrance into the estuary of small streams from developed catchments. However these depositions are very localised and are not likely to affect overall flood levels anywhere on the S. Johor. Selected water surface profiles are shown on Figure 1.15 for various conditions of tide and river discharge.

#### 1.8.5 Tidal Water Quality.

Partial chemical analysis was carried out on samples taken opposite the PUB intake during the low flow/high tide condition from 9th March to 11th March 1970. The results are shown in Table 1.4.

The normal background level of total chlorides in the S. Johor is approximately 3 ppm. (Appendix A-44 to A-47). Total solids, Iron and Sulphate concentrations normally vary; however the high tide build up of these concentrations as shown in Table 1.4 is quite significant (see Section 1.7.2).

#### 1.8.6 Navigation.

The S. Johor presents the only real possibility in the Project Area of any form of large scale river traffic. At present only a few small passenger boats operate upstream of Kota Tinggi.

Apparently the river was once used for logging transport, although now that the main logging areas are removed from the main stream it is cheaper for the loggers to use motor transport throughout.

The river is navigable for craft having shallow drafts, at least up to the S. Linggiu/S. Sayong confluence, and the minimum navigable depths at Kg. Rantau Panjang (where the river is not tidal) are shown in Table 1.5.

TABLE 1.5 S. Johor - Navigable Depths at Kg. Rantau Panjang

Centre Stream Navigable Depth	Average percent of Time per year, that this depth is exceeded
2 feet	90%
2½ feet	80%
3¼ feet	70%
3½ feet	60%
4½ feet	50%

#### 1.9 Principal Conclusions.

Data obtained during the Project's field investigations have provided significant clarification of the effects of jungle clearance on natural river regimes. Notable changes resulting from jungle clearance include:

- Decreasing run-of-river yields (see Section 1.3.1)
- Increasing flood discharges (see Section 1.4.2)
- Increasing average run-off (see Section 1.3.2)
- Increasing sediment loads (see Section 1.6)

These effects have been determined by comparing observations and measurements on a series of different catchments under existing catchment cover conditions. Further studies are required to refine these conclusions. The continuance of the Project hydrological network, as agreed with the Client, and the large scale land clearance in the Project Area (Supporting Volume 6 Part I), will provide an excellent opportunity to carry out these studies.

TABLE 1.4

Tidal Water Chemical Analysis  
S. Johor at P.U.B. Intake

Date	Time hours	Total Chlorides ppm	Total solids ppm	Iron as Fe ppm	Arsenic as As ppm	Sulphates as SO4 ppm	Flow conditions at the P.U.B. Intake
9/3/70	1250	72	230	0.80	N11	20.6	Flow moving upstream Peak tide height/Flow moving upstream Tide level falling/ Flow just moving upstream.
	1432	230	480	0.52	N11	34.6	
	1500	240	535	0.44	N11	37.5	
10/3/70	1351	130	290	0.56	N11	33.0	Flow moving upstream Peak Tide height/Flow moving upstream Tide level falling/ Flow just moving upstream.
	1508	280	560	0.36	N11	37.1	
	1530	300	580	0.28	N11	39.1	
11/3/70	1404	60	200	0.90	N11	19.0	Flow moving upstream Flow moving upstream Peak tide height/Flow moving upstream.
	1503	130	465	0.36	N11	33.0	
	1547	240	470	0.28	N11	34.6	

This would involve maintaining and operating river recording stations presently installed throughout and after jungle clearance has taken place. As further areas are cleared additional rain-gauges should be installed to increase the density of the existing network. A very high research type standard of field measurement and equipment maintenance will be necessary. Regular six monthly data reviews and field inspection should be carried out by the Engineer/Hydrologist who will be responsible for the ultimate preparation of the findings for publication.

Specific attention should be given to the problem of pollution (Section 1.7) and the recommendation to treat at source all effluents to acceptable standards in order to prevent deterioration of raw river water quality.

On the S. Johor Estuary some form of engineering solution (Section 4.7) will be required to control saline intrusion in the vicinity of the PUB intake (Section 1.8).

A flood warning system on the S. Johor should be considered (Section 1.4) as providing an immediate method of reducing losses caused by flooding at Kota Tinggi. Additional data are required to determine the benefit that could be obtained by the construction of a dam on the S. Linggiu (Section 1.4.3)

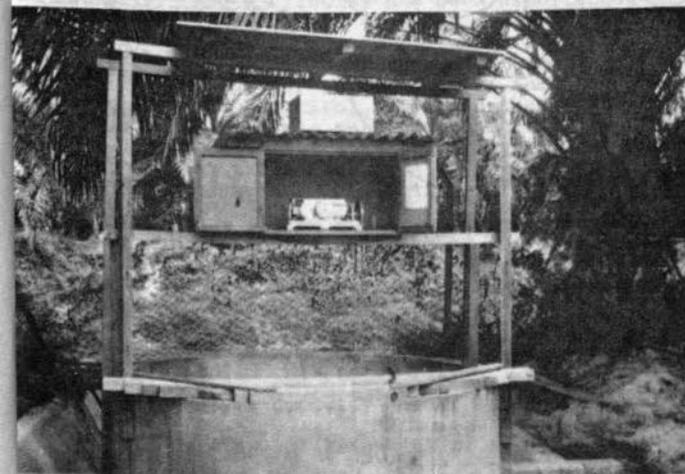
The severe drought in 1971 has unfortunately occurred outside the period of Project field investigation. However as requested by the DID, the Project has given as much additional assistance as was possible, and a large amount of field data have been and continue to be collected. It is essential that the data be worked up into useable design form and a comprehensive report on the 1971 drought prepared as soon as possible. This will enable the engineering significance of the effect of severe droughts with return periods in excess of normal design criteria to be ascertained (see Section 1.3.2).



S. Permandi at M27 $\frac{1}{2}$  - Negretti and Zambra pressure bulb recorder. During the December 1969 flood the water level was approximately 4 inches below the top of the stick gauge, and it would have been over the head of the man who is inspecting the concrete/steel-peg bench mark in the foreground. The foot bridge used for high flow measurement can be seen behind the recorder.



S. Pengeli at Road Bridge - Negretti and Zambra pressure bulb recorder. In January 1971 the flood peak reached the sloping roof on top of the recorder. When the recorder was removed for cleaning the water level had fallen to approximately 2 inches above the bottom of the circular chart.

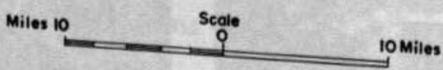
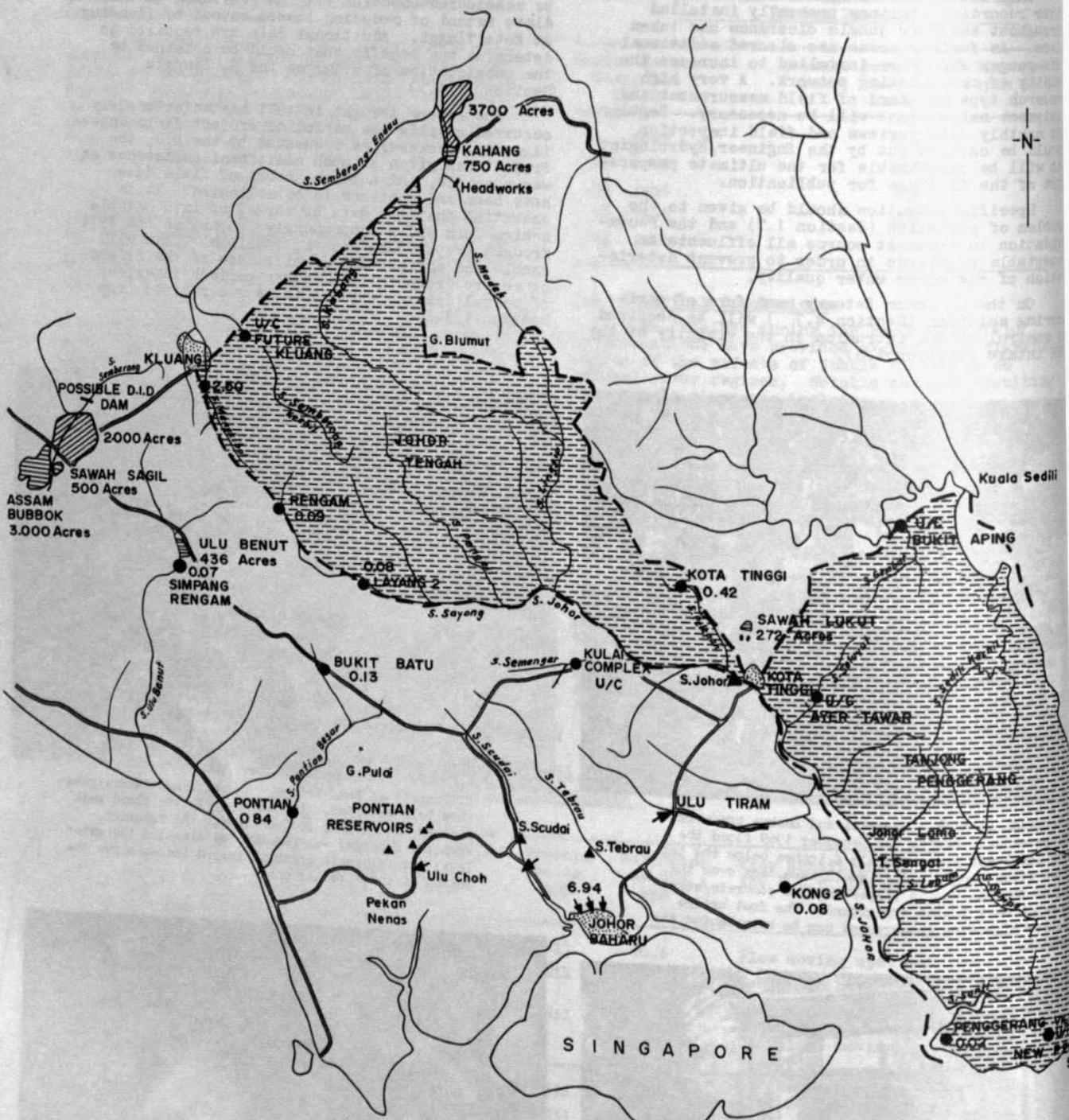


S. Sayong at Layang Layang - Munro float recorder installed on top of the JKR access well on the Layang Layang intake. The second roof was installed to reduce the high temperatures inside the recorder caused by high incidence of direct sunlight.



Pollution by effluent on S. Johor at Kg. Rantau Panjang (Section 1.7). Note dead fish.

EXISTING WATER RESOURCE DEVELOPMENTS



- Project Area ———— [Hatched Box]
- Existing JKR intakes ———— ●
- Under construction ———— U/C
- Source under planning ———— U/P
- Average water abstracted in 1969 (in m.g.d) ———— 0.42
- P.U.B sources in Johor state ———— ▲
- Metered offtakes on P.U.B mains for Johor state ———— →
- Existing D.I.D irrigated area ———— [Dotted Box]
- Possible future D.I.D irrigated area ———— [Hatched Box]

EXISTING WATER RESOURCE DEVELOPMENTS**2.1 Introduction**

This chapter describes briefly the present development of water resources, within and adjacent to the Project Area. Developments outside the Project Area have to be considered as their future demands may be dependant upon Project Area sources. In such cases sources and schemes to meet water demands arising from the Project proposals could be affected and there could be possible constraints on land development for agriculture.

Figure 2.1 shows the following:-

- a) The locations of the present (including those under construction or planning in 1970) sources of water for the main JKR piped water supply areas, within, adjacent, and to the south of the Project Area.
- b) The locations of the sources in Johor State from which the Public Utilities Board (PUB), Singapore, abstract water under the terms of two Agreements, dated 1961 and 1962, between Johor State and the City of Singapore.
- c) The sources of water, location and acreages of existing and possibly future DID irrigation schemes for padi cultivation adjacent to the Project Area.

All other JKR water supply schemes and DID irrigation schemes within Johor State are too remote from the Project Area to warrant inclusion in the study. The extensive land drainage schemes in the District of Pontian are also excluded as they could not affect or be affected by water resource or land development proposals in the Project Area.

**2.2 Water Supply Developments****2.2.1 JKR Water Supply Areas.****2.2.1.1 General Description.**

All JKR supplies, except for parts of the Districts of Johor Baharu and Pontian (in the near future) are based on run-of-river flows. Water is pumped or gravitates to treatment works which in all cases except for Kota Tinggi and Penggerang village incorporate sedimentation, filtration and sterilization. The Kota Tinggi treatment works includes filtration and sterilization only and the Penggerang village supply includes sterilization only. Treatment of all supplies is generally satisfactory. Some difficulty has been experienced on occasions at the intake on the S. Pontian Besar (supplying Pontian) due to pollution caused by the large swamp area in the catchment, resulting in rationing during three years out of the last five years. The S. Mengkibol, which is the source of supply for Kluang, is subject to increasing pollution due to urban and industrial development in the catchment but there have been no serious treatment problems to date due to pollution.

The Johor Baharu supply is purchased from the PUB Singapore (under the terms of the two Agreements mentioned in 2.1b) and treated water is taken through metered offtakes on the PUB's mains. The JKR are at present implementing (1970) a scheme to supplement the supply of Pontian District from an additional offtake on the PUB mains near Ulu Choh.

Details of area of supply, present consumption (1969) and works capacity are shown in Table 2.1.

**2.2.1.2 Development Potential of Existing Sources.****a) Run-of-river intakes**

Based on Figure 1.5 the estimated reliable yield (in mgd) of existing run-of-river sources, for return periods of 1 year in 10 years,

and 1 year in 5 years, are shown in Table 2.2. These values take into account the type and proportions of catchment cover (i.e. jungle covered or developed) as existing in 1970. For comparison Table 2.2 also lists yields based on 0.2 cusecs/square mile of catchment area, (irrespective of type of catchment cover), which is the present design criterion used by the JKR in Johor State.

The catchments of the S. Semberong Kechil, S. Seluyut and S. Gembot are within the Project Area and the run-of-river yields of these rivers may be expected to reduce considerably due to land clearance and associated developments. The changed catchment conditions and estimates of associated reduced future yields are shown in Table 2.3. It is emphasized that the future yields of jungle catchments outside the Project Area may also be expected to reduce if land clearance for agricultural development takes place. However, as far as is known there are no proposals at present for agricultural developments in these catchments.

**b) Bulk Purchase from PUB Singapore**

Under Clause 14 of the 1961 Agreement, Johor State is entitled to 12 percent of the water which passes the causeway on a daily basis and which the PUB has abstracted from the Pontian reservoirs (centred on Gunung Pulai), S. Scudai and S. Tebrau. The present nominal combined plant capacity of the three sources is about 90 mgd. On the above basis Johor State's maximum present entitlement is about 9.6 mgd. However, Clause 14 includes provision, subject to procedure and negotiation, that the PUB supply more water if Johor State can prove, by meter records, that the 12 percent is inadequate to meet current demands. The limit of this entitlement is "the capacity of the Pulai Catchment Reserve". The Pulai Catchment Reserve is not explicitly defined in the Agreement, but assuming that it means the 10 square miles of reservoir catchment centred on Gunung Pulai and provided Clause 14 was fully implemented, then the limit of Johor State's entitlement is estimated to have a yield of about 18 mgd.

Under Clause 11 of the 1962 Agreement, Johor State is entitled to 2 percent of the water which passes the causeway on a daily basis and which the PUB has abstracted from the S. Johor. The present nominal plant capacity is 30 mgd and Johor State's future entitlement depends on the future abstraction of the PUB. This is not known. However there is provision for the PUB to abstract up to "a maximum of 250 mgd" (Clause 5) and the limit of Johor State's future entitlement under this maximum abstraction rate would be just under 5 mgd.

There is a provision in the 1962 Agreement for Johor State to buy the Gunung Pulai and Pontian Waterworks (reservoirs and treatment works), if they wish, by giving four years notice in writing to Singapore. As stated above the yield of this source is estimated at about 18 mgd.

**2.2.2 PUB Singapore.**

Under the 1961 Agreement the waters of the S. Scudai, S. Tebrau and the catchments draining to the Pontian reservoirs have been allocated to Singapore. The S. Scudai and S. Tebrau are run-of-river schemes, and gated barrages are provided downstream of the intakes. The maximum amount of water that can be abstracted is limited by the present plant capacities which are 30 mgd, 40 mgd and 20 mgd for S. Scudai, S. Tebrau and Pontian reservoirs respectively. However the amount of water actually abstracted varies and depends upon

the availability of water and operation methods decided by the PUB. It is known that river flows in the S. Scudai and S. Tebrau have fallen below 30 mgd and 40 mgd respectively. These catchments are outside the Project Area and will not be affected by Project land developments.

Under the 1962 Agreement the PUB operate a run-of-river intake on the S. Johor about one and a half miles upstream of Kota Tinggi. The present nominal plant capacity is 30 mgd. At the intake the river is tidal but as far as is known there has been no restriction on pumping due to tidal effects or shortage of water since the scheme was commissioned in 1967. As stated in Section 2.2.1.2b, there is provision in the Agreement for the PUB to abstract "up to a maximum of 250 mgd." The catchment draining to the intake is approximately 600 square miles of which about 380 square miles are in the Project Area. The variability of river flows at the intake will be affected by Project land developments. At present about 36 percent of the whole catchment area has been developed agriculturally and the reliable run-of-river yields, for return periods of 1 year in 10 years and 1 year in 5 years, are estimated at 111 mgd and 148 mgd respectively. It is estimated that about 76 percent of the whole catchment area will eventually be developed for agriculture. This takes into account Project proposals within the catchment and assumes that all land below 20 degree slope outside the Project Area will be developed agriculturally. For this future catchment condition the reliable run-of-river yields for return periods of 1 year in 10 years and 1 year in 5 years are estimated to reduce to 53 mgd and 72 mgd respectively. All the above yield figures, which do not make allowance for saline intrusion, are substantially below the 250 mgd quoted in the 1962 Agreement. This is discussed further in Section 4.7.

All PUB sources in Johor State include treatment works, and treated water only is conveyed to Singapore.

#### 2.2.3 Water Supplies other than JKR Piped Supplies - Within the Project Area.

Private estates obtain their supplies, for domestic purposes and processing factories, from small run-of-river intakes on nearby streams or from wells. The water is normally pumped, and in some instances limited treatment is given.

Small kampongs and the scattered rural population obtain their supplies from wells or nearby streams. The water is drawn by hand and no treatment is normally given. Wells are not sealed at the top and are vulnerable to pollution, especially after flooding. When required, the State Health Department sterilize wells with chloramine.

All these abstractions are quite small. In Johor Tengah they will not be affected as the sources are located upstream of land which will be affected by Project developments. In Tanjong Penggerang, where the catchment areas are relatively small, it is possible that a few of these sources, located in the lower reaches of river, could be affected by Project developments. However the JKR are implementing schemes to provide piped water to the larger kampongs located on the west and south coasts of Tanjong Penggerang.

#### 2.3 DID Irrigation Developments

There are no existing or projected DID irrigation schemes for padi or other crops within the Project Area.

In all existing schemes adjacent to the Project Area (Figure 2.1) only single cropping is practised, and the acreages actually planted each year, except at Sawah Lukut, are variable. All schemes rely on run-of-river flows from sources located outside the Project Area.

At Assam Bubok and Sawah Sagil there has been restricted planting due mainly to shortage of water. For example the acreage cultivated each year during 1954-59 varied from about 200 acres to 3000 acres out of 4000 acres available. Assam Bubok relies on the natural flows of small streams passing through the area and the land is flooded by a controlled drainage system. At Sawah Sagil water is pumped from the S. Sembrong. To increase the availability of water the DID have made a preliminary investigation of a storage reservoir upstream on the S. Sembrong; if this proves feasible then an additional 2000 acres of padi development would be considered. However it is understood from the State DID Engineer that the cost of the dam is relatively high and that the projected proposals may not be implemented; if storage is not provided the existing areas may be abandoned. To supply either the existing or projected schemes from the Project Area would be expensive as storage facilities, long pipe lines and pumping would be required.

At Kahang there has never been any restriction of planting due to shortage of water, but the acreage cultivated each year, over the last 20 years has varied from about 70 acres to 270 acres out of 750 acres available. These restrictions have been due mainly to the difficulty of keeping settlers in the area. The source of water is the S. Madek with water being diverted by gated headworks and led to the irrigated area by open canal. The projected area of 3700 acres at Kahang is very provisional and no detailed planning or soil survey has been carried out. If this additional area is developed, then water could be made available either by the provision of regulatory storage on the S. Madek or by pumped run-of-river abstraction from the S. Sembrong - Endau. It would not be necessary to rely on water originating from the Project Area.

There has never been any restriction of planting at Ulu Benut or Sawah Lukut due to shortage of water, although there have been limitations at Ulu Benut caused by settlers working at alternative occupations. There are no projected irrigation schemes in these areas.

It can be concluded that present and projected DID irrigation schemes will not be dependant on the water resources of the Project Area. They will also be unaffected by land development proposals in the Project Area.

#### 2.4 Other Developments

The DID are at present implementing a scheme for flood alleviation at Kluang. Apart from this there are no flood mitigation, hydro-power or main drainage schemes within or immediately adjacent to the Project Area.

TABLE 2.1

Existing and Projected JKR Water Supply Areas

Supply Area	Area of Supply	Location with respect to Project Area	JKR Est. of Pop. served 1969	Consumption 1969 (mgd)	Approximate Commissioning date of works	Works Capacity mgd
Johor Baharu	District of J.B. (excluding M. Sedenak) and Pekan Nenas (District of Pontian)	Outside	135000	6.94	Bulk Purchase from PUB	
Pontian	District of Pontian (excluding P. Nenas)	Outside	38000	0.84	1930	1.05
Simfang Rengam	S. Rengam L.C. (District of Kluang)	Outside	4300	0.07	1958	0.40
Bukit Batu	M. Sedenak (District of Johor Baharu)	Outside	12700	0.13	1967	0.72
Kluang	Kluang town, S. Lalang (District of Kluang)	Partly within	49000	2.50	1940 (New works under construction on S. Semberong Kechil).	2.50
Kota Tinggi	K. Tinggi town, FLDA Pasak and rural	Partly within	11400	0.42	1940	0.96
Rengam	Rengam L.C. (District of Kluang)	Partly within	4100	0.09	1958	0.17
Layang Layang	Layang <sup>2</sup> L.C. (District of Kluang) and FLDA Tak Way Heng (District of Johor Baharu)	Partly within	5400	0.08	1966	0.60
Penggerang Village	Penggerang Village	Within	900	0.02	pre-1940	0.04
FLDA Kulai Complex	FLDA Kulai Complex	Outside			Under construction by JKR	0.75
FLDA Ayer Tawar	FLDA Ayer Tawar, Kg. Johor Lama and Telok Sengat	Within			Under construction by JKR	0.70
FLDA Bukit Aping	FLDA Bukit Aping and Kg. Kuala Sedili	Partly within			Under construction by JKR	0.66
South Penggerang	Along southern coast of Penggerang peninsular	Within			Under planning by JKR	

JKR WATER SUPPLIES  
EXISTING SCHEMES AND SCHEMES UNDER CONSTRUCTION  
YIELD OF CATCHMENTS (mgd)

TABLE 2.2 Catchment Cover Conditions as 1970

JKR Supply Area	Source (River)	Catchment Description		Yield (mgd)		
				Return Period		Based on 0.2 cusecs per sq. mile
				1 In 10 yrs	1 In 5 yrs	
Kluang	Mengkibol	22	100 D	.81	1.2	2.4
Kluang	Semberong Kechil <sup>+</sup>	80	90 J 10 D	9.0	12.0	8.7
Kota Tinggi	Pelepah	3.1	100 J	.19	.27	.33
Pontian	Pontian Besar	58	34 J 44 D 22 S	5.3	7.3	6.3
Simpang Rengam	Ulu Benut	66	20 J 75 D 5 S	4.3	5.9	7.1
Layang Layang	Sayong	38	100 D	2.1	2.8	3.6
Rengam	Sayong	7.25	100 D	.38	.54	.78
Bukit Batu	Pontian Besar	21	60 J 40 D	1.7	2.3	2.3
FLDA Kulai Complex	Semangar <sup>+</sup>	19.7	100 D	1.1	1.5	2.1
FLDA Ayer Tawar	Seluyut <sup>+</sup>	23.7	100 J	2.8	3.8	2.5
FLDA Bukit Aping	Gembot <sup>+</sup>	23.4	63 J 20 D 17 S	2.3	3.1	2.5
Pengerang Village	Small stream	50 (acres) approx.	100 J	Not available	Not available	0.008
South Pengerang	Small stream+ mining pond	Catchment area and storage available not known - under investigation by JKR				

TABLE 2.3 Future Catchment Cover Conditions due to Project land developments

River	Catchment Description		Yield (mgd)	
			Return Period	
			1 In 10 yrs	1 In 5 yrs
Semberong Kechil <sup>+</sup>	80	10 J 90 D	3.2	4.0
Seluyut <sup>+</sup>	23.7	100 D	1.3	1.9
Gembot <sup>+</sup>	23.4	83 D 17 S	1.3	1.9

<sup>+</sup>New source under construction 1970

J - Jungle : D - Developed : S - Swamp

FORECAST OF DEMAND FOR WATER**3.1 Existing JKR Water Supply Areas****3.1.1 Population Data.**

At the time (January 1970) of forecasting in this report the demand for water there had been no comprehensive Population Census carried out for West Malaysia since 1957. A Census was carried out in August 1970 but at the time of making the estimates of water demand, the preliminary count of the Census was not available. For this reason and for the other reasons stated in Supporting Volume 10, primary reliance has been placed on the 1967 Estimates of population contained in Research Paper No.1 published by the Department of Statistics in March 1969.

Research Paper No.1 (Table 4) estimates the population for Johor State in 1967 as 1.33 millions, which implies a growth rate in the State's population between 1957 and 1967 of about 3.5 percent per annum. At the time of making these estimates, no published data were available on the growth of the population in various parts of Johor State.

However Project investigations, and estimates received from District Officers, show that growth per annum from 1957 to 1970 has varied from 1-2 percent (Kota Tinggi town, Rengam, Layang Layang) to possibly 5 percent or more (Kluang town).

For the purposes of forecasting water demand, a growth rate of about 3.5 percent per annum has been assumed for the population in the supply areas. It should be emphasised that this is the estimate for the supply areas and not for Johor State as a whole. The estimate is slightly above the likely growth rate for West Malaysia, of about 3 percent per annum over the next 20 years. (See Research Paper "Population Projections by Age, Race and Sex for West Malaysia (1967-1997)" published by the Department of Statistics in November 1969).

**3.1.2 Supply Areas to be Included in Study.**

In order to ascertain which supply areas (Table 2i) should be included in the study an initial appraisal of future demands was made. This was based on expansion of supply areas, population growth rate of 3.5 percent per annum, and allowing a water allocation as follows:-

	Classi- fication	Water Allocation gph/day
Population > 5000 in 1957 Census	Urban	60
Principal Village in 1957 Census	Rural	40
Other Population	Scat- tered	20

Details are given in Appendix B-1. It was concluded that the yields of present sources (Section 2.2.1.2) were adequate for all areas except Johor Baharu, Kluang, Pontian and Kota Tinggi. These areas therefore been included in the study and more detailed estimates of future demands have been made (Section 3.1.3).

**3.1.3 Johor Baharu, Kluang, Pontian and Kota Tinggi Supply Areas.**

Future demands for each area have been forecast by the following methods:-

a) By extrapolation of past consumptions tabulated in Appendix B-2. During 1959-69 consumption in Johor Baharu increased by 130 percent. This high rate of increase was largely due to new areas being provided with piped water from 1960. The approximate effect of the extension of the supply area has been distinguished by proportioning populations and the 'natural' increase in consumption has been estimated at 70 percent. During 1959-69

consumption in Johor State, Kluang, Kota Tinggi and Pontian increased by 97 percent, 66 percent, 50 percent and 75 percent respectively. Two extrapolations have been made for each supply area. One based on the rate of increase in consumption in Johor State; the other based on the rate of increase of consumption of its own supply area. (Appendix B-3).

b) By expanding the areas of supply (Appendix B-1), assuming population growth rate of 3.5 percent per annum, increasing water allocation up to year 2000 as section 3.1.2, and including a nominal allowance for industry (Appendix B-4).

c) As b) but assuming that only 50 percent of the 'scattered' population is connected. In comparison with b), this restriction on expansion of the supply areas, reduces demands in the year 2000, by 6.5 percent at Johor Baharu and Kluang, 14 percent at Kota Tinggi and 35 percent at Pontian.

d) For Kluang and Kota Tinggi, additional forecasts have been made. These are based on the present (1970) estimated populations of Kluang town (61,000), and Kota Tinggi town (8,300), and growth rates of 5.3 percent and 4.5 percent respectively. Developments in the Project Area may be expected to sustain the high growth rate (5.3 percent - section 3.1.1) in Kluang town and accelerate the low growth rate (1 percent - section 3.1.1) in Kota Tinggi town.

These forecasts of demand, which are plotted in Appendices B-5 to B-8, give a range of values from which reasonable design demands can be evaluated. These are summarised in Table 3.1.

TABLE 3.1 Adopted Design Demands (mgd)

Supply Areas	1969	1980	1990	2000
Johor Baharu	6.94	13.5	25.0	47.0
Kluang	2.50	5.2	9.3	16.0
Pontian	0.84	2.0	4.0	8.0
Kota Tinggi	0.42	0.80	1.5	2.8

**3.2 Projected Industrial Area and Port near Kg. Pasir Gudang**

The proposed location of the industrial area and port complex is near Kg. Pasir Gudang on the north bank of the Johor Straits about 8-9 miles east of Johor Baharu town. The recommendations of a pre-feasibility report, carried out in 1970, have been accepted by the Government and a more detailed study is now under progress (1971).

Detailed development plans have not yet been formulated and it is not known what type of industries will be attracted to and established in the area. Two forecasts of demand have been made, based on the following:

a) Preliminary planning data provided by the State Engineer.

b) Industrial water demands of 3 mgd/1000 acres (similar to Petaling Jaya, Selangor) and 5 mgd/1000 acres (similar to Jurong, Singapore).

c) Per capita consumption of 50-60 gallons/day by year 2000.

Details are given in Appendix B-9. These forecasts of demand give a range of values from

which reasonable design demands can be evaluated. These are summarised in Table 3.2.

TABLE 3.2 Adopted Design Demands (mgd)

Supply Area	1970	1980	1990	2000
Industrial Area and Port Complex	0	8	18	30

### 3.3 PUB offtake on S. Johor

The total water demand for Singapore has approximately doubled during the last 15 years. The demand is at present about 100 mgd and will probably rise to 350-400 mgd by the year 2000.

Taking the higher value and assuming that all future additional demand would be met by increased abstractions from the S. Johor, then the maximum abstraction rate of 250 mgd (provided for by the 1962 Agreement) would be required by about 1995. The build up of abstractions would be as shown in Table 3.3.

TABLE 3.3 Possible Build-up of Abstractions on PUB Offtake on S. Johor - (mgd)

1970	1980	1990	1995
30 (Present)	90	190 (Maximum)	250

It is emphasized that this is the estimated maximum build up of abstractions. The build-up could be much less if Singapore decided to make up future deficiencies in supplies from alternative sources, such as desalination.

### 3.4 Project Area - Existing Population

The future demands of the existing population in Mukims Kluang, Rengam, Ulu S. Johor (part), Layang Layang (Johor Tengah); and Mukims Kota Tinggi, Sedili Besar, Johor Lama (Tanjong Penggerang) have been included in the future demands of existing or proposed JKR water supply areas.

The population in the remainder of Johor Tengah (parts of Mukims Ulu S. Johor and Kahang) and Mukim Sedili Kecil (Tanjong Penggerang) is very small and scattered and its future demand is negligible.

The existing population in Mukim Tg. Surat (Tanjong Penggerang) is largely in estates and small villages on the S. Lebam; these have their own private supplies and the future demand, based on 1957 Census figures, is estimated at about 0.25 mgd.

The existing population in Mukims Pantai Timor and Penggerang (Tanjong Penggerang) except Kg. Pasir Gogak, will be served by the new JKR South Penggerang source and the future demand is estimated at about 0.8 mgd (Appendix B-1). The future demand of Kg. Pasir Gogak (1957 Population - 676) is estimated at about 0.12 mgd.

### 3.5 Project Area - Project Developments

#### 3.5.1 Village Domestic Water Supplies.

Supporting Volume 8 gives details of the number, date of implementation, initial population and estimated rate of growth of population of the proposed villages. The maximum population is assumed to be reached 15 years after date of initial settlement and has generally been based on an initial family size of 5 rising to 8.

Per capita consumption initially has been taken as 20 gallons per day rising to a maximum of 40 gallons per day. Based on the above the maximum domestic water demand is estimated at 4.2 mgd

in Johor Tengah and 2.7 mgd in Tanjong Penggerang. Details for individual villages are given in Appendices B-11 and B-12.

#### 3.5.2 Agricultural Processing Water Supplies.

The agricultural processing developments requiring water are palm oil mills, rubber processing factories and tapioca factories.

Supporting Volume 6 outlines the assumed agricultural cropping pattern and discusses the possible locations and phasings of processing facilities.

##### a) Palm Oil Mills

The water requirement of palm oil processing is about 300 gallons/ton fresh fruit bunches (ffb). A factory capacity of 1 ton ffb/hour, working a 20 hour day, requires 6000 gallons of water per day. The assumed location, phasing of capacity and estimated water requirements of the proposed project mills are shown in Appendix B-13.

The total ultimate water requirements, during the peak harvest month, are estimated at 1.32 mgd in Johor Tengah and 0.60 mgd in Tanjong Penggerang.

The peak month harvest is expected to be about 12.5 percent of the annual harvest and the average water requirement may be taken as 67 percent of the peak.

##### b) Rubber Factories

The water requirement of crumb processing (assuming crumb production by hevea method) is about 4 gallons/pound dry rubber content (drc). A factory capacity of 1 ton drc/day working a 24 hour day, requires 9000 gallons of water per day.

The assumed location, phasing of capacity and estimated water requirements of the proposed project factories are shown in Appendix B-13.

The total ultimate water requirements, during the peak harvest month, are estimated at 0.63 mgd in Johor Tengah and 0.63 mgd in Tanjong Penggerang.

The peak month harvest is expected to be about 10.5 percent of the annual harvest and the average water requirement may be taken as 80 percent of the peak.

##### c) Tapioca Factories

The water requirement for tapioca processing (for starch conversion process) is about 2000 gallons/ton wet root (wr). A factory capacity of 1 ton wr/hour, working a 24 hour day, requires 48000 gallons of water per day.

There is only one tapioca factory proposed; its location, phasing of capacity and estimated water requirements are shown in Appendix B-13.

The total ultimate water requirement, during the peak harvest month, is estimated at 0.30 mgd.

The peak month harvest is expected to be about 12.5 percent of the annual harvest and the average water requirement may be taken as 67 percent of the peak.

#### 3.5.3 Industrial Water Supplies.

The principal industrial development will be timber processing, incorporating sawmilling, plymilling and chipping etc. (Supporting Volume 5). The water requirements of these are negligible.

A limited amount of industry may be attracted into the Project Area. It is proposed in Supporting Volume 8 that sites of 200 acres each should be allocated for industrial development in Johor Tengah and Tanjong Penggerang. Water demand would depend entirely on the type of industries established but would not be expected to exceed about 0.6 mgd at each site. (Based on 3 mgd/1000 acres at Petaling Jaya, Selangor).

#### 3.5.4 Tourist Industry.

Supporting Volume 7 describes the potential and proposals for developing a tourist industry between Tanjong Siang and Tanjong Punggai on the east coast of Tanjong Penggerang.

The water demands for the initial and possible ultimate developments are estimated at 0.3 mgd and 9.0 mgd respectively. (Appendix B-10).

#### 3.5.5 Dairy and Beef Enterprises.

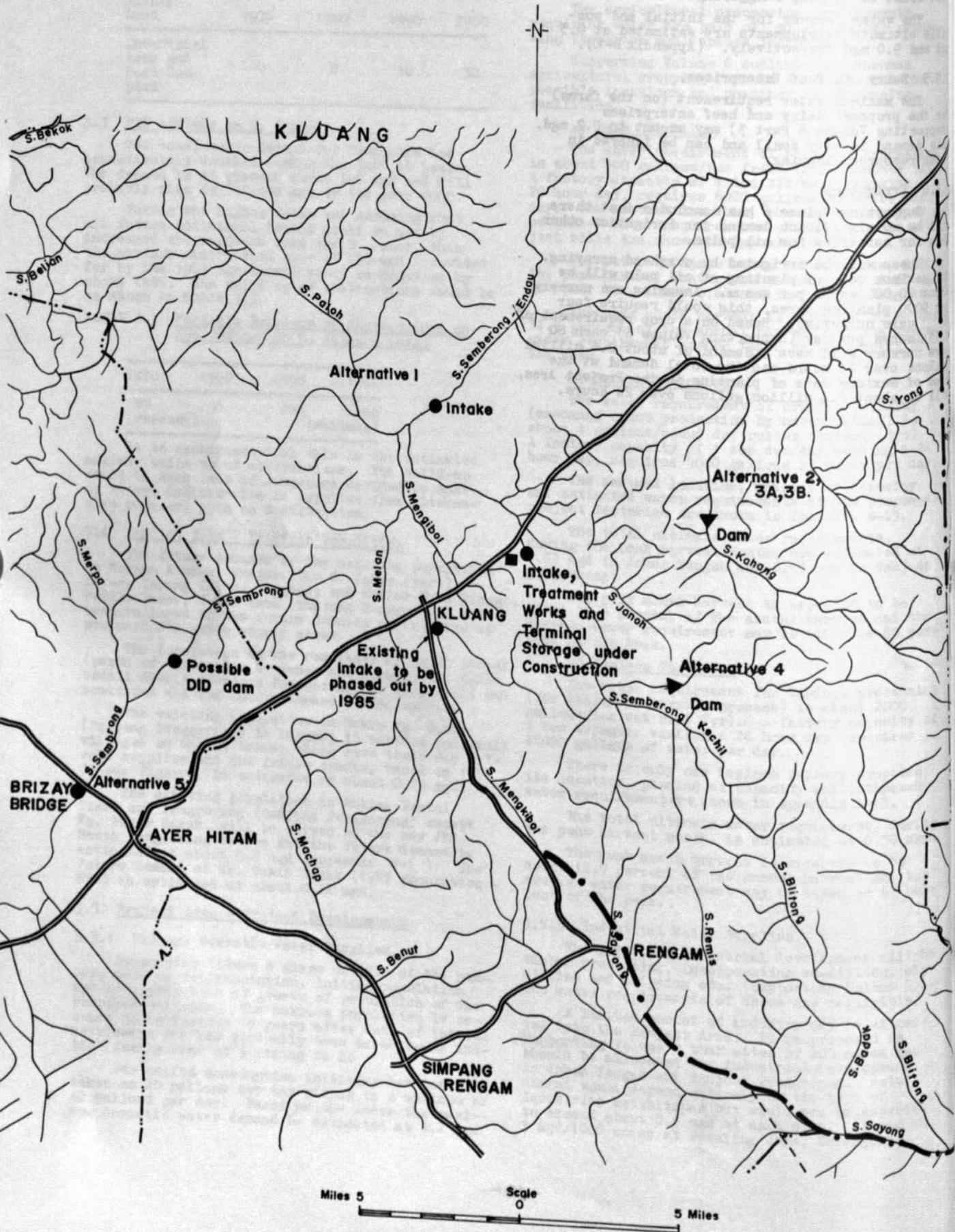
The maximum water requirement (on the farms) for the proposed dairy and beef enterprises (Supporting Volume 6 Part 3) may amount to 0.2 mgd. This demand is very small and can be ignored in water resource planning.

#### 3.5.6 Irrigation.

Supporting Volume 6 has concluded that there will be no significant demand for irrigation other than for nurseries for oil palms.

These will be irrigated by overhead spraying. The maximum rate of planting of oil palm will be about 20,000 acres per annum. Assuming one nursery per 5000 planting acres, this would require four 80 acre nurseries. Based on a crop requirement of 0.33 inches per day (Supporting Volume 6) each 80 acre nursery will have a demand of about 0.6 million gallons over 24 hours and the total demand at the time of maximum rate of planting in the Project Area, will be about 2.4 million gallons over 24 hours.

KLUANG WATER SUPPLY AREA - THE ALTERNATIVE SOURCES



FUTURE WATER RESOURCE DEVELOPMENTS4.1 Introduction

Chapter 3 shows that the major demand for water within the area of study over the next 30 years will be for domestic and industrial water supplies. The water resources of the Project Area are large compared to the total projected demands, particularly as there are several potential sites for regulation storage. (Figures 1 and 2 Appendix D).

The study of future water supply developments is therefore essentially an economy study i.e. an economic comparison of alternative feasible engineering schemes and dates of construction to meet the projected demands. Present values of total costs have been compared using discount rates of 5, 10 and 15 percent per annum. The capital and operating costs adopted are based on information given by the State and Federal JKR and from other comparable schemes in West Malaysia.

Capital and operating costs for overhead spray irrigation schemes are based on information supplied by FLDA and on discussions with equipment suppliers.

Benefit: cost method of analysis was used for the Kota Tinggi flood mitigation study. Costs are based on information supplied by the State DID and other comparable schemes elsewhere.

A straightforward comparison of the capital cost of reservoir construction was used for the regulation of the S. Johor study. Costs are based on comparable schemes in W. Malaysia.

All costs are for 1970 and constant prices have been assumed throughout.

4.2 Water Supply Developments4.2.1 Kluang Water Supply Area.4.2.1.1 Introduction.

It is understood from the State Engineer that the intake on the S. Mengkibol will be phased out about 1985 due to increasing pollution of the river (Section 2.2.1) and the age of the plant. At the intake, at present under construction on the S. Semberong Kechil, the yield is estimated to reduce from 9.00 mgd to 3.2 mgd due to land clearance and the associated development (Tables 2.2 and 2.3). The Project Programme expects that land clearance will commence about 1972 and will be completed about 1987. In addition several villages are proposed in the S. Semberong Kechil catchment and their demand is estimated at about 1.00 mgd, leaving a nett reliable yield at the new intake of 2.2 mgd after land clearance. Appendix C-1 shows these conditions graphically superimposed on the demand curve. The demand exceeds the yield by 1981/82 and the nett deficiency in yield by the year 2000 is 13.8 mgd.

The capacity of the intake, on the S. Semberong Kechil about 3½ miles north-east of Kluang town, pipelines, terminal storage and treatment works under construction by JKR is 4 mgd. The reliable yield of the S. Mengkibol is estimated at 0.8 mgd (Table 2.1) and the present reliable quantity of water that can be treated is therefore 4.80 mgd. The demand will exceed this by 1978. Allowing for the phasing out of the treatment works on the S. Mengkibol in 1985 the nett deficiency in works capacity by the Year 2000 is 12 mgd. There is ample area available at the site of the treatment works and terminal storage for expansion, so additional treatment works and terminal storage could be sited in the same locations.

4.2.1.2 The Alternatives Considered.

To cater for the above demands the following alternatives have been considered (Figure 4.1)

1. Run-of-river intake on S. Semberong-Endau (downstream of confluence of S. Paloh and S. Semberong Kechil) and direct supply to the above treatment works.

2. Storage on S. Kahang and direct supply to the above treatment works.

3. Regulation of S. Semberong Kechil from storage on S. Kahang.

A. Water transfer by pumping.

B. Water transfer by gravity through a tunnel.

4. Regulation of S. Semberong Kechil from storage in its own catchment.

5. Extracting water from the S. Semberong located to the West of Kluang and direct supply to new treatment works west of Kluang (This alternative was only considered briefly and an economic analysis has not been carried out).

The phasing of the different works for alternatives 1 to 4 is shown in Appendix C - 1. The phasing of pipelines and the selection of diameters is not optimal: these would require further investigation in future studies. In alternatives 1 and 2 the intake, raw water pumping station and raw water pipelines under construction on the S. Semberong Kechil would not be expanded beyond the present capacity of 4 mgd. In alternatives 3A, 3B and 4 these works would be expanded to a capacity of 16 mgd.

The phased expansion of the treatment works and treated water pipelines to a capacity of 16 mgd, and the provision of bulk terminal storage is common to all alternatives; the capital and operational costs of these are included in the economic analysis of each alternative.

4.2.1.3 Alternative 1 - Intake on S. Semberong-Endau.

This source can be developed to yield 13.8 mgd by direct abstraction. A run-of-river intake and raw water pumping station would be constructed on the S. Semberong-Endau about 1½ miles downstream of the confluence of the S. Paloh and S. Semberong Kechil. Raw water would be pumped through 6 miles of pipelines to the treatment works. The pipelines could be laid in two phases, 33-inch internal diameter for the first phase and 27 inch internal diameter for the second phase. Excluding the catchment draining to the intake in the S. Semberong Kechil, the catchment area draining to the intake is 220 square miles, of which 80 square miles is jungle or swamp and 140 square miles is developed. Based on Figure 1.5, the run-of-river yield, for a return period of 1 year in 10 years, is estimated at 15 mgd.

The capital cost of this scheme is shown in Appendix C - 2.

If the 80 square miles of jungle, upstream of the chosen intake site, were cleared in the future for agricultural development, then the reliable yield is estimated to fall from 15 mgd to 8.5 mgd. To obtain the required yield from a fully developed catchment would require a catchment area of about 360 square miles. The intake would have to be located about another 8 miles downstream and the capital cost of the raw water pipelines to the treatment works would be more than doubled.

4.2.1.4 Alternative 2 (Storage on S. Kahang - Direct Supply to Treatment Works).

In order to exploit this source to yield 13.8 mgd it is necessary to provide storage. A suitable dam site is located on 1" map 124 (Grid Reference: W.M.625,516). The catchment area draining to the dam site is 24.4 square miles and is at present jungle covered. A general description of the geology of the dam site, based on a study of existing geological maps and surface field inspection by an engineering geologist, is included in Appendix D. The site is best suited for an earthfill embankment dam. The dam site has been surveyed but the reservoir area has not been surveyed. Estimates of storage available and capital costs for various conservation levels are tabulated in Appendix C-8. If the catchment remained jungle covered the required storage is estimated at 700 million gallons. Assuming that the bottom 10 feet of storage could not be used due to the swampy nature of the flooded area, then a dam height, measured from stream bank level, of 30 feet would be required. This allows for a freeboard of 10 feet, giving a conservation level of 135 m.s.l. The dam crest would be about 1180 feet long.

Raw water would be pumped from the reservoir direct to the treatment works. It is not possible to gravitate due to high intervening ground. The pipelines would be 5½ miles long and could be laid in two phases; 30 inch internal diameter for the first phase and 27 inch internal diameter for the second phase.

The capital cost of this scheme is shown in Appendix C-3

4.2.1.5 Alternative 3A and 3B - (Regulation of S. Semborong Kechil from Storage on S. Kahang).

It is possible to increase the yield by 13.8 mgd, at the intake on the S. Semborong Kechil, by making controlled releases from storage located on the S. Kahang. The dam site would be as Alternative 2, but in this case the required storage is estimated at 400 million gallons. Allowing for a freeboard of 10 feet, a dam height of 27 feet would be required. Conservation level would be 132 MSL and the dam crest would be about 1140 feet long.

Water could be transferred from the reservoir to the catchment of the S. Semborong Kechil by either of the following methods:-

A) By pumping over the catchment divide. From a study of the 1 in 25,000 maps it is estimated that the minimum pipeline length would be 1½ miles. The reservoir draw-off works would be located about 1½ miles upstream of the dam and water discharged into a tributary of the S. Jonah. The pipelines could be laid in two phases; 30 inch internal diameter for the first phase and 27 inch diameter for the second phase.

B) By gravity through a tunnel. From a study of the 1 in 25,000 maps it is estimated that the minimum tunnel length would be 3 miles. The necessity to line the tunnel or not would depend on the results of detailed site investigations, including deep drillings. For the economic analysis a 6 foot diameter lined tunnel has been assumed - this being the minimum practical diameter to construct. The tunnel would be constructed in one phase.

The capital costs of alternatives 3A and 3B are shown in Appendices C-4 and C-5 respectively.

4.2.1.6 Alternative 4 - (Regulation of S. Semborong Kechil from Storage in its own Catchment).

It is possible to increase the yield by 13.8 mgd, at the intake on the S. Semborong Kechil, by making controlled releases from storage located in its own catchment. A suitable dam site is located on 1" map 124 (Grid Reference: WM. 608,417). The

catchment area draining to the dam site is 18.3 square miles and is at present jungle covered. The site has not been visited by an engineering geologist but based on a study of existing geological maps (Appendix D). The site would probably be best suited for an earthfill embankment dam. The dam site has been surveyed but the reservoir area has not been surveyed. Estimates of storage available and capital costs for various conservation levels are tabulated in Appendix C-9. Assuming that the bottom 10 feet of storage could not be used due to the swamp nature of the flooded area, then a dam height, measured from stream bank level, of 25 feet would be required. This allows for a freeboard of 10 feet, giving a conservation level of 135 MSL. The dam crest would be about 2600 feet long.

Controlled releases would be made from the reservoir direct to the natural river channel downstream, to increase the yield at the intake as required.

The capital cost of this scheme is shown in Appendix C-6.

4.2.1.7 Alternative 5 - Extraction of water from S. Semborong located to the West of Kluang.

Consideration has been given to extracting water from this source as follows:-

- A) Abstraction by utilizing the proposed DID dam for irrigation (Section 2.3).
- B) Run-of-river abstraction.

A) The area draining to the proposed DID dam (1" map 123, Grid Reference WM 318,408) is approximately 50 square miles. The main purpose of the dam is for irrigation and controlled releases would be made from the reservoir to regulate flows at diversion intakes at the existing and projected irrigation schemes, located about 5-6 miles downstream. The average diversion demand for irrigation (6000 acres double cropped padi) is estimated at 100 cusecs.

This catchment is outside the Project Area and therefore has not been studied in detail. However, assuming that sufficient storage could be provided, the Project studies of storage/yield relationship within the Project Area suggest that sufficient water would be available to meet the above irrigation demand and an additional water supply demand of 26 cusecs (13.8 mgd) for Kluang.

The shortest pipeline route and lowest static pumping head, to treatment works and terminal storage, located west of Kluang, would be obtained by locating the water supply intake at the dam. The main pipeline would be 9 miles long, which is 1½ times the length of pipeline in Alternative 1. In addition the static pumping head would be about 30-40 feet higher than that in Alternative 1. Also part of the dam cost would be chargeable to the water supply scheme.

B) In order to obtain 13.8 mgd by run-of-river abstraction it would be necessary to locate the intake about 10 miles downstream of Brizay Bridge. The catchment to the intake would be 200 square miles, of which 70 square miles is jungle covered area with the remainder largely artificially drained and fully developed. The main pipeline would be 20 miles long, which is three times the length of pipeline in Alternative 1. In addition the static pumping head would be 40-50 feet higher than that in Alternative 1.

The above takes no account of present irrigation demand at Sawah Sagil (Section 2.3). If this is included then the water supply intake would have to be located even further downstream, involving a longer pipeline and higher pumping head.

It can be concluded that, due to higher capital and operating costs, any proposals under

Alternative 5 would be more expensive than Alternative 1 and need not be considered further.

#### 4.2.1.8 Economic Comparison of Alternatives.

The capital to be invested and the annual operating costs up to the year 2000 for Alternatives 1-4, are tabulated in Appendix C-7, together with the present values, as at 1972, of all costs at discount rates of 5, 10 and 15 percent per annum.

The figures given for present value take into account all capital costs of construction and site investigations, and annual operation costs i.e. power for pumping, labour, chemicals and annual maintenance, up to the outlet from bulk terminal storage. Land acquisition and compensation costs are excluded as there is insufficient data available for their estimation. However their costs would be very small compared to other capital costs and would not affect the conclusions.

The present values, as at 1972, in million dollars are as follows:-

Alternative	Discount Rate percent per annum		
	5	10	15
1	12.06	7.12	4.72
2	13.56	8.42	5.75
3A	11.45	7.28	5.11
3B	14.80	9.83	7.02
4	12.20	7.96	5.63

At all discount rates Alternatives 2, 3B and 4 are always less attractive than Alternatives 1 and 3A. The relative attractiveness of Alternatives 1 and 3A changes with the discount rate; Alternative 3A being more economical at discount rates less than about 9 percent per annum. Sensitivity analysis shows that the above rankings remain unaffected by changes of plus or minus 15 percent in the assumed rate of growth of demand.

The indirect benefits associated with Alternatives 2, 3A, 3B and 4, such as recreational use of the reservoirs and flood mitigation in the valleys immediately below the dams, would be similar.

The only indirect costs that could arise from these alternatives would be any opportunities foregone because the reservoir and catchment areas would be no longer available to utilize for mining and agricultural development. The opportunity cost (i.e. benefit foregone) to mining is nil since there are no economically exploitable minerals in the areas (Supporting Volume 2). The opportunity cost to agriculture of the catchments is very small due to the availability of alternative potential agricultural land. If the catchments were developed there would be some additional dam construction and water treatment costs, which would probably exceed the opportunity cost to agriculture of the reservoir areas.

There are no indirect benefits associated with Alternative 1 but because the town of Kluang is within the catchment draining to the proposed intake there may be indirect costs associated with pollution control of the river, especially at low flows. There are no sewage treatment works at Kluang town: sewage and trade wastes discharge into the S. Mengkibol about 7/8 miles upstream of the proposed intake. The Project studies indicate that there is potential in Kluang town for further urban expansion and industrial developments, created partly by the land development of the adjacent area of Johor Tengah. The consequence of this will be a large increase in domestic and trade wastes discharged into the river. In order to safe-guard the quality of water at the intake in future years,

pollution would have to be controlled by introducing appropriate legislation and by affording the necessary treatment for these wastes.

As the new source for water supply is required by 1981/82, it is considered that, with the limited data available, 1985 is the latest date by which sewerage facilities would require to be provided. It is not possible, at this time, to state if deferment or phasing of sewerage facilities would be permissible after 1985, as this largely depends on the rate of growth of Kluang. This could be an important factor in future studies.

A policy decision would have to be made by the Government regarding the allocation of costs of any future scheme for the provision of water borne sanitation and sewage treatment at Kluang. If it were considered that these facilities are a normal requirement of a growing community then the expenditure could not reasonably be regarded as an indirect cost against Alternative 1. If such facilities are provided solely to protect the source of water supplies then the expenditure must be regarded as an indirect cost.

Assuming the latter to be the case and assuming that sewerage facilities would have to be provided by 1985 then the maximum amount of capital that could be spent in 1985 to ensure that the present value of Alternative 1 remained more attractive than Alternative 3A is as follows:-

Discount Rate (per annum)	Capital (Million Dollars)
10 percent	0.55
15 percent	2.40

A detailed study of the cost of providing sewerage facilities has not yet been carried out but the cost would be much in excess of the above amounts. The population of Kluang town will probably rise to about 150,000 by 1985. The cost of providing modern sewerage facilities in new towns of this size in the United Kingdom would lie in the range of 50-70 million dollars.

#### 4.2.1.9 Conclusion.

On the assumption that water borne sanitation and sewage treatment facilities at Kluang would be provided solely to safeguard the quality of the water at the intake on the S. Semberong - Endau (Alternative 1), it is concluded that the most economical scheme investigated is Alternative 3A.

This would involve the construction of an earthfill dam on the S. Kahang and the controlled transfer of water from the reservoir by pumping over the watershed to the catchment of the S. Semberong Kechil during periods of low flow. The intake, pumping station, treatment works and bulk terminal storage under construction on the S. Semberong Kechil would be expanded to a capacity of 16 mgd. Phasing of the appropriate works is shown in Appendix C-1.

For the reasons outlined in Section 4.2.1.8 it is recommended that the catchment draining to the dam remains as jungle.

Certain further studies will be required to prove the technical and economic feasibility of this scheme. These are outlined in Chapter 5.

#### 4.2.2 Kota Tinggi Water Supply Area.

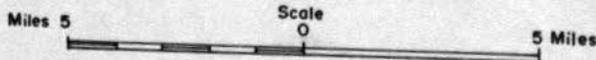
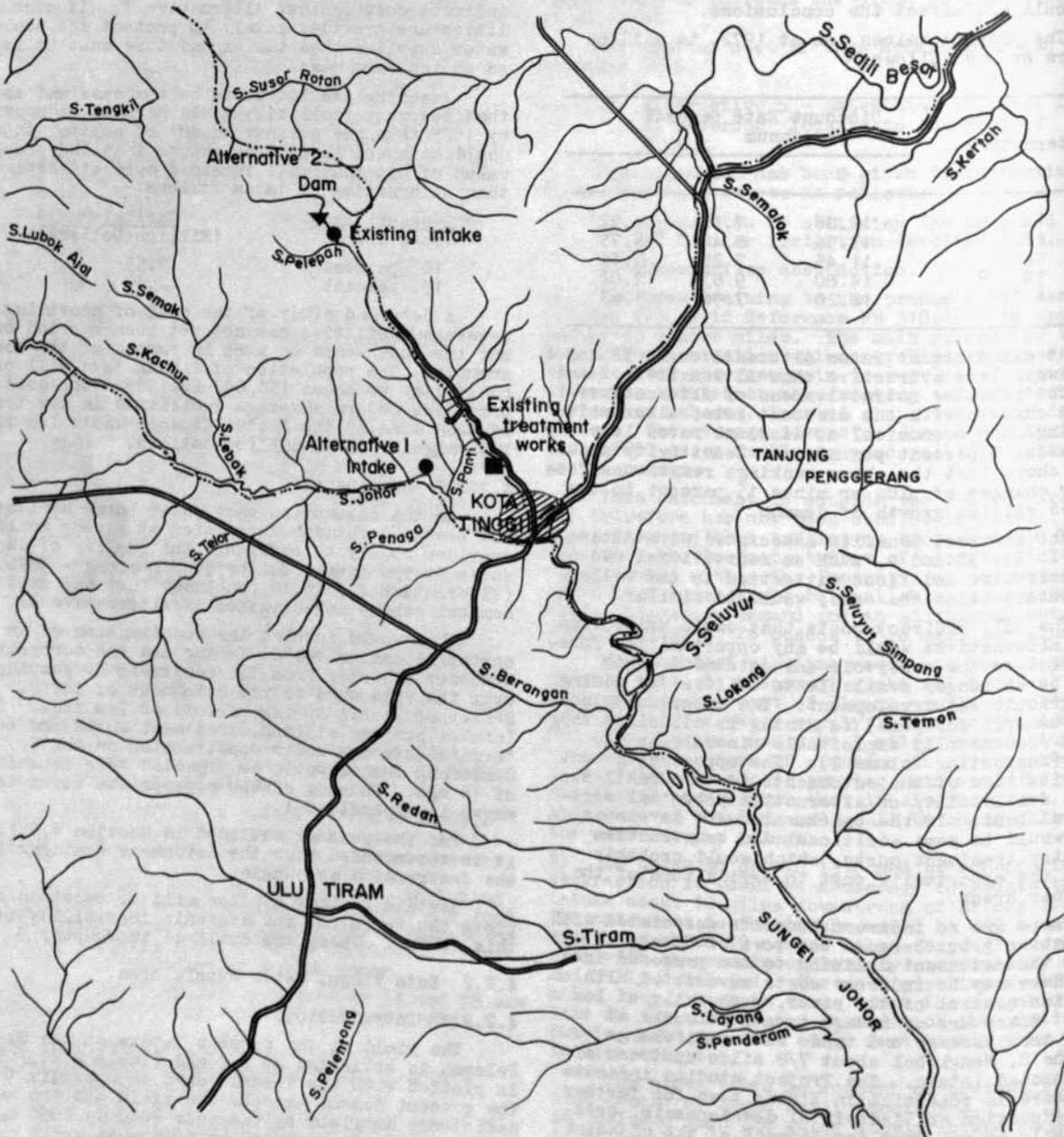
##### 4.2.2.1 Introduction.

The yield at the present intake on the S. Pelepah is estimated at 0.2 mgd (Table 2.2). This is plotted with the demand curve in Appendix C-10. The present demand exceeds the yield and the nett deficiency in yield by the year 2000 is 2.60 mgd. The capacity of the existing treatment works and pipelines is 1.00 mgd and the nett deficiency in works capacity by the year 2000 is 1.6 mgd.

FIGURE 4.2



KOTA TINGGI WATER SUPPLY AREA  
THE ALTERNATIVE SOURCES



#### 4.2.2.2 The Alternatives Considered.

To cater for the above demand the following alternatives have been considered (Figure 4.2).

1. Direct abstraction from S. Johor approximately  $\frac{1}{2}$  mile upstream of the confluence of the S. Panti and S. Johor.
2. Regulation of S. Pelepah from storage in its own catchment.

The phasing of the different works for each alternative is shown in Appendix C-10. In Alternative 2 the existing treatment works would be expanded from 1.00 mgd to 2.8 mgd; in Alternative 1 new treatment works would be constructed of capacity 2.60 mgd. The reason for this is that the existing supply system is under gravity pressure from the intake to terminal storage and incorporates pressure filters. Raw water from the S. Johor is of entirely different quality requiring sedimentation and it would be impractical to connect this into the existing treatment works.

The phasing of pipelines and the selection of diameters is not optimal: these would require further investigation in future studies.

The S. Johor is the closest run-of-river source to meet the future demand of Kota Tinggi. The nearest alternative sources for the full demand are the S. Sedili Besar and S. Tiram. These are much further away and capital and operating costs (pumping would be required) would be much higher. The next largest catchment nearest to Kota Tinggi is the S. Seluyut. The catchment area is 23.7 square miles and is at present jungle covered. Under Project plans this catchment will be developed for agriculture and the run-of-river yield is estimated to reduce from 2.8 mgd to 1.3 mgd (Tables 2.2 and 2.3). The JKR are at present exploiting this river to supply FLDA Ayer Tawar and parts of the west coast of Tanjong Penggerang. The estimated future yield of 1.3 mgd will only just be sufficient to meet the demands of this supply area. These sources therefore are not considered further in this report.

#### 4.2.2.3 Alternative 1 - (Intake on S. Johor).

There would be no difficulty in obtaining 2.60 mgd from this source by direct abstraction. A run-of-river intake and raw water pumping station would be constructed, on the north bank of the S. Johor, approximately  $\frac{1}{2}$  mile upstream of the confluence of S. Panti and S. Johor. Raw water would be pumped to new treatment works about 300 yards away. The treatment works would incorporate sedimentation, filtration and sterilization and treated water would be pumped a distance of about 1 mile to terminal storage located on high ground about  $\frac{1}{2}$  mile east of the existing JKR treatment works. Raw water and treated water pipelines could be laid in 3 phases; 10 inches internal diameter for the 1st and 2nd phases, and 12 inches internal diameter for the 3rd phase.

The capital cost of this scheme is shown in Appendix C-11.

#### 4.2.2.4 Alternative 2 - (Regulation of S. Pelepah from Storage in its own Catchment).

It is possible to increase the yield by 2.6 mgd, at the intake on the S. Pelepah, by making controlled releases from storage located in its own catchment. A suitable dam site is located on 1" Map 126 (Grid Reference: WN. 089.220). The catchment draining to the dam site is 2.8 square miles and is at present jungle covered. The site has not been visited by an engineering geologist but based on a study of existing geological maps (Appendix D) the site could possibly be suitable for concrete, rockfill or earthfill dams. Detailed site investigations would be required to establish which type of construction would be best

suitable to the site. For the economic analysis an earthfill embankment dam has been assumed. The dam site has been surveyed but the reservoir area has not been surveyed. The required storage for regulation is estimated at 200 million gallons. This would require a dam height, measured from streams bank level, of 70 feet. This allows for a freeboard of 10 feet, giving a conservation level of 440 MSL. The dam crest would be about 710 feet long. Details of the estimated capital cost of the dam are given in Appendix C-14.

The existing 10 inch internal diameter gravity pipeline from the intake to the present treatment works would meet the demand to the year 1982 and an additional 15 inch internal diameter pipeline would then be laid to cater for the demand up to the year 2000. The existing treatment works incorporating filtration and sterilisation would be expanded.

The capital cost of this scheme is shown in Appendix C-12.

#### 4.2.2.5 Economic Comparison of Alternatives.

The capital to be invested and the annual operating costs up to the year 2000 for each alternative, are tabulated in Appendix C-13, together with the present values, as at 1972, of all costs at discount rates of 5, 10 and 15 percent per annum.

The figures given for present value take into account all capital costs of construction and site investigations, and annual operation costs i.e. power for pumping, labour, chemicals and annual maintenance, up to the outlet from bulk terminal storage. Land acquisition and compensation costs are excluded as there are insufficient data for their estimation. However their costs would be very small compared to other capital costs and would not affect the conclusions.

The present values, as at 1972, in million dollars are as follows:-

Alternative	Discount Rate (percent per annum)		
	5	10	15
1	3.51	2.45	1.94
2	5.01	4.55	4.27

At all discount rates Alternative 1 is more attractive than Alternative 2. Sensitivity analysis shows that the above ranking remains unaffected by changes of plus or minus 15 percent in the assumed rate of growth of demand.

There are no indirect benefits or costs associated with Alternative 1.

The reservoir in Alternative 2 could have some indirect benefit as it could provide recreational facilities for boating and fishing. However the value of the benefit would not be extensive as the surface area of the reservoir at the conservation level adopted would be about 26 acres only.

The only indirect costs that could arise with Alternative 2 are associated with mining and agricultural development of the catchment, see economic comparison of alternative supplies to Kluang town (Section 4.2.1.8). Only a small proportion of the catchment is below the 20 degree slope line and suitable for agricultural development. Because of this, and due to the availability of alternative potential agricultural land, the opportunity cost of the catchment to agriculture is negligible. The catchment has been prospected and is known to contain iron and deposits of tin. However it is understood that the

mining consultants consider that these could not be exploited economically due to insufficient reserves and the technical problems of separation of the iron and tin ores. The opportunity cost of the catchment to mining can therefore be taken as zero.

#### 4.2.2.6 Conclusion.

It is concluded that the most economical scheme investigated is Alternative 1.

This would involve the construction of a run-of-river intake on the north bank of the S. Johor, new treatment works of capacity 2.60 mgd and new terminal storage located about 1 mile east of the existing JKR treatment works. The existing JKR treatment works would be retained.

Phasing of the appropriate works is shown in Appendix C-10.

Certain further studies will be required to prove the technical and economic feasibility of this scheme. They are outlined in Chapter 5

#### 4.2.3 Pontian, Johor Baharu, Industrial Area and Port Complex Water Supply Areas.

##### 4.2.3.1 Introduction.

These water supply demand areas all lie in the southern part of Johor State and are therefore considered under one section in this report.

##### a) Pontian

It is understood from the State Engineer that the intake on the S. Pontian Besar, at present supplying Pontian, will be phased out about 1985 due to increasingly difficult water treatment problems at the intake and the age of the plant. The demand is now approaching the capacity of the treatment works (1.00 mgd) and the JKR are at present implementing a new scheme (capacity 2.5 mgd) involving a new offtake from the PUB's mains near Ulu Choh. Pontian District is very low lying and is largely artificially drained - the remainder being swamp land. There are no catchments within the District capable of yielding the estimated demand of 8 mgd in the year 2000. A careful study of surrounding catchments has been made but those capable of yielding 8 mgd either have water demands on them or are too far away from an economic point of view. There are adjacent catchments capable of yielding less than 8 mgd. These are the S. Pulai, S. Melana, S. Danga and S. Melayu. The largest of these, which is also the nearest to existing terminal storage, is the S. Pulai. The headwaters of this river have been allocated to Singapore under the 1961 Agreement. The remaining catchment area, which is developed, is about 21 square miles measured to the limit of tidal influence. The run-of-river yield is estimated at 1.00 mgd. The cost of delivering 1 mgd from this source to terminal storage is estimated at 69 cents/1000 galls. The cost of water per 1000 gallons from other adjacent catchments would be greater as their yields are smaller and they are further away from terminal storage. It can be concluded that the future demand for Pontian should therefore be met from increased abstractions from the PUB's mains at a cost of 50 cents per 1000 gallons as provided for in Clause 16 of the 1961 Agreement between Johor State and Singapore.

##### b) Johor Baharu (including Kulai Town)

The Johor Baharu supply area extends north west as far as Kulai town. Consideration has been given to disconnecting Kulai town and surrounding area from the PUB mains and supplying water from an alternative source. The nearest source to meet the estimated demand of 4.7 mgd for Kulai town in the year 2000 is the S. Sayong (tributary of S. Johor). Based on capital and operating costs, and taking delivery point of

treated water to be terminal storage located within 1 mile of Kulai town, the economic study gave the following present values, as at 1972, in million dollars.

Alternative	Discount Rate percent per annum		
	5	10	15
Purchasing water from PUB at 50 cents per 1000 galls.	7.7	4.7	3.4
New source on S. Sayong	8.2	6.2	5.3

It can be concluded therefore that Kulai town should remain connected to the Johor Baharu supply area and its future demand met from the PUB mains at a cost of 50 cents/1000 gallons at the offtake.

##### c) Industrial Area and Port Complex

It is understood that the JKR are implementing a scheme to increase the size of the intake on the S. Serai (C.A. = 4.8 square miles) and the Kong Kong treatment works to supply the village of Maasi and to provide an initial supply to the Industrial and Port area. This will only amount to about 100,000 gallons per day and cannot be considered as a long term solution for the new port and associated industrial area whose demand by the year 2000 is estimated at 30 mgd.

##### d) (a) + (b) + (c) Combined.

Due to the relatively high future demands of Johor Baharu (47 mgd) and Industrial Area and Port (30 mgd), and the lack of a suitable adequate source close to Pontian, these three areas have been considered as one area of demand. The composite demand curve is shown in Appendix C-15.

The yield of the present sources is estimated as follows:

- 18 mgd from PUB. 1961 Agreement (Section 2.2.1.2).
- 0.6 mgd from PUB. 1962 Agreement (Section 2.2.1.1)
- 1.0 mgd Capacity of Pontian treatment works (Table 2.1).

This gives a present total yield of 19.6 mgd. This total will alter in time. It will decrease when the Pontian intake is phased out and it will increase if and when the PUB abstract more water from their intake on S. Johor. The build up of the PUB demand on the S. Johor is not known and for this study is assumed to reach a maximum of 100 mgd by 1978, thus entitling Johor State to a total supply of 2 mgd under the 1962 Agreement. The resultant yield curve has been superimposed on the demand curve in Appendix C-15. The demand exceed the yield by 1978/79 and the nett deficiency in yield by the year 2000 is 65 mgd. It should be noted that if the PUB demand on the S. Johor increased to the maximum of 250 mgd allowable by the 1962 Agreement, then Johor State's entitlement would rise to a total of 5 mgd i.e. 3 mgd more than the 2 mgd assumed for this study. This would decrease the nett deficiency in yield by the year 2000 to 62 mgd and would only have a marginal effect on the timing of the different phases considered.

##### 4.2.3.2 The Alternatives Considered.

To cater for the above demand the following alternatives, each involving more than one source, have been considered.

1. a) Increased abstractions from the PUB mains,

to meet the demands up to 1978/79.

- b) Phased abstractions of 15, 20 and 35 mgd from an intake, located near Kg. Semangar, on the S. Johor to meet the increase in demand from 1978/79 to year 2000. (See Appendix C-19 for notes on selection of pipeline route and location of intake).

2. a) As 1(a) above.

- b) Phased abstractions of 15 and 20 mgd from the proposed barrage scheme on the estuary of the S. Tebrau just to the east of Johor Baharu town. For this study a minimum reliable yield of 35 mgd has been taken for this scheme. This would meet the demand until 1992/93.

- c) Abstraction of 30 mgd from an intake on the S. Johor as 1(b) but with a capacity to meet the increase in demand from 1992/93 to year 2000.

A flow diagram and the phasing of the works for each alternative is shown in Appendix C-15. The phasing of pipelines and the selection of diameters is not optimal: these would require further investigation in future studies.

There are two major rivers, the S. Scudai and S. Tebrau which are close to the area of demand and represent potential water supply sources. They are only partially developed at present and could provide further significant yields, particularly if operated in conjunction with regulating storage. However, as staged in Section 2.2.2, under the 1961 Agreement the whole of the waters of these two rivers have been allocated for the use of Singapore and they are not considered in this report as a source of supply available to Johor State.

There are other rivers, with smaller catchment areas than the S. Scudai and S. Tebrau, which are closer to the area of demand than the S. Johor. These are the S. Pulai, S. Melana, S. Tiram, S. Layang and S. Redam. The largest of these is the S. Tiram with a catchment area, which is mostly developed, of about 40 square miles measured to the limit of tidal influence. The run-of-river yield is estimated at 2-3 mgd. Yields of this order would contribute little to the large demands being considered. Again, however, significant yields could be obtained if operated in conjunction with regulating storage. The only potential regulating storage in the vicinity is the proposed Tebrau Barrage. However, the amount of storage available at the barrage is quite small compared to its catchment size. In this circumstances the increase in yield from the S. Tiram would be very small especially as both catchments would tend to experience drought periods at the same time.

None of the above sources are therefore considered further in this report.

#### 4.2.3.3 Alternative 1

The layout of this alternative is shown in Figure 4.3.

Phase 1 involves supplying the industrial and port area from a new offtake on the PUB mains to meet the demand of 7 mgd by 1978/79. The pipeline would be 12½ miles long (from point H to point D). Assuming that the pressure head in the PUB mains is 265 MSL, a 27 inch internal diameter pipeline is required to cater for 7 mgd.

To meet the demand after 1978/79 an intake and raw water pumping station would be constructed on the S. Johor just downstream of the confluence of the S. Semangar and S. Johor (point A). Raw water would be pumped through 1000 feet of pipeline to treatment works, incorporating sedimentation, filtration and sterilization (point B). Treated water would be pumped through 12½ miles of pipeline to bulk terminal storage (12 hours supply)

located at point C and set at a suitable elevation to command the demand area. The water would then gravitate to further terminal storages at point D (12 hours supply) located to command the port area; and point K, the location of existing terminal storage for Johor Baharu, through a common pipeline CE, about 1½ miles long and separate pipelines ED about 10 miles long and EK about 7 miles long. Pipelines could be laid in 3 phases (phases 2, 3, and 4) as follows:

line	Internal diameter (inches)		
	Phase 2	Phase 3	Phase 4
A-B	37	43	52
B-C	37	43	52
C-E	39	44	51
E-D	26	27	30
E-K	31	36	44

The capital cost of this scheme, including the pipeline in phase 1 from the PUB mains to the Port terminal storage is shown in Appendix C-16.

#### 4.2.3.4 Alternative 2

The layout of this alternative is shown in Figure 4.4.

Phase 1 is as for as Alternative 1.

The intake from the Tebrau reservoir would be situated about 1½ miles upstream of the barrage on the east bank of the S. Tebrau (point B<sub>1</sub>). Raw water would be pumped through 1500 feet of pipeline to treatment works, incorporating sedimentation, filtration and sterilization. Treated water would be pumped to terminal storage at point D (as Alternative 1) and to terminal storage at point C<sub>1</sub> (12 hours supply). Water would gravitate from C<sub>1</sub> to K, the location of existing terminal storage for Johor Baharu. It has been necessary to introduce point C<sub>1</sub> in this alternative as land at a suitable elevation to command the demand area is not available at point K to accommodate a large increase in terminal storage. Pipeline lengths B<sub>1</sub>D, B<sub>1</sub>C<sub>1</sub> and C<sub>1</sub>K are 10 miles, 5½ miles and 4 miles respectively.

After 1992/93 the additional demand of 30 mgd to the year 2000 would be met by run of river abstraction from the S. Johor. This would be similar to the fourth phase in Alternative 1.

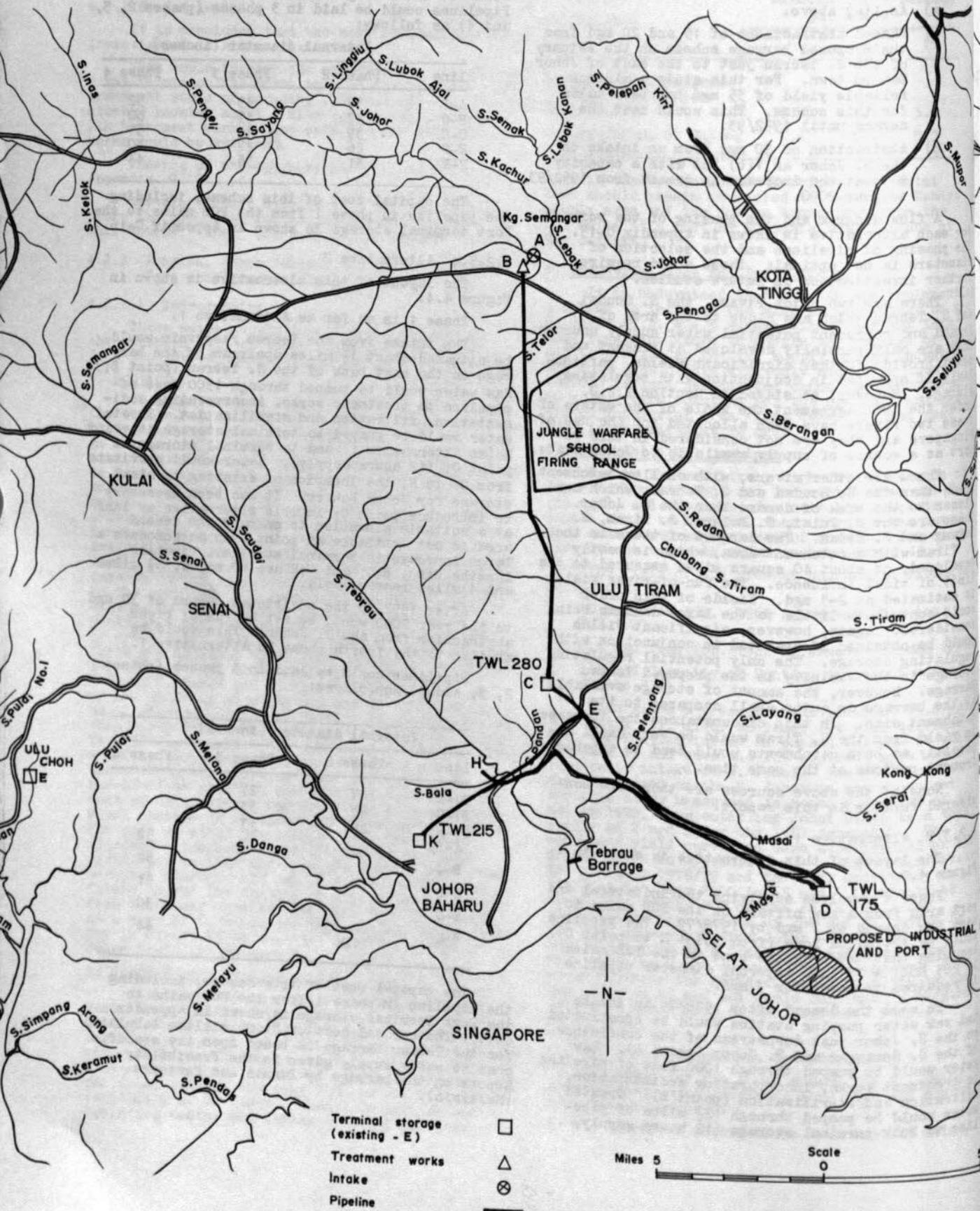
Pipelines could be laid in 3 phases (phases 2, 3, and 4) as follows:

Line	Internal diameter (inches)		
	Phase 2	Phase 3	Phase 4
B <sub>1</sub> -D	27	27	
B <sub>1</sub> -C <sub>1</sub>	27	33	
C <sub>1</sub> -K	28	33	
A-B			52
B-C			52
C-E			51
E-D			30
E-K			44

The capital cost of this scheme, including the pipeline in phase 1 from the PUB mains to the Port terminal storage is shown in Appendix C-17. The capital cost of \$1.03 million tabulated for the Tebrau barrage is based upon the specific cost to water supply given in the Feasibility Report on the barrage by Binnie and Partners (Malaysia).

FIGURE 4.3

PONTIAN, JOHOR BAHRU, INDUSTRIAL AREA  
AND PORT WATER SUPPLY AREAS  
ALTERNATIVE I





#### 4.2.3.5 Economic Comparison of Alternatives.

The capital to be invested and the annual operating costs up to the year 2000 for each alternative are tabulated in Appendix C-18 together with the present values, as at 1972, of all costs at discount rates of 5, 10 and 15 percent per annum.

The figures given for present value take into account all capital costs of construction and site investigations, and annual operation i.e. power for pumping, labour, chemicals and annual maintenance up to the outlet from terminal storage at point D and the inlet of terminal storage at point K. Land acquisition costs and compensation costs are excluded as there is insufficient data available for their estimation. However their costs would be very small compared to other capital costs and would not affect the general conclusions, although they may be an important factor in the detailed selection of pipeline route from S. Johor to Johor Baharu. Capital costs do not include the cost, or any part of the cost, of a reservoir in the Johor catchment, see later in this sub-section.

The present values, as at 1972, in million dollars are as follows:-

Alternative	Discount rate		
	5	10	15
1	72.55	45.72	32.43
2	61.24	38.07	27.03

At all discount rates Alternative 2 is more attractive than Alternative 1. Sensitivity analysis shows that the above rankings remain unaffected by changes of plus or minus 25 percent<sup>+</sup> in the assumed rate of growth of demand.

There are no indirect benefits associated with Alternative 1. Indirect benefits associated with Alternative 2 include possible recreational use of the Tebrau reservoir and upstream flood relief for minor floods. (Feasibility Report by Binnie & Partners (Malaysia)).

Both alternatives require abstraction of water from the S. Johor by Johor State. In Alternative 1 abstractions would commence in 1978/79 and build up to a maximum of 65 mgd by year 2000; in Alternative 2 abstractions would commence in 1992/93 and build up to a maximum of 30 mgd by year 2000. These demands are significant and would affect the availability of water at the PUB intake on the S. Johor, about 1½ miles upstream of Kota Tinggi. An interpretation of the legal implications of this, with regard to the 1962 Agreement between Johor State and the City of Singapore, is outside the Terms of Reference. The technical implication of these abstractions together with the effects on availability of water at the PUB intake, due to Project developments in the catchment of the S. Johor are discussed in Section 4.7.

If the Malaysian Authorities decide to provide or share in the provision of regulating storage in the Johor catchment, then the cost (or shared cost) should be added to each Alternative. However the ranking of the Alternatives would remain unchanged. In fact the attractiveness of Alternative 2 with respect to Alternative 1 would increase because slightly less regulating storage would be required and the date at which storage would be required would be later.

#### 4.2.3.6 Conclusion.

At 10 percent discount rate Alternative 2 is cheaper by \$7.6 million present value in 1972. However only \$1.2 million out of the total cost of the Tebrau barrage has been included, the remaining \$8.3 million being attributable principally to access East of the S. Tebrau. So long as the benefits from this use exceeds about \$0.7 million present value in 1972 Alternative 2 is to be recommended.

This would involve phased development from the following three sources:-

- a) A new off-take on the PUB mains

b) Construction of a barrage on the estuary of the S. Tebrau

c) A run-of-river intake on the S. Johor.

Phasing of the associated works, (pipelines, pumping stations, treatment works, and terminal storage) is shown in Appendix C-15.

Certain further studies will be required to prove the economic and technical feasibility of this scheme. These are outlined in Chapter 5.

#### 4.2.4 Project Developments.

##### 4.2.4.1 Introduction.

For the preliminary village and processing factory locations in the Draft Project Report, a wide range of alternative methods of meeting the estimated water demands were compared economically. The general schemes considered were as follows:-

##### Johor Tengah

(a) Grouping the villages into several areas of demand and supplying individual areas from either a separate intake or from an existing JKR source.

(b) Supplying each village from a separate intake.

##### Tanjong Penggerang

(c) Grouping the villages into several areas of demand and supplying individual areas from either small reservoirs, intakes or existing JKR sources. The small dams considered were on the S. Seluyut, S. Papan, S. Sening and S. Lebam.

Due to the small catchment sizes in Tanjong Penggerang it would not be practical to supply each village from a separate intake unless a return period of failure of less than once in 5 years was acceptable.

For Johor Tengah the economic analysis showed that group schemes were the most attractive. For Tanjong Penggerang the economic analysis showed that the villages should be combined into three groups, with sources of supply being a small reservoir on the S. Lebam, an intake on the S. Sedili Kechil and expansion of an existing JKR source (S. Gembot).

Since the Draft Project Report, the number, size and location of villages and processing factories has changed as a result of more refined planning and requirements laid down by the Steering Committee. Whilst the total maximum water demand has not sensibly altered, the number of villages has been reduced. One consequence of this is that the expansion of the JKR scheme on the S. Gembot, on the northern boundary of Tanjong Penggerang, as recommended in the Draft Project Report, is no longer necessary.

For certain village groups, more detailed economic analysis has been carried out, using the present value method and taking account of the phased implementation of village construction and allowing for stage development of the proposed water supply facilities. The analysis shows that group schemes remain the most economic; an example for village group T1-T6, is given in Appendix C-20. The only alteration to the sources recommended in the Draft Project Report is that the villages located in the catchment of the S. Semberong Kechil should be supplied from a new intake on that river.

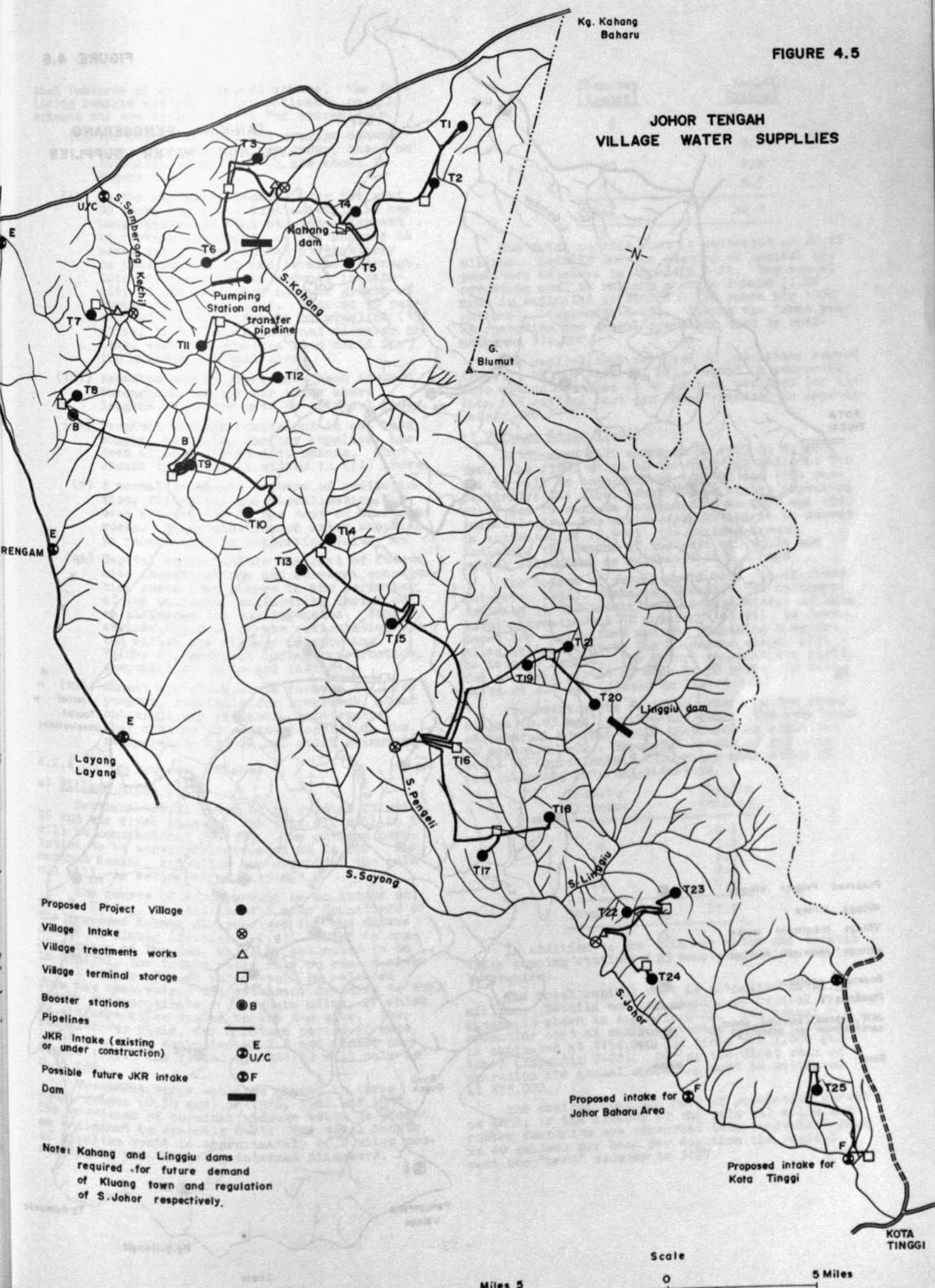
The layout of the proposed schemes in Johor Tengah are shown in Figure 4.5 and in Tanjong Penggerang are shown in Figure 4.6.

Section 4.2.4.2 describes briefly the essen-

<sup>+</sup>For this supply area a range of plus or minus 25 percent, compared to plus or minus 15 percent adopted for Kluang and Kota Tinggi, has been adopted due to the greater uncertainty of the future demands of the Industrial Area and Port.

FIGURE 4.5

JOHOR TENGAH  
VILLAGE WATER SUPPLIES



- Proposed Project Village ●
- Village Intake ⊗
- Village treatments works △
- Village terminal storage □
- Booster stations ● B
- Pipelines —
- JKR Intake (existing or under construction) ● E, ● U/C
- Possible future JKR intake ● F
- Dam —

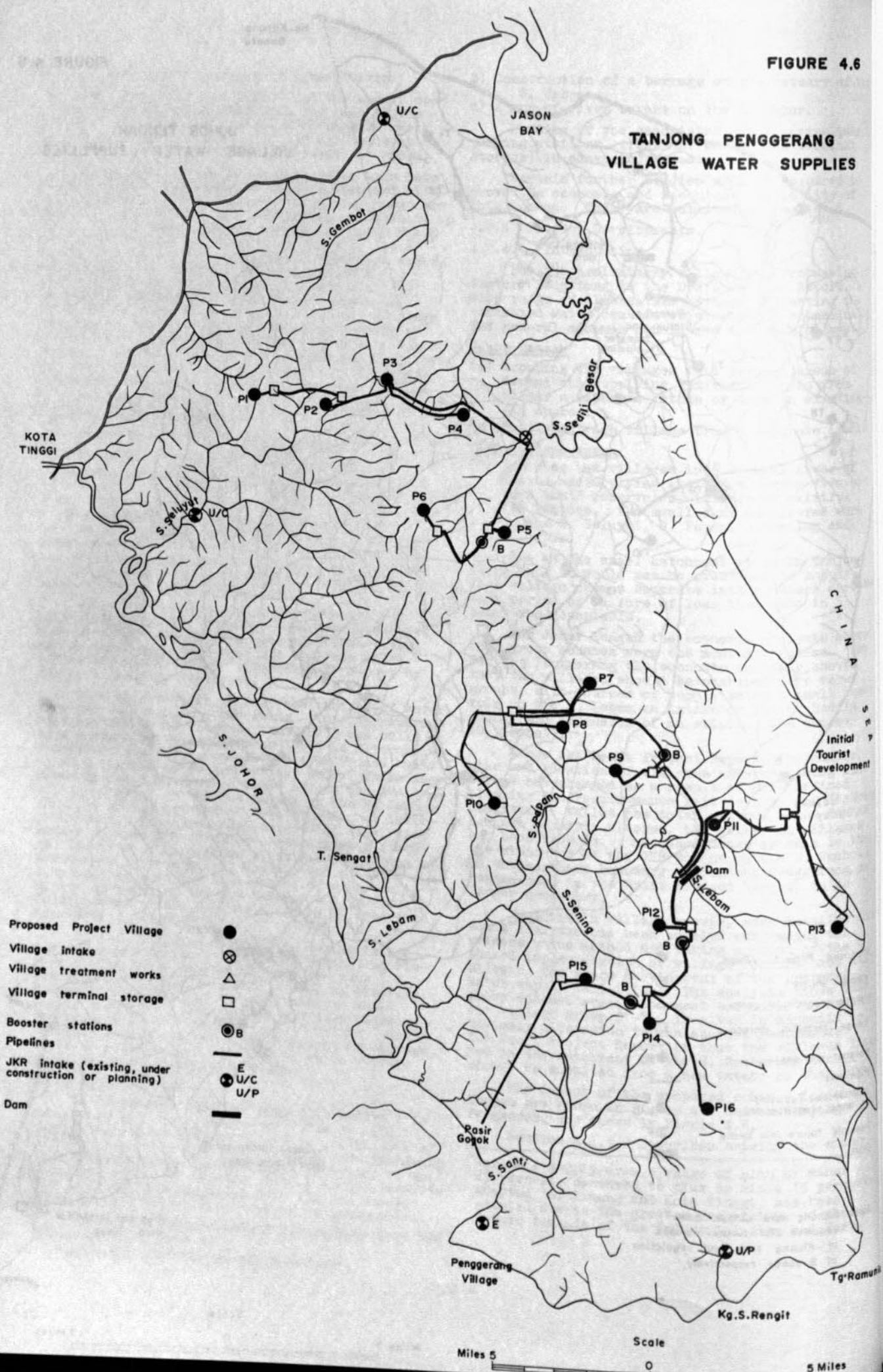
Note: Kahang and Linggiu dams required for future demand of Kluang town and regulation of S. Johor respectively.

Scale  
0 5 Miles

Miles 5

FIGURE 4.6

TANJONG PENGGERANG VILLAGE WATER SUPPLIES



- Proposed Project Village Intake ●
- Village intake ⊗
- Village treatment works △
- Village terminal storage □
- Booster stations ⊙B
- Pipelines —
- JKR intake (existing, under construction or planning) ⊙E
- Dam —

Scale  
Miles 5 0 5 Miles

tial features of each proposed scheme. The following remarks are generally applicable to all schemes and are included here for convenience.

- (i) The composite peak and average demand curves for each village group, based on Appendices B-10 to B-13, are shown in Figure 4.7.
- (ii) As the estimated demands over the next 30 years may alter substantially it has been considered that stage development of certain components of the schemes is essential. This applies particularly to treatment works and terminal storage. Later stages could be reduced in capacity if the projected rate of growth of demand is not realised. Because 90 percent of the total length of pipeline (151 miles) is 12 inches internal diameter or less, each pipe run has been sized for its maximum eventual flow.
- (iii) Asbestos cement pipes have been assumed throughout, except for a few short lengths which may have to be steel pipes.
- (iv) Terminal storage equivalent to one days supply, including factory supplies, has been allowed for in each scheme. This should be phased as stated in (ii) above.
- (v) A normal treatment process of sedimentation, filtration and sterilisation has been allowed for in the cost of treatment works. Fluoridisation of water supplies is recommended in Supporting Volume 4.
- (vi) Capital costs include the cost of future site investigations and surveys, construction costs from source to the perimeter of the villages, engineering design and an allowance for contingencies. They exclude the cost of the reticulation system within the village (Supporting Volume 8), interest during construction, compensation costs and inflation.
- (vii) Annual operation costs include fuel for pumping, chemicals for treatment, labour and civil and equipment maintenance. They exclude the cost of operating the reticulation system and staff overheads.

#### 4.2.4.2 The Proposed Schemes

##### a) Village Group T1-T6

Settlement will commence in 1976 at T3 and T6 and the first stage of the palm oil mill at T4 will be commissioned in 1979. The maximum population to be served is estimated at 21,200. The maximum demand, including the demand of the palm oil mill, is estimated at 1.15 mgd.

The source of supply would be an intake on the S. Kahang, located about 1 mile downstream of the proposed Kahang dam required for the future demand of Kluang (Section 4.2.1). Prior to commissioning of the dam, which is estimated to be in 1981/82, the intake would rely on run-of-river flows. After 1981/82 water would be released from the reservoir. The catchment draining to the intake is approximately 27 square miles, of which 24.4 square miles drains to the dam site. The run-of-river yield, for a return period of once in 10 years, is estimated at 2.2 mgd (based on Figure 1.5). The demand by 1981/82 will only be 0.45 mgd.

Treatment works would be phased in three equal stages (0.38 mgd) in 1976, 1982 and 1988. The provision of terminal storage would be phased as explained in Appendix C-21. The total length of pipeline would be approximately 20.2 miles consisting of the following internal diameters.

Diameter (inches)	Length (miles)
6	7.8
8	9.1
10	2.8
12	0.5
<b>Total</b>	<b>20.2</b>

The total capital cost is estimated at \$2.77 million. Details and the phasing of capital expenditure is shown in Appendix C-21. The annual operating cost at maximum average demand (1.05 mgd) is estimated at \$107,800 (28 cents per 1000 gallons). (Appendix C-28). During the first year of operation the annual operating cost is estimated at \$14,000.

The capital cost per head of population served is \$131; if the palm oil mill demand is converted into equivalent head at 40 gallons per head per day then the capital cost per "head" reduces to approximately \$96.

##### b) Village Group T7-T12

Settlement will commence in 1980 at T9 and T10. The first stage of the palm oil mills at T10 and T9 will be commissioned in 1982 and 1984 respectively; the first stage of the rubber factories at T7 and T9 will be commissioned in 1982 and 1990 respectively. The maximum population to be served is estimated at 18,900. The maximum demand, including the demand of the palm oil mills and rubber factories, is estimated at 1.66 mgd.

The source of supply would be a run-of-river intake on the S. Semberong Kechil. The catchment draining to the intake is 60 square miles; of this total approximately 52 square miles will be developed for agriculture and the remaining 8 square miles, which is above the 20 degree slope, will be left as jungle. The future run-of-river yield, for a return period of once in 10 years, is estimated at 2.4 mgd. (Based on Figure 1.5)

Treatment works would be phased in two equal stages (0.83 mgd) in 1980 and 1987. The provision of terminal storage would be phased as explained in Appendix C-22. The total length of pipeline would be approximately 27.9 miles consisting of the following internal diameters.

Diameter (inches)	Length (miles)
6	10.4
8	1.3
10	6.3
12	9.5
15	0.4
<b>Total</b>	<b>27.9</b>

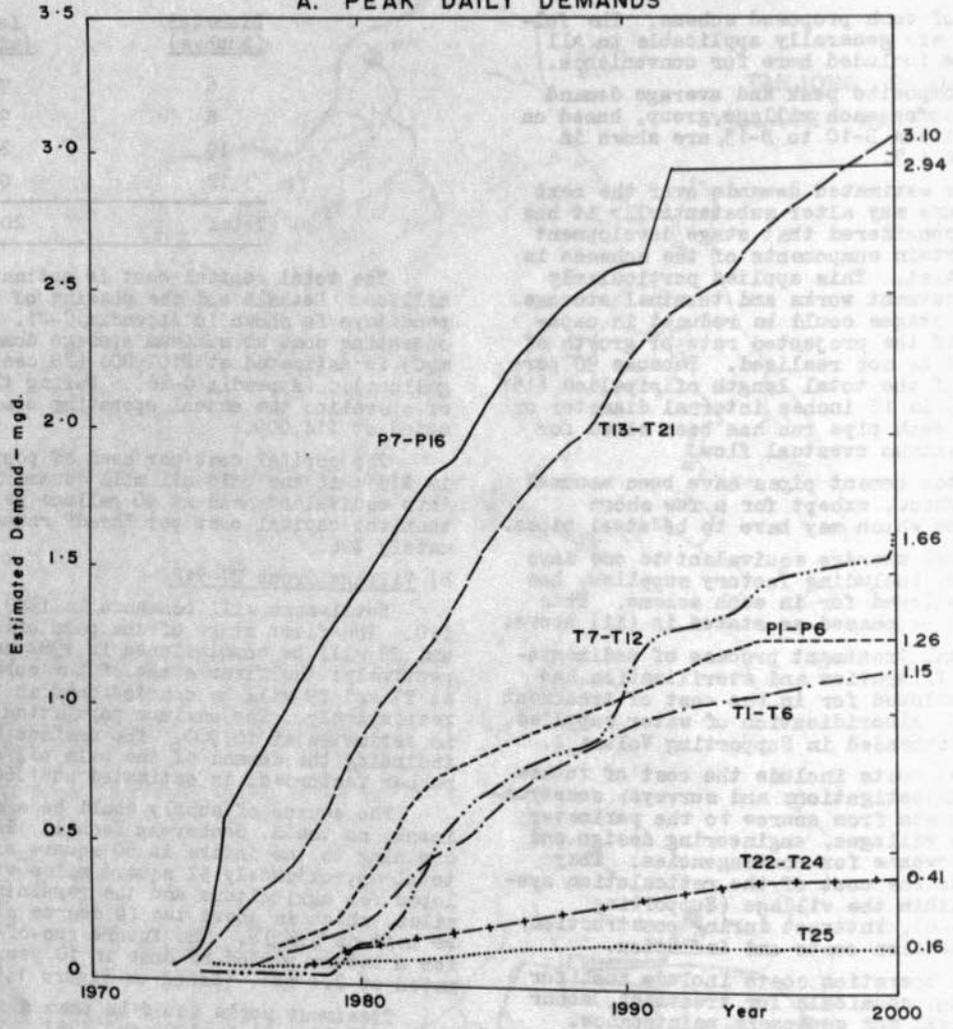
In addition to the main raw water and treated water pumping stations two booster stations would be required.

The total capital cost is estimated at \$4.38 million. Details and the phasing of capital expenditure is shown in Appendix C-22. The annual operating cost at maximum average demand (1.40 mgd) is estimated at \$154,000 (30 cents per 1,000 gallons) (Appendix C-28). During the first year of operation the annual operating cost is estimated at \$33,000.

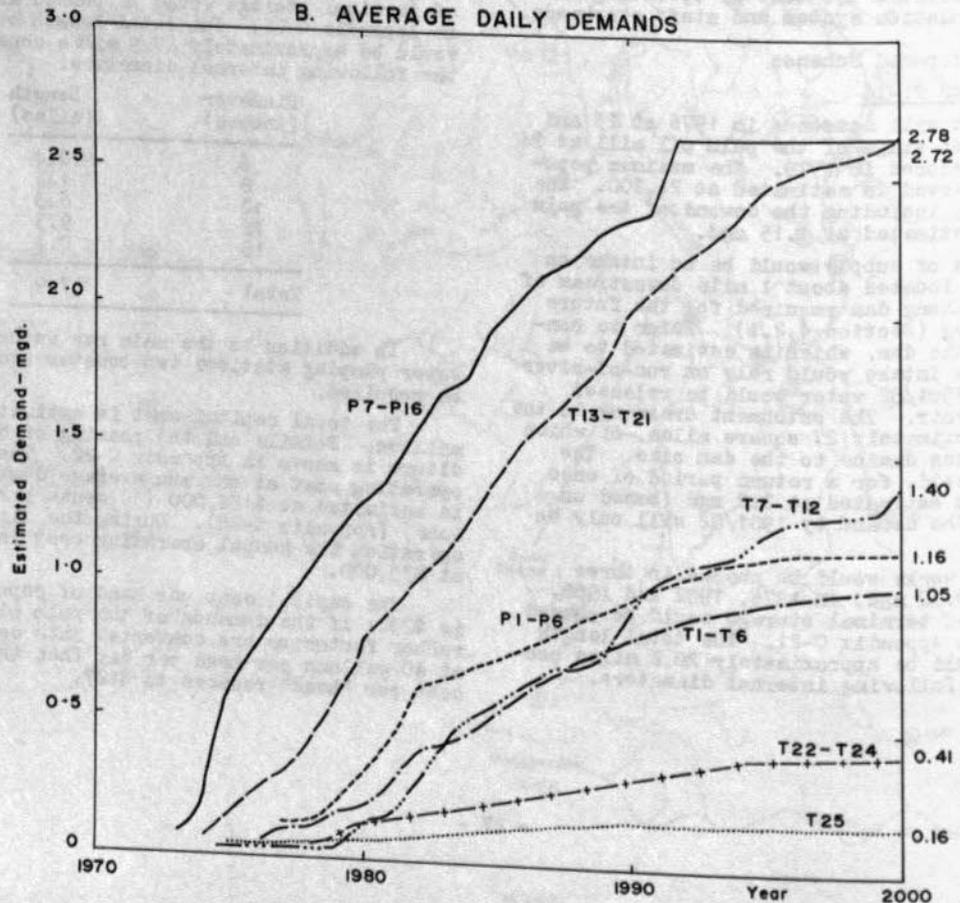
The capital cost per head of population served is \$232; if the demands of the palm oil mills and rubber factories are converted into equivalent head at 40 gallons per head per day then the capital cost per "head" reduces to \$127.

**ESTIMATED WATER DEMANDS FOR VILLAGE GROUPS**  
(Including processing factory demands)

**A. PEAK DAILY DEMANDS**



**B. AVERAGE DAILY DEMANDS**



c) Village Group T13-T21

Settlement will commence in 1974 at T16 and T17. The first stages of the palm oil mills at T16 (2 No) and T19 will be commissioned in 1978, 1980 and 1985 respectively; the first stage of the rubber factory at T19 will be commissioned in 1990 and the first stage of the tapioca factory at T16 will be commissioned in 1975. The maximum population to be served is estimated at 45,900. The maximum demand, including the demand of the palm oil, rubber and tapioca factories is estimated at 3.10 mgd.

The source of supply would be a run-of-river intake on the S. Pengeli. The catchment draining to the intake is 57 square miles; of this total approximately 37 square miles will be developed for agriculture and the remaining 20 square miles, which is above the 20 degree slope, will be left as jungle. The future run-of-river yield, for a return period of once in 10 years, is estimated at 4.2 mgd. (Based on Figure 1.5)

Treatment works would be phased in two equal stages (1.55 mgd) in 1974 and 1984. The provision of terminal storage would be phased as explained in Appendix C-23. The total length of pipeline would be approximately 30.7 miles consisting of the following internal diameters.

Diameter (inches)	Length (miles)
4	0.4
6	8.0
8	20.6
12	1.3
18	0.4
<b>Total</b>	<b>30.7</b>

The total capital cost is estimated at \$5.55 million. Details and the phasing of capital expenditure is shown in Appendix C-23. The annual operating cost at annual average demand (2.78 mgd) is estimated at \$207,200 (20.4 cents per 1,000 gallons) (Appendix C-28). During the first year of operation the annual operating cost is estimated at \$30,000.

The capital cost per head of population served is \$121; if the demands of the palm oil, rubber and tapioca factories are converted into equivalent head at 40 gallons per head per day then the capital cost per "head" reduces to \$77.

d) Village Group T22-T24

There are no processing factories proposed in this village group. Settlement will commence in 1978 at T22. The maximum population to be served is estimated at 10,400. The maximum demand is estimated at 0.41 mgd.

The source of supply would be a run-of-river intake on the S. Johor about 1½ miles downstream of the confluence of the S. Linggiu and S. Sayong. The catchment draining to the intake is approximately 430 square miles and there would be no difficulty in obtaining 0.41 mgd at this location.

Treatment works would be phased in two equal stages (0.2 mgd) in 1978 and 1984. The provision of terminal storage would be phased as explained in Appendix C-24.

The total length of pipeline would be approximately 9.7 miles consisting of the following internal diameters.

Diameter (inches)	Length (miles)
4	3.8
6	1.3
8	4.6
<b>Total</b>	<b>9.7</b>

The total capital cost is estimated at \$1.28 million. Details and the phasing of capital expenditure is shown in Appendix C-24. The annual operating cost at maximum demand is estimated at \$52,300 (35 cents per 1,000 gallons) (Appendix C-28). During the first year of operation the annual operating cost is estimated at \$14,000.

The capital cost per head of population served is \$122.

e) Village T25

There are no processing factories proposed in this village. Settlement will commence in 1975. The maximum population to be served is estimated at 4,000 and the maximum demand is estimated at 0.16 mgd.

The source of supply would be the proposed new intake on the S. Johor for Kota Tinggi (Section 4.2.2). The proposed intake and adjacent treatment works would be expanded over and above the phased expansion required for the future demand of Kota Tinggi. The total length of pipeline would be approximately 4.8 miles consisting of the following internal diameters.

Diameter (inches)	Length (miles)
4	0.1
6	0.3
8	0.4
<b>Total</b>	<b>4.8</b>

The total capital cost is estimated at \$0.44 million; details are given in Appendix C-25. The annual operating cost at maximum demand is estimated at \$10,200 (17.7 cents per 1,000 gallons) (Appendix C-28). During the first year of operation the annual operating cost is estimated at \$4,500.

The capital cost per head of population served is \$109.

f) Village Group P1-P6

Settlement will commence in 1977 at P2 and P3. The first stage of the palm oil mill at P3 will be commissioned in 1980. The maximum population to be served is estimated at 23,900. The maximum demand, including the demand of the palm oil mill, is estimated at 1.26 mgd.

The source of supply would be a run-of-river intake on the S. Sedili Kechil. The catchment draining to the intake is approximately 26 square miles all of which will be developed. The run-of-river yield, for a return period of once in 10 years, is estimated at 1.4 mgd. (Based Figure 1.5).

Treatment works would be phased in two stages; 0.84 mgd in 1977 and 0.42 mgd in 1984. The provision of terminal storage would be phased as explained in Appendix C-26.

The total length of pipeline would be approximately 18.4 miles consisting of the following internal diameters.

Diameter (inches)	Length (miles)
4	4.8
6	6.0
8	3.1
10	4.3
12	0.2
<b>Total</b>	<b>18.4</b>

In addition to the main raw water and treated water pumping stations one booster station would be required.

The total capital cost is estimated at \$2.85 million. Details and the phasing of capital expenditure is shown in Appendix C-26. The annual operating cost at maximum average demand (1.16 mgd) is estimated at \$127,500 (30 cents per 1000 gallons) (Appendix C-28). During the first year of operation the annual operating cost is estimated at \$25,000.

The capital cost per head of population served is \$119; if the palm oil mill demand is converted into equivalent head at 40 gallons per head per day then the capital cost per "head" reduces to \$91.

g) Village Group P7-P16

The demand curve (Figure 4.7) includes for the demands of the initial tourist development (0.3 mgd) and Kg. Pasir Gogak (0.12 mgd). Settlement will commence in 1973 at P10. The first stage of the palm oil mill at P14 will be commissioned in 1978 and the first stage of the rubber factory at P11 will be commissioned in 1982. The maximum population to be served is estimated at 51,100; 47,100 in the villages and service population for the tourist development, 1000 tourists and 3000 in Kg. Pasir Gogak. The maximum demand, including the demand of the palm oil mill and rubber factory, is estimated at 2.94 mgd.

Initially the source of supply would be a run-of-river intake on the S. Lebam. The catchment draining to the intake is 9 square miles and the run-of-river yield (assuming a jungle covered catchment), for a return period of once in 10 years, is estimated at 0.9 mgd. This would meet the projected demand until about 1977. A small dam, located at 1" map 132 grid reference WS 540.873 immediately upstream of the intake, would then be necessary to meet further demands. The dam site has not been visited by an engineering geologist but based on a study of existing geological maps (Appendix D) and field visits near to the site, the site would probably be best suited for an earthfill embankment dam. Estimates of storage available and capital costs for various conservation levels are given in Appendix C-29. Assuming that the bottom 10 feet of storage could not be used due to the swampy nature of the flooded area, then a dam height, measured from stream bank level, of 25 feet would be required. This allows for a free board of 10 feet, giving a conservation level of 30 msl. The dam crest would be about 1200 feet long. The capital cost of the dam is estimated at \$3.2 million.

Treatment works would be phased in two equal stages (1.47 mgd) in 1974 and 1980. The provision of terminal storage would be phased as explained in Appendix C-27. The total length of pipeline would be approximately 39.7 miles consisting of the following internal diameters.

Diameter (inches)	Length (miles)
4	1.0
6	3.6
8	23.0
10	7.4
12	4.3
18	0.4
<b>Total</b>	<b>39.7</b>

In addition to the main raw water and treated water pumping stations four booster stations would be required.

The total capital cost is estimated at \$9.53 million. Details and the phasing of capital expenditure is shown in Appendix C-27. The annual

operating cost at maximum average demand (2.72 mgd) is estimated at \$233,700 (23.5 cents per 1000 gallons) (Appendix C-28). During the first year of operation the annual operating cost is estimated at \$37,000.

The capital cost per head of population served is \$187; if the tourist demand and the demands of the palm oil mill and rubber factory are converted into equivalent head at 40 gallons per head per day then the capital cost per "head" reduces to approximately \$129.

If the full capacity for tourism and associated urban development is realised (Supporting Volume 7), then an additional demand of approximately 9 mgd could be created (Appendix B10). This would require raising the dam on the S. Lebam by approximately 10 feet to give a storage capacity of about 1400 million gallons and a conservation level of 40 msl. The cost of dam raising is estimated very approximately at \$1.5 million. Additional pipelines, treatment works etc. would also be required. Phased development would be preferable, say in three equal stages of 3 mgd. The capital cost of each stage is estimated at \$3.4 million.

It is recommended that the catchment draining to the dam site on the S. Lebam remains as jungle. The opportunity cost (i.e. benefit foregone) to agriculture is very small due to the availability of alternative potential agricultural land. The opportunity cost to mining cannot be evaluated as the amount of economically exploitable minerals is not known. However Supporting Volume 2 recommends prospecting in the catchment and the Project has recommended to the State Commissioner of Lands and Mines that this prospecting should be carried out at an early date. Storage will be needed by about 1977 and exploitation of any minerals should be completed by 1976.

The proposed route of the Penggerang highway passes very close to the dam site. It is recommended that the topographic survey of the dam site and reservoir area and site investigations should be carried out at the same time as the detailed survey for the highway route. This would enable engineering and economic decisions regarding the exact siting of the highway route and dam to be made and would avoid the possible conflict of interests that may arise if both surveys are not carried out at the same time.

4.2.4.3 Summary of Total Costs and Rate of Return

The total capital cost is estimated at \$26.80 million; \$14.42 million in Johor Tengah and \$12.38 million in Tanjong Penggerang. The sum of \$26.80 million includes \$0.45 million for future site investigations and surveys; \$2.0 million for future planning, detailed design, preparation of contract documents etc. and \$2.0 million for contingencies. Annual cost of operation will increase as the demand increases and is estimated to reach approximately \$0.9 million at maximum demand. A summary of the timing of capital investment, build up of annual operating costs, total costs and estimated rate of growth of average demand from 1972 to 2000 for all the schemes combined, is shown in Table 4.1.

TABLE 4.1

Summary of Total Costs 1972-2000

(All costs in Thousand Dollars)

Year	Average Demand - mgd			Capital to be invested			Annual Operating Costs			Total Costs
	Johor Tengah	Tanjong Penggerang	Total	Johor Tengah	Tanjong Penggerang	Total	Johor Tengah	Tanjong Penggerang	Total	
1972	-	-	-	2608	2451	5059	-	-	-	5059
1973	-	0.07	0.07	438	1770	2208	-	25	25	2233
1974	0.09	0.20	0.29	1021	435	1456	42	40	82	1538
1975	0.24	0.60	0.84	482	4969	5451	52	70	122	5573
1976	0.39	0.75	1.14	1669	628	2297	73	82	155	2452
1977	0.51	1.02	1.53	142		142	84	120	204	346
1978	0.71	1.20	1.91	2900	1273	4173	112	133	245	4418
1979	0.95	1.38	2.33		14	14	128	149	277	291
1980	1.35	1.62	2.97	801		801	168	171	339	1140
1981	1.57	1.81	3.38		230	230	185	188	373	603
1982	2.00	2.14	4.14	2312	426	2738	223	216	439	3177
1983	2.25	2.35	4.60				246	237	483	483
1984	2.54	2.44	4.98	1215	65	1280	267	242	509	1789
1985	2.87	2.68	5.55				294	262	556	556
1986	3.17	2.82	5.99	392		392	317	270	587	979
1987	3.36	2.96	6.32				331	284	615	615
1988	3.60	3.06	6.66	391		391	357	296	653	1044
1989	3.79	3.21	7.00				367	307	674	674
1990	4.22	3.30	7.52		118	118	408	314	722	840
1991	4.50	3.38	7.88				430	321	751	751
1992	4.69	3.70	8.39				446	348	794	794
1993	4.83	3.74	8.57				456	352	808	808
1994	4.98	3.76	8.74				467	354	821	821
1995	5.22	3.78	9.00				490	356	846	846
1996	5.32	3.79	9.11				494	358	852	852
1997	5.41	3.79	9.20				503	358	861	861
1998	5.51	3.79	9.30	43		43	510	358	868	911
1999	5.60	3.79	9.39				516	358	874	874
2000	5.74	3.79	9.53				530	358	888	888

- Notes: 1. For details of capital to be invested see Appendices C-21 to C-27
2. For details of annual operating costs at maximum demand see Appendix C-28
3. The timing of capital investment is taken as 2 years before the dates of commissioning given in Appendices C-21 to C-27 to allow for construction period.

**FIGURE 4.8**  
**WATER SUPPLY SCHEMES**  
**COSTS REVENUES AND CHARGES**

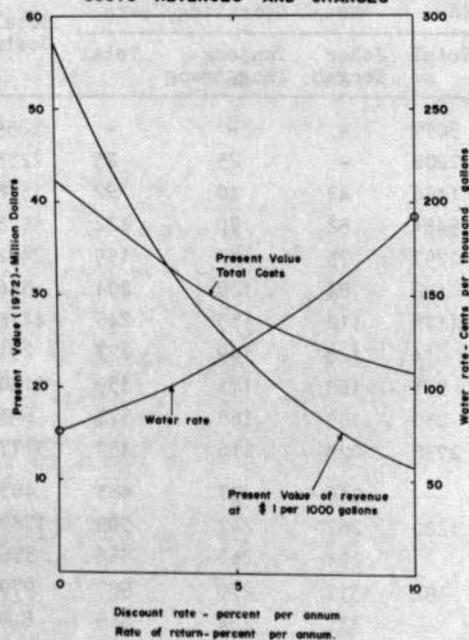


Figure 4.8 shows the present value of total costs for discount rates of nil, 5 percent and 10 percent per annum. The Figure also shows the present value of total revenue at a charge for water consumption of \$1 per 1000 gallons. This is the charge now levied in Johor State for domestic water consumption. The intersection of the total cost and revenue curves shows the rate of return from the water supply schemes if this charge of \$1 is levied. The rate of return is shown to be about 3 percent per annum. Below this rate of interest a surplus is earned; for interest rates of above 3 percent per annum, there would be a loss at a charge of \$1. At an interest rate of, for example, 10 percent per annum, the loss would be about \$10 million over the period of about 30 years.

The Figure also shows the water rate (in cents per 1000 gallons) that would need to be levied to yield a given rate of return. For example, if a rate of return of 10 percent per annum is required the average charge for water consumed would need to be about \$1.90 per 1000 gallons. However the water supply schemes should probably be considered in the context of the land development as a whole and Figure 4.8 is shown in order to clarify the relationship between costs, charges and revenues.

#### 4.2.4.4 Conclusions.

The most economic method of meeting the domestic and processing factory water demands is by grouping the villages into areas of demand. Seven separate schemes are proposed; four of these would rely on run-of-river flows, one would require expansion of the proposed scheme for Kota Tinggi and two would rely on run-of-river flows initially and subsequently would rely upon proposed reservoirs. Schemes should be implemented in stages to match the rate of growth of demand.

It is recommended that the catchment draining to the proposed dam on the S. Lebam remains as jungle and that the detailed survey of the dam site and reservoir area and site investigations be carried out at the same time as the survey for the Penggerang Highway is carried out.

The layout of the schemes and estimated costs are based on very limited field data. Certain further studies will be necessary to prove the technical and economic feasibility of the schemes. These are outlined in Chapter 5.

### 4.3 Irrigation Developments

As stated in Section 3.5.6 the only demand for irrigation will be for oil palm nurseries. Each 5000 acres of oil palm planting will require an 80 acre nursery for a period of 14 months. The irrigation equipment would then be dismantled and set up in a new location for the next development area.

The exact location of the nurseries will not be determined until land clearance has commenced. An important factor in the selection of site will be the reliability of the source of water supply.

For an 80 acre nursery, which has a demand of 0.6 mgd (1.1 cusecs), the intake should be located so that the upstream catchment area is at least that shown in Table 4.2.

TABLE 4.2 Minimum Catchment Areas Draining To Irrigation Intakes

Area	Type of catchment cover	Min. Catchment Area (sq.miles)
NW Johor Tengah	Jungle	10
	Developed	16
Remainder of Project Area	Jungle	8
	Developed	11

These values are based on Figure 1.5 and are for a 1 year in 10 year return period of failure. They also assume that during periods of low river flow the nursery would be irrigated continuously over 24 hours. If the nursery irrigation was limited to 12 working hours each day then the minimum catchment areas required would be approximately double.

The capital cost for a spray irrigation system for an 80 acre nursery is estimated at \$55000 and the annual operating cost is estimated at \$40,000 (Appendix C-30).

### 4.4 Land Drainage Developments

Due to the present unsuitability of the deep peats of Tanjong Penggerang for agricultural use, there is no demand for major drainage schemes.

It is possible that selected small areas elsewhere, mostly located in river valleys, may have to be artificially drained for certain crops.

The observation density of soil survey is such that there is insufficient detail available of soil type and water table level to identify these areas with accuracy. The layout of any small drainage schemes should follow standard DID practice, and the depth and spacing of drains should take into account experience gained on similar schemes with the same crops.

Fallen trees are partially obstructing some of the small streams in the Project Area. With the removal of these trees local ground water drainage could be improved. In some instances local flood levels could be reduced by the removal of major obstructions. However, it is important to realise that extensive removal of obstructions may be expected to have the effect of increasing the downstream flood discharge peaks and levels.

### 4.5 Hydro-Power Developments

A study of the 1 inch to 1 mile and 1 in 25,000 contoured maps has shown that the topogra-

phy of the Project Area is unsuitable for large scale hydro-power development.

In Tanjong Penggerang the relief is low and the highest ground is just over 600 feet MSL. Catchment areas in the region are very small and the number and size of catchment areas above 100 MSL are negligible.

Johor Tengah consists mostly of undulating land below 200 MSL except for the hills near G. Blumut which rises to just over 3,000 feet MSL. The number and size of catchment areas above 200 MSL, centred round G. Blumut, are very small and the opportunities to transfer water between catchments are remote.

Power could be generated by construction of some of the dams considered elsewhere in this report by utilizing the head created by the dam. However the dam heights considered are relatively low and a brief economic analysis, based on capital costs alone, has shown that the cost per firm unit (kw hr) leaving the generators would be in the range of 20-50 cents. These costs assume that the dam would be built for hydro-power purposes only. They do not therefore provide a basis for assessing the value of providing hydro power generation at a reservoir constructed and operated for water supply regulation.

Firm power is power that can be relied upon to be available about 98 percent of days. Hydro electric power capacity, if it is firm, is of particular value because it saves the cost of providing an amount of other generating capacity (probably thermal) at what may be a much higher cost. All hydro electric energy generated, that can be absorbed into the grid, also saves the running costs of generation by other means. The evaluation of hydro electric schemes therefore requires a careful assessment of the load curve and the amount by which alternative capacity can be reduced. It also requires a detailed operations study of the river regulation scheme to assess the amount of hydro capacity that can be considered firm, the amount of capacity to be installed and the total energy likely to be developed. In certain cases re-regulation of power releases can be adopted in order to allow hydro power generation to be phased in with the peaks of the general load curve.

Of the three dams recommended for development for water supply purposes, on the S. Linggiu, S. Kahang and S. Lebam, only the S. Linggiu dam may have potential for power generation due to its larger catchment area (80 square miles) and slightly greater dam height (45 feet maximum depth of water). However, unless additional storage is provided for hydro power, no firm power may be obtainable due to the small head remaining at full reservoir draw down.

A preliminary estimate indicates that the annual energy output would be 3.0 to 4.0 million units approximately. An economic analysis should be made in future reservoir studies and should take into account realistic power demand projections and patterns. A decision should be reached at the detailed design stage whether or not to include hydro power generation facilities in the project. Certain facilities might not be able to be included after this stage.

#### 4.6 Flood Mitigation Developments

##### 4.6.1 Introduction.

The general aspects of flooding are discussed in Section 1.4. The flood plains of most of the rivers in the Project Area are wide compared to the main channel widths, and the only positive method of extensively reducing flood levels in such cases would be by providing upstream storage. After land clearance it may be possible to identify small areas which could be protected from flooding by bunds. Each case would require a detailed study involving topographical surveys, knowledge of frequencies of flood levels and a cost:benefit analysis to be made

for alternative proposals. It is not possible to identify such areas from the existing 1 inch to 1 mile and 1 in 25000 contoured maps and therefore no study has been undertaken.

Large areas of the towns of Kluang and Kota Tinggi, both partly within the Project Area, were flooded in December 1969, during the monsoon period. Kluang is situated on the S. Mengkibol with an upstream catchment area of 30 square miles and Kota Tinggi is situated on the S. Johor with an upstream catchment area of 600 square miles.

The DID are at present implementing a flood mitigation scheme at Kluang. The remainder of this section only deals with an appraisal of alternative engineering methods of mitigating flooding at Kota Tinggi.

##### 4.6.2 Flood Mitigation at Kota Tinggi.

###### 4.6.2.1 Frequency of Flooding.

The incidence of flooding and corresponding stage heights during the period 1942-69 inclusive are shown in Table 4.3.

TABLE 4.3 Recent Historical Floods at Kota Tinggi

Date	Stage (MSL)	Remarks
1942	Not known	Stage described as high by local inhabitants.
1948	15.23	About 1 foot higher than 1969
Jan. 1951	16.20 <sup>+-</sup>	Level mentioned in 1952 DID Report 12.90
Jan. 1952	12.00 <sup>+</sup>	DID Report available. Level given in report 11.00
Dec. 1954	12.60 <sup>+</sup>	
Dec. 1956	12.27	
Mar. 1964	6.00	DID Report available. River did not overflow banks at Kota Tinggi.
Dec. 1967	14.40 <sup>+</sup>	Double peaked flood
Jan. 1968		
Dec. 1969	14.23	J.K.R. Level 13.75

<sup>+</sup>Levels shown on flood maps provided by D.I.D.

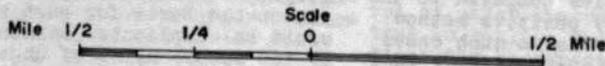
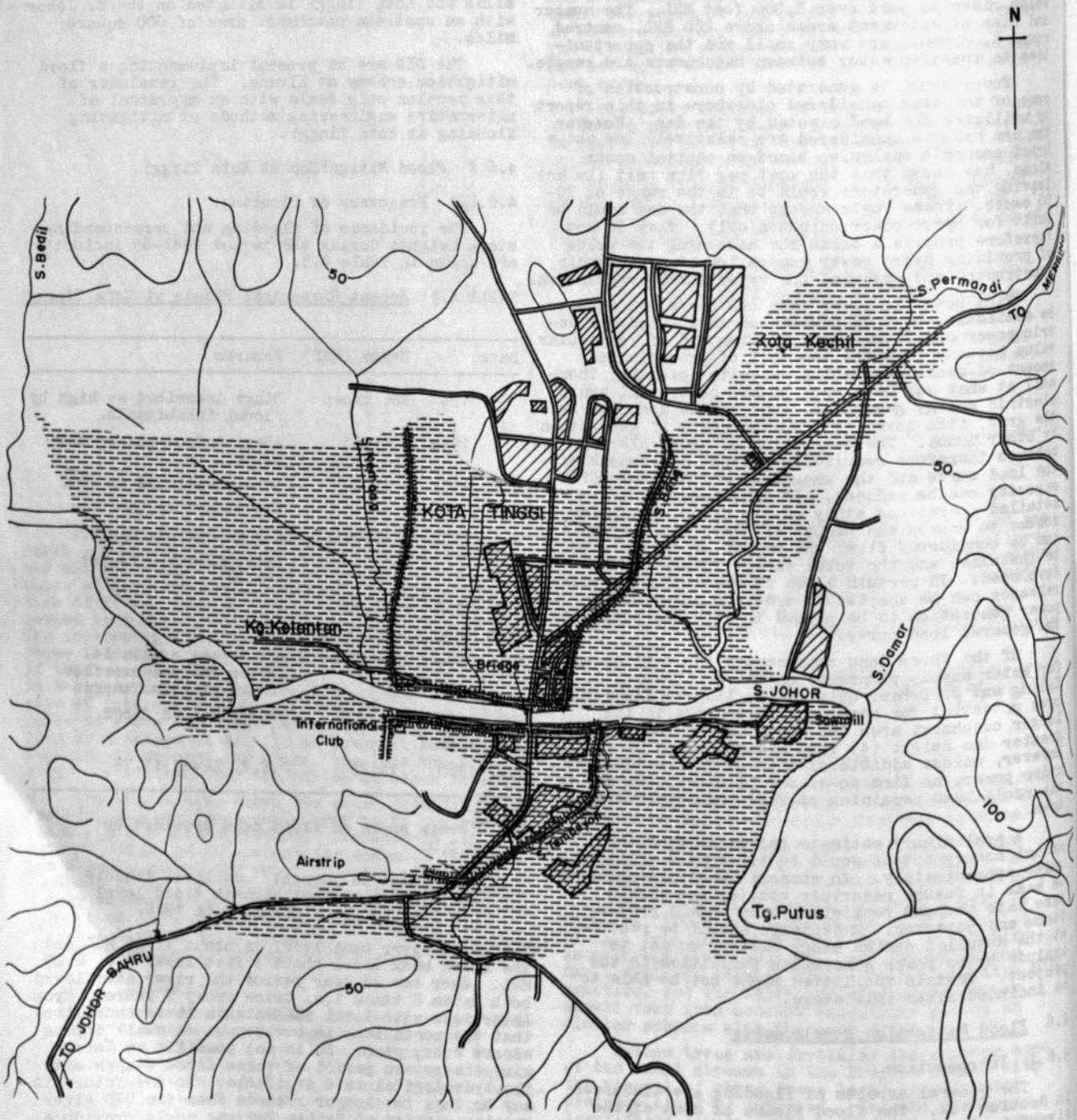
<sup>-</sup>This level is suspect as local inhabitants consider that highest flood level in last 25 years occurred in 1948.

The south river bank level is about 11.00 MSL and the north bank level about 3 feet lower i.e. 8.00 MSL. Over the 28 year period the river overflowed both banks 8 times i.e. twice every 7 years. From interviews with local inhabitants it is understood that the north bank is overtopped to small depths almost every year. It is not possible to determine the return period of these flood stages with the hydrological data available. In the future it may be that the longer records from the DID river gauging station at Rantau Panjang could provide a reasonable basis for such a study but the analysis would be complicated because there is approximately 160 square miles of ungauged catchment between Rantau Panjang and Kota Tinggi and also parts of the north bank at Kota Tinggi can be flooded by the S. Permandi alone.

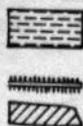
The hydrological studies (Section 1.4.2)

FIGURE 4.9

KOTA TINGGI-FLOODED AREA 1969 AND POSSIBLE BUND LAYOUT



Approximate limit of 1969 flooding  
Proposed bund  
Existing built up areas



indicate that for small catchments, peak flood discharge, and therefore downstream flood stage, will increase markedly due to land clearance. Substantial increases in large catchments are also possible, and it is considered that for storm conditions identical to those that produced the 1969 flood, the S. Johor could run at levels up to 2 feet higher at Kota Tinggi, due to the change in river regime. The frequency of flooding will also tend to increase as a result of jungle clearance and for this study a frequency of once in 3 years has been assumed.

#### 4.6.2.2 The December 1969 and January 1971 Floods. (See also Section 1.4.1).

On 9th and 10th December 1969 heavy rainfall occurred over most of the State of Johor and the rain gauge at Mawai Estate, about 3 miles north east of Kota Tinggi recorded a fall of 17 inches over 24 hours. The river overtopped the banks early morning 10th December and the flood stages increased to a maximum level of 14.23 MSL over the next 2 days. The flood had receded sufficiently by 15th December to allow road traffic to pass through the town. The area flooded is shown in Figure 4.9.

The photographs on page 35 were taken during the 1969 flood.

The heavy floods of January 1971 occurred mainly in the northern areas of Johor State and the S. Johor did not overflow its banks at Kota Tinggi.

#### 4.6.2.3 Flood Damage and Losses.

No records are available to evaluate flood damage and losses prior to 1969 but the following extracts on flood damage are from the 1952 and 1964 Flood Reports produced by the D.I.D.

##### January 1952 Report:

"The inhabitants of Kota Tinggi Town after their experience of the 1951 Flood, moved out of the low lying areas early, so apart from the inconvenience and the dirt, there was little damage. In other areas only loss of crops was reported."

##### March 1964 Report:

"Apart from the inconvenience and the silt, the flood caused practically no damage. In the low lying farming areas the small food crops were destroyed."

It should be noted that both these floods had a lower maximum flood stage than the 1969 flood and that in fact the river in 1964 did not overflow its banks at Kota Tinggi (Table 4.3).

To obtain information on the damage and losses caused by the 1969 flood, discussions were held with the Chairman of the Kota Tinggi Chinese Chambers of Commerce, the District Officer of Kota Tinggi and other Government Authorities.

The results of the investigations show damages and losses of \$118,000 in Kota Tinggi (Table 4.4). Of this total about \$83,000 was borne by the private sector and \$35,000 by the public sector in the form of subsidies. In addition damages and losses were incurred on present agricultural developments in the flood plain of the S. Johor upstream of Kota Tinggi. Between Kota Tinggi and the site of a possible flood storage reservoir (Section 4.7.8.) on the S. Johor located about 16 miles upstream, the damages and losses have been estimated at \$16,000 (Table 4.5).

As damages and losses caused by previous floods are not available it has not been possible to determine a stage/damage curve. Assuming that the flood loss and damage would not vary much with the stages listed in Table 4.3 and taking a frequency of flooding of once in 3 years the annual flood loss and damage would be about \$40,000 in Kota Tinggi and about \$5,000 in the flood plain upstream to the reservoir site. Of the total of \$40,000 about \$28,000 would be borne by the private sector and \$12,000 by the public sector.

TABLE 4.4 Damages and Losses Caused by 1969 Flood at Kota Tinggi

#### A Private Sector

##### 1 Physical Damage

###### Personal

	\$	\$
Damage to houses, furniture, clothing etc.	13,250	

###### Business

Damage to property and loss of stock	70,000	83,250
--------------------------------------	--------	--------

##### 2 Commercial Loss

See note below

		Nil
Total (1)		83,250

#### B Public Sector

##### 1 Physical Damage

Damage to Government buildings etc.		11,160
-------------------------------------	--	--------

##### 2 Relief Costs

Food, grants, beds, boats etc.	13,610	
Vaccines etc. (approx.)	10,000	23,610

Total (2)	34,770	
Total (1) + (2)	118,020	

**NOTE:** In an interview the Chairman of the Kota Tinggi Chinese Chamber of Commerce stated that the commercial losses to business due to the 1969 flood were negligible. Most businesses affected were in the distribution sectors and sales lost due to floods were made up in the following weeks. Transport of goods from the East coast to the south must also have been affected but there is no data on this. It should be noted that the flooding at Kota Tinggi was not the only cause of disruption as certain stretches of the road from the east coast to the south were impassable due to flooding from catchments other than the Johor river. Commercial losses have therefore been taken as nil.

TABLE 4.5 Damages and Losses Caused by 1969 Floods in River Valley Between Possible dam site and Kota Tinggi.

	\$	\$
1. 17 acres of small holders crops destroyed	5,000	
2. 1500 acres of rubber trees under water for 5/6 days (approximately)	11,000	16,000

The very low figures of \$40,000 and \$5,000 are probably due to the fact that the inhabitants of Kota Tinggi are well prepared for floods and that the flood plain mostly acts as storage volume giving low velocities capable of little physical damage.

#### 4.6.2.4 Flood Mitigation Measures.

##### a) Reservoir Storage.

The possible dam sites in the catchment of the S. Johor are discussed in Section 4.7 and their locations are shown in Figure 4.13.

The site with the greatest potential for mitigating floods at Kota Tinggi is on the S. Johor (Grid Reference WM 935:189) because it commands approximately 70 percent of the catchment draining to Kota Tinggi. Of the remaining sites, Linggiu A (Grid Reference WM 923:308) has the largest catchment area (80 square miles), equivalent to 13 percent of the catchment of Kota Tinggi. As stated in section 1.4.3 it is possible that storage at this site could have some measure of flood mitigation benefit downstream but it is not possible to quantify this until longer term records are available. The catchment areas of the other dam sites are less than 10 percent of the catchment at Kota Tinggi and flood mitigation benefit from these sites would be insignificant. For the above reasons only the site on the S. Johor is discussed further with respect to flood mitigation.

The flood level of the S. Johor at this site has not been established but probably lies in the range 35-45 MSL. For a reservoir conservation level of 60 MSL and a dam crest of 70 MSL the estimated capital cost of the dam is \$12.2 million (Appendix C-39).

The reservoir would have other benefits, notably it would be capable of regulating the flows in the S. Johor to meet possible future abstraction for water supplies (Section 4.7) so it would be unfair to charge the whole cost of the dam against flood control. The future provision of regulating storage in the S. Johor catchment, and the amount of such storage, depends on factors and decisions outside the Terms of Reference. If a decision is made to provide regulation for the probable maximum demands likely to be placed on the river over the next 30 years then the most economic adequate storage can be obtained by constructing dam A on the S. Linggiu at an estimated capital cost of \$8.1 million (Section 4.7.11). The proportion of the capital cost of the dam on the S. Johor attributable to flood control can therefore be taken as \$4.1 million. To this must be added the value of the inundated land. The area of the inundated land would be about 15 square miles of which about 2500 acres, including 1000 acres in the PLDA Kulai Complex, is developed for agriculture. If the value of developed land is assessed at no more than \$1000 per acre (the discounted cost of developing alternative land to the same standard) the compensation costs would amount to \$2.5 million. This gives an approximate total cost of \$6.6 million. There are other disadvantages associated with this reservoir - these are given in Section 4.7.8 (b).

(b) Barrage Storage

Although at low flows the tide has about a 10 foot range at Kota Tinggi, this effect is dampened out as the river flow increases. Figure 4.10 shows the hourly variation in flood level at Kota Tinggi from 1 p.m. 12th December to 1 p.m. 14th December during the 1969 flood and it is seen that the flood level was only marginally affected by the tide, to the extent of a few inches. Therefore it can be concluded that tides have virtually no effect on flood levels at Kota Tinggi. Consequently a tidal barrage on the Johor estuary downstream of Kota Tinggi would not mitigate the flooding.

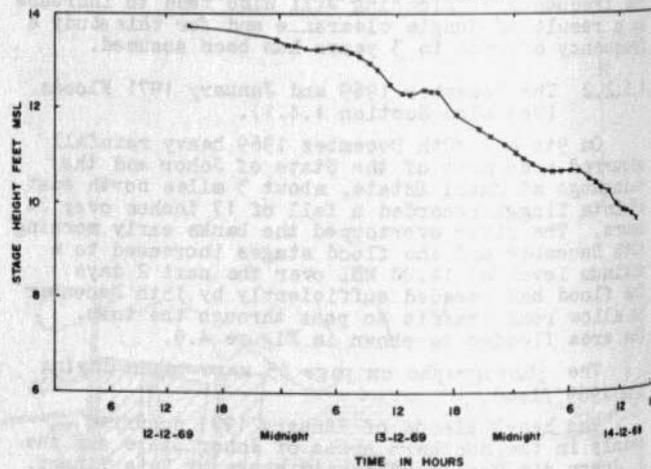
(c) Relief Channel

Due to topography it is not practical to provide a flood relief channel from upstream of Kota Tinggi into a neighbouring catchment.

The benefits to be derived from providing a relief channel in the present flood plain from say Kg. Kelantan to Tg. Putus would be marginal and could not be evaluated until detailed investigations, preferably including model tests, were carried out.

Regarding costs there would be at least 1 million cubic yards of excavation involved, an addi-

FIGURE 4.10  
FLOOD LEVEL IN KOTA TINGGI TOWN  
DECEMBER 1969 FLOOD



tional large bridge would have to be constructed on the main road and a significant part of the town would have to be relocated involving land acquisition costs.

The approximate cost of the excavation of the channel and the new bridge can be taken as \$3.4 million. To this must be added the cost of some form of control headworks, \$3 million, relocation of roads (1 mile at \$100,000) and acquisition of about 40 acres of the town (including property) estimated at \$0.4 million making a very approximate total cost of \$6.9 million.

(d) River Channel Improvements

Widening the river through the town would have much the same effect as a relief channel in the flood plain. Costs would be at least as high as for the relief channel.

In view of the small slope of the river bed any regrading or deepening (i.e. dredging) of the river bed through the town would only have marginal benefits and could not be considered as a realistic solution to the flooding. It appears at present (Section 1.8.4) that the effects of sediment deposition on the river bed level at Kota Tinggi and in fact down past Nam Heng Estate is small, but dredging in this stretch of river may be necessary in the future if the sediment load in the S. Johor increases.

River channel improvements (e.g. dredging) in the S. Johor upstream would have no effect on flood stages at Kota Tinggi. The flood stage at Kota Tinggi is governed by the river discharge, river bed level at Kota Tinggi and the storage available in the flood plain. None of these factors would be affected by upstream dredging.

(e) Bunding

The flood stage in 1969 was just over 14 MSL. Allowing 2 feet for an increase in stage due to change in river regime the minimum crest level of bunds would be 18 MSL.

A preliminary survey of parts of Kota Tinggi has been carried out and a reasonable minimum layout of bunds is shown in Figure 4.9. More detailed investigation, including model tests would

be required to determine the correct alignment and height of bunds.

On the south bank of the river the bunds would be generally 7 feet high. West of the bridge the bund would extend from the bridge abutment to the International club and then turn at approximately right angles into high ground about 600 feet away. East of the bridge the bund would extend as far as the west bank of S. Tembeyoh and then would be turned back along the west bank of the S. Tembeyoh until it meets high ground near the airstrip after crossing the main Kota Tinggi - Johor Baharu road.

Bunding of the S. Johor east of S. Tembeyoh would be possible but would be expensive. Bund dimensions would increase due to lower ground levels. The area is lightly populated and the only major enterprise is a large sawmill situated directly on the banks of the S. Johor. To protect the sawmill by bunds would require relocation of a large part of the sawmill. The inclusion of the catchment area of the S. Tembeyoh behind the bund would present a major drainage problem and it would probably be necessary to divert the S. Tembeyoh over a distance of about 1 mile to Tg. Putus.

On the north bank of the river the bunds would be generally 10 feet high. West of the bridge the bund would extend to the east bank of the S. Kemang and then turn at approximately right angles into high ground about 3000 feet away. Bunding of the S. Johor west of the S. Kemang would be possible but would be expensive. The extended bund would only be required to protect Kg. Kelantan which flooded to depths of 10-12 feet in 1969. Bund dimensions would increase in this area due to lower ground levels and a large part of Kg. Kelantan would have to be relocated to make way for the bunds. Also the inclusion of the catchment area of the S. Kemang behind the bund would present a major drainage problem and there is no practical way of diverting this tributary. East of the bridge the bund would extend for a distance of about 600 feet and then turn northwards behind the built up area until meeting the Kota Tinggi - Mersing road and then north east along the south side of this road until meeting the S. Bang crossing. It would then cross the road and run along the west bank of the S. Bang until reaching high ground. Instead of terminating the bund running north east at the S. Bang crossing it would be possible to extend this to the S. Permandi crossing. However the bund area would then include the catchment area of the S. Bang and as the additional protected area is lightly populated this extension does not appear desirable.

The bunded area south of the river is about 150 acres and north of the river about 300 acres and each would require a pumping station to remove internal water when the S. Johor was in flood. The drainage system in each area would require careful study to prevent local flooding and the size of the pumping stations would depend on a detailed study of the allowable ponding behind the bunds. All property roads etc. within 100-150 feet (depending on local circumstances) of the river bank would have to be relocated to allow the construction of the bunds.

The cost of the bunding is estimated at \$1.4 million. To this must be added the cost of the pumping stations which (based on 50 cusec and 100 cusec pumps for the south and north bunded areas respectively) are estimated at \$1.2 million, requisition of about 65 acres of the town (including property) estimated at \$0.6 million and relocation of roads (1½ miles at \$100,000) making a very approximate total cost of \$3.35 million.

It should be noted that there is a certain danger in relying on bunds to protect an urban area. They give full protection up to a certain flood stage and at higher stages are overtopped.

People in bunded protected areas feel secure and invest in development if there are no high



flows for a long time. Any break in the bund due to overtopping or weakness at high flow might conceivably cause more total damage than would be the case with no bunds.

#### 4.6.2.5 Comparison of Annual Costs and Benefits.

Flood control planning requires a comparison of the annual cost and benefits, both tangible and intangible, of control measures for each alternative scheme. The tangible benefits are the avoidance of damage and expenditure on relief work when flooding is controlled; the intangible benefits are the avoidance of the dislocation and discomfort of a flooded town.

Total annual costs (including operating costs), annual benefits to private and public sectors and net additional finance required from public sector for each scheme considered are shown in Table 4.6.

avoiding periodic inconvenience and distress to the people involved. Before adopting subsidies on this scale consideration should be given to a policy of restricting development on the low ground and of encouraging relocation of existing low lying dwellings on higher ground.

#### 4.7 Regulation of S. Johor

##### 4.7.1 Introduction.

The S. Johor is the largest river in the Project Area. The river forms part of the southern boundary of the Johor Tengah region. Its catchment area is 610 square miles at Kota Tinggi; of this total about 380 sq. miles are within Johor Tengah region.

As stated in Section 1.2.2 the DID operate a river gauging station at Rantau Panjang (about 15

TABLE 4.6

Flood Mitigation Measures - Annual Costs, Benefits and Additional Public Sector Finance

Scheme	Capital Cost of Flood Mitigation Measures	Annual Cost of Capital Cost at 10%	Operating Cost	Total Annual Cost	Annual Benefits		Net Additional Finance required from public sector (Annual) (5 less 7)	
					Private Sector	Public Sector		
	\$ million	\$	\$	\$	\$	\$	\$	
1	2	3	4	5	6	7	8	
Storage on S. Johor	a) dam	4.1 <sup>+</sup>	0.1% of (a)=0.004	664,000	33,000	12,000	652,000	
	b) Developed Area flooded	2.5						660,000
Relief Channell	a) Channell	2.40	0.5% of (a)+(b)+ (c)+(d) = .003	693,000	28,000	12,000	681,000	
	b) Bridge	1.00						690,000
	c) Control Works	3.00						3,000
	d) Roads	0.10						3,000
	e) Land acquisition	0.40						3,000
Bund	a) Bunds	1.40	0.5% of (a)+(c)= .008	367,000	28,000	12,000	355,000	
	b) Pumping Stations	1.20						335,000
	c) Roads	0.15						32,000
	d) Land acquisitions	0.60						32,000

+ Capital cost of dam on S. Johor \$ 12.2 million  
 Capital cost of alternative regulating reservoir (estimated max) \$ 8.1 million  
 Net Cost attribution to flood control (estimated min.) \$ 4.1 million

Annual benefits are based on the estimate of tangible damages and losses incurred in the 1969 flood (\$118,000 in Kota Tinggi and \$16000 in upstream flood plain to reservoir site) and assuming a frequency of flooding of equal severity once in every 3 years.

#### 4.6.2.6 Conclusion.

Table 4.6 shows that the nett additional finance required annually from the public sector for the schemes considered varies from \$335,000 to \$681,000.

Subsidies of the order indicated represent a very heavy investment indeed for the sake of

miles upstream of Kota Tinggi) where the catchment area is 440 square miles. The station was commissioned in August 1963 and the mean daily flows at Rantau Panjang are tabulated in Appendices A 36 to A 42.

The Terms of Reference draw particular attention to the S. Johor because of its importance as a main source of water supply for Singapore. A regulation study has been necessary because of the possible effects of Project developments within the catchment and possible water exports from the catchment (Section 4.2.3), on the variability of flow at the PUB run-of-river intake located about 1½ miles upstream of Kota Tinggi.

The nominal capacity of the existing PUB intake and treatment works is 30 mgd and the possible future maximum abstraction, under the 1962 Agreement, is 250 mgd (Section 2.2.2). These represent the largest present and potential future abstractions on the river.

#### 4.7.2 Natural River Flows at PUB Intake.

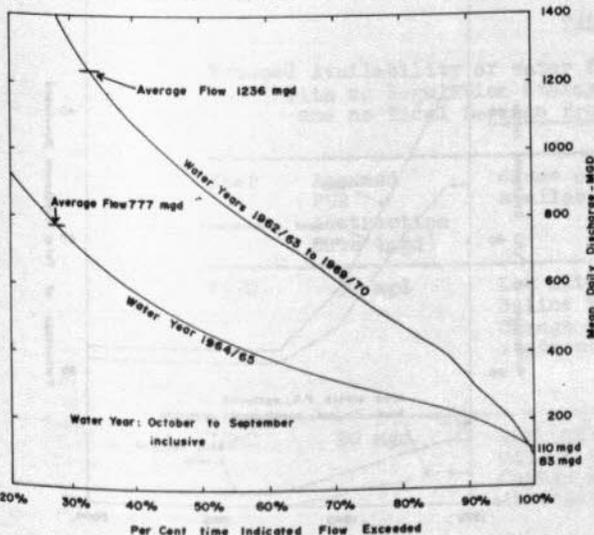
The catchment area draining to the intake is approximately 600 square miles, Natural river flows at the intake have been estimated from the record of daily flows at Rantau Panjang and have been summarised in the form of a flow: duration curve (Figure 4.11) for:-

- a) Water Years 1963/64 to 1969/70
- b) Water Year 1964/65

The water year 1964/65 has the longest period of sustained low flows in the above period. The average and minimum daily flows at the intake for the period 1963/64 to 1969/70 are estimated at 1236 mgd and 83 mgd respectively. The average and minimum daily flows for the water year 1964/65 are estimated at 777 mgd and 110 mgd respectively.

FIGURE 4.11

ESTIMATED FLOW: DURATION CURVES AT PUB INTAKE ON S.JOHOR



#### 4.7.3 Present River Abstractions (1970).

The present abstractions at and above the PUB intake are:-

- a) PUB-Singapore As stated in Section 4.7.1 this is nominally 30 mgd and abstractions represent exports from the catchment.
- b) JKR-Johor State The JKR operate 4 water supply intakes within the catchment serving Kota Tinggi, Layang Layang, Rengam and FLDA Kulai Complex (under construction - 1970). The total demand on these 4 intakes is approximately 1.14 mgd (Figure 2.1). The Kota Tinggi demand (0.42 mgd) results in a corresponding reduction in flow at the PUB intake since any return flow from the area served occurs downstream thereof. The areas served by the other 3 intakes, whose combined demand is 0.72 mgd, are all within the catchment area. A proportion of this demand will therefore return to the river.
- c) Kulai Sugar Factory A new sugar estate, adja-

cent to part of the Kulai/Kota Tinggi road has been established within the catchment area. The owners have made application to construct a processing factory on the estate in the near future. The exact location of the source of water for the factory has not yet been decided but it will certainly be within the catchment of the S. Johor. One proposal has been the S. Kelapa Orang, a tributary of the S. Johor, about 6 miles upstream of Kota Tinggi. The owners have stated to the State Engineer that the total initial water demand will be 7.0 mgd; of this total 6.7 mgd will be used for cooling and recirculation and 0.3 mgd will be used for processing and domestic consumption.

The nett abstraction from the catchment can therefore be taken as 0.3 mgd approximately.

d) There are minor private abstractions by estates and others. These are insignificant and have been ignored.

#### 4.7.4 Probable Maximum Future Abstractions Year 2000.

The probable maximum future abstractions at and above the PUB intake are:-

a) PUB Singapore Under the assumptions made in Section 3.3 the maximum abstraction rate of 250 mgd, provided for by the 1962 Agreement, could be required by about 1995.

#### b) JKR-Johor State

The combined maximum demand of Layang Layang, Rengam and FLDA Kulai Complex is estimated at 4 mgd.

The future demands of Johor Baharu, Pontian, Industrial Area and Port may have to be met from the S. Johor. (Section 4.2.3). If the Tebrau barrage is constructed the maximum demand on the S. Johor would be 30 mgd; if the barrage is not constructed then the maximum demand would be 65 mgd. These abstractions represent exports from the catchment.

The future demand of Kota Tinggi may have to be met from the S. Johor. (Section 4.2.2). The maximum demand is estimated at 2.8 mgd and abstractions represent exports from the catchment above the PUB intake.

#### c) Kulai Sugar Factory

No information is available on whether this factory will be expanded beyond its planned initial capacity or not. For this study it is assumed that it will not and that the water demand will remain constant up to the year 2000.

#### d) Project Developments

Proposed Villages T13-T25 (Figure 4.5) are located within the catchment. Their maximum demand, including agricultural processing factories, is estimated at 3.6 mgd (Appendices B-11 and B-13).

As it is probable that there will not be more than one oil palm nursery operating in the S. Johor catchment at any one time, maximum irrigation demand has been taken as 0.6 mgd. (Sections 3.5.6 and 4.3)

Maximum abstractions due to Project development within the catchment are therefore estimated at 4.2 mgd. A proportion of this demand will return to the catchment.

#### d) Catchment Area outside Project Area

About 220 square miles of the catchment area is outside the Project Area (Section 4.7.1); of this total 160 square miles is at present developed for agriculture. The demands of FLDA Kulai Complex and the sugar factory have already been included; other present abstractions are negligible. As the area is outside the Project Area, no development proposals have been formulated under

this study. It is not possible to predict what additional water using enterprises (if any) will be established in the future. For this study future additional water abstractions have been assumed to be negligible.

e) Summary of abstractions

The estimated rate of build up of abstractions to the above maximum values is shown in Table 4.7.

TABLE 4.7 Estimated Maximum Rate of Build up of Abstractions on S. Johor.

Area of Supply	Abstractions - MGD			
	1970	1980	1990	2000
<b>1. Singapore</b>				
PUB (Total 1)	30	90	190	250
<b>2. Johor State</b>				
a) Johor Baharu, Pontian and Industrial Area	Nil (Nil)	2.5 (Nil)	27 (Nil)	65 (30)
b) Kota Tinggi	0.4	0.8	1.5	2.8
c) Layang Layang Rengam and FLDA Kulai Complex	0.7	1.0	1.5	4.0
d) Project developments	Nil	1.9	3.3	4.2
e) Kulai Sugar Factory	0.3	0.3	0.3	0.3
<b>Total (2)</b>	<b>1.4</b> (1.4)	<b>6.5</b> (4.0)	<b>33.6</b> (6.6)	<b>76.3</b> (41.3)
<b>Total (1) + (2)</b>	<b>31.4</b> (31.4)	<b>96.5</b> (94.0)	<b>223.6</b> (196.6)	<b>326.3</b> (291.3)

- Notes
- (i) PUB maximum abstraction by 1995 (Section 3.3)
  - (ii) Values tabulated for 2(a) is for case of Tebrau barrage not being constructed. Values in brackets are applicable if Tebrau barrage is constructed (Section 4.2.3)
  - (iii) Values tabulated for 2(c) and 2(d) ignore return flow to catchment.

Return flows from supply areas Layang Layang, Rengam, FLDA Kulai Complex and Project developments have been ignored, as they would be very small compared to the total combined abstractions being considered, at any point in time.

4.7.5 Other Demands on the S. Johor.

In addition to the reductions caused by upstream abstractions, the flow available for abstraction at the PUB intake may be limited by other factors.

These are:-

- a) The effects of saline intrusion
- b) The effects of changes in catchment cover
- c) The effects of upstream pollution.

a) Saline intrusion

The salinity study of the Johor estuary (Section 1.8.2) shows that salt water can reach the PUB intake during low river flows. There are two alternative methods of preventing saline intrusion.

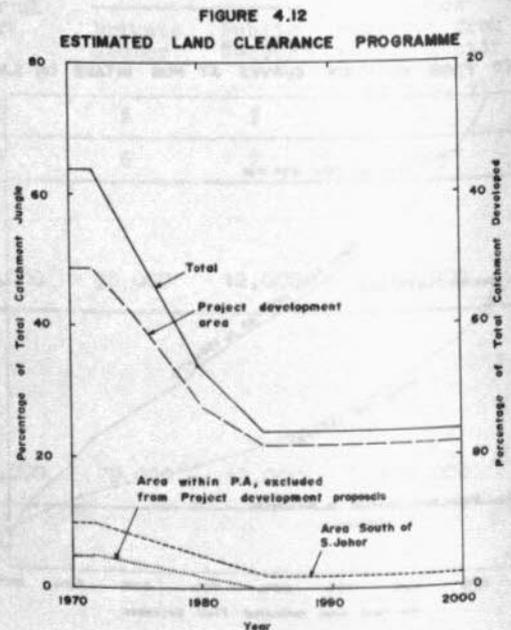
(i) By allowing, on average, a river flow of 100 mgd to pass the intake (Section 1.8.2).

(ii) By constructing a tidal gated barrage downstream of the intake.

b) Change in Catchment Cover

Land clearance and associated developments will alter the variability of river flows. Of particular importance will be the further lowering of low river flows (Section 1.3.1. ).

At present about 64 percent of the whole catchment area is jungle covered. Maximum possible development area is approximately 76 percent of the catchment area. This assumes that the catchment to dam site A on the S. Linggiu (Section 4.7.8) will be left as jungle and that no land above 20 degree slope will be developed for agriculture. Figure 4.12 shows an estimated land clearance programme. This takes account of Project proposals and assumes that other areas, capable of agriculture development, within the catchment will be cleared by 1985.



Though land clearance is likely to increase the average run-off (Section 1.4.2 ) the increase will occur during the flood periods and low flow characteristics will be little affected.

c) The effects of upstream pollution

During low river flows the S. Johor at Rantau Panjang is presently polluted, beyond recommended International standards for water supply, by factory effluents and also by tin mining effluents. (Section 1.7). Future tin mining activities are not known but organic pollution may be expected to become worse due to the increased discharge of factory effluents, unless measures are taken to counteract it. A possible method of reducing pollution could be by diluting effluents with unpolluted water, which would be released from upstream storage. It should be noted that under this system pollution in the tributaries between the factories and the main river channel downstream of the storage, would not be prevented.

Based on Project proposals and making allowance for some expansion of existing factories, the volume of effluent which will eventually be discharged into the catchment will probably be about 1 mgd, with BODs ranging from 1000 ppm (rubber factories) to 20,000 ppm (palm oil mills). The dilution requirement would be enormous and in the United Kingdom for instance a dilution ratio of 500 to 1 might be called for by the appropriate Authority. This would be a very expensive and less satisfactory method of preventing pollution compared to biologically treating effluents at source as recommended in Section 1.7.2 and is not discussed further in this report.

4.7.6 Supplies available for Abstraction at PUB Intake 1970-2000 with no Storage provided in Catchment of S. Johor and no Gated barrage provided downstream of the intake.

Data of historical river flows in the Project Area cover too short a period for a frequency analysis to be made of the variability of flows in the S. Johor but the indications are that the

drought of the water year 1964/65, which has the longest period of sustained low flows in the period of record (1963/64 to 1969/70) (Section 4.7.2), has a probability of recurring once in 30 years approximately. The data for 1964/65 have therefore been used as the basis for low flow conditions that might occur in the future from 1970 to 2000. During this period the supplies available for abstraction at the PUB intake could be affected by three factors: maintenance of minimum flow downstream of the intake for control of saline intrusion, effect on river flows of projected increases in jungle clearance of the catchment and effect of projected upstream abstractions. Each of these effects in a year such as 1964/65 on the supplies available for abstraction and on river flows is shown on Figures 1, 2 and 3 in Appendix C-31.

The effects will be additive and give an indication of the number of days, in a year such as 1964/65, when various rates of abstraction would not be fully practicable at the PUB intake because of the factors considered above. For the projected maximum rate of build-up of abstractions (Table 4.7) the number of days for the years 1970, 1980, 1990 and 2000 are given in Table 4.8.

TABLE 4.8

Reduced Availability of Water for Abstraction at PUB Intake For Water Year 1964/65 with no Regulation Storage provided on S. Johor and no Tidal Barrage Provided Downstream of Intake.

Year	Assumed PUB Abstraction Rate (mgd)	Cause of reduction in availability of water	No. of Days Affected
1970	30 mgd	Low natural river flows	Nil
		Saline intrusion	5
		Change in catchment cover	Nil
		Abstractions by Johor State	Nil
		Total	5
1980	90 mgd	Low natural river flows	Nil
		Saline intrusions	30
		Change in catchment cover	5
		Abstractions by Johor State	Nil
		Total	35
1990	190 mgd	Low natural river flows	28
		Saline intrusions	60
		Change in catchment cover	30
		Abstractions by Johor State	20
		Total	138
2000	250 mgd	Low natural river flows	62
		Saline intrusion	60
		Change in catchment cover	35
		Abstractions by Johor State	35
		Total	192

The days when full abstraction would not be practicable could be significant to the PUB, since they would imply restrictions in pumping. The restrictions could be obviated, or at least reduced, by provision of regulatory storage in the catchment or a combination of regulation and a tidal barrage downstream of the PUB intake. Alternatively, the PUB could meet occasional deficiencies of supply by other means, such as the provision of desalination plant or by higher rates of abstraction when river flows permitted and additional carry-over storage in Singapore. These alternatives are outside the Terms of Reference and have not been studied.

#### 4.7.7 The Regulation Storage Required by the Year 2000.

Taking the present (1970) catchment conditions (negligible upstream abstractions and catchment cover as described in Section 2.2.2) as a starting point, the volume of storage required to regulate flows at the PUB intake in the future depends upon:-

- (i) The level of abstraction at the intake
- (ii) The method of repulsion of saline intrusion
- (iii) The necessity (from an engineering point of view) to offset the effects on the variability of natural river flows of:-
  - a) Any future changes in catchment cover
  - b) Any future significant upstream abstractions from the catchment by Johor State.

Item (i) depends upon the present Agreement (1962) and possibly future arrangements between Malaysian Authorities and Singapore. The alternative methods of dealing with Item (ii) are given in Section 4.7.5. The legal necessity of Item (iii) depends upon interpretation of the present Agreement. Future arrangements between Malaysian Authorities and Singapore have not been specified to the Consultants and legal interpretation of the 1962 Agreement is outside the Terms of Reference.

In the circumstances an evaluation has been made of the volumes of storage required for different PUB abstractions in the range 30 mgd to 250 mgd for the following combinations of catchment cover conditions and upstream abstractions by Johor State.

Catchment Cover	Upstream abstractions by Johor State
As 1970	Nil
As 1985 onwards (maximum development)	Nil
As 1985 onwards	41 mgd
As 1985 onwards	76 mgd

Projected changes in catchment cover are shown in Figure 4.12. Abstractions of 41 mgd by Johor State

allow for 30 mgd exported to Johor Baharu area; approximately 3 mgd exported to Kota Tinggi; and approximately 8 mgd abstracted to meet demands within the catchment area; abstractions of 76 mgd by Johor State allow for 65 mgd exported to Johor Baharu area plus 3 mgd and 8 mgd as above. (Table 4.7).

The storage analysis is based on Figure 1.6 and the results are shown in Figures 1 and 2 in Appendix C-32. Figure 1 (Appendix C-32) is applicable when saline intrusion is prevented by construction of a gated barrage downstream of the intake; Figure 2 (Appendix C-32) is applicable when

saline intrusion is prevented by allowing, on average, 100 mgd of river water to pass the intake (Section 4.7.5). These curves assume that the PUB have first right to the water in the S. Johor.

The storage required varies considerably and values are summarized in Table 4.9.

There are inevitably operating losses associated with regulation reservoirs. Stored water may be lost by evaporation from the reservoir surface and possible seepage through, under or around the dam. Released water may be lost by evaporation from the river surface, percolation into strata between the reservoir and the abstraction point and operational inability to time release correctly. In addition compensation water may have to be provided, when the reservoir is not making regulation releases or spilling, in order to maintain reasonable conditions in the downstream river channels. These losses are difficult to estimate systematically. For the economic study (Section 4.7.10) an allowance of 15 percent of the required regulation storage has been added to cover them all.

For the particular case of the estimated maximum rate of increase of abstractions, the storage required through time from 1970 to 2000 is shown in Appendix C-33.

#### 4.7.8 The Potential Dam Sites.

A study of the 1 inch to 1 mile and 1 in 25000 contoured maps has shown that the topography is suitable for dam sites located at the grid references given in Table 4.10.

The catchments to dam sites D and E on the S. Pengeli are very small. These sites would not be worth exploiting for regulation of the S. Johor and are not considered further. Dam sites A and C on the S. Pengeli are located about 1/4 mile from each other on the same tributary and are therefore alternatives. The valley profile at each site is similar and costs would therefore be similar. As dam site C has the slightly smaller catchment area it is not discussed further.

The locations of the remaining sites are shown in Figure 4.13. Preliminary estimates of elevation/storage relationship and capital costs of construction with various dam heights have been made. Details, and the basis of the estimates, are given in Appendices C-34 to C-39. The relationship between the capital cost of dam construction and the corresponding storage for each site is plotted in Appendix C-40.

Dam sites on the S. Johor, S. Semangar and S. Linggiu have been visited by an engineering geologist; dam sites on the S. Pengeli have not. Preliminary geological appraisals, based on a study of existing geological maps and surface field inspections where undertaken, are included in Appendix D.

There may be additional costs, or benefits, associated with the dam sites. These are discussed below.

##### a) S. Pengeli and S. Linggiu Sites.

The catchments draining to the sites on the S. Pengeli and S. Linggiu are at present jungle covered. There are no tin mines in operation in these catchments. Due to the availability of alternative potential agricultural land the benefit foregone from not developing the land, below 20 degree slope, for agriculture in each catchment is very small. For the S. Pengeli sites and site B on the S. Linggiu the benefit foregone can be taken as zero as there are only a few square miles of land below the 20 degree slope in these catchments. For site A on the S. Linggiu the area below the 20 degree slope is approximately 30 square miles and the benefit foregone is estimated at \$0.3 million. If the catchment is left as jungle then this sum should be added to the estimated dam construction cost.

TABLE 4.9

Summary of Alternative Regulation Storages Required in Year 2000  
(Based on Water Year 1964/65)

Assumed PUB Abstraction (mgd) in Year 2000	Storage Required (million gallons) - Year 2000						
	(1) To regulate natural river flows to indicate abstraction at PUB intake	(2) To offset changes in catchment cover	Total (1)+(2)	(3) To allow for 41 mgd <sup>†</sup> abstracted by J. State	Total (1)+(2) + (3)	(4) To allow for additional abstraction of 35 mgd by Johor State to Johor Baharu area	Total (1)+(2)+(3)+(4)
<b>a) Excluding Saline Intrusion</b>							
30	Nil	600	600	700	1300	900	2200
100	1000	1200	2200	1000	3200	1200	4400
150	1900	1700	3600	1300	4900	1500	6400
200	3400	2000	5400	1700	7100	1800	8900
250	5200	2400	7600	2200	9800	2400	12200
<b>b) Including Saline Intrusion</b>							
30	1500	1500	3000	1100	4100	1300	4400
100	3500	1900	5400	1800	7200	1600	8800
150	5300	2200	7500	2500	10000	2000	12000
200	7600	2800	10400	2900	13300	2500	15800
250	10700	3300	14000	3200	17200	3000	20200

<sup>†</sup>30 mgd exported to Johor Baharu area.

3 mgd exported to Kota Tinggi

8 mgd to meet demands in catchment.

TABLE 4.10 Possible Dam Sites

River	Dam Ref.	Catchment Area (Sq. miles)	Location	
			1 inch Map No.	Grid Reference
Pengeli	A	12.4	125	WM 739:333
	B	8.4	125	WM 806:322
	C	11.9	125	WM 734:340
	D	4.0	125	WM 721:330
	E	1.9	125	WM 766:333
Linggiu	A	80.0	125	WM 923:308
	B	23.4	125	WM 859:408
Semangar-		53.0	130	WM 990:111
Johor	-	420	130	WM 935:189

The benefit foregone from not mining the catchment area cannot be evaluated as the amount of economically exploitable minerals is not known. However Supporting Volume 2 recommends prospecting in the catchments of both the S. Linggiu sites and site B on the S. Pengeli and the Project has recommended that this prospecting should be given high priority and carried out at an early date. There would be very little flood mitigation benefit associated with either of the S. Pengeli sites as

their catchment areas are small. It is possible that storage on the S. Linggiu could have some measure of flood mitigation benefit downstream. However, as stated in Section 1.4.3 this cannot be quantified at present, and no benefit has been allowed.

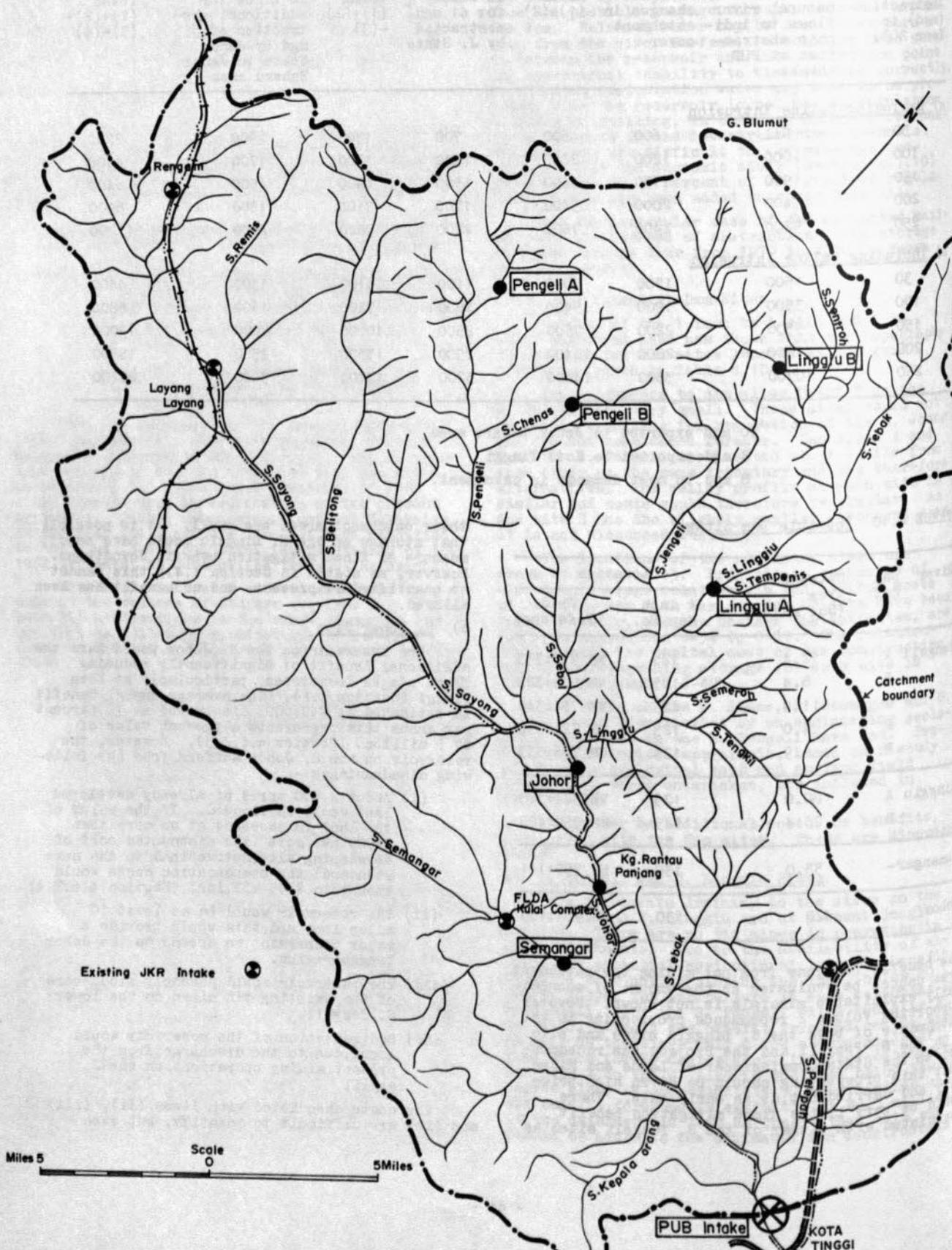
**b) S. Johor Site**

The reservoir on the S. Johor would have the additional benefit of significantly reducing flood stages downstream, particularly at Kota Tinggi (Section 4.6). The average annual benefit is estimated at \$45,000; discounted at 10 percent per annum this represents a present value of \$0.5 million. (Section 4.6.2.3). However, the reservoir on the S. Johor suffers from the following disadvantages:-

- (i) About 2,500 acres of already developed land would be flooded. If the value of the land is assessed at no more than \$1000 per acre (the discounted cost of developing alternative land to the same standard) the compensation costs would amount to \$2.5 million. (Section 4.6.2.4)
- (ii) The reservoir would be at least 10 miles long and this would provide a major constraint to access to the Johor Tengah region.
- (iii) The reservoir could possibly flood some of the existing tin mines on the lower S. Tengkil.
- (iv) Sedimentation of the reservoir would occur due to the discharge from the present mining operations on the S. Tengkil.

The costs associated with Items (ii), (iii) and (iv) are difficult to quantify, but even

REGULATION STORAGE SITES CONSIDERED



ESTIMATED CAPITAL COSTS OF ALTERNATIVE RESERVOIRS CONSIDERED

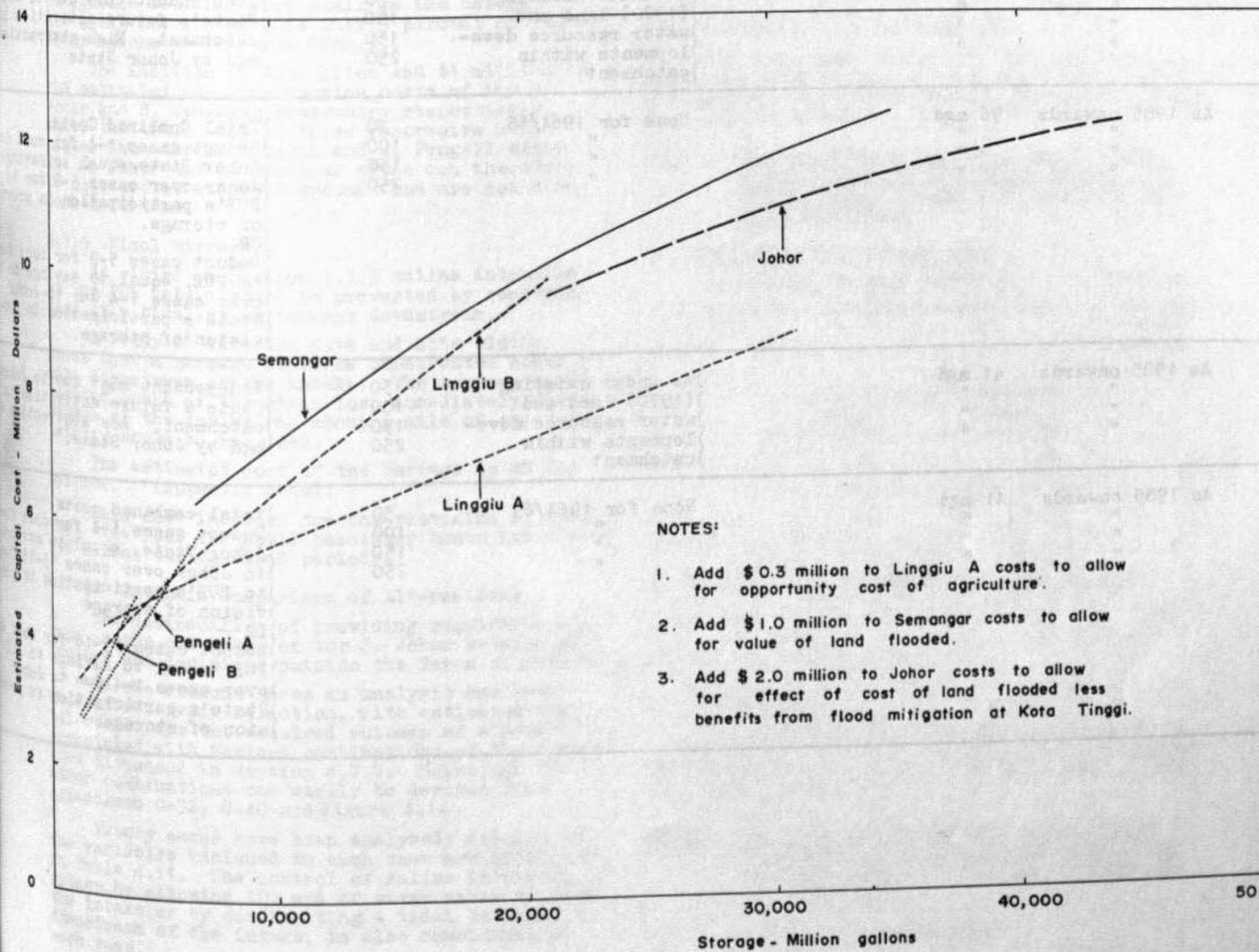


TABLE 4.11

The Alternative Cases of Regulation Degree Considered

Case No.	Catchment Cover	Johor State Abstractions	PUB Shortage Situation at Intake	PUB design demand (mgd)	Remarks
1	As 1970	As 1970 (negligible)	None for 1964/65	30	} Independant cost due PUB
2	"	"	"	100	
3	"	"	"	150	
4	"	"	"	250	
5	As 1985 onwards	76 mgd	} As under existing (1970) land and water resource deve- lopments within catchment	30	} Independant cost due to Joh State's future activities catchment. High abstraction mgd by Johor State
6	"	"		100	
7	"	"		150	
8	"	"		250	
9	As 1985 onwards	76 mgd	None for 1964/65	30	} Total Combined Costs. } Deduct cases 1-4 for cost } Johor State, equal to savings } Johor over cases 5-8 due to } PUB's participation in provision } of storage. } OR } Deduct cases 5-8 for cost } to PUB, equal to savings to } over cases 1-4 due to Johor } State's participation in pro } vision of storage.
10	"	"	"	100	
11	"	"	"	150	
12	"	"	"	250	
13	As 1985 onwards	41 mgd	} As under existing (1970) land and water resource deve- lopments within catchment	30	} Independant cost due to Joh State's future activities catchment. Low abstraction mgd by Johor State.
14	"	"		100	
15	"	"		150	
16	"	"		250	
17	As 1985 onwards	41 mgd	None for 1964/65	30	} Total combined costs. } Deduct cases 1-4 for cost } Johor State, equal to savin } to Johor over cases 13-16 } to PUB's participation in } vision of storage } OR } Deduct cases 13-16 for cost } PUB, equal to savings to } over cases 1-4 due to Joho } State's participation in p } sion of storage.
18	"	"	"	100	
19	"	"	"	150	
20	"	"	"	250	

neglecting these the effect of the costs of Item (1) less the benefits of downstream flood mitigation would be to increase the cost of the reservoir on the S. Johor by \$2 million.

c) Semangar Site

The reservoir would flood part of the new Kota Tinggi/Kulai road; the cost of road realignment has been included in the dam construction costs. The reservoir would also flood about 1,000 acres of already developed land. At approximately \$1,000 per acre this would amount to \$1 million. This sum should be added to the estimated dam construction costs. The benefit of downstream flood mitigation would be very small as the catchment is low lying and its area is only 9 percent of the S. Johor catchment (at Kota Tinggi).

The addition of \$2 million and \$1 million to the estimated dam construction costs of the S. Johor and S. Semangar reservoirs respectively, makes the total cost of these reservoirs much higher than the S. Linggiu and S. Pengeli sites. The S. Johor and S. Semangar sites can therefore be rejected on economic grounds and are not discussed further.

4.7.9 Tidal Barrage.

As stated in Section 4.7.5 saline intrusion at the PUB intake could be prevented by construction of a tidal gated barrage downstream.

A study of existing data and site visits shows that a barrage could be constructed about 1/4 mile downstream of the intake. The barrage would be located south of the river loop immediately downstream of the intake and about 1/4 mile of river retaining would be required.

The estimated cost of the barrage is \$M 4.2 million. (Appendix C-40).

This cost includes for the provision of a 24 foot wide lock for small passenger boats and elevated access during flood periods.

4.7.10 Economic Comparison of Alternatives.

The desirability of providing regulation storage in the catchment of the S. Johor depends on factors and decisions outside the Terms of Reference.

In the circumstances an analysis has been made of reservoir selection, with estimated capital costs, for the required volumes of storage associated with various combinations of the variables discussed in Section 4.7.7. Solutions for other combinations can easily be derived from Appendices C-32, C-40 and Figure 4.14

Twenty cases have been analysed; details of the variables included in each case are summarised in Table 4.11. The control of saline intrusion, either by allowing 100 mgd of river water to pass the intake or by constructing a tidal barrage downstream of the intake, is also considered in each case.

Cases 1-4 indicate the volume and cost of storage (or storage/barrage combination) that the PUB would have to provide to ensure no shortages in the indicated PUB design demands, in a year such as 1964/65, under the assumptions that there will be no further land development in the catchment and that future upstream abstractions by Johor State will remain negligible.

Cases 5-8 assume that storage (or storage/barrage combination) would be provided solely to counteract the adverse effect on the availability of low flows for abstraction, in a year such as 1964/65, of projected land clearance and probable maximum future upstream abstractions (76 mgd) in the year 2000 by Johor State. Releases would be made from storage to prevent river flows at the intake falling below 1964/65 actual flows. The indicated PUB design demands would not be ensured

and shortages of water would occur at the intake as under present (1970) land and water resource developments within the catchment.

Cases 9-12 assume that storage (or storage/barrage combination) would be provided to ensure no shortages in the indicated PUB design demands, in a year such as 1964/65, under projected land clearance and probable maximum future upstream abstractions (76 mgd) by Johor State.

Cases 13-16 are similar to cases 5-8 except that probable minimum future abstractions (41 mgd) by Johor State have been assumed.

Cases 17-20 are similar to cases 9-12 except that probable minimum future abstractions (41 mgd) by Johor State have been assumed.

The costs associated with the cases considered may help to form a basis for the allocation of costs for any future storage provided jointly by Johor State and the PUB. (Table 4.11).

Case 1 Catchment cover as 1970; Johor State abstractions as 1970 (negligible); PUB design demand 30 mgd - no shortage of water at intake.

a) Regulation by storage only

Regulation storage required : 1500 mg  
Allow for operating losses etc. : 200 mg  
1700 mg

Linggiu		Pengeli	
A	B	A	B

Cost of storage \$mn 4.4 3.6 2.8 2.9

b) Regulation by storage and tidal barrage

Regulation storage required Nil  
Cost of barrage \$4.2 mn.

c) Conclusion

The most economic solution is therefore to construct dam A on the Pengeli to give a storage of 1700 million gallons at an estimated capital cost of \$2.8 million.

Case 2 Catchment cover as 1970; Johor State abstractions as 1970 (negligible); PUB design demand 100 mgd - no shortage of water at intake.

a) Regulation by storage only

Regulation storage required : 3500 mg  
Allow for operating losses etc 500 mg  
4000 mg

Linggiu		Pengeli	
A	B	A	B

Cost of storage \$mn. 4.9 4.6 4.1 4.8

b) Regulation by storage and tidal barrage

Regulation storage required : 1000 mg  
 Allow for operating losses etc. : 200 mg  
 1200 mg

	Linggiu		Pengeli	
	A	B	A	B
Cost of storage \$mn.	4.3	3.4	2.8	2.8
Cost of barrage \$mn.	4.2	4.2	4.2	4.2
Total cost \$mn	8.5	7.6	7.0	7.0

c) Conclusion

The most economic solution therefore is to construct dam A on the Pengeli to give a storage of 4000 million gallons at an estimated capital cost of \$4.1 million.

Case 3 Catchment cover as 1970; Johor State abstractions as 1970 (negligible); PUB design demand 150 mgd - no shortage of water at intake

a) Regulation by storage only

Regulation storage required : 5300 mg  
 Allow for operating losses etc. : 800 mg  
 6100 mg

	Linggiu		Pengeli	
	A	B	A	B
Cost of storage \$mn.	5.3	5.3	5.3	-

b) Regulation by storage and tidal barrage

Regulation storage required : 1900 mg  
 Allow for operating losses etc. : 300 mg  
 2200 mg

	Linggiu		Pengeli	
	A	B	A	B
Cost of storage \$mn.	4.5	3.8	3.2	3.4
Cost of barrage \$mn.	4.2	4.2	4.2	4.2
Total cost \$mn	8.7	8.0	7.4	7.6

c) Conclusion

The cost of the required storage of 6100 million gallons is the same for dam sites A and B on the Linggiu and dam site A on the Pengeli. The estimated capital cost is \$5.3 million.

Case 4 Catchment cover as 1970; Johor State abstractions as 1970 (negligible); PUB design demand 250 mgd - no shortage of water at intake.

a) Regulation by storage only

Regulation storage required : 10700 mg  
 Allow for operating losses etc. : 1600 mg  
 12300 mg

	Linggiu		Pengeli	
	A	B	A	B
Cost of storage \$mn.	6.3	7.2	-	-

b) Regulation by storage and tidal barrage

Regulation storage required : 5200 mg  
 Allow for operating losses etc. : 800 mg  
 6000 mg

	Linggiu		Pengeli	
	A	B	A	B
Cost of storage \$mn.	5.3	5.3	5.3	-
Cost of barrage \$mn.	4.2	4.2	4.2	-
Total cost \$mn	9.5	9.5	9.5	-

c) Conclusion

The most economic scheme is therefore to construct dam A on the Linggiu to give a storage of 12300 million gallons at an estimated capital cost of \$6.3 million.

Case 5 Catchment cover as 1985 onwards; Johor State abstractions 76 mgd (probable maximum in Year 2000); PUB design demand 30 mgd - water shortages at intake as under present land and water resource developments in catchment.

a) Regulation by storage only

Regulation storage required : 2900 mg  
 Allow for operating losses etc. : 400 mg  
 3300 mg

	Linggiu		Pengeli	
	A	B	A	B
Cost of storage \$mn	4.7	4.2	3.7	4.2

b) Regulation by storage and tidal barrage

Regulation storage required : 2200 mg  
 Allow for operating losses etc. : 300 mg  
 2500 mg

	Linggiu		Pengeli	
	A	B	A	B
Cost of storage \$mn	4.6	3.9	3.3	3.5
Cost of barrage \$mn	4.2	4.2	4.2	4.2
Total cost \$mn	8.8	8.1	7.5	7.7

c) Conclusion

The most economic solution therefore is to construct dam A on the Pengeli to give a storage of 3300 million gallons at an estimated capital cost of \$5.7 million.

Case 6 Catchment cover as 1985 onwards; Johor State abstractions 76 mgd (probable maximum in Year 2000); PUB design demand 100 mgd - water shortages at intake as under present land and water resource developments in catchment.

a) Regulation by storage only

Regulation storage required : 5300 mg  
 Allow for operating losses etc. : 800 mg  
 6100 mg

	Linggiu		Pengeli	
	A	B	A	B
Cost of storage \$mn	5.3	5.3	5.3	-

b) Regulation by storage and tidal barrage

Regulation storage required : 3400 mg  
 Allow for operating losses etc. : 500 mg  
 3900 mg

	Linggiu		Pengeli	
	A	B	A	B
Cost of storage \$mn	4.9	4.6	4.1	4.8
Cost of barrage \$mn	4.2	4.2	4.2	4.2
Total cost \$mn	9.1	8.8	8.3	9.0

c) Conclusion

The cost of the required storage of 6100 million gallons is the same for dam sites A and B on the Linggiu and dam site A on the Pengeli. The estimated capital cost is \$5.3 million.

Case 7 Catchment cover as 1985 onwards; Johor State abstractions 76 mgd (probable maximum in Year 2000); PUB design demand 150 mgd - water shortages at intake as under present land and water resource developments in catchment

a) Regulation by storage only

Regulation storage required : 6700 mg  
 Allow for operating losses etc. : 1000 mg  
 7700 mg

	Linggiu		Pengeli	
	A	B	A	B
Cost of storage \$mn	5.6	5.8	6.4	-

b) Regulation by storage and tidal barrage

Regulation storage required : 4500 mg  
 Allow for operating losses etc. : 700 mg  
 5200 mg

	Linggiu		Pengeli	
	A	B	A	B
Cost of storage \$mn	5.1	4.9	4.7	-
Cost of barrage \$mn	4.2	4.2	4.2	-
Total cost \$mn	9.3	9.1	8.9	-

c) Conclusion

The most economic solution therefore is to construct dam A on the Linggiu to give a storage of 7700 million gallons at an estimated capital cost of \$5.6 million.

Case 8 Catchment cover as 1985 onwards; Johor State abstractions 76 mgd (probable maximum in Year 2000); PUB design demand 250 mgd - water shortages at intake as under present land water resource developments in catchment

a) Regulation by storage only

Regulation storage required : 9500 mg  
 Allow for operating losses etc. : 1400 mg  
 10900 mg

	Linggiu		Pengeli	
	A	B	A	B
Cost of storage \$mn	6.1	6.8	-	-

b) Regulation by storage and tidal barrage

Regulation storage required : 7000 mg  
 Allow for operating losses etc. : 1000 mg  
 8000 mg

	Linggiu		Pengeli	
	A	B	A	B
Cost of storage \$mn	5.7	5.9	6.5	-
Cost of barrage \$mn	4.2	4.2	4.2	-
Total cost \$mn	9.9	10.1	10.7	-

c) Conclusions

The most economic solution therefore is to construct dam A on the Linggiu to give a storage of 10900 million gallons at an estimated capital cost of \$6.1 million.

Case 9 Catchment cover as 1985 onwards; Johor State abstractions 76 mgd (probable maximum in Year 2000); PUB design demand 30 mgd - no shortage of water at intake

a) Regulation by storage only

Regulation storage required : 4400 mg  
 Allow for operating losses etc. : 700 mg  
 5100 mg

	Linggiu		Pengeli	
	A	B	A	B
Cost of storage \$mn	5.1	4.9	4.7	-

b) Regulation by storage and tidal barrage

Regulation storage required : 2200 mg  
 Allow for operating losses etc. : 300 mg  
 2500 mg

	Linggiu		Pengeli	
	A	B	A	B
Cost of storage \$mn	4.5	3.9	3.3	3.5
Cost of barrage \$mn	4.2	4.2	4.2	4.2
Total cost \$mn	8.7	8.1	7.5	7.7

c) Conclusion

The most economic solution therefore is to construct dam A on the Pengeli to give a storage of 5100 million gallons at an estimated capital cost of \$4.7 million.

Case 10 Catchment cover as 1985 onwards; Johor State abstractions 76 mgd (probable maximum in Year 2000); PUB design demand 100 mgd - no shortage of water at intake.

a) Regulation by storage only

Regulation storage required : 8800 mg  
 Allow for operating losses etc. : 1300 mg  
 10100 mg

	Linggiu		Pengeli	
	A	B	A	B
Cost of storage \$mn	6.0	6.5	-	-

b) Regulation by storage and tidal barrage

Regulation storage required : 4400 mg  
 Allow for operating losses etc. : 700 mg  
 5100 mg

	Linggiu		Pengeli	
	A	B	A	B
Cost of storage \$mn	5.1	4.9	4.7	-
Cost of barrage \$mn	4.2	4.2	4.2	-
Total cost \$mn	9.3	9.1	8.9	-

c) Conclusion

The most economic solution therefore is to construct dam A on the Linggiu to give a storage of 10100 million gallons at an estimated capital cost of \$6.0 million.

Case 11 Catchment cover as 1985 onwards; Johor State abstractions 76 mgd (probable maximum in Year 2000); PUB design demand 150 mgd - no shortage of water at intake

a) Regulation by storage

Regulation storage required : 12000 mg  
 Allow for operating losses etc. : 1800 mg  
 13800 mg

	Linggiu		Pengeli	
	A	B	A	B
Cost of storage \$mn	6.6	7.7	-	-

b) Regulation by storage and tidal barrage

Regulation storage required : 6400 mg  
 Allow for operating losses etc. : 1000 mg  
 7400 mg

	Linggiu		Pengeli	
	A	B	A	B
Cost of storage \$mn	5.5	5.7	6.2	-
Cost of barrage \$mn	4.2	4.2	4.2	-
Total cost \$mn	9.7	9.9	10.4	-

c) Conclusion

The most economic solution is therefore to construct dam A on the Linggiu to give a storage of 13800 million gallons at an estimated capital cost of \$6.6 million.

Case 12 Catchment cover as 1985 onwards; Johor State abstractions 76 mgd (probable maximum in Year 2000); PUB design demand 250 mgd - no shortage of water at intake

a) Regulation by storage only

Regulation storage required : 20200 mg  
 Allow for operating losses etc. : 3000 mg  
 23200 mg

	Linggiu		Pengeli	
	A	B	A	B
Cost of storage \$mn	8.1	10.4	-	-

b) Regulation by storage and tidal barrage

Regulation storage required : 12200 mg  
 Allow for operating losses etc. : 1800 mg  
 14000 mg

	Linggiu		Pengeli	
	A	B	A	B
Cost of storage \$mn	6.6	7.7	-	-
Cost of barrage \$mn	4.2	4.2	-	-
Total cost \$mn	10.8	11.9	-	-

c) Conclusion

The most economic solution is therefore to construct dam A on the Linggiu to give a storage of 23200 million gallons at an estimated capital cost of \$8.1 million.

Case 13 Catchment cover as 1985 onwards; Johor State abstractions 41 mgd (probable minimum in Year 2000); PUB design demand 30 mgd - water shortages at intake as under present land and water resource developments in catchment.

a) Regulation by storage only

Regulation storage required : 2600 mg  
 Allow for operating losses etc. : 400 mg  
 3000 mg

	Linggiu		Pengeli	
	A	B	A	B
Cost of storage \$mn	4.7	4.1	3.6	3.9

b) Regulation by storage and tidal barrage

Regulation storage required : 1300 mg  
 Allow for operating losses etc. : 200 mg  
 1500 mg

	Linggiu		Pengeli	
	A	B	A	B
Cost of storage \$mn	4.3	3.4	2.8	2.9
Cost of barrage \$mn	4.2	4.2	4.2	4.2
Total cost \$mn	8.5	7.6	7.0	7.1

c) Conclusion

The most economic solution therefore is to construct dam A on the Pengeli to give a storage of 3000 million gallons at an estimated capital cost of \$3.6 million.

Case 14 Catchment cover as 1985 onwards; Johor State abstractions 41 mgd (probable minimum in Year 2000); PUB design demand 100 mgd - water shortages at intake as under present land and water resource developments in catchment.

a) Regulation by storage only

Regulation storage required : 3700 mg  
 Allow for operating losses etc. : 500 mg  
 4200 mg

	Linggiu		Pengeli	
	A	B	A	B
Cost of storage \$mn	5.0	4.7	4.2	4.9

b) Regulation by storage and tidal barrage

Regulation storage required : 2200 mg  
 Allow for operating losses etc. : 300 mg  
 2500 mg

	Linggiu		Pengeli	
	A	B	A	B
Cost of storage \$mn	4.6	3.9	3.3	3.5
Cost of barrage \$mn	4.2	4.2	4.2	4.2
Total cost \$mn	8.8	8.1	7.5	7.7

c) Conclusion

The most economic solution therefore is to construct dam A on the Pengeli to give a storage of 4200 million gallons at an estimated capital cost of \$4.2 million.

Case 15 Catchment cover as 1985 onwards; Johor State abstractions 41 mgd (probable minimum in Year 2000); PUB design demand 150 mgd - water shortages at intake as under present land and water resource developments in catchment.

a) Regulation by storage only

Regulation storage required : 4700 mg  
 Allow for operating losses etc. : 700 mg  
 5400 mg

	Linggiu		Pengeli	
	A	B	A	B
Cost of storage \$mn	5.2	5.0	4.9	-

b) Regulation by storage and tidal barrage

Regulation storage required : 3000 mg  
 Allow for operating losses etc. : 500 mg  
 3500 mg

	Linggiu		Pengeli	
	A	B	A	B
Cost of storage \$mn	4.8	4.2	3.8	4.4
Cost of barrage \$mn	4.2	4.2	4.2	4.2
Total cost \$mn	9.0	8.4	8.0	8.6

c) Conclusions

The most economic solution therefore is to construct dam A on the Pengeli to give a storage of 5400 million gallons at an estimated capital cost of \$4.9 million.

Case 16 Catchment cover as 1985 onwards; Johor State abstractions 41 mgd (probable minimum in Year 2000); PUB design demand 250 mgd - water shortages at intake as under present land and water resource developments in catchment.

a) Regulation by storage only

Regulation storage required : 6500 mg  
 Allow for operating losses etc. : 1000 mg  
 7500 mg

	Linggiu		Pengeli	
	A	B	A	B
Cost of storage \$mn	5.5	5.7	6.2	-

b) Regulation by storage and tidal barrage

Regulation storage required : 4600 mg  
 Allow for operating losses etc. : 700 mg  
 5300 mg

	Linggiu		Pengeli	
	A	B	A	B
Cost of Storage \$mn	5.2	5.0	4.9	-
Cost of barrage \$mn	4.2	4.2	4.2	-
Total cost \$mn	9.4	9.2	9.1	-

c) Conclusion

The most economic solution therefore is to construct dam A on the Linggiu to give a storage of 7500 million gallons at an estimated capital cost of \$5.5 million.

Case 17 Catchment cover as 1985 onwards; Johor State abstractions 41 mgd (probable minimum in Year 2000); PUB design demand 30 mgd - no shortage of water at intake.

a) Regulation by storage only

Regulation storage required : 4100 mg  
 Allow operating losses etc. : 600 mg  
 4700 mg

	Linggiu		Pengeli	
	A	B	A	B
Cost of storage \$mn	5.1	4.8	4.5	5.2

b) Regulation by storage and tidal barrage

Regulation storage required : 1300 mg  
 Allow for operating losses etc. : 200 mg  
 1500 mg

	Linggiu		Pengeli	
	A	B	A	B
Cost of storage \$mn	4.3	3.4	2.8	2.9
Cost of barrage \$mn	4.2	4.2	4.2	4.2
Total cost \$mn	8.7	7.6	7.0	7.1

c) Conclusion

The most economic solution therefore is to construct dam A on the Pengeli to give a storage of 4700 million gallons at an estimated capital cost of \$4.5 million.

Case 18 Catchment cover as 1985 onwards: Johor State abstractions 41 mgd (probable minimum in year 2000); PUB design demand 100 mgd - no shortage of water at intake

a) Regulation by storage only

Regulation storage required : 7200 mg  
 Allow for operating losses etc.: 1100 mg  
 8300 mg

	Linggiu		Pengeli	
	A	B	A	B
Cost of storage \$mn	5.7	5.9	6.6	-

b) Regulation by storage and tidal barrage

Regulation storage required : 3200 mg  
 Allow for operating losses etc. : 500 mg  
 3700 mg

	Linggiu		Pengeli	
	A	B	A	B
Cost of storage \$mn	4.9	4.4	4.0	4.5
Cost of barrage \$mn	4.2	4.2	4.2	4.2
Total cost \$mn	9.1	8.6	8.2	8.7

c) Conclusion

The most economic solution therefore is to construct dam A on the Linggiu to give a storage of 8300 million gallons at an estimated capital cost of \$5.7 million.

Case 19 Catchment cover as 1985 onwards: Johor State abstractions 41 mgd (probable minimum in Year 2000); PUB design demand 150 mgd - no shortage of water at intake

a) Regulation by storage only

Regulation storage required : 10000 mg  
 Allow for operating losses etc. : 1500 mg  
 11500 mg

	Linggiu		Pengeli	
	A	B	A	B
Cost of storage \$mn	6.2	7.0	-	-

b) Regulation by storage and tidal barrage

Regulation storage required : 4900 mg  
 Allow for operating losses etc. : 700 mg  
 5600 mg

	Linggiu		Pengeli	
	A	B	A	B
Cost of storage \$mn	5.2	5.0	5.1	-
Cost of barrage \$mn	4.2	4.2	4.2	4.2
Total cost \$mn	9.4	9.2	9.3	4.2

c) Conclusion

The most economic solution therefore is to construct dam A on the Linggiu to give a storage of 11500 million gallons at an estimated capital cost of \$6.2 million.

Case 20 Catchment cover as 1985 onwards: Johor State abstractions 41 mgd (probable minimum in Year 2000); PUB design demand 250 mgd - no shortage of water at intake

a) Regulation by storage only

Regulation storage required : 17200 mg  
 Allow for operating losses etc. : 2600 mg  
 19800 mg

	Linggiu		Pengeli	
	A	B	A	B
Cost of storage \$mn	7.6	9.5	-	-

b) Regulation by storage and tidal barrage

Regulation storage required : 9800 mg  
 Allow for operating losses etc. : 1500 mg  
 11300 mg

	Linggiu		Pengeli	
	A	B	A	B
Cost of storage \$mn	6.2	6.9	-	-
Cost of barrage \$mn	4.2	4.2	-	-
Total cost \$mn	10.4	11.1	-	-

c) Conclusion

The most economic salution therefore is to construct dam A on the Linggiu to give a storage of 19 800 million gallons at an estimated capital cost of \$7.6 million.

4.7.11 General Conclusions

1. It is possible to regulate flows at the PUB intake up to 250 mgd., taking into account all other maximum demands likely to be placed on the catchment by the year 2000, by the provision of storage of approximately 23000 million gallons. The most economical dam site to provide this storage is located on the S. Linggiu at map reference WM 923:308 (dam site A). The dam would be approximately 55 feet high above stream bank level and the total capital cost is estimated at \$8.1 million.
2. For lesser degrees of regulation requiring storage in the range 6000 million gallons to 23000 million gallons dam A on the S. Linggiu remains the most economical.
3. For lesser degrees of regulation requiring storage up to 6000 million gallons dam A on the S. Pengeli, at map reference WM 739:333 would be the most economic.
4. Within the range of demands considered the repulsion of saline intrusion at the PUB intake can more economically be accomplished by providing storage rather than by the construction of a tidal barrage downstream.

Conclusions 1 and 2 will have to be reviewed in the light of the results of the recommended mineral prospecting in the catchments of the S. Linggiu. If the value of the mineral potential is zero or if exploitation of any mineral resources can be completed before the provision of storage is needed then the conclusions remain unaltered. If there are still exploitable mineral resources when storage is needed then the opportunity cost of each dam site to mining should be evaluated and included in the economic comparison of alternatives (Section 4.7.10).

The exact date that storage will be needed cannot be decided at present. This will depend upon factors such as future abstraction capacity at the PUB intake, restricted pumping time that the PUB may be prepared to accept, and the date when the Johor Baharu area will be supplied from the S. Johor. Based on the latter a reasonable estimate of the earliest date would be 1978/79.

The land development plan allows for the construction of dam A on the S. Linggiu. The plan also allows for the whole of the S. Linggiu catchment above the dam being excluded from agriculture development and remaining as jungle. This decision is based on the fact that the opportunity cost to agriculture is very small (Section 4.7.8) and would likely be exceeded by the incremental cost in providing a comparable reservoir in a developed catchment.

Certain further studies will be required to prove the technical feasibility of the proposed dam. These are discussed in Chapter 5.

FURTHER STUDIES5.1 Introduction

The proposed schemes have been based on existing maps supplemented by very limited field data. In order to prove the technical feasibility of these schemes, prepare preliminary designs and to obtain more refined costs it will be necessary to carry out further investigations and studies. These can be broadly classified as follows:-

- 1) Hydrological
- 2) Topographical surveys
- 3) Site investigations
- 4) Land utilization surveys
- 5) Raw water quality survey
- 6) Groundwater Studies

5.2 Hydrological

As stated in Chapter 1 the Project hydrological network has been handed over in situ to the DID. It is considered imperative that the network, with permanent improvements as discussed and agreed with the DID, should be operated and maintained without interruptions for a considerable number of years after land clearance has taken place. The exact length of time cannot be decided at present as this will depend on what conclusions can be drawn at a particular date from the analysis of the data collected up to that date. As stated in Section 1.9 regular data reviews at six monthly intervals should be carried out. It will be very important for the Engineer/Hydrologist responsible for the network to have up to date information on the state of the catchments draining to the recording stations, i.e. how much has been developed and how much is jungle at any point in time.

The analysis of the data will give the following:-

- a) More refined conclusions of the effects of jungle clearance on run-of-river flows over a range of catchment sizes. This in turn will give a sounder basis for the siting of run-of-river intakes in the future.
- b) More refined conclusions on general storage/yield relationships, which will enable more accurate estimates of the storage requirements at the proposed reservoirs to be made.
- c) Frequencies of flood discharges and the level of flood discharge to be allowed for in the design of major works such as the spillways, and diversion arrangements connected with the proposed dams.

The importance of analysing, as soon as possible all hydrological data collected during the current (1971) drought is emphasized (Section 1.9) as the results of the analysis may give immediate refinement to the run-of-river yields and storage/yield relationships adopted in this report.

5.3 Topographical Surveys5.3.1 Water Supply Schemes(a) Introduction

In general ground surveys will be required along all proposed pipeline routes, and at the sites of proposed intakes, pumping stations, treatment works and terminal storage.

(b) Kluang Water Supply (Section 4.2.1)

It will probably be necessary to survey several routes to establish the most economic alignment of the transfer pipeline from the Kahang Reservoir to the catchment of the S. Semberong Kechil, and to locate the pumping station. Additional survey will also be required at the site of the new (under construction 1970) treatment works and terminal storage, which are recommended for expansion, to obtain the most economic layout of the additional works.

(c) Kota Tinggi Water Supply (Section 4.2.2)

Straight forward survey as outlined in (a) above is all that will be required for this scheme.

(d) Johor Baharu, Industrial Area Water Supply (Section 4.2.3)

Notes on the selection of pipeline route from the S. Johor to the Johor Baharu area are given in Appendix C-19. As stated in that Appendix it is considered that it will be necessary to survey both pipeline routes in order to establish the most economic pipeline alignment and location of intake. The remaining surveys associated with this scheme should be straight forward.

(e) Project Village Supplies (Section 4.2.4)

It will be necessary to carry out the required surveys as soon as land clearance commences. The proposed locations of terminal storage are very tentative. The detailed siting of villages must ensure that there is ground reasonably close and at a suitable elevation to locate terminal storage so that adequate pressures can be maintained in the reticulation system.

5.3.2 Reservoir Area and Dam Sites(a) Reservoir Areas

Contour surveys of the proposed reservoir areas are required to produce elevation/capacity curves, which in turn gives the basis for deciding the conservation level and dam height required to impound the required quantity of water as determined from 5.2 (b). Surveys could probably best be carried out by aerial survey methods. Accuracy of survey should be such that a contoured plan with vertical intervals not greater than 5 feet can be produced. Concurrent ground surveys would also be necessary to establish required control and to provide any additional data necessary to achieve the required contour interval.

(b) Dam Sites

Contour surveys of dam sites are required to establish more accurate volume of fill material required and to prepare preliminary layouts for the dam heights derived from (a) above. Ground surveys would be suitable and the accuracy of the survey should be such that contoured plans with a vertical interval of not more than two feet can be produced. Ground surveys will also be required at all possible borrow areas to establish volumes of fill available for dam construction.

5.4 Site Investigations5.4.1 Water Supply Schemes.

It will be necessary to take borings and excavate trial pits at the proposed locations of all structures. Borings and trial pits may also be required along the routes of the larger diameter

pipelines e.g. from the S. Johor to Johor Baharu. Sampling and a certain amount of soil testing in a soil mechanics laboratory may be necessary.

#### 5.4.2 Reservoir Areas and Dam Sites

A comprehensive site investigation involving deep drillings, borings, trial pits and extensive laboratory testing of soil samples will be necessary. At dam sites these are necessary to establish the extent of alluvium, the strength of foundations and abutments and to give information to decide the type of cut off required. At borrow areas these are necessary to establish the strength and consolidation characteristics of fill material. Some investigation may be necessary on the reservoir perimeters to establish the likelihood of leakage and the possible extent of any required grouting.

It is important that investigations of this nature are carried out under the close supervision of an engineering geologist or engineer with wide experience in the work.

#### 5.5 Land Utilization Surveys

These will be required to establish possible compensation costs in certain instances. Compensation costs may be an important factor to be considered in the selection of pipeline route from the S. Johor to Johor Baharu.

Surveys in reservoir areas should also be carried out so that more accurate estimates of reservoir site clearance can be established.

#### 5.6 Raw Water Quality Survey

Further sampling and laboratory analysis of raw water should be carried out at the locations of the proposed water supply intakes. This will enable the most economic chemical treatment and size of individual components of the treatment works to be determined.

#### 5.7 Groundwater Studies

Review Group 1 at the presentation of Draft Project Report asked that the Master Plan Report should include

"Recommendations for Further Studies to be conducted on the Groundwater Potential".

It is emphasized that the groundwater study carried out under the Project has been based on existing general geological maps and a short field visit by an engineering geologist. The conclusions from this limited study on groundwater (Appendix D) are therefore very tentative.

This study indicated that the most promising areas having groundwater potential for development are the Pengeli sands and Panti sandstones in Johor Tengah. The raised beaches on the east coast of Tanjong Penggerang may also have potential. The Pengeli sands are mostly located west of the S. Pengeli, in an area not to be developed by Project proposals.

In Johor Tengah only villages T1 to T6 and T16 to T21 are located within or close to the estimated outcrop area of the Panti sandstones formations. In Tanjong Penggerang only the initial tourist development area and village P13 are located close to the raised sand beaches.

The yield of boreholes in the Panti sandstones may be in the range 0.1 - 0.2 mgd. For village group T1-T6, 6-12 boreholes would be required to meet the ultimate demand of approximately 1.2 mgd; for village group T16 to T21, 13-26 boreholes would be required to meet the ultimate demand of approximately 2.6 mgd. The yield of wells in the raised sand beaches may be in the range 0.2-0.4 mgd. For the initial tourist development and village P13 either 1 or 2 wells would be required to meet the ultimate demand of approximately 0.4 mgd.

The table below gives a broad indication as to the savings which might be achieved should adequate groundwater supplies be identified.

To determine whether these estimated savings are possible the following investigations would have to be carried out.

- (i) When the final village locations have been decided, carry out further examinations of geological sections and surface geological mapping. These will give guidance on the requirements for drilling and/or geophysical investigations.
- (ii) In the Panti sandstones exploratory drilling would involve say three holes at village group T1 to T6 and three holes at village group T16 to T21. A certain amount of geophysical survey, using resistivity and/or seismic techniques, as appropriate, may be required also. The cost of the three holes at each village group would probably be about \$100,000. Intermediate pump tests during drilling and a full completion pump test would be required. If the drilling was successful then these holes could be reamed out and completed as production wells.
- (iii) At the raised sand beaches a detailed geological/geophysical survey to define the outcrop area, and the thickness and extensions underground, beneath other deposits, of the sands, would be required. If the survey was favourable than say nine boreholes, on a grid, for pump testing could be sunk around one outcrop. The cost of the nine holes would probably be about \$150,000.
- (iv) Water quality surveys to assess any necessary treatment.
- (v) Assess the results of the investigations at each site, estimate the long term yield, and cost of groundwater supplies. Compare costs with the costs of surface water schemes.
- (vi) If groundwater costs are favourable then drill more holes or wells if and as required and prepare water supply schemes.

The Government will have to decide whether the cost of the investigations are warranted in relation to the uncertainty of obtaining groundwater and hence the savings.

Area	Estimated Costs & Savings \$-Million			Approximate Cost of Investigatory Drilling
	Surface Water Supply	Range of Groundwater Supply	Range of possible Savings	
Village T1-T6	2.77(a)	2.3-1.5	0.47-1.27	0.10
Village T16-T21	4.50(b)	4.5-3.0	0 -1.50	0.10
Initial Tourist Development and Village P13.	1.20(c)	0.8-0.5	0.5 -0.7	0.15

- (a) See Appendix C-21.
- (b) Proportionate cost of village group T13-T21 - See Appendix C-23.
- (c) Proportionate cost of village group P7 - P16 - See Appendix C-27.

## APPENDIX A

## APPENDIX A-1

RIVER GAUGING STATION HISTORY TO 28.2.71

NAME : S. Mupor at M32 $\frac{1}{2}$

GRID REFERENCE : WN 248-178

CATCHMENT AREA: 8.4 square miles.

ACCESS :

- 1) From Johor Baharu to M32 $\frac{1}{2}$  on the Kota Tinggi/Mersing road.
- 2) Entrance is through a rubber plantation on the right hand side of the road, where 4 or 5 huts can be seen.
- 3) Walk for about 2 to 3 minutes along track from the huts to the recorder.
- 4) The road is sealed and a car can be used for transport.

CURRENT METER MEASUREMENTS :

- 1) 42 measurements during period 27.12.69 to 24.1.71.
- 2) Range of discharge measured; 3.8 c/s to 235 c/s.

DISCHARGE CONTROL :

- 1) Channel control - not tidal.
- 2) Bed is sandy, but fairly firm and generally stable.

BENCH MARKS :

- 1) 6 ft. x  $\frac{1}{2}$  inch water pipe with 1 ft. x 1 ft. concrete slab near the recorder.
- 2) Value on top of pipe:- 27.63 O.D. = 6.5 ft. on gauge.

HISTORY REMARKS :

- 1) Stick gauge installed 6.12.69 - still in place Feb. 1971 (range 0 - 10.00 ft.)
- 2) Recorder (Negretti & Zambra pressure bulb, 0-20 ft.) installed 20.12.69 - still in place Feb. 1971.
- 3) No problems encountered with the recorder, apart from occasional deflation of bulb.
- 4) All flows were measured from the gauging bridge near the recorder.
- 5) Measurements were taken of the suspended sediment load during 1970.
- 6) Future flow measurements should be normally taken at least once monthly and at least once weekly during dry periods.
- 7) Future instrumentation should be wet-well/float type capable of operation in the range 0 to 10 ft. gauge height.
- 8) Vegetation cover is mainly jungle with very small percentage rubber on the lower side of the catchment around the recorder.
- 9) The Station was handed over to the DID as from 28.2.71, in situ, and in working order.

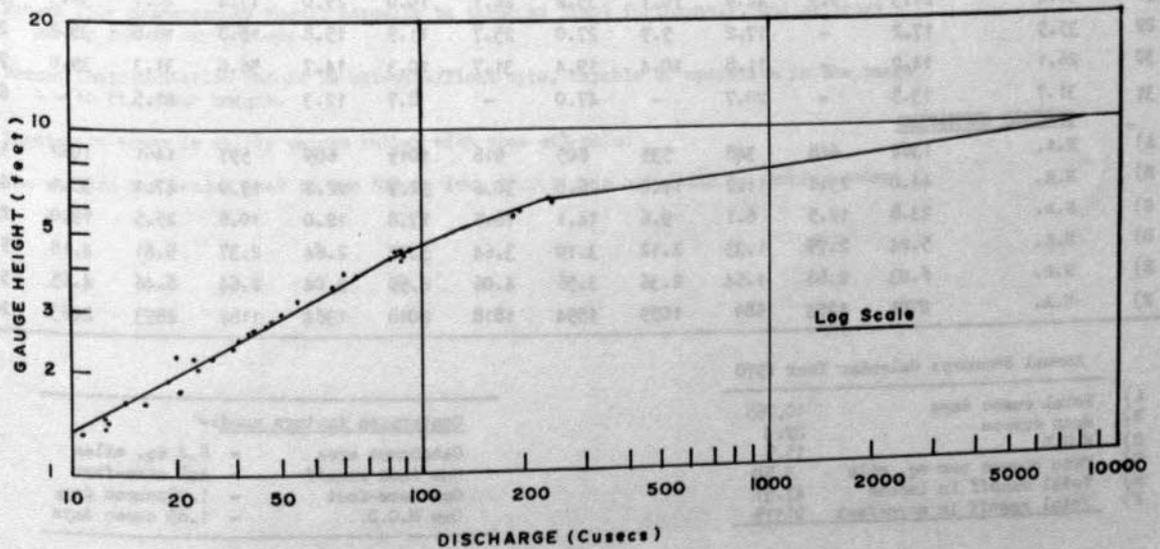
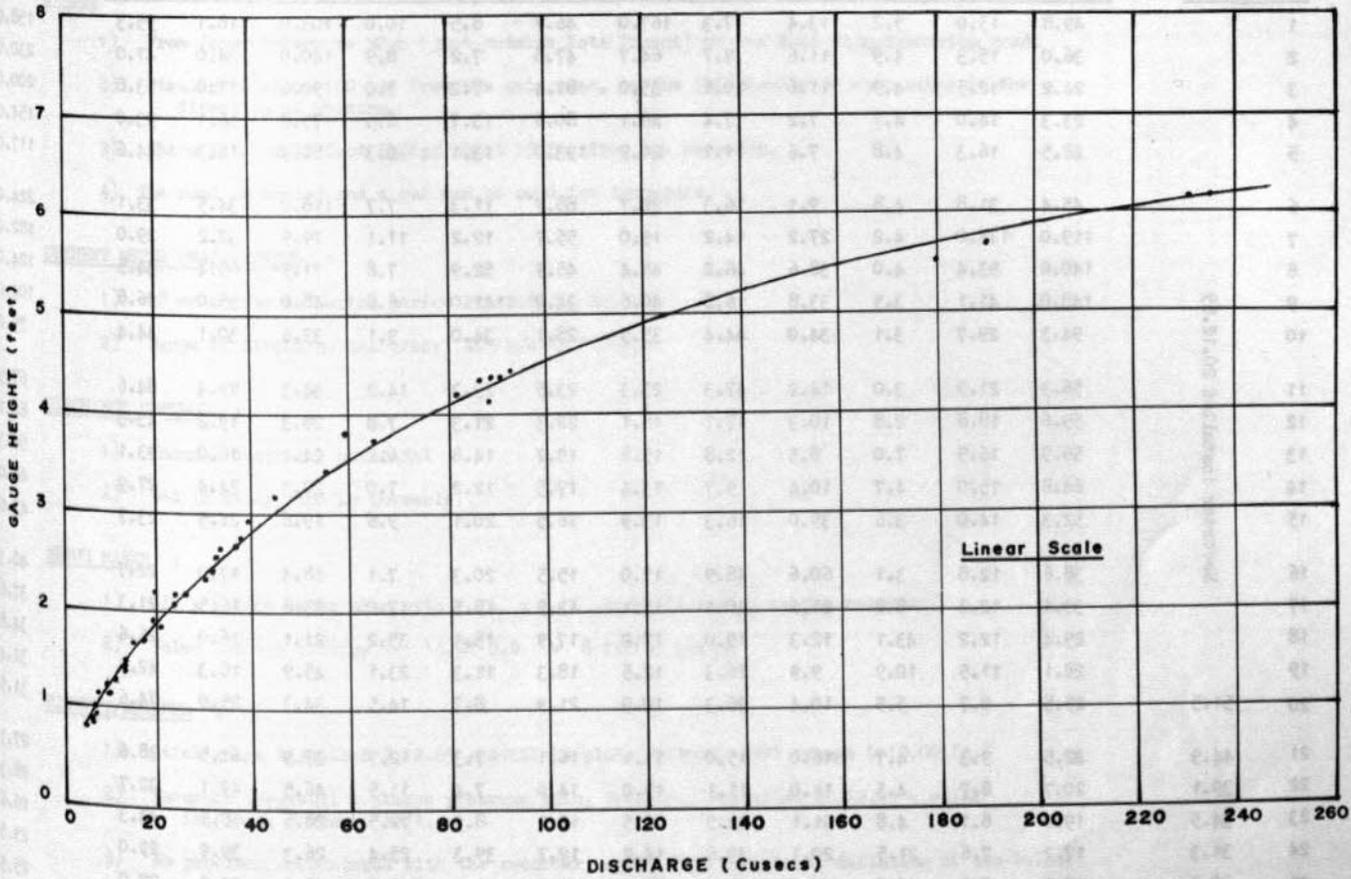
## APPENDIX A-2

S. MUFOR AT M321DISCHARGE MEASUREMENTS, MADE BY THE PROJECT FROM 27.12.69 TO 28.2.71

Meas. No.	Date	Surface Width (Feet)	Cross-Section Area (Sq. ft.)	Mean Velocity (Fps)	Gauge Height (Feet)	Discharge (Cusecs)	Current Meter Positions	No. of Vertical Sections	Rising Falling or Stationary (R, F or S)	Defining Rating Curve No.
1	27.12.69	17.5	42.8	0.84	2.69	36	.2, .8	8	F	1
2	29.12.69	17.0	41.8	0.79	2.61	33	.2, .8	11	F	1
3	3.1.70	16.5	34.2	0.73	2.19	25	.2, .8	10	S	1
4	4.1.70	17.0	32.9	0.69	2.04	23	.2, .8	10	F	1
5	6.1.70	19.0	65.5	0.99	3.76	65	.2, .8	12	R	1
6	6.1.70	19.0	61.7	0.96	3.83	59	.2, .8	12	S	1
7	7.1.70	35.5	128	1.81	6.15	231	.2, .8	22	S	1
8	7.1.70	36.5	130	1.81	6.13	235	.2, .8	23	F	1
9	10.1.70	21.0	81.0	1.14	4.43	92	.2, .8	13	F	1
10	10.1.70	21.0	80.4	1.07	4.37	86	.2, .8	13	F	1
11	19.1.70	17.5	42.9	0.71	2.45	31	.2, .8	11	S	1
12	24.1.70	17.0	34.2	0.59	1.86	20	.2, .8	16	S	1
13	25.1.70	measurement abandoned - meter not functioning correctly								
14	31.1.70	16.5	30.5	0.47	1.66	14	.2, .8	16	R	1
15	10.2.70	17.0	42.9	0.67	2.36	29	.2, .8	16	F	1
16	12.2.70	17.0	35.6	0.53	1.90	19	.2, .8	16	S	1
17	22.2.70	15.5	24.1	0.36	1.24	8.7	.2, .8	9	S	1
18	28.2.70	14.0	21.5	0.27	1.00	5.9	.2, .8	9	S	1
19	3.3.70	14.0	19.7	0.24	0.91	4.8	.2, .8	13	S	1
20	7.3.70	14.0	18.4	0.21	0.82	3.8	.2, .8	12	R	1
21	14.3.70	14.5	20.1	0.24	0.89	4.8	.2, .8	14	S	1
22	19.3.70	16.0	27.6	0.46	1.43	13	.2, .8	10	F	1
23	21.3.70	14.0	19.9	0.28	0.92	5.5	.2, .8	13	S	1
24	28.3.70	18.0	57.1	0.77	3.17	44	.2, .8	17	F	1
25	4.4.70	15.0	24.2	0.38	1.18	9.3	.2, .8	14	S	1
26	19.4.70	16.0	29.0	0.43	1.39	12	.2, .8	15	F	1
27	26.4.70	15.0	26.0	0.41	1.33	11	.2, .8	14	F	1
28	3.5.70	16.0	28.5	0.44	1.48	12	.2, .8	15	F	1
29	17.5.70	17.5	53.2	0.74	2.90	39	.2, .8	11	F	1
30	31.5.70	17.0	32.9	0.49	1.71	16	.2, .8	15	S	1
31	5.7.70	28.0	115	1.66	5.69	191	.2, .8	13	F	1
32	5.7.70	27.5	112	1.62	5.52	181	.2, .8	13	F	1
33	6.7.70	21.5	83.3	1.07	4.34	89	.2, .8	20	F	1
34	6.7.70	20.0	78.2	1.13	4.13	88	.6	13	R	1
35	23.8.70	16.0	24.7	0.27	1.10	6.6	.2, .8	15	S	1
36	25.10.70	18.5	58	0.95	3.44	55	.2, .8	16	R	1
37	13.12.70	17.5	47	0.68	2.58	32	.2, .8	11	S	1
38	20.12.70	20.5	80	1.10	4.36	88	.2, .8	13	F	1
39	27.12.70	18.0	34.3	0.57	2.22	20	.2, .8	16	S	1
40	10.1.71	20.0	82	0.99	4.21	81	.2, .8	17	F	1
41	17.1.71	18.0	54.7	0.68	2.79	37	.2, .8	11	R	1
42	24.1.71	17.5	43.4	0.52	2.18	22	.2, .8	11	R	1

Note:- Due to rounding of figures for publication the calculation of discharge from the quoted area and velocity may not agree exactly with the discharge figure above.

**S. MUPOR AT M 32 1/4**  
**RATING CURVE No.1**



APPENDIX A-4

S. MUPOR AT M321

MEAN DAILY DISCHARGES IN CUSECS, CALCULATED BY THE PROJECT FROM 20.12.69 TO 31.1.71

1969		1970												1971
Day	Dec.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.
1		49.8	15.0	5.2	13.4	7.3	167.0	46.7	8.5	10.0	103.0	18.1	95.3	158.0
2		36.0	15.3	4.9	11.6	7.7	64.7	47.8	7.2	8.9	140.0	24.0	47.0	230.0
3		24.2	12.5	4.9	11.6	10.6	35.0	81.4	7.2	7.0	90.6	17.0	53.8	200.0
4		23.3	14.0	4.7	7.2	7.4	28.1	80.6	13.7	6.5	75.8	16.1	93.0	154.0
5		28.5	16.3	4.8	7.6	11.1	21.9	193.0	13.1	6.3	80.7	16.3	44.6	117.0
6		45.4	31.8	4.8	9.1	16.3	20.7	88.7	11.3	7.7	118.0	34.5	33.1	224.9
7		119.0	174.0	4.2	27.2	14.2	19.0	55.7	12.2	11.1	79.9	32.2	29.0	182.0
8		140.0	93.4	4.0	38.6	46.2	45.4	45.9	52.9	7.8	71.9	65.4	34.5	124.0
9		148.0	41.1	3.5	33.8	16.8	40.6	34.0	141.0	6.8	48.0	35.0	26.8	104.0
10		94.3	29.7	3.1	34.0	44.4	35.5	28.1	34.0	9.1	39.6	30.1	44.4	79.0
11		56.3	21.9	3.0	14.2	47.3	23.3	23.5	23.3	14.2	34.3	29.4	84.6	67.9
12		59.6	18.8	2.8	10.3	17.7	18.1	22.3	21.3	7.8	28.3	19.2	43.3	62.1
13		56.9	16.5	7.0	8.5	12.8	15.8	19.2	14.8	6.2	24.4	16.0	33.1	56.3
14		64.8	15.0	4.7	10.4	9.7	13.4	17.5	12.2	7.0	20.3	24.4	27.9	48.0
15		52.3	14.0	3.6	35.0	16.3	13.9	16.5	20.1	9.6	19.6	21.5	23.7	43.6
16		38.6	12.8	3.1	60.6	48.9	17.0	15.5	20.3	7.1	18.4	17.0	22.7	40.3
17		33.1	12.2	8.8	21.6	40.1	15.1	13.9	15.5	17.0	33.8	16.5	21.3	37.6
18		29.4	12.2	43.1	12.3	19.0	17.2	17.9	15.1	35.2	21.1	16.0	26.6	34.8
19		28.1	11.5	10.9	9.9	16.3	12.5	18.3	11.3	23.1	45.9	16.3	42.9	32.4
20	51.5	25.5	9.7	5.5	10.4	26.3	10.9	21.9	8.7	14.5	34.3	25.0	74.6	31.5
21	44.9	22.5	9.3	4.7	16.0	15.0	11.1	16.1	7.3	12.7	37.9	61.5	38.6	27.7
22	39.1	20.7	8.7	4.5	11.0	11.1	15.0	14.0	7.4	11.5	46.5	49.1	32.7	28.3
23	34.5	19.0	8.1	4.8	41.1	12.9	28.5	12.2	8.9	12.5	28.5	35.5	43.3	26.6
24	31.3	17.2	7.6	21.5	20.1	33.6	14.2	12.7	39.3	25.4	26.3	39.9	29.0	23.5
25	30.3	17.9	7.3	45.7	12.3	27.4	27.4	12.7	32.9	125.0	45.4	32.9	27.0	25.5
26	30.3	21.9	6.9	14.7	9.3	88.3	63.7	11.1	21.3	69.3	34.0	71.9	20.7	34.8
27	40.9	25.7	6.1	23.2	7.9	51.5	39.3	10.7	36.0	28.3	22.5	141.0	29.9	25.9
28	36.4	21.3	5.9	42.9	10.1	35.2	26.1	10.0	29.0	17.4	20.7	56.3	33.6	20.9
29	35.5	17.2	-	17.2	9.9	27.0	25.7	11.9	15.8	15.8	18.8	35.2	27.9	18.3
30	26.1	14.2	-	11.8	10.4	19.4	31.7	10.3	14.7	56.0	31.3	39.0	76.6	16.3
31	31.7	13.5	-	20.7	-	47.0	-	8.7	12.3	-	21.5	-	67.5	15.8
+		<u>MONTHLY SUMMARIES</u>												
A)	N.A.	1364	648	348	535	805	918	1019	689	597	1461	1052	1329	2290
B)	N.A.	44.0	23.1	11.2	17.8	26.0	30.6	32.9	22.2	19.9	47.1	35.1	42.9	73.9
C)	N.A.	23.8	12.5	6.1	9.6	14.1	16.5	17.8	12.0	10.8	25.5	19.0	23.2	39.9
D)	N.A.	5.24	2.75	1.33	2.12	3.10	3.64	3.92	2.64	2.37	5.61	4.18	5.11	8.79
E)	N.A.	6.03	2.86	1.54	2.36	3.56	4.06	4.50	3.04	2.64	6.46	4.65	5.87	10.12
F)	N.A.	2701	1283	689	1059	1594	1818	2018	1364	1182	2893	2083	2631	4534

Annual Summary: Calendar Year 1970

A)	Total cusec days	10,765
B)	Mean cusecs	29.4
C)	M.G.D.	15.9
D)	Mean cusecs per sq. mile	3.50
E)	Total runoff in inches	47.57
F)	Total runoff in acre-feet	21315

Conversion factors used:-

Catchment area	= 8.4 sq. miles
One inch runoff	= 448 acre-feet
One acre-foot	= 1.98 cusec days
One M.G.D.	= 1.85 cusec days

## APPENDIX A-5

RIVER GAUGING STATION HISTORY TO 28.2.71NAME : S. Permandi at M27 $\frac{1}{4}$ 

GRID REFERENCE : WN 197-107

CATCHMENT AREA : 9.1 sq. miles

ACCESS :

- 1) From Johor Baharu to M27 $\frac{1}{4}$  (just outside Kota Tinggi) on the Kota Tinggi/Mersing Road.
- 2) Station is about 100 yds from the main road, on the left hand side when going in the direction of Mersing.
- 3) There is a small foot bridge about 10 ft. from the recorder.
- 4) The road is sealed and a car can be used for transport.

CURRENT METER MEASUREMENTS :

- 1) 48 measurements during period 20.12.69 to 24.1.71.
- 2) Range of discharge measured; 4.3 c/s to 218 c/s.

DISCHARGE CONTROL :

- 1) Channel control - not tidal
- 2) Bed is sandy, and is moveable.

BENCH MARKS :

- 1) 6ft x  $\frac{1}{2}$  inch water pipe with 1 ft. x 1 ft. concrete slab near the recorder.
- 2) Value on top of pipe :- 14.94 O.D. = 8 ft. on gauge.

HISTORY/REMARKS :

- 1) Stick gauge installed 7.12.69 - still in place February 1971 (range 0-10,00 ft.)
- 2) Recorder (Negretti & Zambra pressure bulb, 0-20 ft.) installed 20.12.69 - still in place, February 1971.
- 3) No problems encountered with the recorder, apart from occasional deflation of the bulb.
- 4) Low flows were measured by wading, about 100 ft. upstream of the recorder. High flows were measured by rods, from the foot-bridge near the recorder.
- 5) Measurements were also taken of the suspended sediment load during 1970.
- 6) Future flow measurements should normally be taken at least fortnightly, and at least weekly during dry periods.
- 7) Future instrumentation should be wet-well/float type, capable of operation in the range 0 - 10 ft. gauge height.
- 8) Vegetation cover is mainly mature rubber with some oil-palm.
- 9) The station was handed over to the DID as from 28.2.71, in situ, and in working order.

APPENDIX A-6

S. PERMANDI AT M27

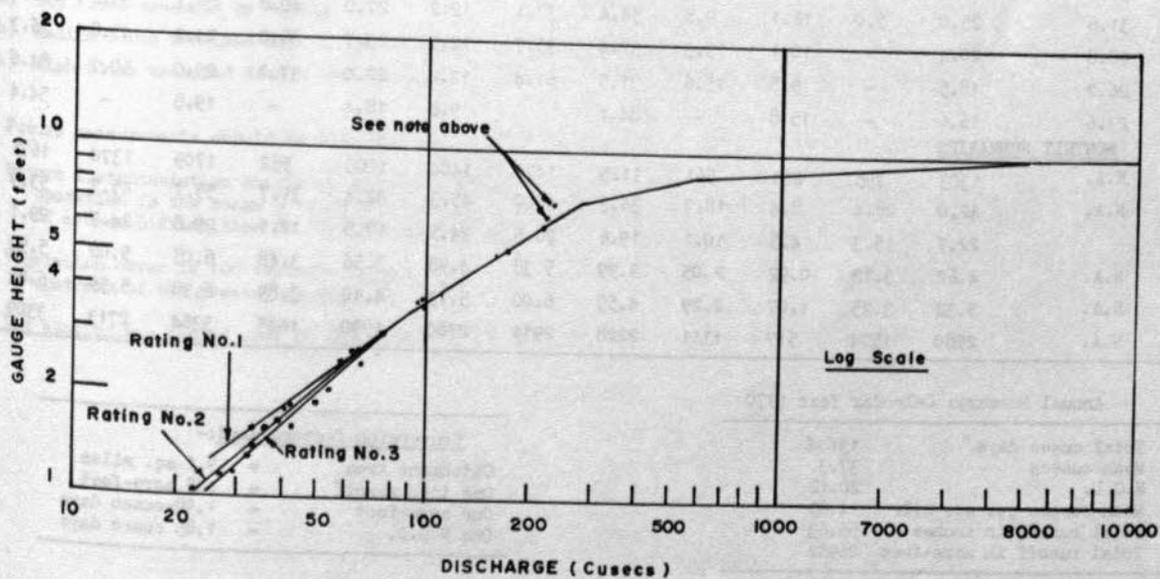
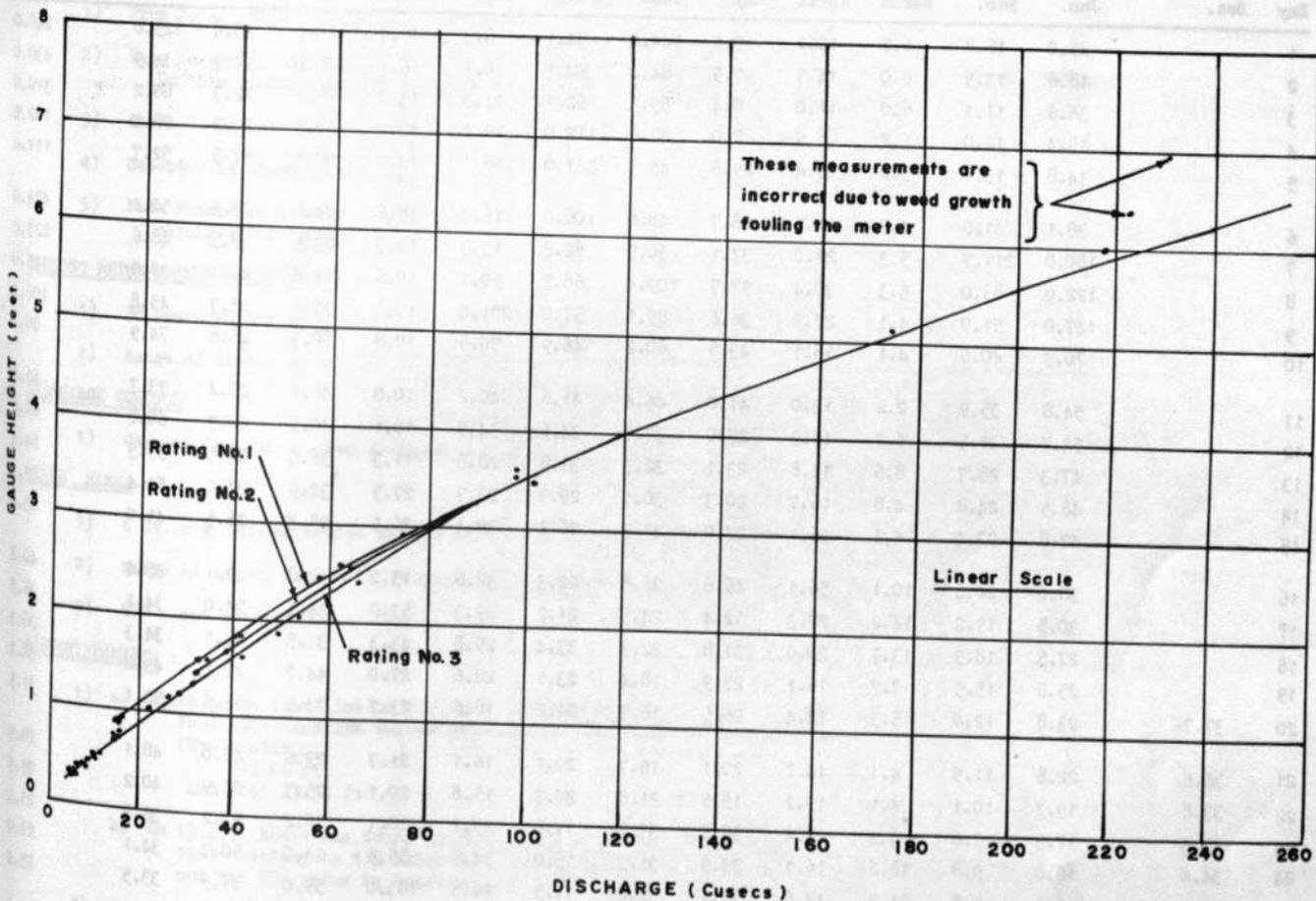
DISCHARGE MEASUREMENTS, MADE BY THE PROJECT FROM 20.12.69 TO 28.2.71

Meas. No.	Date	Surface Width (Feet)	Cross-Section Area (Sq. ft.)	Mean Velocity (Fps)	Gauge Height (Feet)	Discharge (Cusecs)	Current Meter Positions	No. of Vertical Sections	Rising Falling or Stationary (R, F or S)	Defining Rating Curve
1	20.12.69	19.0	28.4	1.46	1.81	41				
2	20.12.69	19.0	28.7	1.40	1.80	40	.2, .8	9	F	1
3	27.12.69	18.0	23.0	1.40	1.57	32	.2, .8	9	S	1
4	3 .1.70	16.5	11.5	1.42	0.89	16	.2, .8	8	F	1
5	4 .1.70	17.0	11.8	1.26	0.86	15	.6	10	F	1
6	4 .1.70	17.0	12.1	1.30	0.86	16	.2, .8	16	S	1
7	6 .1.70	20.0	44.8	1.43	2.57	64	.2, .8	10	S	1
8	6 .1.70	20.0	42.9	1.45	2.59	62	.2, .8	12	R	1
9	7 .1.70	23.0	99.7	1.76	5.15	175	.2, .8	11	F	1
10	7 .1.70	25.5	121.0	1.80	5.99	218	.2, .8	13	R	1
11	10.1.70	19.0	39.4	1.46	2.43	57	.2, .8	13	R	1
12	17.1.70	18.0	23.3	1.39	1.41	32	.2, .8	11	F	1
13	19.1.70	16.5	17.9	1.50	1.16	27	.2, .8	17	R	2
+14	24.1.70	16.5	12.8	1.50	1.16	27	.2, .8	10	S	2
+15	25.1.70	17.0	12.4	1.09	0.80	14	.2, .8	16	S	2
+16	31.1.70	17.0	12.8	0.91	0.77	13	.2, .8	16	S	2
17	31.1.70	17.0	12.8	0.91	0.77	12	.2, .8	16	R	2
18	10.2.70	17.5	26.7	1.23	0.77	16	.6	16	S	2
19	12.2.70	18.0	21.8	1.45	1.66	39	.2, .8	16	S	2
+20	21.2.70	16.0	11.1	1.46	1.30	32	.2, .8	17	S	2
+21	22.2.70	16.0	10.3	0.93	0.58	10	.6	17	F	3
22	23.2.70	15.0	9.6	0.85	0.55	8.8	.2, .8	15	S	3
23	28.2.70	15.0	8.2	1.09	0.50	10	.6	10	S	3
24	Ditto	14.5	8.4	0.94	0.39	7.7	.6	14	S	3
25	3 .3.70	15.0	7.4	1.05	0.39	8.8	.6	9	S	3
26	7 .3.70	14.5	6.5	0.79	0.34	5.9	.6	9	S	3
27	14.3.70	15.0	7.6	0.69	0.30	4.5	.6	14	S	3
28	19.3.70	15.0	8.8	0.68	0.30	5.2	.6	14	S	3
29	21.3.70	15.0	6.9	0.82	0.39	7.2	.6	14	S	3
30	28.3.70	16.0	12.5	0.63	0.28	4.3	.6	9	S	3
31	4 .4.70	16.0	9.5	1.16	0.67	14	.6	14	S	3
32	19.4.70	16.5	12.5	1.09	0.48	10	.6	15	F	3
33	26.4.70	15.5	8.9	1.26	0.75	16	.6	15	R	3
34	3 .5.70	15.0	8.4	1.24	0.51	11	.6	15	S	3
35	17.5.70	18.0	33.2	1.10	0.42	9.3	.6	15	S	3
(+)36	5 .7.70	51.0	175.0	1.48	1.86	49	.6	14	F	3
(+)37	5 .7.70	40.5	154.0	1.32	6.98	231	.2, .8	11	F	3
38	6 .7.70	18.0	71.9	1.44	6.39	223	.2, .8	13	F	3
39	6 .7.70	18.0	69.8	1.36	3.53	98	.6	18	F	3
40	23.8.70	16.0	12.0	1.46	3.47	102	.2, .8	16	F	3
41	15.11.70	15.5	26.0	1.25	0.72	15	.6	16	R	3
42	22.11.70	16.5	41.0	1.61	1.60	42	.6	15	S	3
43	13.12.70	16.0	35.0	1.61	2.40	66	.2, .8	9	F	3
44	20.12.70	18.0	60.0	1.54	2.02	54	.2, .8	10	F	3
45	27.12.70	14.5	17.3	1.63	3.59	98	.2, .8	10	F	3
46	10.1 .71	17.5	40.0	1.70	1.19	29	.6	11	F	3
47	17.1 .71	15.5	24.0	1.87	2.90	75	.2, .8	13	S	3
48	24.1 .71	15.0	16.0	1.45	1.55	35	.2, .8	10	S	3
				1.37	1.03	22	.2, .8	14	S	3

Notes + - meter used for these measurements was faulty; hence ignore Velocity and Discharge.  
 (+) - long grass fouled the meter propellor; true discharge greater than that shown.  
 (?) - possibly the rating has changed; more measurements needed to confirm this.

Due to rounding of figures for publication the calculation of discharge from the quoted area and velocity may not agree exactly with the discharge figure above.

S. PERMANDI AT M 27 1/4  
RATING CURVES No.1, 2, 3



APPENDIX A-8

S. FERMANDI AT M27<sup>2</sup>

MEAN DAILY DISCHARGES IN CUSECS. CALCULATED BY THE PROJECT FROM 20.12.69 TO 31.1.71

1969		1970											1971	
Day	Dec.	Jan.	Feb.	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.	Jan.
1		21.0	16.8	6.2	10.1	9.1	244.0	54.1	8.9	16.7	120.0	25.4	125.0	246.0
2		18.6	13.9	6.0	14.5	7.9	84.4	52.1	10.1	16.1	250.0	30.7	74.9	430.0
3		36.6	11.1	6.0	11.0	8.4	59.3	62.1	11.3	13.0	95.1	22.3	66.2	310.0
4		15.4	12.0	6.2	8.9	7.0	47.8	119.0	12.2	12.0	69.3	20.3	78.2	182.0
5		14.8	13.0	5.0	16.4	29.8	45.3	321.0	16.1	13.0	90.1	17.5	52.7	117.0
6		38.1	41.6	4.3	12.5	28.7	48.6	106.0	16.4	15.6	94.6	28.5	50.1	474.0
7		180.0	211.7	5.3	27.0	37.1	50.9	82.8	13.3	13.3	83.5	28.5	48.6	227.0
8		122.0	85.0	5.3	30.4	97.7	109.4	68.7	90.1	10.8	71.8	44.4	39.9	125.0
9		147.0	51.0	4.1	27.9	36.6	89.1	57.0	201.0	10.8	57.6	28.7	45.8	108.0
10		70.3	40.6	4.1	18.1	43.8	60.2	46.9	50.6	10.8	50.3	26.8	74.9	80.2
11		54.8	35.9	2.2	13.0	41.0	46.4	41.6	40.2	10.8	46.1	25.4	93.7	66.8
12		52.7	31.5	6.7	15.3	27.0	37.7	34.6	34.9	10.1	40.5	20.9	60.8	60.8
13		47.3	28.7	8.6	11.8	23.1	32.3	31.8	28.5	11.3	36.0	24.0	55.3	54.4
14		48.5	24.8	4.8	16.7	20.3	30.1	29.3	23.7	27.9	32.9	24.0	51.4	49.2
15		42.8	23.4	4.1	46.1	27.0	27.3	26.2	39.4	26.5	28.7	28.5	41.0	43.6
16		38.0	20.6	10.1	56.1	46.6	26.8	22.3	32.6	15.0	33.8	39.7	35.4	40.2
17		30.8	19.2	14.2	27.3	52.4	24.5	21.2	29.3	53.0	34.1	54.0	34.1	38.8
18		27.5	18.9	13.7	20.0	31.8	22.3	23.4	29.8	43.3	31.5	42.5	34.3	36.3
19		25.8	15.5	7.7	16.1	27.9	18.4	23.1	22.6	27.0	44.7	46.1	43.0	32.7
20	37.7	23.8	12.0	5.3	14.4	26.5	16.7	21.2	18.6	23.7	73.6	73.6	92.1	31.5
21	36.6	22.8	11.5	4.1	14.7	20.1	16.7	20.1	16.1	21.7	29.6	148.0	48.1	28.5
22	33.8	19.7	10.1	4.1	19.2	15.6	31.8	20.3	15.8	20.1	25.7	65.9	40.2	25.3
23	33.3	17.3	9.6	4.3	25.4	38.5	37.7	17.0	25.1	18.1	26.2	53.2	36.3	25.1
24	34.4	16.8	9.8	18.6	16.1	39.9	31.3	15.0	34.9	55.8	24.0	50.7	34.1	22.3
25	35.2	16.1	9.8	21.2	12.6	37.1	32.6	14.5	26.5	183.0	59.0	47.5	33.5	25.4
26	37.5	32.6	7.2	11.3	9.6	65.9	36.3	13.9	27.6	106.0	33.2	69.6	30.7	25.7
27	36.6	41.1	5.0	16.1	8.9	68.7	27.6	12.2	38.0	52.4	28.5	129.0	36.3	24.5
28	31.6	25.0	5.0	16.1	9.8	54.4	37.1	12.2	27.0	40.8	25.1	58.2	38.8	20.3
29	28.8	20.4	-	10.1	15.3	39.4	35.7	12.5	23.7	36.0	24.2	45.8	36.3	17.8
30	26.2	18.5	-	9.8	15.6	31.5	61.4	12.2	22.0	37.7	29.0	50.7	84.6	17.8
31	23.6	16.6	-	15.8	-	84.1	-	9.8	18.4	-	19.8	-	54.4	16.7
<b>MONTHLY SUMMARIES</b>														
A)†	N.A.	1303	795	261	561	1125	1470	1404	1005	952	1709	1370	1671	3004
B)	N.A.	42.0	28.4	8.4	18.7	36.3	49.0	45.3	32.4	31.7	55.1	45.7	53.9	96.9
C)		22.7	15.3	4.5	10.1	19.6	26.5	24.5	17.5	17.1	29.8	24.7	29.1	52.1
D)	N.A.	4.62	3.12	0.92	2.05	3.99	5.38	4.98	3.56	3.48	6.05	5.02	5.92	10.65
E)	N.A.	5.32	3.25	1.07	2.29	4.59	6.00	5.73	4.10	3.89	6.98	5.59	6.82	12.26
F)	N.A.	2580	1574	517	1111	2228	2911	2780	1990	1885	3384	2713	3309	5948

Annual Summary: Calendar Year 1970

A)†	Total cusec days	13626
B)	Mean cusecs	37.3
C)	M.G.D.	20.12
D)	Mean cusecs per sq. mile	4.09
E)	Total runoff in inches	55.63
F)	Total runoff in acre-feet	26982

Conversion factors used:-

Catchment Area	=	9.1 sq. miles
One inch runoff	=	485 acre-feet
One acre-foot	=	1.98 cusec days
One M.G.D.	=	1.85 cusec days

## APPENDIX A-9

RIVER GAUGING STATION HISTORY TO 28.2.71

NAME : S. Linggiu at Road Bridge

GRID REFERENCE : WM 924-255

CATCHMENT AREA : 112 sq. miles

ACCESS :

- 1) From Kulai, then through Fraser Estate.
- 2) Keep following the "main" road when travelling through Fraser Estate and ignore "minor" forks. Do this regardless of what apparent direction these roads appear to take.
- 3) Cross S. Sayong, S. Pengelli, then travel for another 7 miles to S. Linggiu.
- 4) Recorder is about 50 ft. upstream of the road bridge, and is on the left bank.
- 5) From Fraser Estate the road is unsealed. It is mainly a logging road, and a Landrover is required for transport.

CURRENT METER MEASUREMENTS :

- 1) 38 measurements were done during the period 14.1.70 to 17.2.71.
- 2) Range of discharge measured; 83 c/s to 1420 c/s.

DISCHARGE CONTROL :

- 1) Channel Control - bed is sandy but stable.

BENCH MARKS :

- 1) 6 ft. x  $\frac{1}{2}$  inch waterpipe with 1 ft. x 1 ft. concrete slab about 10 ft. from the recorder.
- 2) Value on top of pipe = 13.34 gauge height based on 0-6.66 staff - (see note 1 below).
- 3) TEM - not tied to O.D.

HISTORY/REMARKS :

- 1) a) Stick gauge installed on 7.1.70. It was raised 2 ft. on 21.1.70 - still in place Feb. 1971, and TEM values given above, correspond to this latter position -  
 (Two sections; }  
     0-6.66 ft.    }  
     and 6.66-13.33 ft. )
- b) On 17.2.71 there was found to be a datum difference between these two sections, such that "reading on top stick - 0.12 = reading on bottom stick". This was not corrected and the TEM value is based on the bottom stick (0-6.66), as all recorder charts were set from this stick.
- 2) Recorder (Negretti & Zambra pressure bulb, 0-20 ft.) was installed 7.1.70 - still in place Feb. 1971.
- 3) Apart from occasional deflation of the bulb no problems were encountered with the recorder.
- 4) a) Low flows measured by wading  
 b) Medium flows measured from a boat using wading rods  
 c) High flows measured from a boat using a winch  
 } all measurements were done at a section, 500 ft. upstream of the bridge, which was accessed by a track cut on the right bank near the bridge.
- 5) Future measurements should be done at least once per month.
- 6) Future instrumentation should be a Leupold & Stevens float type with a wet-well, capable of operation in the range 0 to 25 ft. gauge height, and installed on the right bank near the bridge. (because of access difficulties to the left bank during flood periods)
- 7) Vegetation cover is 100 percent Jungle. There are tin mining operations in progress on the S. Tempenis, upstream of the present gauge.
- 8) The station was handed over to the DID as from 28.2.71, in situ, and in working order.

APPENDIX A-10

S. LINGGIU AT ROAD BRIDGE

DISCHARGE MEASUREMENTS, MADE BY THE PROJECT FROM 14.1.70 TO 28.2.71

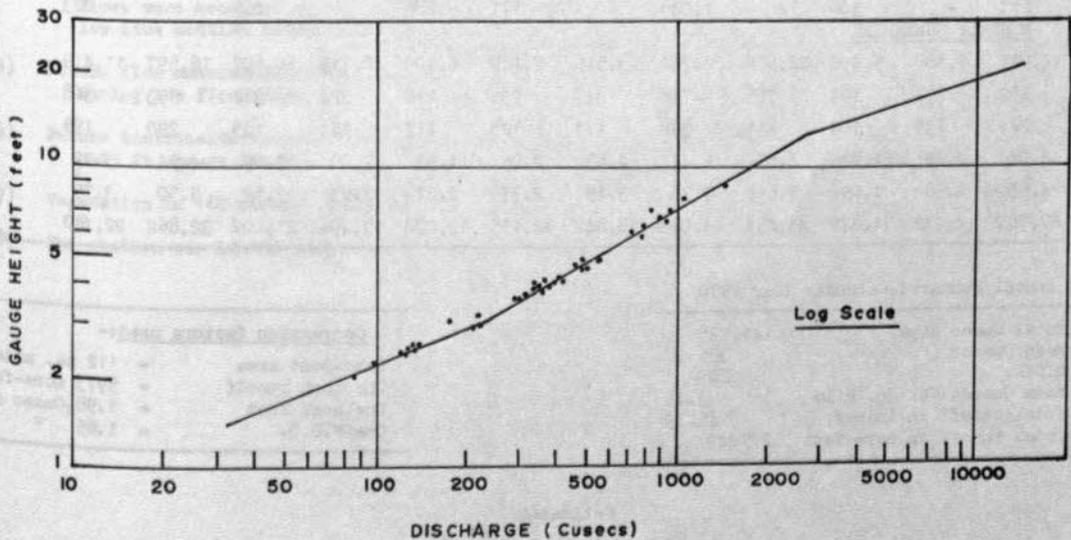
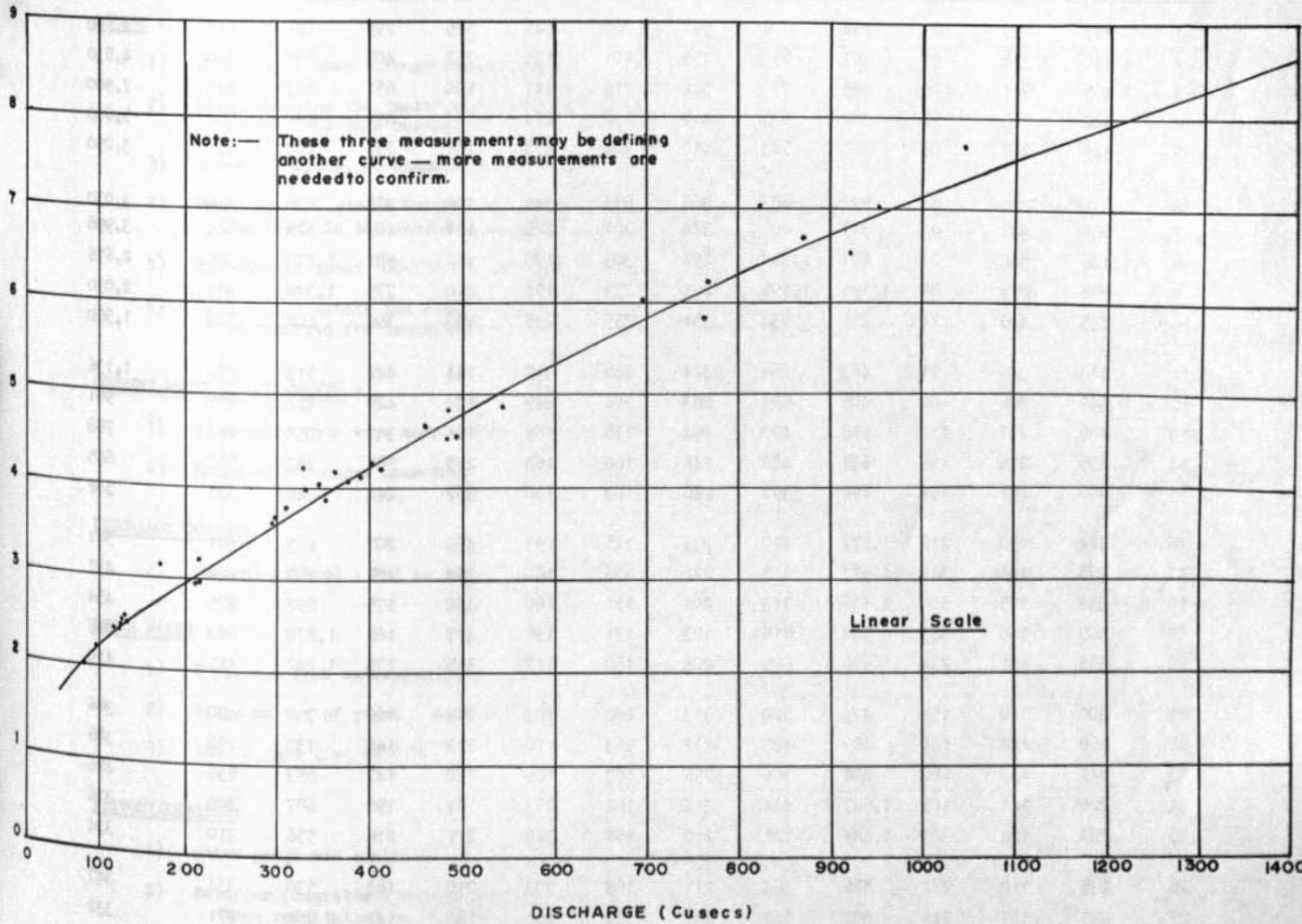
Meas. No.	Date	Surface Width (Feet)	Cross-Section Area (Sq. ft.)	Mean Velocity (Fps)	Gauge Height (Feet)	Discharge (Cusecs)	Current Meter Positions	No. of Vertical Sections	Rising Falling or Stationary (R, F or S)	Defining Rating Curve No.
+1	14.1.70	79	245	1.98	4.55	485	.5	13	R	1
+2	14.1.70	79	261	1.89	4.56	495	.5	14	R	1
+3	21.1.70	80	195	1.53	3.67	299	.2, .8	15	F	1
+4	21.1.70	80	197	1.51	3.64	297	.2, .8	15	F	1
5	28.1.70	80	235	1.66	4.13	391	.2, .8	15	F	1
6	28.1.70	82	253	1.49	4.08	378	.2, .8	16	F	1
7	4.2.70	80	169	1.30	2.99	220	.2, .8	15	S	1
8	4.2.70	80	169	1.28	2.99	216	.2, .8	15	S	1
9	11.2.70	80	211	1.68	3.87	355	.2, .8	15	F	1
10	22.2.70	75	109	1.22	2.56	133	.2, .8	14	F	1
11	25.2.70	77	110	1.10	2.42	121	.2, .8	15	S	1
12	25.2.70	77	109	1.15	2.42	125	.2, .8	14	S	1
13	4.3.70	75	92	1.06	2.23	98	.2, .8	14	S	1
14	11.3.70	76	88	0.94	2.01	83	.2, .8	14	S	1
15	22.3.70	77	127	1.07	2.52	136	.2, .8	15	R	1
16	25.3.70	78	257	1.57	4.26	403	.2, .8	15	R	1
17	8.4.70	80	427	2.15	6.54	920	.2, .8	15	R	1
18	18.4.70	80	424	2.46	7.68	1045	.2, .8	16	F	1
19	19.4.70	79	299	2.56	5.82	765	.6	15	F	1
20	22.4.70	81	227	1.83	4.20	415	.2, .8	16	S	1
21	29.4.70	80	267	2.05	4.89	547	.2, .8	15	R	1
22	3.5.70	77	335	2.30	6.22	770	.2, .8	14	F	1
23	7.5.70	78	373	2.34	6.70	873	.2, .8	14	F	1
24	8.5.70	79	512	2.78	8.53	1420	.6	14	R	1
25	10.5.70	76	365	2.61	7.01	953	.2, .8	14	S	1
26	11.5.70	76	311	2.25	6.02	700	.1, .8	14	F	1
27	19.8.70	77	120	1.07	2.48	128	.2, .8	15	S	1
28	7.10.70	77	218	1.53	3.99	333	.2, .8	14	F	1
29	27.10.70	77	135	1.00	2.54	135	.2, .8	14	S	1
30	4.11.70	78	176	1.24	3.21	218	.2, .8	15	F	1
31	11.11.70	78	268	1.82	4.85	487	.2, .8	15	F	1
32	9.12.70	78	208	1.50	3.79	313	.2, .8	15	F	1
33	20.12.70	75	265	1.74	4.69	462	.2, .8	14	R	1
34	21.12.70	79	231	1.51	4.04	349	.2, .8	15	F	1
35	30.12.70	78	236	1.55	4.18	366	.2, .8	15	R	1
36	12.1.71	77	362	2.28	7.03	826	.2, .8	14	F	1(?)
37	20.1.71	80	229	1.45	4.22	331	.2, .8	15	F	1(?)
38	17.2.71	75	154	1.13	3.14	174	.6	11	R	1(?)

Note + - Gauge Heights quoted for these measurements have been corrected to the same datum as all other measurements. (See Station History)

(?) - possibly the rating has changed; more measurements needed to confirm this.

Due to rounding of figures for publication the calculation of discharge from the quoted area and velocity may not agree exactly with the discharge figure above.

**S.LINGGIU AT ROAD BRIDGE**  
**RATING CURVE No.1**



APPENDIX A-12

S. LINGGIU AT ROAD BRIDGE

MEAN DAILY DISCHARGES IN CUSECS, CALCULATED BY THE PROJECT FROM 1.1.1970 TO 31.1.1971

Day	1970												1971
	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.
1	515 <sup>+</sup>	217	101	298	876	991	261	145	195	295	184	617	1,660
2	490 <sup>+</sup>	318	97	463	611	735	201	135	157	407	231	560	4,830
3	465 <sup>+</sup>	247	100	449	777	562	219	147	130	651	243	449	7,900
4	440 <sup>+</sup>	213	97	352	635	460	238	274	147	691	241	530	5,600
5	525 <sup>+</sup>	207	86	322	583	417	707	258	107	755	202	453	3,050
6	640 <sup>+</sup>	220	83	297	883	366	695	349	109	478	198	356	3,030
7	880	447	82	373	895	324	381	229	132	403	325	324	3,998
8	1,146	846	81	687	1,317	298	303	178	156	981	1,278	346	2,676
9	998	874	80	1,196	1,196	291	252	191	210	775	1,320	344	2,030
10	735	449	74	751	934	351	255	255	193	386	604	312	1,560
11	543	346	71	483	784	324	228	310	144	422	513	274	1,136
12	449	286	86	405	594	283	204	249	124	429	422	255	961
13	439	237	153	918	499	264	178	189	181	341	334	283	788
14	456	216	195	637	432	246	166	163	255	285	283	568	685
15	500	201	191	790	392	246	163	190	352	244	246	395	588
16	424	190	216	1,577	420	235	145	193	456	207	225	301	541
17	375	196	342	1,577	633	222	136	180	354	181	289	246	497
18	332	175	500	1,136	713	201	151	160	490	175	592	225	454
19	369	160	383	739	816	193	171	138	417	166	1,870	292	426
20	335	151	234	530	669	205	180	117	315	175	1,242	415	410
21	300	140	151	473	520	313	202	103	282	160	731	420	386
22	268	144	140	409	427	232	213	110	223	148	737	292	386
23	240	135	180	802	366	256	187	169	130	147	853	238	426
24	226	126	165	1,647	444	217	162	253	187	198	687	205	376
25	220	124	327	1,444	721	210	154	329	211	216	556	310	334
26	235	112	282	826	764	211	183	303	210	183	530	334	347
27	349	107	219	602	849	237	151	288	183	142	554	271	332
28	381	104	415	667	779	217	163	265	175	144	429	282	307
29	291	-	322	655	895	196	157	255	190	240	346	262	276
30	238	-	243	1,451	790	213	172	298	300	317	332	437	273
31	217	-	300	-	1,048	-	171	286		265		823	270
<b>MONTHLY SUMMARIES</b>													
A) <sup>+</sup>	14,021	7,188	5,996	22,956	22,262	9,516	7,149	6,709	6,715	10,607	16,597	11,419	46,533
B)	452	257	193	765	718	317	231	216	224	342	553	368	1,501
C)	244	139	104	414	388	171	125	117	121	185	299	199	811
D)	4.04	2.29	1.72	6.83	6.41	2.83	2.06	1.93	2.00	3.05	4.94	3.29	13.40
E)	4.65	2.38	1.99	7.61	7.38	3.15	2.37	2.22	2.23	3.52	5.50	3.79	15.43
F)	27,762	14,232	11,872	45,453	44,079	18,842	14,155	13,284	13,296	21,002	32,862	22,610	92,135

Annual Summary: Calendar Year 1970

A) <sup>+</sup>	Total Cusec days	
B)	Mean Cusecs	141,135
C)	M.G.D.	386
D)	Mean Cusecs Per Sq. Mile	209
E)	Total runoff in inches	3.45
F)	Total runoff in acre-feet	46.79
		279,449

Conversion factors used:-

Catchment area	=	112 sq. mile
One inch runoff	=	5973 acre-feet
One acre foot	=	1.98 Cusec days
One M.G.D.	=	1.85 " "

<sup>+</sup> Estimated.

## APPENDIX A-13

RIVER GAUGING STATION HISTORY TO 28.2.71

NAME : S. Sebol at Road Bridge

GRID REFERENCE : WM 892-231

CATCHMENT AREA : 8.6 sq. miles

ACCESS :

- 1) From Kulai, then through Fraser Estate.
- 2) Keep following the "main" road when travelling through Fraser Estate and ignore "minor" forks. Do this regardless of what apparent direction these roads appear to take.
- 3) Cross S. Sayong, S. Pengelli then for another 4-5 miles to S. Sebol.
- 4) There are two wooden bridges about  $\frac{1}{2}$  mile apart, both over approx. the same size channel. The Sebol is the second (i.e. closest of the two to Linggiu).
- 5) Recorder is about 100-150 ft. downstream of the bridge, on the right bank.
- 6) From Fraser Estate the road is unsealed. It is mainly a logging road, and a Landrover is required for transport.

CURRENT METER MEASUREMENTS :

- 1) 23 measurements were made during the period 10.5.70 to 17.2.71.
- 2) Range of discharge measured; 3.5 c/s to 558 c/s.

DISCHARGE CONTROL :

- 1) Channel control - bed is sandy but fairly stable.

BENCH MARKS :

- 1) 6 ft. x  $\frac{1}{2}$  inch waterpipe with 1 ft. x 1 ft. concrete slab about 3 ft. from the recorder.
- 2) Value on top of pipe; 9.07 gauge height.
- 3) TBM - not tied to O.D.

HISTORY/REMARKS :

- 1) Stick gauge was installed on 9.5.70 - still in place Feb. 1971 (range 0-10.00 ft.)
- 2) Recorder (Negretti & Zambra pressure bulb 0-10 ft.) installed 20.5.70 and removed 1.7.70; then reinstalled on 23.9.70 - still in place Feb. 1971.
- 3) Rats chewed through the tubing on one occasion - apart from that, the only trouble was with occasional deflation of the bulb.
- 4) Normal flow measurements were done from a log gauging bridge at the recorder site. High flows were measured on the road by wading. Very low flows were measured at a narrow low flow section immediately downstream of the bridge.
- 5) Future flow measurements should normally be done at least monthly, and at least weekly during low flow times.
- 6) Future instrumentation should be a wet-well/float type, capable of operation in the range 0-15 ft. gauge height.
- 7) Vegetation is 100 percent jungle.
- 8) The station was handed over to the DID as from 28.2.71, in situ, and in working order.

APPENDIX A-14

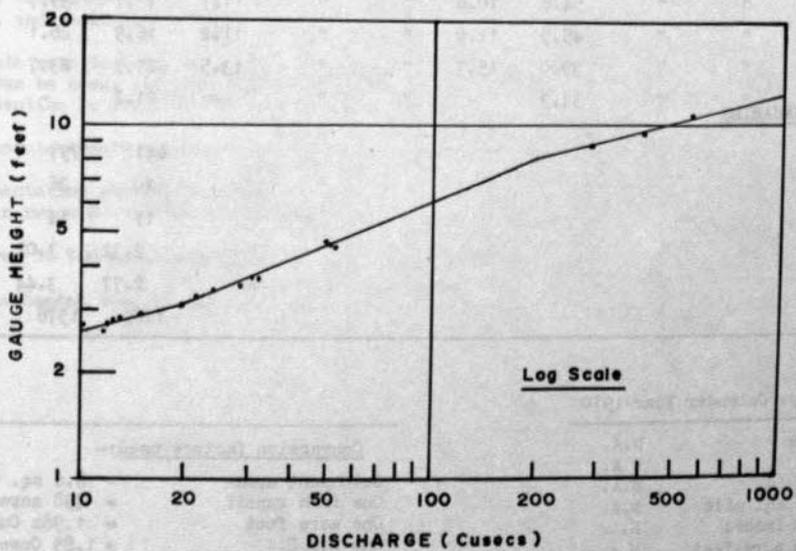
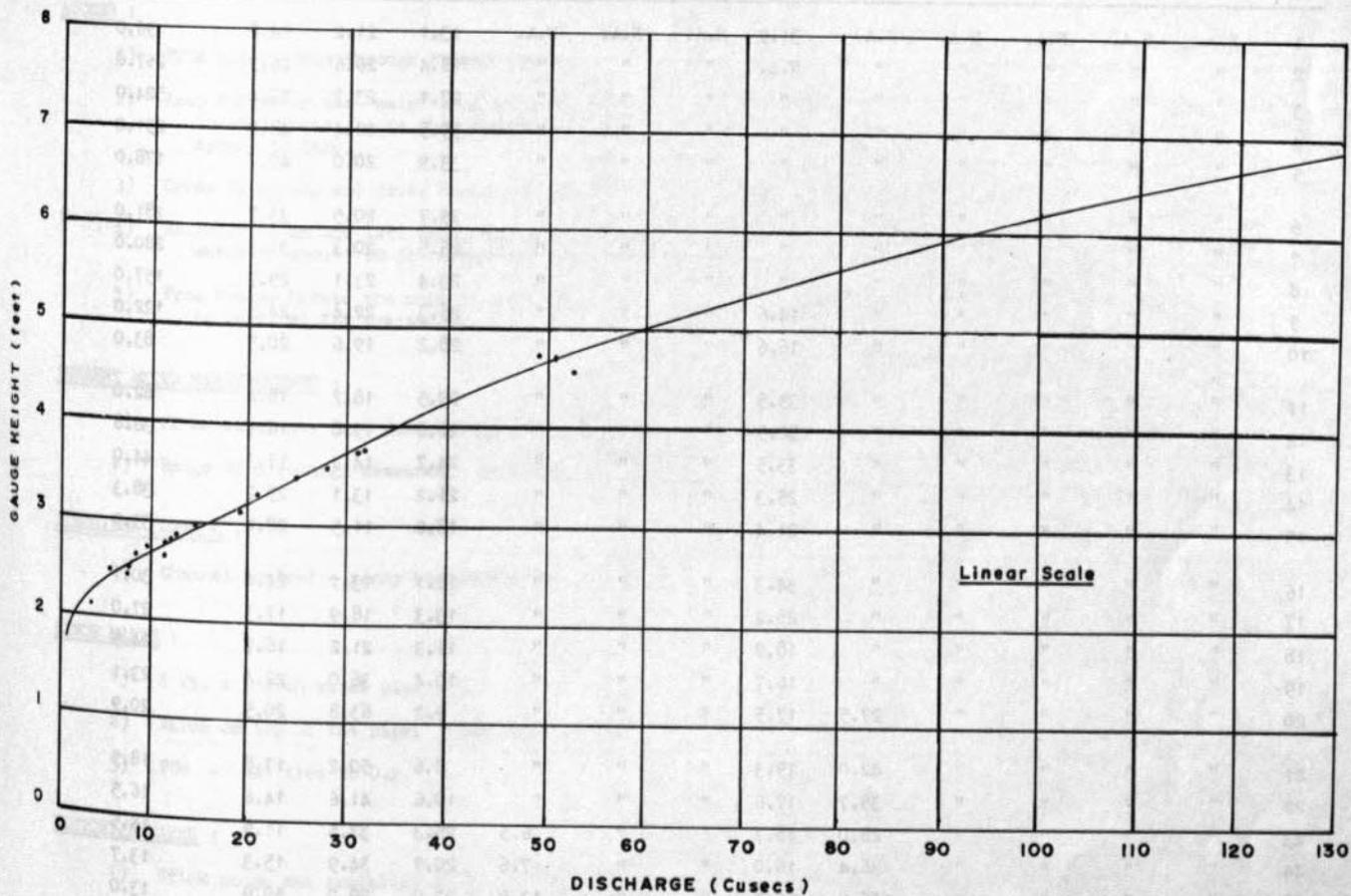
S. SEBOL AT ROAD BRIDGE

DISCHARGE MEASUREMENTS, MADE BY THE PROJECT FORM 10.5.70 TO 28.2.71

Meas. No.	Date	Surface Width (Feet)	Cross-Section Area (Sq. ft.)	Mean Velocity (Fps)	Gauge Height (Feet)	Discharge (Cusecs)	Current Meter Positions	No. of Vertical Sections	Rising Falling or Stationary (R, F or S)	Defining Rating Curve No.
1	10.5.70	15.5	74.2	0.67	4.73	49.7	.2, .8	14	F	1
2	20.5.70	15.0	58.0	0.54	3.77	31.3	.6	7	R	1
3	9.6.70	15.5	47.8	0.31	2.95	14.8	.2, .8	9	S	1
4	17.6.70	15.0	56.4	0.50	3.58	28.2	.2, .8	14	S	1
5	15.7.70	15.0	41.6	0.18	2.51	7.8	.2, .8	14	S	1
6	22.7.70	15.0	44.9	0.27	2.76	11.9	.2, .8	14	F	1
7	29.7.70	15.5	43.7	0.27	2.63	11.7	.2, .8	9	R	1
8	5.8.70	15.5	45.0	0.27	2.80	12.3	.2, .8	9	R	1
9	12.8.70	15.5	50.8	0.38	3.12	19.5	.2, .8	14	S	1
10	19.8.70	15.0	43.0	0.20	2.63	8.6	.2, .8	14	S	1
11	9.9.70	15.0	40.0	0.15	2.46	5.9	.2, .8	14	S	1
12	23.9.70	15.0	40.0	0.20	2.47	7.8	.2, .8	14	F	1
13	25.11.70	16.0	59.0	0.54	3.75	32.0	.2, .8	14	F	1
14	9.12.70	15.0	51.0	0.47	3.44	24.0	.2, .8	13	F	1
15	16.12.70	15.5	51.0	0.42	3.30	21.2	.2, .8	13	S	1
16	22.12.70	15.0	44.0	0.29	2.88	12.8	.2, .8	9	S	1
17	23.12.70	15.0	41.5	0.24	2.76	10.1	.2, .8	9	S	1
18	30.12.70	15.5	71.4	0.74	4.58	52.8	.2, .8	15	R	1
19	2.1.71	80	214	1.89	9.75	406	.6	10	R	1
20	3.1.71	400	335	1.66	10.86	558	.2, .8	21	F	1
21	4.1.71	400	160	1.80	8.97	288	.2, .8	9	R	1
22	12.1.71	13.4	72.0	0.71	4.71	51.1	.2, .8	7	S	1
23	17.2.71	5.3	4.9	0.71	2.13	3.5	.6	10	S	1

**Note:-** Due to rounding of figures for publication the calculation of discharge from the quoted area and velocity may not agree exactly with the discharge figure above.

**S. SEBOL AT ROAD BRIDGE**  
**RATING CURVE No.1**



APPENDIX A-16

S. SEBOL AT ROAD BRIDGE

MEAN DAILY DISCHARGE IN CUSECS, CALCULATED BY THE PROJECT FROM 20.5.1970 TO 31.1.71

Day	1970												1971
	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.
1	N.A.	N.A.	N.A.	N.A.	N.A.	31.9	N.A.	N.A.	N.A.	13.1	21.2	24.6	96.0
2	"	"	"	"	"	N.A.	"	"	"	18.4	26.6	26.3	267.0
3	"	"	"	"	"	"	"	"	"	27.1	23.7	29.4	524.0
4	"	"	"	"	"	"	"	"	"	39.5	22.4	48.0	291.0
5	"	"	"	"	"	"	"	"	"	33.9	20.0	49.7	178.0
6	"	"	"	"	"	"	"	"	"	29.7	20.5	33.7	181.0
7	"	"	"	"	"	"	"	"	"	25.5	20.3	31.9	280.0
8	"	"	"	"	"	"	"	"	"	23.4	23.1	29.7	157.0
9	"	"	"	"	"	14.6	"	"	"	25.3	22.4	24.5	122.0
10	"	"	"	"	"	16.6	"	"	"	28.2	19.6	20.5	83.0
11	"	"	"	"	"	33.5	"	"	"	29.5	18.2	18.4	62.0
12	"	"	"	"	"	52.5	"	"	"	28.6	19.8	16.9	38.8
13	"	"	"	"	"	33.5	"	"	"	24.7	14.4	17.3	44.0
14	"	"	"	"	"	25.3	"	"	"	21.2	13.1	29.2	38.3
15	"	"	"	"	"	21.4	"	"	"	18.2	11.5	28.0	33.9
16	"	"	"	"	"	34.3	"	"	"	15.1	13.1	24.4	30.1
17	"	"	"	"	"	25.2	"	"	"	13.3	18.9	17.3	27.0
18	"	"	"	"	"	18.9	"	"	"	11.3	21.2	16.7	24.5
19	"	"	"	"	"	16.7	"	"	"	10.4	36.0	22.4	23.1
20	"	"	"	"	27.5	17.5	"	"	"	9.2	63.8	20.5	20.9
21	"	"	"	"	42.0	19.3	"	"	"	8.6	50.2	17.8	18.5
22	"	"	"	"	35.7	17.6	"	"	"	10.6	41.6	14.6	16.5
23	"	"	"	"	28.0	18.7	"	"	6.5	25.3	37.5	11.9	15.5
24	"	"	"	"	36.4	16.0	"	"	7.6	20.7	34.9	15.3	13.7
25	"	"	"	"	136.0	13.3	"	"	13.9	23.0	29.0	59.9	13.0
26	"	"	"	"	129.0	12.2	"	"	11.0	19.1	28.8	91.0	14.9
27	"	"	"	"	76.4	12.4	"	"	9.5	14.8	37.7	55.4	14.4
28	"	"	"	"	54.8	10.6	"	"	11.7	13.7	35.7	54.8	12.8
29	"	"	"	"	45.5	11.0	"	"	11.2	16.9	28.1	43.5	11.5
30	"	"	"	"	39.0	15.7	"	"	13.5	21.9	23.7	45.7	10.1
31	"	"	"	"	34.3	-	"	"	-	21.2	-	48.7	8.8
<u>MONTHLY SUMMARIES</u>													
A)†										641	797	988	2671
B)										20	26	31	86
C)										11	14	16	46
D)										2.32	3.02	3.60	10.00
E)										2.77	3.44	4.27	11.54
F)										1269	1578	1956	5288

Annual Summary: Calendar Year 1970

A)†	Total Cusec days	N.A.
B)	Mean Cusec days	N.A.
C)	M.G.D.	N.A.
D)	Mean Cusecs per sq. mile	N.A.
E)	Total runoff in inches	N.A.
F)	Total runoff in acre-feet	N.A.

Conversion factors used:-

Catchment area	= 8.6 sq. miles
One inch runoff	= 458 acre-feet
One acre foot	= 1.98x Cusec days
One M.G.D.	= 1.85 Cusec days

## APPENDIX A-17

RIVER GAUGING STATION HISTORY TO 28.2.71

NAME : S. Pengeli at Road Bridge

GRID REFERENCE : WM 847-195      CATCHMENT AREA : 57 sq. miles

ACCESS :

- 1) From Kulai, then through Fraser Estate.
- 2) Keep following the "main" road when travelling through Fraser Estate and ignore "minor" forks. Do this regardless of what apparent direction these roads appear to take.
- 3) Cross S. Sayong and drive about 2 miles to S. Pengeli
- 4) Recorder is on the left bank, (about 20 ft. from the road) on a bend in the river, which is about 100 ft. along the road from the bridge.
- 5) From Fraser Estate the road is unsealed. It is mainly a logging road, and a Landrover is required for transport.

CURRENT METER MEASUREMENTS :

- 1) 22 measurements were done during the period 28.1.70 to 22.12.70.
- 2) Range of discharge measured; 30 c/s to 303 c/s.

DISCHARGE CONTROL :

- 1) Channel control - sandy but stable bed.

BENCH MARKS :

- 1) 6 ft. x  $\frac{1}{2}$  inch water pipe with 1 ft. x 1 ft. concrete slab near the recorder.
- 2) Value on top of the pipe; 11.62 gauge height.
- 3) TEM - not tied to O.D.

HISTORY/REMARKS :

- 1) Stick gauge was installed on 22.2.70 - still in place February 1971 (range 0-10.00 ft.)
- 2) Recorder (Negretti & Zambra pressure bulb, 0-20 ft.) was installed 22.2.70 and removed on 7.1.71 after the flooding in January 1971. It was reinstalled on 12.1.71 - still in place February 1971.
- 3) No trouble was encountered with the recorder apart from complete submergence in January 1971 flood, and occasional deflation of the bulb.
- 4) All measurements were done by wading, for which 7 ft. gauge height is the limit. At this height it can be done, but with some difficulty due to the depth and velocity. The measuring section is about 50 ft. upstream of the road bridge.
- 5) Future measurements should normally be done monthly; and weekly during dry times.
- 6) Future instrumentation should be Leupold and Stevens float type with wet-well, capable of operation in range 0 - 20 ft. gauge height.
- 7) Vegetation cover is 100 percent jungle.
- 8) The station was handed over to the DID as from 28.2.71, in situ, and in working order.

APPENDIX A-18

S. PENGELL AT ROAD BRIDGE

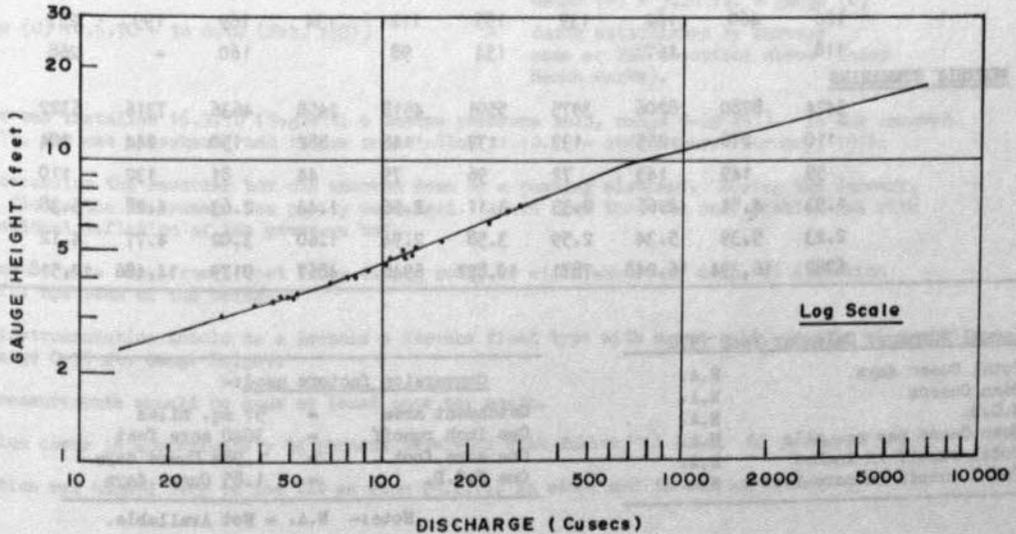
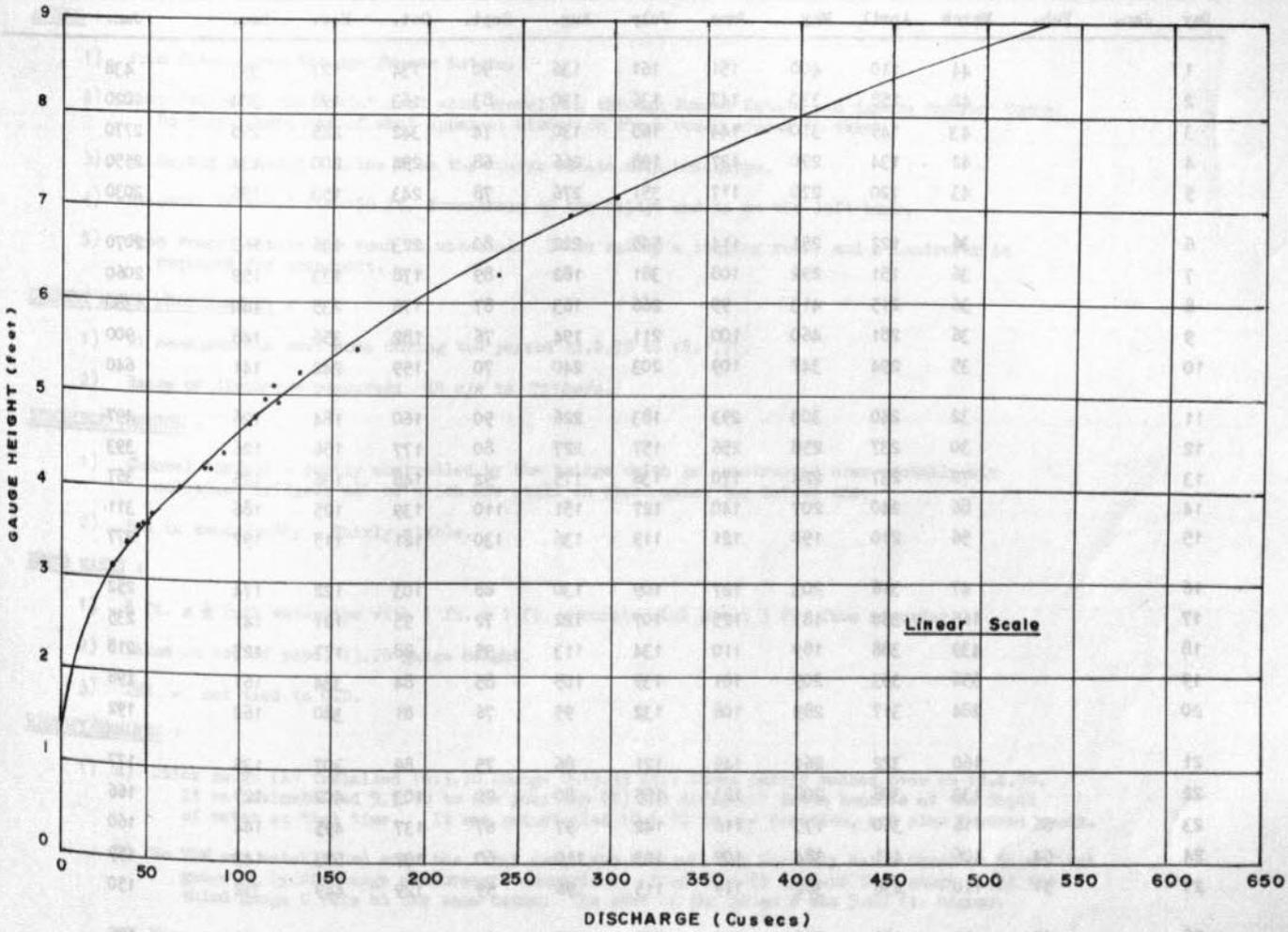
DISCHARGE MEASUREMENTS, MADE BY THE PROJECT FROM 28.1.70 TO 28.2.71

Meas. No.	Date	Surface Width (Feet)	Cross-Section Area (Sq. ft.)	Mean Velocity (Fps)	Gauge Height (Feet)	Discharge (Cusecs)	Current Meter Positions	No. of Vertical Sections	Rising Falling or Stationary (R, F or S)	Defining Rating Curve No.
1	28.1.70	39	124	0.75	4.33	93	.6	13	S	1
2	4.2.70	39	103	0.78	3.96	81	.2, .8	12	S	1
3	11.2.70	39	140	0.86	5.05	120	.2, .8	12	S	1
4	22.2.70	35	48	1.11	3.65	54	.2, .8	17	S	1
5	24.2.70	36	46	1.08	3.56	50	.2, .8	17	S	1
6	24.2.70	36	46	1.08	3.56	49	.2, .8	17	S	1
7	25.2.70	36	45	1.07	3.53	48	.2, .8	17	S	1
8	4.3.70	35	37	1.05	3.33	39	.2, .8	16	F	1
9	4.3.70	Measurement abandoned - meter not functioning								
10	11.3.70	35	30	1.00	3.08	30	.2, .8	17	S	1
11	16.3.70	35	40	1.13	3.43	45	.2, .8	17	F	1
12	20.3.70	49	182	1.52	6.88	277	.2, .8	11	F	1
13	22.3.70	42	113	1.19	5.20	134	.2, .8	19	S	1
14	25.3.70	41	92	1.19	4.72	110	.2, .8	13	S	1
15	8.4.70	46	163	1.46	6.26	239	.2, .8	18	F	1
16	29.4.70	50	202	1.50	7.07	303	.2, .8	18	R	1
17	15.7.70	40	106	1.15	4.88	122	.2, .8	16	S	1
18	22.7.70	44	135	1.21	5.44	164	.2, .8	14	R	1
19	19.8.70	41	98	1.09	4.66	107	.2, .8	19	S	1
20	9.9.70	39	80	1.03	4.16	82	.2, .8	15	S	1
21	21.10.70	39	76	1.12	4.16	85	.2, .8	14	S	1
22	22.12.70	42	99	1.32	4.90	131	.2, .8	12	S	1

**Note:-** Due to rounding of figures for publication the calculation of discharge from the quoted area and velocity may not agree exactly with the discharge figure above.

**S. PENGELI AT ROAD BRIDGE**

**RATING CURVE No.1**



DISCHARGE (Cusecs)

APPENDIX A-20

S. PENGELI AT ROAD BRIDGE

MEAN DAILY DISCHARGES IN CUSECS, CALCULATED BY THE PROJECT FROM 23.2.1970 TO 31.1.71

Day	1970												1971
	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.
1			44	110	400	151	161	136	90	134	127	395	438
2			42	158	330	147	136	130	83	163	198	324	1020
3			43	145	310	144	165	130	74	342	225	298	2770
4			42	134	290	127	198	266	68	294	200	234	2550
5			43	120	270	117	351	276	78	243	153	196	2030
6			36	122	251	114	545	222	80	223	136	169	2070
7			36	151	292	108	381	182	89	178	133	159	2060
8			36	215	413	99	266	163	87	176	235	160	1380
9			36	281	460	100	211	194	76	182	356	148	900
10			35	294	347	109	203	240	70	159	242	141	640
11			32	240	303	293	183	226	90	160	184	126	497
12			30	237	258	256	157	227	80	177	156	126	393
13			72	237	224	170	136	175	92	148	136	125	357
14			86	240	207	140	127	151	110	139	125	186	311
15			56	210	190	121	119	136	130	121	115	197	277
16			47	316	203	127	109	130	88	103	122	174	252
17			165	354	187	125	107	122	72	93	121	141	235
18			439	388	189	110	134	113	95	88	177	127	218
19			556	353	209	101	139	105	85	84	334	161	198
20			284	317	289	106	132	95	76	81	380	162	192
21			160	322	261	149	121	86	75	80	307	135	177
22			133	308	208	123	155	80	70	103	402	128	166
23		56	116	360	175	116	142	97	67	137	495	144	160
24		54	106	411	384	109	123	110	60	137	523	143	159
25		51	110	456	362	119	115	96	59	129	449	352	150
26		47	91	432	276	124	157	96	64	112	322	331	155
27		46	84	320	223	116	133	118	66	94	291	304	155
28		46	95	295	188	110	148	101	64	87	259	294	141
29			126	294	176	105	138	105	86	140	214	237	134
30			126	460	164	139	155	112	134	169	199	237	133
31			118		167		154	98		160	-	268	127
A)+	<u>MONTHLY SUMMARIES</u>												
B)			3424	8280	8206	3975	5501	4518	2458	4636	7316	6322	20,445
C)			110	276	265	133	177	146	882	150	244	204	660
D)			59	149	143	72	96	79	44	81	132	110	357
E)			1.93	4.84	4.65	2.33	3.11	2.56	1.44	2.63	4.28	5.38	11.58
F)			2.23	5.39	5.34	2.59	3.58	2.94	1.60	3.02	4.77	4.12	13.32
			6782	16,394	16,248	7871	10,892	8946	4867	9179	14,486	12,518	40,481

Annual Summary: Calendar Year 1970

A)+	Total Cusec days	N.A.
B)	Mean Cusecs	N.A.
C)	M.G.D.	N.A.
D)	Mean Cusec per sq. mile	N.A.
E)	Total runoff in inches	N.A.
F)	Total runoff in acre-feet	N.A.

Conversion factors used:-

Catchment area	=	57 sq. miles
One inch runoff	=	3040 acre feet
One acre foot	=	1.98x Cusec days
One M.G.D.	=	1.85 Cusec days

Note:- N.A. = Not Available.

## APPENDIX A-21

RIVER GAUGING STATION HISTORY TO 28.2.71

NAME : S. Sayong (Lower) at Road Bridge

GRID REFERENCE : WM 826 - 178

CATCHMENT AREA : 166 sq. miles

ACCESS :

- 1) From Kulai, then through Fraser Estate.
- 2) Keep following the "main" road when travelling through Fraser Estate and ignore "minor" forks. Do this regardless of what apparent direction these roads appear to take.
- 3) S. Sayong is about 7 miles from the Fraser Estate main buildings.
- 4) Recorder is about 100-150 ft. downstream of the bridge and is on the left bank.
- 5) From Fraser Estate the road is unsealed. It is mainly a logging road, and a Landrover is required for transport.

CURRENT METER MEASUREMENTS :

- 1) 21 measurements were done during the period 24.2.70 to 18.1.71.
- 2) Range of discharge measured; 49 c/s to 7270c/s.

DISCHARGE CONTROL :

- 1) Channel control - partly controlled by the bridge which is constructed over probably six collapsed bridges, all of which are still in place under the latest one.
- 2) Bed is sandy/muddy - fairly stable.

BENCH MARKS :

- 1) 6 ft. x  $\frac{1}{2}$  inch waterpipe with 1 ft. x 1 ft. concrete slab about 3 ft. from recorder.
- 2) Value on top of pipe, 13.20 gauge height.
- 3) TBM - not tied to O.D.

HISTORY/REMARKS :

- 1) a) Stick gauge (A) installed 16.3.70 (range 0-13.33 ft.) found partly washed over on 18.4.70. It was reinstalled 9.5.70 to new position (B) and different datum because of the depth of water at that time. It was reinstalled 10.6.70 to new position, and also lowered again.
- b) No TBM was established when the first gauge was damaged, and the only datum check on this first gauge is by discharge measurement comparison. From this it appears that gauge A and the third gauge C were at the same datum. The zero of the gauge B was 5.20 ft. higher.
- c) Hence:-
 

Gauge (A) 16.3.70 - 9.5.70	- datum assumed by discharge measurements to be same as (C).
Gauge (B) 9.5.70 - 9.6.70	- datum established by survey: Gauge (B) + 5.20 ft. = gauge (C)
Gauge (C) 10.6.70 - to date (Feb. 1971)	- datum established by survey: same as TBM described above (Under Bench Marks).
- 2) Recorder was installed 16.3.70 (Negretti & Zambra pressure bulb, range 0-20 ft.). It was removed 1.7.70, for use elsewhere, and it was reinstalled 21.10.70 - still there February, 1971.
- 3) On one occasion the recorder box was knocked down by a passing elephant. During the January, 1971 floods the instrument was partly submerged. Apart from this the only problem was with occasional deflation of the pressure bulb.
- 4) Measurements were made from a boat using wading rods, or winch when very deep, at a section 300 ft. upstream of the bridge.
- 5) Future instrumentation should be a Leupold & Stevens float type with a wet-well, capable of operation in range 0-30 ft. Gauge Height.
- 6) Future measurements should be done at least once per month.
- 7) Vegetation cover is approximately 34 percent developed with Rubber/Oil Palm; 66 percent Jungle.
- 8) The station was handed over to the DID as from 28.2.71, in situ, and in working order.

## APPENDIX A-22

S. SAYONG (LOWER) AT ROAD BRIDGEDISCHARGE MEASUREMENTS, MADE BY THE PROJECT FROM 24.2.70 TO 28.2.71

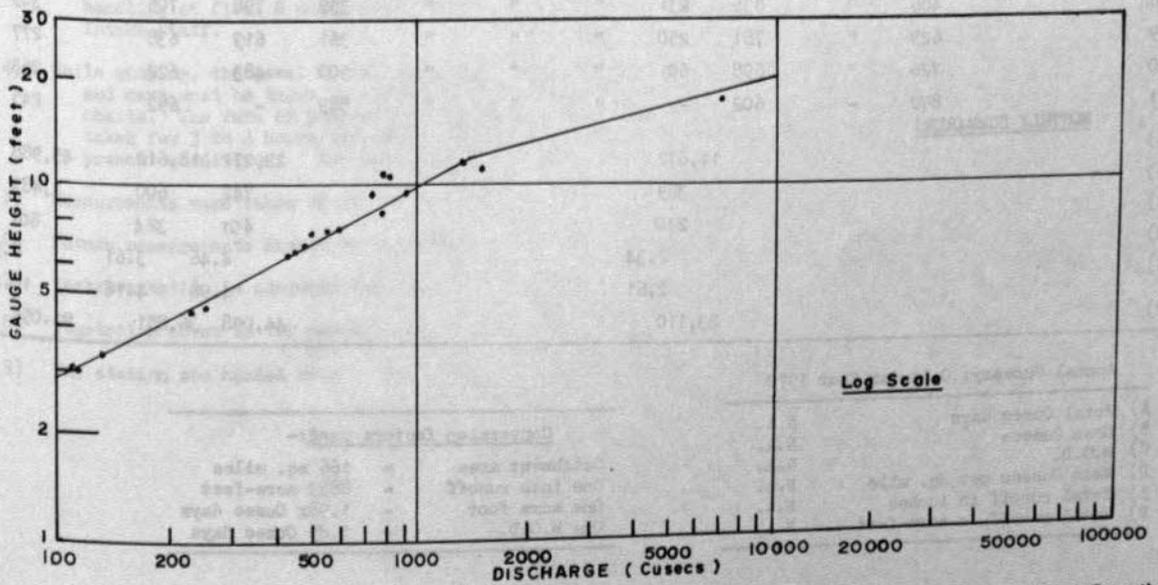
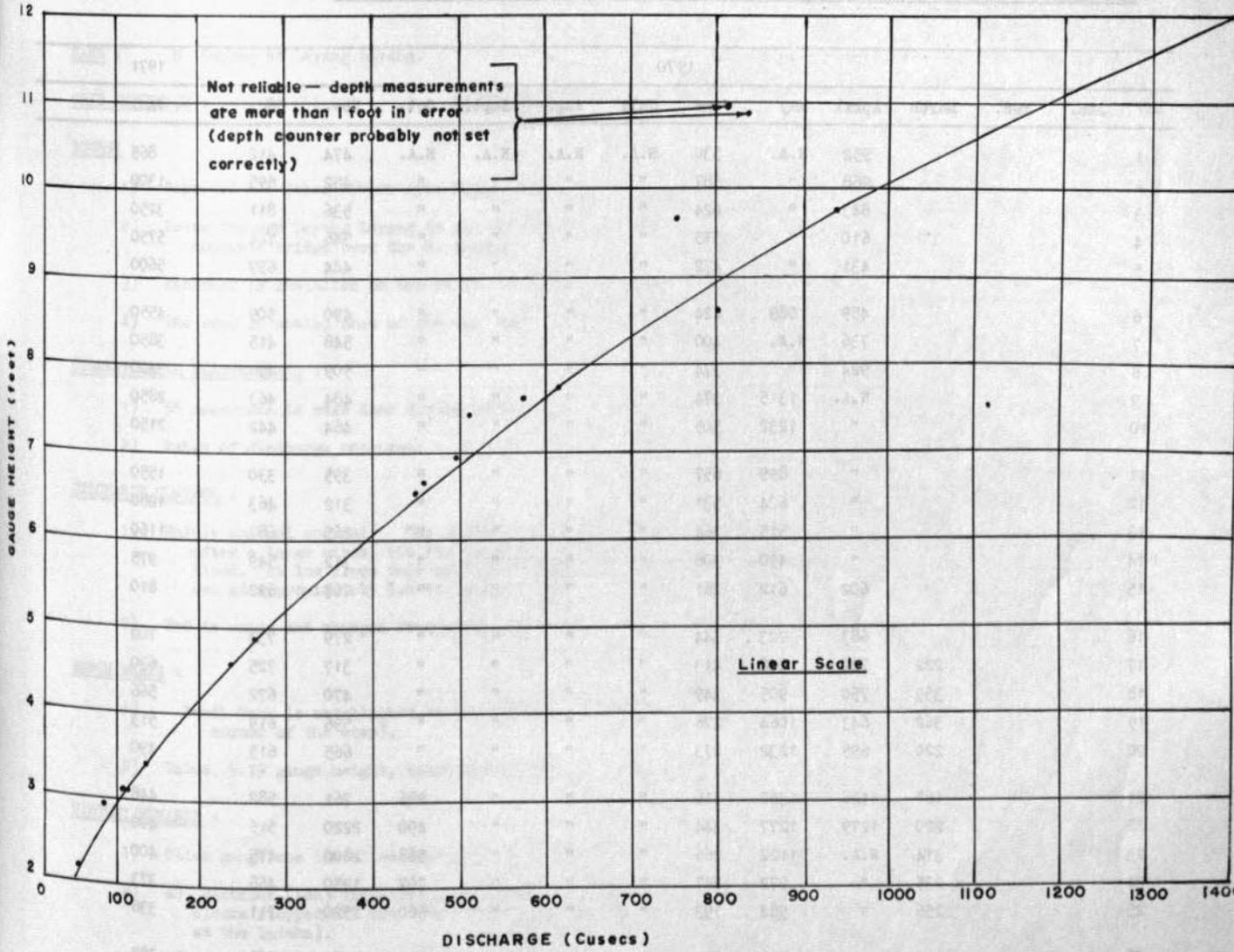
Meas. No.	Date	Surface Width (Feet)	Cross-Section Area (Sq. ft.)	Mean Velocity (Fps)	Gauge Height (Feet)	Discharge (Cusecs)	Current Meter Positions	No. of Vertical Sections	Rising Falling or Stationary (R, F or S)	Defining Rating Curve No.
1	24.2.70	42	180	0.61	3.10	110	.2, .8	16	F	1
2	24.2.70	42	183	0.59	3.10	107	.2, .8	16	F	1
3	4.3.70	45	184	0.45	2.94	82	.2, .8	16	F	1
4	11.3.70	42	148	0.33	2.19	49	.2, .8	15	NA	1
5	16.3.70	44	194	0.69	3.40	133	.2, .8	15	S	1
6	20.3.70	50	238	0.99	4.57	235	.2, .8	9	F	1
7	25.3.70	50	245	1.07	4.88	262	.2, .8	18	F	1
8	8.4.70	65	469	1.60	9.68	751	.2, .8	11	R	1
9	8.4.70	70	591	1.59	9.73	940	.2, .8	19	R	1
10	15.4.70	57	423	1.44	7.72	610	.2, .8	22	R	1
11	22.4.70	65	698	1.94	11.62	1353	.2, .8,	22	S	1
12	Ditto	65	676	2.30	11.39	1554	.6	11	F	1
13	9.12.70	57	351	1.27	6.51	447	.2, .8	13	F	1
14	16.12.70	67	515	1.55	8.60	800	.2, .8,	12	F	1
15	21.12.70	58	385	1.48	7.60	571	.2, .8	14	R	1
16	22.12.70	56	359	1.37	6.95	492	.2, .8	13	F	1
17	23.12.70	55	326	1.41	6.65	458	.2, .8	13	F	1
18	6.1.71	2220	8655	0.84	17.70	7270	Surf.	16	F	1
+19	13.1.71	66	540	1.51	10.95	814	.2, .8	12	S	1
+20	13.1.71	66	548	1.53	10.88	837	.2, .8	12	F	1
21	18.1.71	56	344	1.48	7.43	510	.2, .8	10	R	1

Note:- + - Cross-section areas are incorrect - all depths measured for these two measurements are more than one foot in error - probably the depth counter was not correctly set.

Due to rounding of figures for publication the calculation of discharge from the quoted area and velocity may not agree exactly with the discharge figure above.

S. SAYONG (Lower) AT ROAD BRIDGE

RATING CURVE No.1



Note:— Gauge heights above correspond to Gauges A and C mentioned in the description. Gauge C is the present gauge (Feb. 1971).

APPENDIX A-24

S. SAYONG (LOWER) AT ROAD BRIDGE

MEAN DAILY DISCHARGES IN CUSECS, CALCULATED BY THE PROJECT FROM 17.3.1970 TO 31.1.1971

Day	1970												1971
	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.
1				952	N.A.	530	N.A.	N.A.	N.A.	N.A.	474	412	865
2				968	"	587	"	"	"	"	452	695	1300
3				843	"	624	"	"	"	"	536	811	3250
4				610	"	575	"	"	"	"	546	744	5750
5				431	"	472	"	"	"	"	444	699	5600
6				459	689	424	"	"	"	"	490	509	4550
7				736	N.A.	400	"	"	"	"	548	415	3850
8				924	"	374	"	"	"	"	509	450	3400
9				N.A.	1315	374	"	"	"	"	484	463	2850
10				"	1232	505	"	"	"	"	464	442	2150
11				"	899	657	"	"	"	"	395	330	1550
12				"	624	531	"	"	"	"	312	463	1280
13				"	515	364	"	"	"	"	265	687	1160
14				"	490	308	"	"	"	"	312	549	975
15				602	612	261	"	"	"	"	267	692	810
16				683	723	344	"	"	"	"	279	733	700
17			222	742	808	413	"	"	"	"	317	725	630
18			353	750	905	349	"	"	"	"	470	672	566
19			362	643	1064	276	"	"	"	"	596	619	513
20			220	695	1232	273	"	"	"	"	665	615	490
21			167	1128	1362	416	"	"	"	286	761	582	448
22			220	1279	1277	344	"	"	"	490	2220	516	400
23			314	N.A.	1122	266	"	"	"	568	2800	475	400
24			235	"	972	227	"	"	"	707	1950	468	373
25			256	"	984	193	"	"	"	660	1520	711	336
26			219	"	970	229	"	"	"	610	1264	765	352
27			223	"	886	274	"	"	"	466	1032	713	350
28			486	"	835	231	"	"	"	352	798	705	305
29			629	"	781	250	"	"	"	361	619	638	277
30			726	"	698	601	"	"	"	500	483	622	263
31			872	-	602	-	"	"	"	589	-	692	245
A)+	<u>MONTHLY SUMMARIES</u>												
B)						11,672					22,272	18,612	45,988
C)						389					742	600	1,483
D)						210					401	324	801
E)						2.34					4.46	3.61	8.93
F)						2.61					4.98	4.16	10.28
F)						23,110					44,098	36,851	91,056

Annual Summary: Calendar Year 1970

A)+	Total Cusec days	N.A.
B)	Mean Cusecs	N.A.
C)	M.G.D.	N.A.
D)	Mean Cusecs per Sq. mile	N.A.
E)	Total runoff in inches	N.A.
F)	Total runoff in acre-feet	N.A.

Conversion factors used:-

Catchment area	=	166 sq. miles
One inch runoff	=	8853 acre-feet
One acre foot	=	1.98x Cusec days
One M.G.D.	=	1.85 Cusec days

Note:- N.A. = Not available

## APPENDIX A-25

RIVER GAUGING STATION HISTORY TO 28.2.71

NAME : S. Sayong at Layang Layang.

GRID REFERENCE : WM 656-201      CATCHMENT AREA : 38 sq. miles.

ACCESS :

- 1) Turn off the Johor Baharu-Ayer Hitam road at M 35, then drive 9 miles to Layang Layang.
- 2) Drive through Layang Layang to the JKR water supply intake compound, just before the concrete bridge over the S. Sayong.
- 3) Recorder is installed on one of the access wells on the intake pipeline.
- 4) The road is sealed most of the way, and a car can be used for transport.

CURRENT METER MEASUREMENTS :

- 1) 56 measurements were done during period 18.1.70 to 13.2.71.
- 2) Range of discharge measured; 8 c/s to 552 c/s.

DISCHARGE CONTROL :

- 1) Mainly channel control. The rating is continuously being lowered due to settling down after a large oxbow, 100 ft. below intake, was completely out through during Dec. 1969 flood. At low flows this eroding oxbow section acts as a partial weir, which drowned out at approximately 5.6 ft. gauge height.
- 2) Bed is sandy and changes frequently due to the above conditions.

BENCH MARKS :

- 1) Bench Mark is established on the bottom step beside the pump house (on the downstream corner of the step).
- 2) Value, 9.19 gauge height, which corresponds to 75.89 O.D.

HISTORY/REMARKS :

- 1) Stick gauge was installed 20.11.69 - still in place Feb. 1971 (range 0 - 13.33 ft.).
- 2) a) Recorder (Lea) installed 21.12.69 and removed 16.5.70 (could not find the reason why clocks stopped all the time - instrument also damaged slightly during cleaning operations at the Intake).  
b) Recorder (Munro) installed 16.5.70 - still in place February, 1971.
- 3) Apart from clock trouble (which occurred nowhere else) the main trouble was with rough handling of float & counter-weight during cleaning operations by labourers from the Intake staff.
- 4) While pumping, the level in the access well drops about 0.1 ft. due to the hydraulic gradient, and care must be taken to correct all measurement cards after examination of the recorder charts. The rate of pumping is a maximum of approximately 1.5 c/s, however this is only taken for 3 to 4 hours/day, and no allowance has been made, or need be made for this, under present conditions. The measuring section is about 150 ft. downstream of the gauge.
- 5) Measurements were taken of the suspended sediment load during 1970.
- 6) Future measurements should be made weekly until the channel through the oxbow has stabilised.
- 7) Instrumentation is adequate for the future, if once weekly maintenance is available.
- 8) Vegetation cover is 100 percent developed with rubber/oil palm.
- 9) The station was handed over to the DID as from 28.2.71, in situ, and in working order.

## APPENDIX A-26

## S. SAYONG AT LAYANG LAYANG

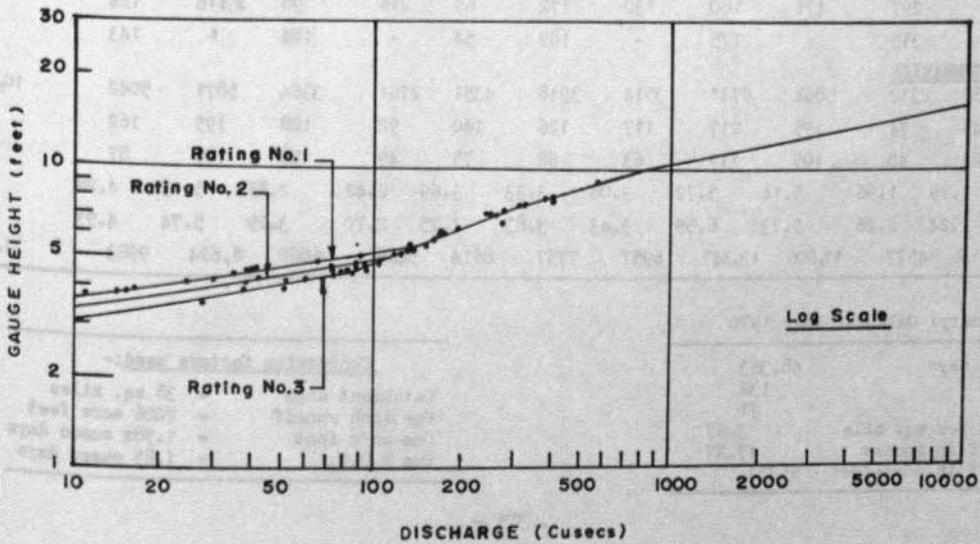
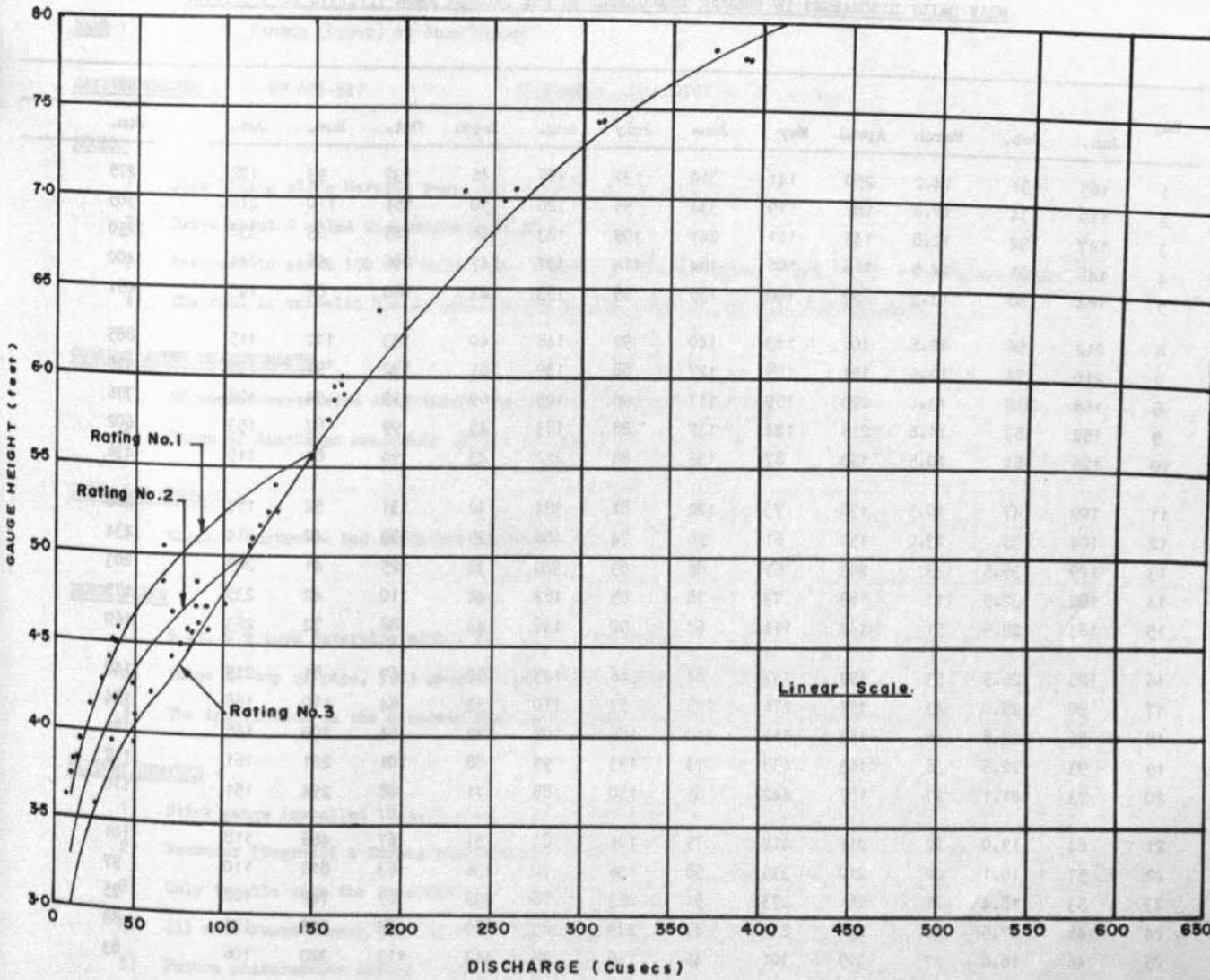
DISCHARGE MEASUREMENTS, MADE BY THE PROJECT FROM 18.1.70 TO 28.2.71

Meas. No.	Date	Surface Width	Cross-Section Area	Mean Velocity	Gauge Height	Discharge	Current Meter Positions	No. of Vertical Sections	Rising Falling or Stationary (R, F or S)	Deflection Rating Curve
		(Feet)	(Sq. ft.)	(Fps)	(Feet)	(Cusecs)				
1	18.1.70	36	51	1.33	5.06	68	.2, .8	17	S	
2	25.1.70	30	33	1.20	4.58	39	.2, .8	14	S	
3	29.1.70	30	31	1.22	4.53	38	.2, .8	14	S	
4	29.1.70	29	31	1.21	4.53	38	.2, .8	14	S	
5	2.2.70	29	29	1.16	4.43	33	.2, .8	28	S	
6	10.2.70	33	51	1.28	4.87	65	.2, .8	22	S	
7	15.2.70	28	26	1.11	4.29	29	.2, .8	18	S	
8	17.2.70	27	22	1.04	4.15	23	.2, .8	13	S	
9	24.2.70	24	17	0.99	3.95	16	.2, .8	16	S	
10	28.2.70	24	15	1.01	3.84	15	.6	15	S	
11	1.3.70	22	14	0.97	3.84	14	.6	22	S	
12	5.3.70	23	12	0.94	3.76	11	.6	15	S	
13	10.3.70	20	10	0.80	3.64	8	.6	19	R	
14	17.3.70	29	30	1.36	4.28	41	.6	14	S	
15	24.3.70	29	31	1.21	4.19	37	.2, .8	18	F	
16	31.3.70	37	166	1.89	7.45	313	.6	14	F	
17	31.3.70	37	166	1.86	7.44	308	.6	14	S	
18	14.4.70	37	109	1.52	5.97	166	.2, .8	18	R	
19	28.4.70	37	114	1.46	6.02	166	.2, .8	18	S	
20	5.5.70	34	62	1.36	4.86	85	.2, .8	16	R	
21	12.5.70	34	55	1.30	4.69	71	.2, .8	16	R	
22	23.5.70	35	153	1.72	7.06	263	.2, .8	17	R	
23	18.7.70	39	126	1.28	5.88	161	.2, .8	18	S	
24	25.7.70	37	113	1.39	5.77	158	.2, .8	17	F	
25	8.8.70	37	86	1.35	5.11	116	.2, .8	16	F	
26	15.8.70	36	98	1.31	5.41	128	.2, .8	17	F	
27	5.9.70	32	37	1.00	3.95	37	.2, .8	15	S	
28	19.9.70	34	65	1.18	4.52	77	.2, .8	16	F	
29	30.9.70	65	366	0.72	6.50	265	.2, .8	15	F	
30	6.10.70	35	93	1.40	5.27	130	.2, .8	11	R	
31	8.10.70	36	92	1.32	5.18	122	.2, .8	11	S	
32	10.10.70	34	66	1.39	4.60	92	.2, .8	10	S	
33	13.10.70	36	96	1.32	5.25	127	.2, .8	11	F	
34	17.10.70	33	51	1.14	4.24	58	.2, .8	11	S	
35	20.10.70	34	65	1.26	4.57	82	.2, .8	11	F	
35a	24.10.70	34	67	1.24	4.59	83	.2, .8	11	S	
36	26.10.70	36	87	1.32	5.07	115	.2, .8	16	F	
37	3.11.70	34	65	1.10	4.44	72	.2, .8	11	S	
38	7.11.70	34	71	1.21	4.63	86	.2, .8	11	F	
39	14.11.70	33	47	1.06	3.95	50	.2, .8	12	S	
40	12.11.70	45	231	1.61	7.85	373	.2, .8	17	F	
41	17.11.70	34	78	1.29	4.74	101	.2, .8	11	R	
42	21.11.70	45	226	1.74	7.80	393	.2, .8	17	F	
43	21.11.70	45	230	1.70	7.80	390	.2, .8	17	F	
44	8.12.70	37	142	1.14	5.97	162	.2, .8	11	R	
45	8.12.70	39	145	1.14	5.92	166	.2, .8	12	R	
46	12.12.70	38	158	1.19	6.37	187	.2, .8	11	F	
47	15.12.70	38	177	1.44	6.99	256	.2, .8	11	R	
48	15.12.70	38	178	1.31	7.05	233	.2, .8	11	F	
49	15.12.70	38	176	1.38	6.97	244	.2, .8	11	F	
+50	9.1.70	46	276	2.00	8.90	552	Surf.	11	F	
51	16.1.71	37	161	0.92	5.57	148	.2, .8	17	F	
52	23.1.71	39	138	0.67	4.73	92	.2, .8	12	S	
53	23.1.71	39	138	0.60	4.73	83	.2, .8	12	S	
54	30.1.71	37	113	0.44	4.11	50	.2, .8	11	S	
55	13.2.71	33	37	0.73	3.59	27	.2, .8	10	S	

Note: + measurement 50 is based on a few surface velocities only

Due to rounding of figures for publication the calculation of discharge from the quoted area and velocity may not agree exactly with the discharge figure above.

**S. SAYONG AT LAYANG LAYANG**  
**RATING CURVE Nos. 1, 2, 3**



APPENDIX A-28

S. SAYONG AT LAYANG LAYANG

MEAN DAILY DISCHARGES IN CUSECS, CALCULATED BY THE PROJECT FROM 1.1.1970 TO 31.1.1971

Day	1970												1971
	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.
1	165	31	14.2	250	141	310	137	157	46	137	93	122	279
2	159	34	12.8	187	119	334	95	126	90	151	110	216	505
3	147	32	12.8	143	111	241	109	123	66	185	83	338	1250
4	148	31	14.5	116	106	184	112	137	47	206	66	241	1400
5	184	38	13.3	98	100	155	99	153	43	180	82	145	1051
6	212	56	12.6	106	113	140	92	148	40	133	112	115	885
7	210	174	12.6	191	159	127	88	139	81	132	91	139	955
8	166	218	13.0	223	159	117	96	129	69	119	94	172	776
9	152	153	11.6	218	124	132	88	183	45	99	87	153	602
10	126	61	10.5	188	87	136	88	222	43	90	84	115	436
11	109	47	10.5	130	73	122	81	384	42	131	52	157	288
12	104	39	13.0	150	61	98	74	466	35	153	40	214	234
13	129	35.5	133	203	69	86	63	320	32	125	41	209	203
14	182	32.5	117	183	73	78	55	182	42	110	42	235	179
15	163	29.5	51	149	111	64	50	136	43	88	72	263	160
16	125	26.5	53	199	137	84	46	125	50	69	81	215	148
17	90	25.0	43	197	276	125	57	110	53	64	110	168	134
18	86	23.8	46	153	512	110	186	102	122	64	200	168	122
19	93	22.6	36	163	498	73	193	95	88	101	261	161	117
20	73	21.1	27	187	442	65	150	88	71	88	294	151	110
21	64	19.0	22	211	418	75	101	83	51	67	466	118	101
22	57	18.1	22	210	335	58	136	70	136	63	818	110	97
23	53	18.4	21	261	273	51	263	76	289	89	742	102	95
24	48	17.5	36	258	234	45	239	85	280	88	555	101	88
25	46	16.6	27	319	301	45	176	78	163	113	320	106	83
26	49	16.6	29	395	401	123	177	82	116	110	216	95	86
27	59	16.0	151	245	410	95	197	88	85	75	205	150	81
28	47	15.1	277	183	316	55	170	76	68	54	190	169	68
29	41		458	175	227	56	139	65	209	78	146	127	60
30	37		297	171	180	130	172	69	216	98	118	124	54
31	35		315		175	-	189	54	-	104	-	143	49
<b>MONTHLY SUMMARIES</b>													
A)+	3359	1268	2312	5862	6741	3514	3918	4351	2761	3364	5871	5042	10,696
B)	108	45	74	195	217	117	126	140	92	108	195	162	345
C)	58	24	40	105	117	63	68	75	49	58	105	87	186
D)	2.85	1.19	1.96	5.14	5.72	3.08	3.33	3.69	2.42	2.85	5.15	4.28	9.07
E)	3.28	1.24	2.26	5.73	6.59	3.43	3.83	4.25	2.70	3.29	5.74	4.93	10.45
F)	6650	2510	4577	11,606	13,347	6957	7757	8614	5466	6660	11,624	9983	21,178

Annual Summary: Calendar Year 1970

A)+	Total Cusec days	48,363
B)	Mean Cusecs	132
C)	M.G.D.	71
D)	Mean Cusecs per sq. mile	3.47
E)	Total runoff in inches	47.27
F)	Total runoff in acre-feet	95751

Conversion factors used:-

Catchment area	=	38 sq. miles
One inch runoff	=	2026 acre feet
One acre foot	=	1.98x cusec days
One M.G.D.	=	1.85 cusec days

APPENDIX A-29

RIVER GAUGING STATION HISTORY TO 28.2.71

NAME : S. Kahang (Upper) at Road Bridge.

GRID REFERENCE : WM 626-527

CATCHMENT AREA : 27 sq. miles.

ACCESS :

- 1) From Kluang along Mersing road, and turn off to the right at M 80.
- 2) Drive about 4 miles to a wooden bridge.
- 3) Recorder is about 100 ft. before the bridge, on the left bank, about 20 ft. in from the road.
- 4) The road is unsealed but in good condition, and a car can be used for transport.

CURRENT METER MEASUREMENTS :

- 1) 28 measurements were done during the period 25.1.70 to 30.1.71.
- 2) Range of discharge measured; 25 c/s to 341 c/s.

DISCHARGE CONTROL :

- 1) Channel control - bed sandy but stable.

BENCH MARKS :

- 1) 6 ft. x  $\frac{1}{2}$  inch waterpipe with 1 ft. x 1 ft. concrete slab about 15 ft. from recorder.
- 2) Value on top of pipe, 7.43 gauge height, which corresponds to 110.56 O.D.
- 3) The inscription on the concrete slab looks more like "71.3", however it is in fact "7.43".

HISTORY/REMARKS :

- 1) Stick gauge installed 18.3.70 - still in place February, 1971 (range 0-13.33 ft.).
- 2) Recorder (Negretti & Zambra pressure bulb, 0-20 ft.) installed 18.3.70.
- 3) Only trouble with the recorder, was occasional deflation of bulb.
- 4) All measurements were done by wading rods, from the upstream side of the wooden bridge.
- 5) Future measurements should be done at least monthly.
- 6) Future instrumentation should be wet-well/float type, capable of operation in the range 0-15 ft. gauge height.
- 7) Vegetation cover is 100 percent Jungle.
- 8) The station was handed over to the DID as from 28.2.71, in situ, and in working order.

## APPENDIX A-30

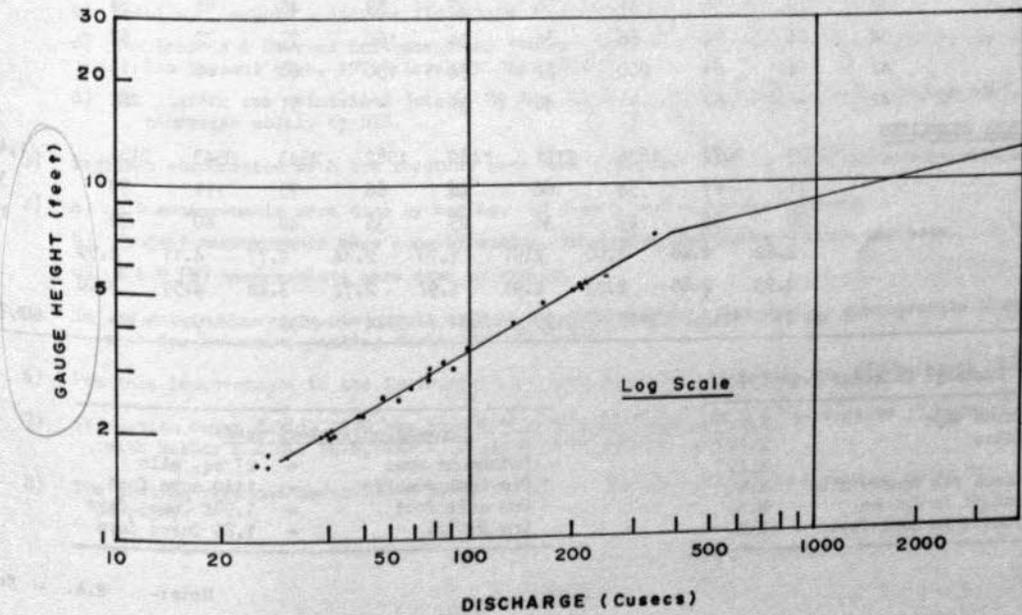
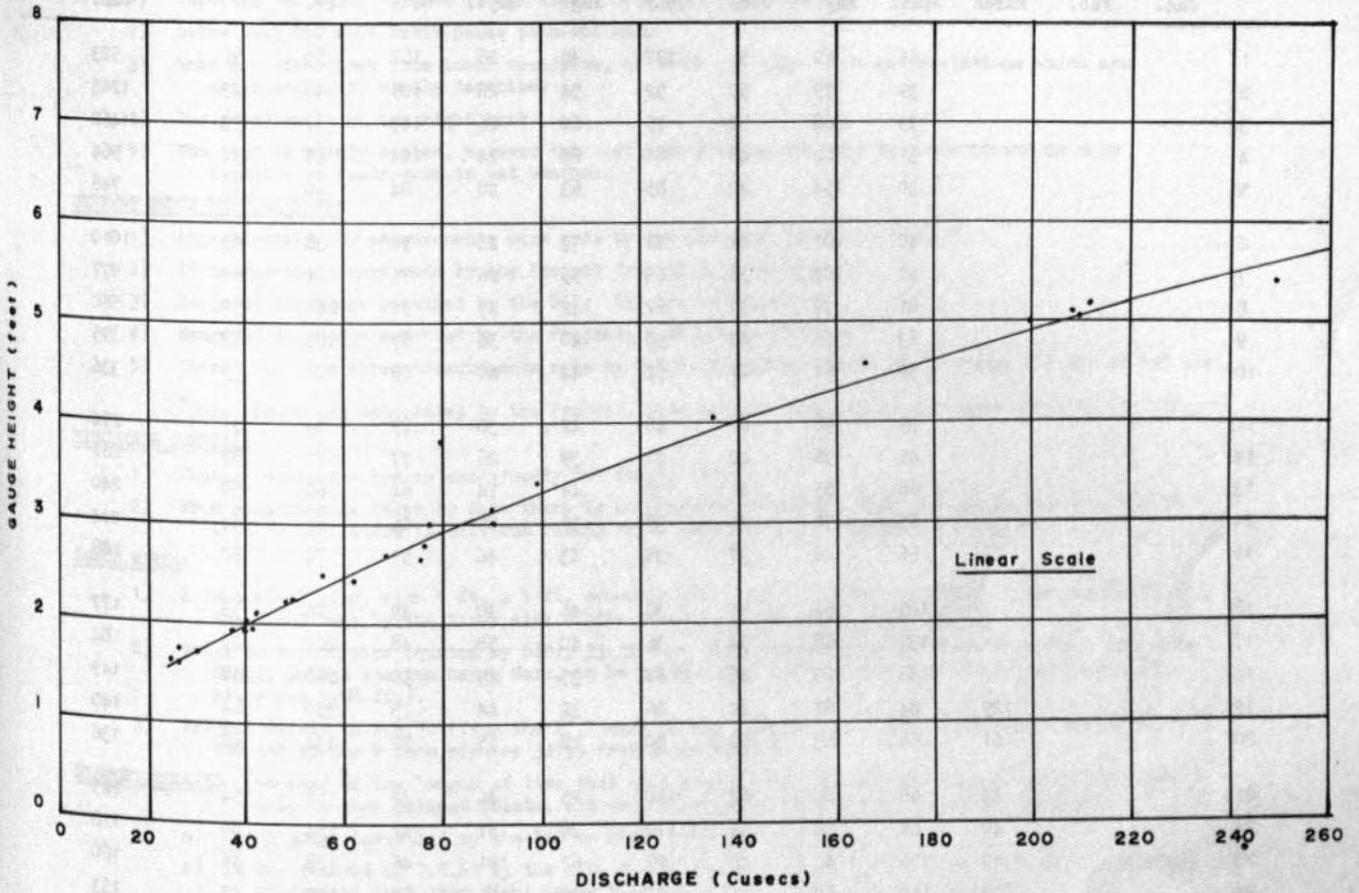
S. KAHANG (UPPER) AT ROAD BRIDGEDISCHARGE MEASUREMENTS MADE BY THE PROJECT FROM 25.1.70 TO 28.2.71

Meas. No.	Date	Surface Width (Feet)	Cross-section Area (Sq. ft.)	Mean Velocity (Fps)	Gauge Height (Feet)	Discharge (Cusecs)	Current Meter Positions	No. of Vertical Sections	Rising Falling or Stationary (R, F or S)	Defining Rating Curve No.
1	25.1.70	16.5	49.7	1.26	2.44	63	.2, .8	12	NA	1
2	23.2.70	18.0	42.0	0.89	1.92	37	.2, .8	8	NA	1
3	2.3.70	16.0	37.5	0.70	1.60	26	.2, .8	10	NA	1
4	8.3.70	16.5	40.4	0.66	1.72	27	.2, .8	15	S	1
5	18.3.70	24.0	103	2.00	4.99	206	.6	12	R	1
6	18.3.70	24.0	105	2.00	5.05	210	.6	11	R	1
7	18.3.70	24.0	106	1.97	5.10	209	.6	11	R	1
8	18.3.70	24.0	106	2.00	5.18	212	.6	11	R	1
9	18.3.70	24.0	122	2.04	5.41	249	.6	12	R	1
10	22.3.70	16.0	42.7	0.97	1.96	41	.2, .8	10	S	1
11	22.3.70	16.0	42.5	0.95	1.96	40	.2, .8	9	S	1
12	29.3.70	16.0	45.1	1.08	2.22	49	.2, .8	12	F	1
13	5.4.70	16.0	38.2	0.79	1.70	30	.2, .8	14	S	1
14	12.4.70	16.0	42.5	0.93	2.00	40	.2, .8	11	S	1
15	18.4.70	16.5	59.5	1.51	3.00	90	.6	14	F	1
16	25.4.70	20.5	67.1	1.48	3.41	99	.2, .8	15	F	1
17	2.5.70	17.0	60.8	1.28	3.00	78	.2, .8	13	R	1
18	23.5.70	16.5	43.9	0.98	2.10	43	.2, .8	12	S	1
19	30.5.70	17.5	55.4	1.24	2.68	68	.2, .8	12	F	1
20	18.7.70	17.5	55.0	1.23	2.64	68	.2, .8	15	S	1
21	12.9.70	16.0	37.0	0.67	1.61	25	.2, .8	12	S	1
22	14.11.70	17.0	48.0	1.17	2.49	56	.2, .8	10	F	1
23	21.11.70	20.5	77.0	1.76	4.08	135	.2, .8	12	F	1
24	5.12.70	17.0	56.0	1.37	2.79	77	.2, .8	10	S	1
25	12.12.70	16.5	46.0	1.09	2.23	50	.2, .8,	10	S	1
26	9.1.71	28.5	162	2.10	7.16	341	.2, .8	13	F	1
27	16.1.71	25.5	96.0	1.70	4.59	163	.2, .8,	15	F	1
28	30.1.71	17.0	61.0	1.41	3.14	85	.2, .8,	10	F	1

Note:- Due to rounding of figures for publication the calculation of discharge from the quoted area and velocity may not agree exactly with the discharge figure above.

**S. KAHANG (Upper) AT ROAD BRIDGE**

**RATING CURVE No.1**



APPENDIX A-32

S. KAHANG (UPPER) AT ROAD BRIDGE

MEAN DAILY DISCHARGE IN CUSECS, CALCULATED BY THE PROJECT FROM 19.3.1970 TO 31.1.1971

Day	1970												1971
	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.
1				41	62	56	172	48	28	187	50	92	523
2				39	79	59	92	54	28	109	48	123	1265
3				33	68	52	95	60	26	103	47	93	1460
4				31	62	48	81	68	24	104	44	92	964
5				30	154	42	85	63	28	84	40	73	748
6				40	107	41	72	73	26	77	38	65	1010
7				48	104	38	63	55	26	76	41	61	977
8				81	79	37	62	42	27	91	241	59	560
9				63	65	42	58	40	36	87	183	57	395
10				50	61	47	52	44	48	86	101	55	336
11				39	58	62	48	42	30	79	84	51	290
12				45	56	42	42	39	26	77	71	52	261
13				68	55	41	38	44	74	64	60	50	240
14				87	51	41	38	36	75	66	62	84	214
15				66	46	37	38	43	46	57	74	62	188
16				105	52	71	36	46	30	49	76	53	177
17				137	68	54	36	40	58	48	203	49	164
18				88	63	46	64	35	49	50	260	48	149
19			129	84	87	42	66	32	44	75	350	84	140
20			61	66	63	52	80	28	55	52	234	62	136
21			47	66	60	67	110	25	46	42	151	54	125
22			40	62	50	49	119	28	51	42	154	50	118
23			40	156	44	46	97	67	191	46	123	46	160
24			39	150	60	46	75	99	101	67	109	47	133
25			44	116	63	67	64	64	147	144	92	71	119
26			38	79	52	48	64	47	168	74	88	53	124
27			34	65	54	46	64	44	105	65	100	75	116
28			57	70	56	41	56	35	89	46	81	64	102
29			52	64	74	66	56	34	150	77	72	57	95
30			42	64	64	200	52	34	150	68	66	118	90
31			42	-	62	-	46	31	-	51	-	185	86
<b>MONTHLY SUMMARIES</b>													
A)†				2133	2079	1626	2121	1440	1982	2343	3343	2185	11,465
B)				71	67	54	68	46	66	75	111	70	369
C)				38	36	29	36	25	35	40	60	38	199
D)				2.62	2.48	2.00	2.51	1.70	2.44	2.77	4.11	2.59	13.66
E)				2.93	2.85	2.23	2.91	1.97	2.72	3.22	4.59	3.00	15.76
F)				4223	4116	3219	4199	2851	3924	4639	6619	4326	22,700

Annual Summary: Calendar Year 1970

A)† Total Cusec days	N.A.
B) Mean Cusecs	N.A.
C) M.G.D	N.A.
D) Mean Cusecs per square mile	N.A.
E) Total runoff in inches	N.A.
F) Total runoff in acre-feet	N.A.

Conversion factors used:-

Catchment area	=	27 sq. mile
One inch runoff	=	1440 acre feet
One acre foot	=	1.98x Cusec days
One M.G.D.	=	1.85 Cusec days

## APPENDIX A-33

RIVER GAUGING STATION HISTORY TO 28.2.71

NAME : S. Johor at Kg. Rantau Panjang.

GRID REFERENCE : WM 984-153

CATCHMENT AREA : 440 sq. miles

ACCESS :

- 1) Turn off the Kulai to Kota Tinggi Road, near the S. Semangar.
- 2) Drive past the FLDA Bukit Besar palm-oil mill.
- 3) Then ask directions from local residents, as there are many turns and deviations which are not possible to simply describe.
- 4) The recorder is on the right bank.
- 5) The road is mainly sealed, however the last 3 or 4 miles the road is unsealed and is only passable to Landrovers in wet weather.

CURRENT METER MEASUREMENTS:

- 1) Approximately 200 measurements were made by the DID from 4.4.62 to 18.2.71.
- 2) 19 measurements were made by the Project from 12.3.70 to 28.2.71.
- 3) Range of discharge measured by the DID; 131 c/s to 12,548 c/s<sup>+</sup>.
- 4) Range of discharge measured by the Project; 206 c/s to 3977 c/s.
- 5) There were also three measurements made by B & P (M) during August 1967 - range 403 c/s to 545 c/s.

<sup>+</sup>This figure was calculated by the Project, from surface velocity measurements taken by the DID.

DISCHARGE CONTROL:

- 1) Channel control - bed is sandy/muddy but fairly stable.
- 2) From measurements taken to date there is no evidence to suggest that the rating changes, and it appears that there is only one rating curve applicable for the period of record.

BENCH MARKS:

- 1) 2 inch steel pipe, with 1 ft. x 1 ft. concrete slab, about 150 feet upstream of the recorder, (on the Right Bank by the river side of the road) - established by DID survey.
- 2) Value on top of pipe (quoted by DID), 33.37 O.D. This was checked, by Project survey, from Kota Tinggi police station Bench Mark, to be 33.18 O.D. (absolute total of closing errors in 15 miles was 1.08 ft.).
- 3) Project survey on 4.8.70 (from the 27.7 mark on the non-vertical stick gauge) gave the level on the top of the 2 inch pipe as 33.33 feet gauge height.

HISTORY/REMARKS (because of the length of time that this station has been in operation, these notes refer only to some salient points, and are not intended to present a complete history)

- 1)
  - a) Stick gauge installed by the DID on right bank jetty during 1962.
  - b) It was removed on 7.8.63 by the DID, to its present (Feb. 1971) location and the gauge datum changed so that "the first gauge readings + 6.95 = present gauge readings".
  - c) The gauge was moved closer to the bank in Sept. 1967 and the datum unchanged.
  - d) The gauge was knocked off vertical by the 67/68 floods and is at present (Feb. 1971) not vertical.
- 2)
  - a) Recorder (Kent float type) installed by DID on 7.8.63 - removed on 4.7.67.
  - b) Recorder (Leupold & Stevens float type) installed by B & P (M) on 4.7.67.
  - c) The Leupold & Stevens instrument was flooded in Dec. 1967 and was reinstalled by the DID to its present (Feb. 1971) level in Jan. 1968.
  - d) The station was maintained jointly by the DID and B & P (M) from July to October 1967, otherwise solely by DID.
- 3) Problems encountered with the recorder have been discussed with the DID Research Station at Ampang.
- 4)
  - a) DID measurements were done by wading, or from a bank operated cableway.
  - b) Project measurements were done by wading, or from a boat using a winch and boom.
  - c) B & P (M) measurements were done by wading.
- 5) In the future, measurements should be done at least monthly, and special arrangements should be made for intensive gauging during dry periods.
- 6) Possible improvements to the instrumentation have been discussed with the DID Research Station at Ampang.
- 7) Vegetation cover during 1970 has been estimated at approximately 25 percent to 35 percent developed with Rubber and Oil Palm, and 65 percent to 75 percent jungle.
- 8) The station remained under DID control throughout the Project and it continues under DID control.

## APPENDIX A-34

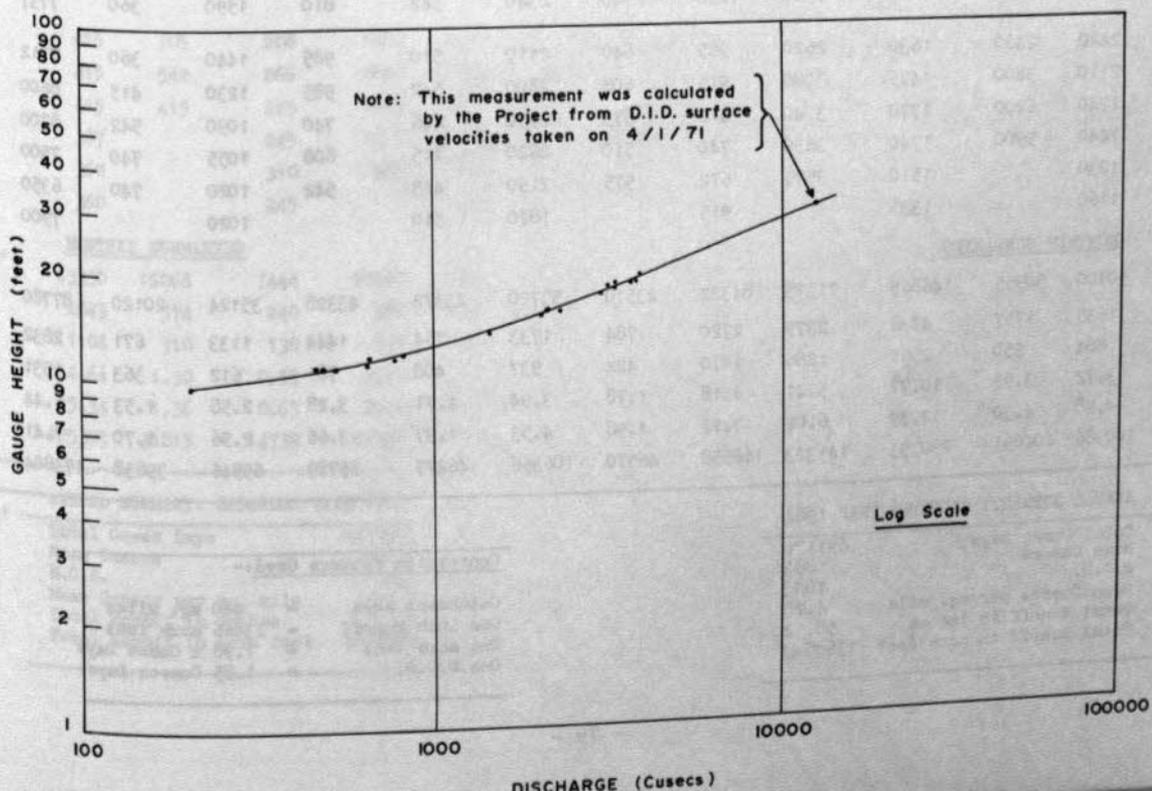
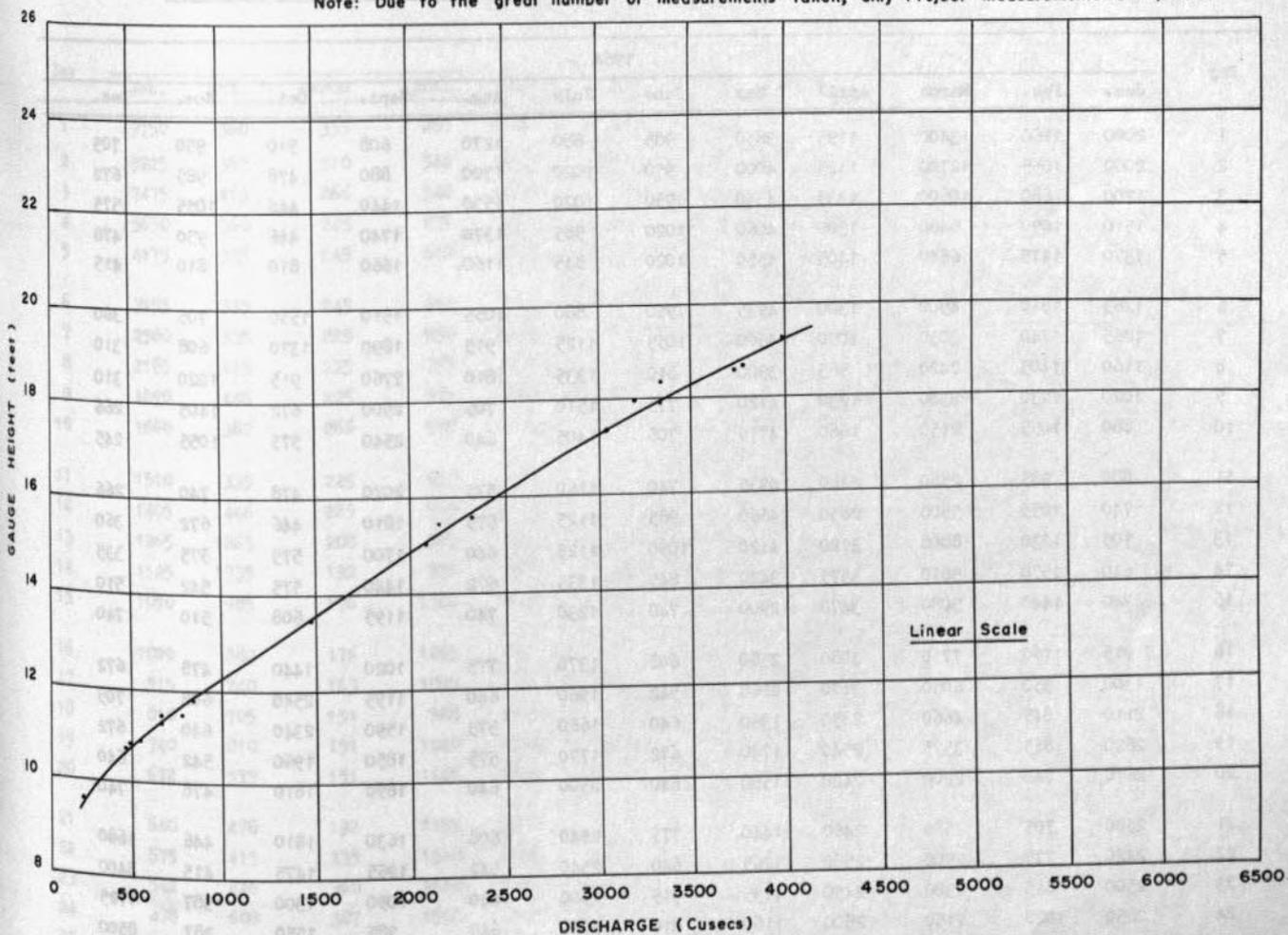
S. JOHORE AT KG. RANTAU PANJANGDISCHARGE MEASUREMENTS, MADE BY THE PROJECT FROM 12.3.70 TO 28.2.71

Meas. No.	Date	Surface Width	Cross-Section Area	Mean Velocity	Gauge Height	Discharge	Current Meter Positions	No. of Vertical Sections	Rising Falling or Stationary (R, F or S)	Defining Rating Curve No.
		(Feet)	(Sq. ft.)	(Fps)	(Feet)	(Cusecs)				
1	12.3.70	139	197	1.05	9.60	206	.2, .8	28	S	1
2	14.3.70	140	371	1.44	10.90	534	.2, .8	28	S	1
3	7.4.70	141	726	2.02	13.53	1465	.2, .8	29	R	1
4	11.4.70	142	1037	2.23	15.65	2318	.2, .8	29	R	1
5	11.4.70	142	941	2.27	15.50	2140	.2, .8	20	S	1
6	21.4.70	145	949	2.18	15.10	2067	.2, .8	29	S	1
7	23.4.70	152	1372	2.42	18.00	3315	.2, .8	29	S	1
8	23.4.70	150	1330	2.40	18.05	3189	.2, .8	29	S	1
9	24.4.70	158	1500	2.48	18.67	3721	.2, .8	30	R	1
10	24.4.70	158	1516	2.49	18.75	3769	.2, .8	30	R	1
11	25.4.70	160	1570	2.33	19.37	3977	.2, .8	31	R	1
12	8.5.70	147	1258	2.41	17.45	3033	.2, .8	29	R	1
13	9.5.70	152	1405	2.36	18.43	3320	.2, .8	29	R	1
14	20.8.70	141	454	1.73	11.50	786	.6	26	S	1
15	25.8.70	138	475	1.76	11.80	836	.2, .8	26	S	1
16	29.8.70	135	429	1.54	11.43	662	.2, .8	26	S	1
17	2.9.70	140	429	1.54	11.30	659	.2, .8	27	S	1
18	18.2.71	143	349	1.38	10.80	481	.2, .8	27	S	1
19	18.2.71	138	330	1.44	10.80	474	.2, .8	27	S	1

Note:- Due to rounding of figures for publication the calculation of discharge from the quoted area and velocity may not agree exactly with the discharge figure above.

S. JOHOR AT KG. RANTAU PANJANG  
 RATING CURVE No.1

Note: Due to the great number of measurements taken, only Project measurements are plotted



APPENDIX A-36

S. JOHOR AT KG. RANTAU PANJANG

MEAN DAILY DISCHARGES, IN CUSECS CALCULATED BY THE PROJECT FROM 1/1/1964 TO 31/12/1964

Day	1964											
	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	2000	1160	13400	1195	3850	985	880	1270	608	510	950	705
2	2000	1055	12700	1125	4000	950	1020	1700	880	478	985	672
3	1700	880	10600	1335	4340	950	1020	1530	1440	446	1055	575
4	1510	1090	8480	1300	4060	1020	985	1370	1740	446	950	478
5	1370	1475	6540	1405	4550	1020	845	1160	1660	810	810	415
6	1265	1810	4500	1300	4935	950	880	1055	1510	1550	705	360
7	1265	1740	3030	1090	4500	1055	1125	915	1890	1370	608	310
8	1160	1405	2420	985	3900	810	1335	810	2760	915	1020	310
9	1020	1230	2380	1230	4120	775	1510	705	2900	672	1405	266
10	880	1055	2150	1660	4715	705	1405	640	2540	575	1055	245
11	880	985	2580	2460	4935	740	1160	575	2070	478	740	266
12	740	1055	5500	2850	4660	985	1125	575	1810	446	672	360
13	705	1230	8000	3120	4120	1090	1125	640	1700	575	575	335
14	640	1550	9610	3575	3420	845	1335	672	1440	575	542	510
15	740	1440	9080	3470	2900	740	1230	740	1195	608	510	740
16	915	1160	7750	3080	2580	608	1370	775	1020	1440	478	672
17	1300	950	6050	3170	2260	542	1960	640	1195	2540	608	705
18	2110	845	4660	2850	1960	640	1660	575	1590	2340	640	672
19	2620	845	3575	2540	1740	672	1770	575	1850	1960	542	640
20	2670	740	2900	2420	1590	640	2500	640	1890	1810	478	740
21	2580	705	2580	2460	1440	775	2940	608	1630	1810	446	1680
22	2420	775	2500	2580	1265	640	2540	542	1265	1475	415	5400
23	2500	845	2380	2450	1195	915	2500	640	1090	1300	387	7725
24	2850	1020	2150	2500	1160	810	2620	640	985	1550	387	8500
25	2760	1550	1890	2580	1090	740	2340	542	810	1590	360	7737
26	2420	2460	1630	2620	985	640	2110	510	985	1440	360	7712
27	2110	3800	1475	3080	915	608	2800	542	985	1230	415	8600
28	1740	6200	1770	3740	810	575	2990	446	740	1090	542	8700
29	1440	9900	1740	3630	740	510	2620	415	608	1055	740	7500
30	1230		1510	3575	672	575	2150	415	542	1020	740	6350
31	1160		1335		915		1870	510		1020		7900

MONTHLY SUMMARIES

A) <sup>+</sup>	50700	50955	146865	71375	84322	23510	53720	23372	43328	35124	20120	87780
B)	1635	1757	4738	2379	2720	784	1733	754	1444	1133	671	2832
C)	884	950	2561	1286	1470	424	937	408	781	612	363	1531
D)	3.72	3.99	10.77	5.41	6.18	1.78	3.94	1.71	3.28	2.58	1.53	6.44
E)	4.28	4.30	12.39	6.02	7.12	1.98	4.53	1.97	3.66	2.96	1.70	7.41
F)	100386	100891	290793	141323	166958	46570	106366	46277	85789	69546	39838	173804

ANNUAL SUMMARY: CALENDER YEAR 1964

A)	Total Cusec Days	691171
B)	Mean Cusecs	1882
C)	M.G.D.	1017
D)	Mean Cusecs per sq. mile	4.28
E)	Total Runoff in inches	58.2
F)	Total Runoff in acre feet	1368541

Conversion Factors Used:-

Catchment area	=	440 sq. miles
One inch runoff	=	23466 acre feet
One acre foot	=	1.98 x Cusec Days
One M.G.D.	=	1.85 Cusecs Days

APPENDIX A-37

S. JOHOR AT KG. BANTAU PANJANG

MEAN DAILY DISCHARGES IN CUSECS, CALCULATED BY THE PROJECT FROM 1/1/1965 TO 31/12/1965

Day	1965											
	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	9750	360	335	287	1125	950	510	335	510	510	3800	3900
2	9225	387	310	542	1475	845	510	387	446	1020	3320	3120
3	7475	415	266	542	1550	810	415	740	446	1335	3520	2580
4	5650	360	245	478	1440	950	360	1510	446	1195	3740	2420
5	4175	335	245	608	1300	950	360	1300	542	915	3575	2300
6	3155	335	245	915	1195	810	310	1020	640	740	2940	2110
7	2580	335	225	950	1230	705	287	1125	640	775	2580	1890
8	2185	415	225	775	1265	640	225	985	608	880	2380	1890
9	1890	446	225	575	1660	608	208	775	575	915	2220	1960
10	1660	387	266	575	2110	510	176	880	510	1020	1920	2110
11	1510	335	225	640	2300	478	575	1090	387	1440	1700	2260
12	1405	446	225	915	2110	446	1230	1090	310	1440	1550	2110
13	1265	1265	208	985	2000	446	910	950	310	1405	1590	2110
14	1125	1335	192	950	1850	415	575	1090	287	1630	1960	2220
15	1090	985	176	1300	1740	387	415	1160	245	1700	2460	2300
16	1020	880	176	1265	1630	387	335	1160	287	1590	2500	2670
17	915	740	163	1055	1740	575	310	915	608	1475	2710	3120
18	810	705	151	985	2220	845	287	810	640	1440	2850	3420
19	740	810	151	1020	2185	880	287	1055	542	1550	2580	3120
20	672	575	151	1125	2150	640	287	1160	575	1300	2340	2420
21	640	478	192	1195	2260	510	266	985	672	1300	2110	2000
22	575	415	335	1510	2030	446	225	880	845	1810	2110	1850
23	542	446	360	1510	1890	387	225	950	672	1850	2070	1920
24	478	608	387	1550	1850	446	266	1265	446	1700	2110	2000
25	446	608	266	1265	1660	608	287	1160	415	2000	2220	2110
26	415	705	208	1160	1475	608	266	950	360	2340	2540	2620
27	415	542	266	1020	1335	510	360	810	542	2620	2800	2760
28	415	415	225	1125	1370	387	310	740	775	2990	3270	2540
29	387	245	1160	1440	335	266	775	705	3470	3740	2300	
30	360	310	985	1265	478	287	705	542	4120	3850	2030	
31	360	245	1055			310	542		4285		1850	
<u>MONTHLY SUMMARIES</u>												
A)*	63330	16068	7444	28967	51905	17992	11640	29299	15528	52760	79055	74010
B)	2043	574	240	966	1674	600	375	945	518	1702	2635	2387
C)	1104	310	130	522	905	324	203	511	280	920	1424	1290
D)	4.64	1.30	0.55	2.20	3.80	1.36	0.85	2.15	1.18	3.89	5.99	5.43
E)	5.34	1.36	0.63	2.44	4.38	1.52	0.98	2.47	1.31	4.45	6.67	6.25
F)	125393	31815	14739	57355	102772	35624	23047	58012	30745	104465	156529	146540

ANNUAL SUMMARY: CALENDER YEAR 1965

A)*	Total Cusec Days	447998
B)	Mean Cusecs	1222
C)	M.G.D.	660
D)	Mean Cusecs per sq. mile	2.78
E)	Total Runoff in inches	37.8
F)	Total Runoff in acre feet	887036

Conversion Factors Used:-

Catchment area	=	440 sq. miles
One inch runoff	=	23466 acre feet
One acre foot	=	1.98 x Cusec Days
One M.G.D.	=	1.85 Cusecs Days

## APPENDIX A-40

S. JOHOR AT KG. RANTAU PANJANGMEAN DAILY DISCHARGES IN CUSECS. CALCULATED BY THE PROJECT FROM 1/1/1968 TO 31/12/1968

Day	1968											
	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	4000	440	148	4500	1660	1700	840	1200	540	510	2300	1645
2	10000	480	142	4175	1850	1610	900	1160	580	484	2580	1482
3	23800	400	137	3685	1850	1490	930	1100	545	810	2340	1400
4	22000	600	132	2990	1760	1400	930	1050	505	1350	2670	1300
5	20000	670	127	2380	1660	2080	900	1020	460	1660	2710	1200
6	14000	540	123	2110	1680	2400	870	1020	420	1510	2440	1500
7	9000	410	118	1920	1660	2200	840	1020	395	1180	2300	1600
8	5000	385	125	1770	1650	2080	800	950	375	1195	2500	1500
9	4900	355	110	1550	1570	1980	900	880	363	1335	2560	1600
10	4600	335	250	1335	1680	1600	1000	820	350	1280	2380	2420
11	4400	318	560	1300	1370	1300	1070	760	340	1610	2150	2300
12	3500	300	500	1530	1230	1195	1140	720	330	2280	1810	2100
13	2750	283	420	1830	1335	1160	1080	700	325	3030	1550	2300
14	2200	270	795	1610	1460	1530	1050	700	320	3120	1405	2400
15	2000	255	2592	1320	1720	1910	1020	900	1003	2460	1350	2280
16	1800	243	3470	1140	2030	1720	1000	1450	1596	1810	2455	2110
17	1600	233	3345	1040	2480	1610	1090	1400	1550	1440	3120	3001
18	1430	225	2699	933	3013	1405	1500	1150	1390	1180	3575	3550
19	1300	218	1870	1070	2870	1230	1520	1050	1003	1020	4060	3080
20	1160	210	1405	1265	2340	1110	1600	1000	747	908	3630	2460
21	1055	202	1055	1300	2130	985	1700	940	1034	821	2940	2000
22	968	195	880	1265	1760	863	1600	980	1590	740	2340	1630
23	880	188	845	1140	1680	823	1470	890	1830	863	1890	1363
24	793	182	1800	1020	1530	933	1350	800	1405	1110	1550	1195
25	705	175	3850	1210	1370	950	1240	730	1040	1440	1980	1055
26	640	170	5280	1350	1300	960	1140	700	845	1680	1940	968
27	600	165	6600	1300	1260	1000	1100	660	950	1830	1905	1195
28	565	158	6300	1230	1250	980	1080	620	845	1850	1940	1340
29	535	152	5000	1160	1500	900	1060	600	705	1890	2050	1600
30	500		4527	1160	1950	870	1010	580	575	1980	1928	1600
31	470		4660		1850		1000	560		1960		1680

MONTHLY SUMMARIES

A)+	147151	8757	59865	51588	54448	41974	34730	28110	23956	46336	70348	56854
B)	4747	302	1931	1720	1756	1399	1120	907	799	1495	2345	1834
C)	2566	163	1044	930	949	756	605	490	432	808	1268	991
D)	10.79	0.69	4.39	3.91	3.99	3.18	2.55	2.06	1.82	3.40	5.33	4.17
E)	12.42	0.74	5.05	4.35	4.59	3.54	2.93	2.37	2.02	3.01	5.94	4.80
F)	291359	17339	118533	102144	107807	83108	68766	55658	47433	91745	139289	112571

ANNUAL SUMMARY: CALENDER YEAR 1968

A)+	Total Cusec Days	624117
B)	Mean Cusecs	1696
C)	M.G.D.	917
D)	Mean Cusecs per sq. mile	3.86
E)	Total Runoff in inches	51.76
F)	Total Runoff in acre feet	1235752

Conversion Factors Used:-

Catchment area	=	440 sq. miles
One inch runoff	=	23466 acre feet
One acre foot	=	1.98 x Cusec Days
One M.G.D.	=	1.85 Cusec Day

APPENDIX A-41

S. JOHOR AT KG. RANTAU PANJANG

MEAN DAILY DISCHARGES IN CUSECS, CALCULATED BY THE PROJECT FROM 1/1/1969 TO 31/12/1969

Day	1969											
	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	1810	810	241	705	1390	1460	1125	548	3950	880	1850	1378
2	2015	618	266	558	1300	1960	985	494	3445	758	1700	1510
3	2070	548	305	747	1755	2162	1300	558	2963	723	1610	1860
4	1590	510	256	971	2102	2520	1353	558	2520	915	1475	2860
5	1550	472	217	672	2380	3120	1590	542	2240	1280	1280	2580
6	1740	434	197	780	2460	3844	2470	656	2440	1180	1320	2185
7	2243	526	187	1050	2130	3575	2320	672	2110	1125	1300	2050
8	2328	708	176	900	1920	2800	1936	591	1770	1140	1320	2150
9	2110	558	170	720	2150	2150	1890	536	1550	1250	1250	2540
10	1782	564	162	700	1770	1720	2150	510	1370	1320	1090	8450
11	1502	614	156	570	1740	1503	2110	494	1265	1280	1020	22600
12	1290	542	150	480	1761	1672	2015	526	1178	1530	1070	22800
13	1125	441	147	360	1390	1810	1862	863	1073	1830	968	18000
14	1038	376	222	390	1148	2078	1756	1125	985	2320	950	13500
15	1003	428	206	560	1013	2078	1538	1335	880	2580	1070	10400
16	1038	567	195	660	1188	2316	1377	1440	793	2620	1090	7800
17	1125	468	217	520	1013	2220	1388	1590	758	2710	1790	5450
18	1220	374	195	660	1048	1908	1237	2015	863	3080	2185	4910
19	1342	335	188	900	1055	1590	1360	2420	880	2960	2020	5440
20	1220	337	180	1200	1440	1339	1610	2500	810	3050	1700	5440
21	985	365	172	1100	2110	1708	1550	2693	1013	3050	1460	5110
22	845	335	165	1300	2560	2252	1482	3395	1070	3370	1390	4340
23	768	277	160	1950	2440	2150	1258	3445	1370	4120	1660	3520
24	700	277	200	1900	1980	1688	1108	3463	1570	4230	1940	2900
25	627	421	235	1500	1550	1398	985	4175	1335	4740	1650	2500
26	681	421	287	1300	1475	1167	845	3630	1180	4420	1550	2240
27	971	299	585	1400	1420	1041	758	3370	1280	2940	1350	2110
28	1083	249	575	1040	1440	1102	689	4148	1090	2420	1195	1850
29	1188		570	1530	1350	1055	656	3928	985	2170	1140	1760
30	1300		1143	1882	1188	1232	601	4088	933	2000	1090	1650
31	1125		978		1153		591	4203		1960		1570
<u>MONTHLY SUMMARIES</u>												
A)+	41414	12874	9103	29005	50819	58618	43895	60511	45669	69951	42483	173453
B)	1336	460	294	967	1639	1954	1416	1952	1522	2256	1416	5595
C)	722	249	159	523	886	1056	765	1055	823	1219	765	3024
D)	3.04	1.05	0.67	2.20	3.73	4.44	3.22	4.44	3.46	5.13	3.22	12.72
E)	3.49	1.09	0.77	2.45	4.29	4.95	3.70	5.11	3.85	5.90	3.58	14.64
F)	82000	25491	18024	57430	100622	116064	86912	119812	90425	138503	84116	343437

ANNUAL SUMMARY: CALENDER YEAR 1969

A)+	Total Cusec Days	637795
B)	Mean Cusecs	1734
C)	M.G.D.	937
D)	Mean Cusecs per sq. mile	3.94
E)	Total runoff in inches	53.82
F)	Total runoff in acre feet	1262836

Conversion Factors Used:-

Catchment area	=	440 sq. miles
One inch runoff	=	23466 acre feet
One acre foot	=	1.98 x Cusec days
One M.G.D.	=	1.85 Cusec day

APPENDIX A-42

S. JOHOR AT KG. RANTAU PANJANG

MEAN DAILY DISCHARGES IN CUSECS, CALCULATED BY THE PROJECT FROM 1/1/1970 TO 31/1/1971

Day	1970												1971
	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.
1	1490	631	310	1540	3520	2220	1475	1500	745	1280	1230	1800	3000
2	1440	852	299	1680	2500	1920	1410	1300	650	1605	1180	1920	5100
3	1335	793	287	1870	2170	1760	1240	1040	580	2290	1390	1950	8400
4	1245	624	279	1510	1950	1610	1330	1270	495	2710	1330	1820	11670
5	1160	591	270	1250	1910	1430	1780	1395	460	2780	1250	1680	12250
6	1335	675	258	1140	2110	1290	2100	1610	585	2370	1140	1400	11270
7	1720	1535	245	1460	2410	1180	1810	1370	660	1840	1280	1200	10820
8	2130	2640	235	1805	3000	1120	1430	1180	705	2010	2360	1290	10310
9	2205	2895	225	2710	3470	1130	1250	1110	630	2120	2550	1320	9220
10	1920	2520	217	2700	3420	1180	1265	1450	615	1760	2100	1300	7630
11	1610	1760	208	2260	3060	1640	1130	1750	640	1820	1650	1120	5910
12	1370	1233	205	1960	2273	1690	980	1700	545	1930	1890	1300	4510
13	1320	950	277	2000	1830	1330	850	1640	650	1770	1150	1450	3480
14	1530	828	486	1940	1650	1080	760	1560	1045	1500	1030	1600	2930
15	1850	723	446	1840	1670	940	690	1440	1110	1330	940	1640	2510
16	1890	650	322	2490	1890	970	640	1240	1230	1120	940	1600	2220
17	1630	581	530	3000	2090	1060	620	1060	1310	960	1045	1500	2020
18	1320	532	1360	2800	2220	990	580	940	1490	840	1217	1310	1850
19	1210	500	1700	2280	2500	880	740	820	1420	810	2650	1430	1720
20	1195	462	1350	2030	2730	840	1400	715	1140	830	3030	1630	1550
21	1070	446	782	2130	2740	1070	1300	650	1040	754	2460	1640	1455
22	960	415	618	2570	2570	1090	1200	620	830	960	2500	1350	1380
23	863	387	716	3330	2210	930	1100	740	860	1230	3020	1300	1380
24	810	360	689	3760	1970	860	2000	1060	985	1290	3550	1200	1290
25	723	347	672	3980	2290	775	1500	835	1060	1270	4700	1920	1200
26	712	335	782	3500	2650	880	1300	740	930	1370	3800	2090	1200
27	765	330	656	2840	2470	980	1000	910	810	1125	3100	1900	1180
28	880	320	1140	2760	2340	870	1300	885	860	900	2400	1880	1110
29	793		1335	2750	2230	830	1220	740	1065	965	1900	1770	1010
30	685		1350	3960	2170	1190	1130	910	1250	1230	1500	1670	930
31	608		1510		2100		1350	800		1420		2040	860

MONTHLY SUMMARIES

A)*	39774	24915	19759	71845	74113	35735	37880	34980	26395	46189	60282	49020	131365
B)	1283	890	637	2395	2391	1191	1222	1128	880	1490	2009	1581	4238
C)	694	481	344	1295	1292	644	661	610	476	805	1086	855	2291
D)	2.92	2.02	1.45	5.44	5.43	2.71	2.78	2.56	2.00	3.39	4.57	3.59	9.63
E)	3.36	2.10	1.67	6.07	6.25	3.02	3.20	2.95	2.23	3.90	5.09	4.14	11.08
F)	78753	49332	39123	142253	146744	70755	75002	69260	52262	91454	119358	97060	260103

ANNUAL SUMMARY: CALENDER YEAR 1970

A)*	Total Cusec Days	520887
B)	Mean Cusecs	1425
C)	M.G.D.	770
D)	Mean Cusecs per sq. mile	3.24
E)	Total Runoff in inches	43.98
F)	Total Runoff in acre feet	1031356

Conversion Factors Used:-

Catchment area	=	440 sq. miles
One inch runoff	=	23466 acre feet
One acre foot	=	1.98 x Cusec Days
One M.G.D.	=	1.85 Cusec day

APPENDIX A-43

PROJECT RAINFALL STATIONS - MONTHLY TOTALS SHOWN IN HUNDREDTHS OF INCHES

Adopted Project Name	Grid Reference	Frequency of reading	Project Station No.	1970												1970 Total	1971	
				Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.		Jan.	Feb.
Sayong Plantation	WM 810-130	Daily	TR1	603	391	1205	1041	1087	826	1057	421	893	930	848	1002	10304	629	288
Pengelli Timber Camp	WM 826-273	Monthly	TR2	825	418	1231	1136	522	560	507	439	662	620	836	1388	9174	820	NR
Linggi Tin Mine	WM 936-246	Weekly	TR3	1180	433	714	1159	736	188	625	806	808	<u>920</u>	<u>1239</u>	<u>836</u>	9644	NR	NR
Kota Tinggi Waterfalls	WN 093-216	Daily	TR4	1016	332	412	1357	1096	637	494	2001	2260	901	1903	793	13202	922	172
Dikit Panjang	WM 996-450	Weekly	TR5	1038	216	647	1508	759	274	300	554	880	978	1272	<u>1155</u>	9581	1353	605
Forestry Department	WM 142-380	Daily	TR6	867	228	728	1372	1049	252	457	1040	644	629	1155	1461	9882	1376	540
Kg. Bantau Panjang	WM 984-154	Daily	TR7	421	730	838	2601	1356	839	513	830	1225	853	1151	1165	12522	773	520
Lower Pengelli Road Bridge	WM 847-195	Weekly	TR8		376	<u>1034</u>	718	1105	120	525	824	<u>806</u>	1259	702	<u>812</u>	NR	<u>707</u>	339
Rup Seng Kung	WM 940-325	Weekly <sup>+</sup>	TR9				1230	1123	99	618	836	NR	NR	NR	779	NR	1025	308
Kg. Kg. Lembu	WN 427-331	Weekly <sup>+</sup>	PR1	492	329	1146	1244	346	729	758	418	836	1594	976	1930	10798	1688	352
Mile 43	WN 349-280	Weekly	PR2	884	370	1247	855	594	403	494	577	1243	1068	1115	1907	10757	1806	324
Upper Seluyut	WN 297-153	Weekly	PR3	1179	NR	(Station abandoned - replaced by PR6)										NR		
Kg. Bahru	WS 487-869	Monthly <sup>+</sup>	PR4		159	288	866	993	909	342	648	606	592	1301	1528	NR	1480	424
Kg. Sedili Kechil	WN 476-228	Weekly	PR5	1625	372	450	551	235	1060	265	238	1024	859	928	1022	8629	1690	263
Upper Mupor	WN 284-148	Weekly	PR6		<u>442</u>	NR	NR	1098	634	573	615	714	571	321	1223	NR	1534	648
Kangar Chemaran	WS 536-905	Monthly	PR7		146	630	828	1058	844	398	850	570	748	1263	1590	NR	1531	354
Mile 35	WN 248-225	Weekly	PR8							355	695	807	1413	1263	1397	NR	1452	412
Upper Mupor A	WN 250-162	Weekly	PR9												1828	NR	NR	NR
Mile 27½	WN 203-113	Weekly	PR10												1348	NR	NR	412

NOTE:-

NR = No record available, or not possible to estimate total from portion of the record available.

XXXX = Record incomplete for the month; XXXX is the estimated rainfall.

<sup>+</sup> = At some stations there was a storage check gauge and a daily gauge. Where the daily readings were incorrect, the weekly or monthly values from the storage gauge were used to complete the monthly totals shown in the table.

CHEMICAL ANALYSIS OF RAW WATER

	S. Mupor at M32½				S. Permandi at M27½				S. Linggiu (Upper)				S. Linggiu at Road Bridge			
	1970	1970	1970	1970	1970	1970	1970	1970	1970	1970	1970	1970	1970	1970	1970	1970
Year	1970	1970	1970	1970	1970	1970	1970	1970	1970	1970	1970	1970	1970	1970	1970	1970
Day/Month	22/2	3/3	26/4	3/5	17/5	24/5	24/5	31/5	25/2	8/3	18/3	6/4	15/4	22/4	29/4	7/5
Gauge Height (feet)	1.24	0.91	1.32	1.47	2.88	2.60	0.55	0.34	0.51	1.84	1.45	1.17	N.A.	N.A.	N.A.	3.61
Discharge (cusecs)	8.6	4.9	9.6	11.8	40.6	33.8	11.3	6.2	10.3	47.2	36.3	28.5	300	928	400	504
Chlorides as Chlorine	2	3	2	3	3	3	3	2	3	2	3	2	3	2	3	2
Total Solids dried @ 105°C - 110°C	20	20	30	25	30	20	35	30	100	55	25	35	40	90	35	35
Oxygen abs. KMnO <sub>4</sub> 4 hrs. 27°C - 30°C	2.25	2.70	2.70	2.80	3.05	3.45	0.85	1.10	4.50	1.55	1.05	0.70	0.80	0.90	1.60	1.30
Ammoniacal Nitrogen	0.01	0.01	0.01	0.01	0.01	0.05	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Albuminoid Nitrogen	0.04	0.01	0.07	0.07	0.07	0.09	0.04	0.02	0.14	0.07	0.07	0.06	0.01	0.01	0.02	0.01
Nitrate Nitrogen	0.06	0.06	0.09	0.06	0.09	0.18	0.06	0.03	0.27	0.78	0.21	0.06	0.06	0.03	0.18	0.12
Nitrite Nitrogen	Nil	Nil	Tr	Tr	Tr	Nil	Nil	Nil	Nil	Tr	Tr	Tr	Tr	Tr	Tr	Tr
Iron as Fe	0.52	0.60	0.44	0.52	0.28	0.36	0.70	0.80	0.80	1.60	0.48	0.32	0.40	0.48	0.64	0.52
Hardness as CaCO <sub>3</sub>	8	6	6	6	4	4	10	8	10	5	6	8	6	6	6	4
Alkalinity CaCO <sub>3</sub>	4	5	3	4	5	3	7	10	3	5	5	5	7	8	6	5
Manganese as Mn	Nil	Nil	0.04	Nil	Nil	Nil	Nil	Nil	0.03	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Arsenic as As	Nil	Nil	Nil	Nil	Nil	Nil	Nil	0.004	Nil	Nil	Nil	0.004	Nil	Nil	Nil	Nil
Aluminium as Al	0.05	0.05	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.02	0.01	0.07	0.06	0.03	0.03
Flouride as F	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	Nil	Nil	<0.05	<0.05
Sulphate as SO <sub>4</sub>	2.5	5.8	6.2	1.0	14.0	4.9	4.1	14.0	4.9	4.1	4.9	4.1	8.7	8.6	14	8
Appearance Turbidity*	sl.T	Clear	V.sl.T	V.sl.T	V.sl.T	sl.T	sl.T	sl.T	sl.T	sl.T	sl.T	sl.T	sl.T	sl.T	V.sl.T	T
Suspended Matter**	sm.Q	V.sm.Q	Sm.Q	Q	Q	sm.Q	sm.Q	V.sm.Q	sm.Q	V.sm.Q	Q	Q	Q	Q	Q	Q
Colour (Hazen Unit)	45	60	35	30	45	50	40	40	70	55	35	30	80	45	40	35
pH	6.3	6.4	6.0	6.1	5.7	6.0	6.4	6.5	5.5	6.1	6.3	6.0	6.6	6.7	6.2	5.9

Note:-

- 1) Analysis was carried out by the Department of Chemistry, Petaling Jaya.
- 2) Discharges quoted, are from the appropriate Rating Table.
- 3) A blank in any column indicates "test not carried out".
- 4) Unless stated otherwise all results are in p.p.m.

+ V.sl.T = Very slightly turbid  
sl.T = slightly turbid  
T = turbid  
\*\* V.sm.Q = Very small quantity  
sm.Q = small quantity  
Q = quantity

CHEMICAL ANALYSIS OF RAW WATER

	S. Pengell at Road Bridge						S. Sayong (Lower) at Road Bridge						S. Sayong at Layang Layang									
	1970	1970	1970	1970	1970	1970	1970	1970	1970	1970	1970	1970	1970	1970	1970	1970	1970	1970	1970			
Year	1970	1970	1970	1970	1970	1970	1970	1970	1970	1970	1970	1970	1970	1970	1970	1970	1970	1970				
Day/Month	22/2	18/3	22/4	29/7	9/9	16/3	15/4	22/4	12/5	10/6	12/8	9/9	16/9	14/4	28/4	23/5	30/5	25/6	27/6	15/8	22/8	13/10
Gauge Height (feet)	3.65	8.62	7.06	5.20	4.16	3.40	7.75	11.62	7.66	6.77	9.68	4.43	5.26	5.97	6.10	7.04	6.06	4.16	4.85	5.35	4.30	5.23
Discharge (cusecs)	54	487	297	138	79	134	615	1310	602	483	928	220	303	175	186	270	182	38	92	132	70	124
Chlorides as Chlorine	3	2	2	2	3	3	3	3	3	3	3	3	2	2	3	5	2	2	2	2	3	6
Total Solids dried @ 105°C - 110°C	30	95	25	30	30	75	50	50	75	90	85	70	85	55	35	30	40	70	100	50	60	60
Oxygen abs. KMnO4, 4 hrs. 27°C - 30°C	1.50	4.55	2.50	2.00	1.70	4.25	3.85	5.75	3.35	4.00	5.90	4.95	6.90	3.75	0.80	3.30	2.95	2.25	3.50	3.20	2.65	4.35
Ammoniacal Nitrogen	0.01	0.01	0.01	0.01	0.06	0.60	0.11	0.01	0.51	0.08	0.04	0.19	0.07	0.16	0.01	0.02	0.13	0.46	0.46	1.56	0.19	0.19
Albuminoid Nitrogen	0.03	0.13	0.03	0.02	0.05	0.14	0.13	0.14	0.14	0.14	0.11	0.21	0.30	0.14	0.02	0.11	0.08	0.13	0.16	0.14	0.07	0.07
Nitrate Nitrogen	0.09	0.21	0.06	0.06	0.12	0.21	0.15	0.12	0.57	0.36	0.12	0.15	0.12	0.24	0.06	0.21	0.39	0.54	0.51	0.45	3.00	0.30
Nitrite Nitrogen	Nil	Nil	Tr	Nil	Nil	Tr	Tr	Tr	Tr	Tr	Nil	Nil	Tr	Tr	Nil	Tr	Nil	Tr	Tr	Tr	Tr	Tr
Iron as Fe	1.7	0.56	0.28	0.32	0.28	0.70	0.14	0.56	0.96	0.68	0.64	0.90	1.3	0.60	0.68	0.48	0.48	0.80	0.96	0.88	0.68	0.96
Hardness as CaCO3	6	6	4	6	10	12	10	10	6	18	12	12	20	10	10	4	6	12	20	12	10	8
Alkalinity as CaCO3	5	4	3	5	6	8	5	3	3	7	5	10	10	2	7	3	3	3	3	3	6	5
Manganese as Mn	Nil	0.02	Nil	Nil	0.02	0.01	Nil	Nil	0.01	0.01	Nil	0.10	Nil	0.15	Nil	Nil	Nil	0.01	Nil	Nil	Nil	Nil
Arsenic as As	Nil	Nil	Nil	Nil	Nil	0.002	Nil	Nil	Nil	Nil	Nil	0.004	0.004	Nil	Nil	Nil	Nil	Nil	0.002	Nil	Nil	0.002
Aluminium as Al	Nil	Nil	Nil	Nil	Nil	0.08	0.16	0.03	0.08	0.08	0.08	0.07	0.12	0.09	0.02	0.09	0.08	0.06	0.05	0.06	0.05	0.09
Fluoride as F	Nil	0.05	0.03	Nil	Nil	Nil	Nil	0.05	0.05	0.05	0.05	0.05	0.05	Nil	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Sulphate as SO4	16.5	6	6	6	6	17.7	7.4	7.4	7.4	10.7	10	10	10	5.4	2.5	9.9	7.8	10.3	7.8	9	3	3
Appearance Turbidity+	sl.T	T	sl.T	sl.T	V.sl.T	sl.T	T	T	T	T	T	V.sl.T	T	T	V.sl.T	T	T	T	T	T	sl.T	sl.T
Suspended Matter++	V.sm.Q	Q	Q	sm.Q	Q	sm.Q	Q	Q	Q	Q	sm.Q	Q	Q	Q	sm.Q	Q	Q	Q	Q	Q	Q	Q
Colour Hazen Unit	35	90	35	40	20	50	55	90	25	90	90	45	90	50	20	80	45	60	80	50	45	60
pH	6.6	6.8	6.5	6.4	5.9	6.2	6.0	5.8	5.8	5.9	6.5	6.3	6.5	5.4	6.4	6.0	5.3	5.6	5.2	5.8	5.8	5.5

Notes:

- 1) Analysis was carried out by the Department of Chemistry, Petaling Jaya.
- 2) Discharges quoted, are from the appropriate Rating Table.
- 3) A blank in any column indicates "test not carried out".
- 4) Unless stated otherwise all results are in P.p.m.

+ V.sl.T. = Very Slightly turbid.  
sl.T. = slightly turbid.  
T. = turbid.

++ V.sm.Q. = Very small quantity.  
sm.Q. = small quantity.  
Q. = quantity.



APPENDIX A47  
CHEMICAL ANALYSIS OF RAW WATER

Year	S. Sebol at Road Bridge					S. Johor Panjang					S. Kahang (upper) at Road Bridge					J	K								
	1970	1970	1970	1970	1970	1970	1970	1970	1970	1970	1970	1970	1970	1970	1970										
Day/Month	29/7	12/8	26/8	9/9	23/9	14/10	14/3	7/4	11/4	25/4	2/5	23/5	8/3	10/10	8/3	4/7	12/11	17/11	10/12	26/4	31/5	9/12	13/12	1/6	14/12
Gauge Height (ft)	6.25	3.12	2.76	2.46	2.47	3.36	10.90	13.55	15.50	19.4	2.99	2.10	1.72	3.05	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Discharge (cusecs)	102	18.5	12.0	6.6	6.8	22.7	542	1457	2185	4000	83	45	30	86	82	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Chlorides as Chlorine	2	2	2	2	2	2	3	3	4	2	3	2.5	3	2	3	3	3	3	3	3	4	2	3	2	6
Total Solids dried @ 105°C - 110°C	30	35	25	25	30	25	425	205	70	100	50	45	30	40	35	65	105	75	35	25	30	25	25	25	25
Oxygen abs. MnO <sub>4</sub> ; 4 hrs. 27°C - 30°C	4.00	5.10	5.05	3.85	4.00	5.60	5.10	4.2	5.35	4.40	2.25	0.70	1.10	1.90	1.45	1.70	6.70	21.45	10.15	2.00	2.90	3.70	1.75	1.32	2.25
Ammoniacal Nitrogen	0.01	0.01	0.04	0.02	0.03	0.01	0.33	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.05	0.39	0.05	0.01	0.01	0.01	0.02	0.02	0.01	0.01
Albuminoid Nitrogen	0.02	0.02	0.03	0.02	0.07	0.02	0.26	0.08	0.14	0.10	0.07	0.03	0.01	0.02	0.01	0.02	0.44	0.24	0.13	0.05	0.06	0.02	0.02	0.02	0.03
Nitrate Nitrogen	0.09	0.12	0.15	0.15	0.12	0.12	0.27	0.27	0.21	0.06	0.15	0.15	0.06	0.12	0.03	0.09	0.03	0.03	0.15	0.18	0.06	0.12	0.06	0.06	0.15
Nitrite Nitrogen	Nil	Nil	Nil	Nil	Nil	Nil	Tr	Tr	Tr	Tr	Tr	Tr	Tr	Tr	Nil	Nil	Tr	Tr	Tr	Tr	Tr	Nil	Nil	Nil	Nil
Iron as Fe	0.10	0.14	0.12	0.16	0.08	1.04	2.56	0.72	0.56	0.52	0.60	0.52	0.44	0.72	0.52	1.20	1.30	0.88	0.28	0.48	0.32	0.52	0.16	0.14	0.14
Hardness as CaCO <sub>3</sub>	6	8	2	8	8	6	10	6	6	8	6	4	4	6	6	10	12	40	10	6	6	6	4	4	4
Alkalinity as CaCO <sub>3</sub>	1	2	4	3	Nil	3	10	6	5	3	6	7	8	8	8	7	12	Nil	Nil	3	2	Nil	Nil	1	Nil
Manganese as Mn	Nil	Nil	Nil	Nil	Nil	Nil	0.02	Nil	0.15	Nil	Nil	Nil	Nil	0.03	Nil	Nil	0.02	0.02	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Arsenic as As	Nil	Nil	Nil	Nil	Nil	Nil	0.008	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	0.008	0.004	0.002	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Aluminium as Al	0.07	0.04	0.04	0.09	0.08	0.09	0.11	0.09	0.04	0.03	0.02	0.03	0.02	0.002	0.04	0.04	0.20	0.12	0.12	0.05	0.09	0.07	0.03	0.03	0.05
Fluoride as F	0.07						Nil	Nil	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	
Sulphate as SO <sub>4</sub>	5	5					12.4	7.4	8.2	11.1	1.0	1.0	1.0	1.0	14	5.8	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3
Appearance Turbidity	Clear	T	V.sl.T	V.sl.T	Clear	Clear	T	T	T	T	T	T	V.sl.T	sl.T	T	T	V.sl.T	Clear	T	Clear	Clear	V.sl.T	Clear	Clear	Clear
Suspended Matter	Nil	sm-q	sm-q	V.sm-q	sm-q	V.sm-q	Q	Q	Q	Q	Q	Q	V.sm-q	V.sm-q	Q	Q	V.sm-q	V.sm-q	Q	sm-q	sm-q	sm-q	sm-q	sm-q	V.sm-q
Colour Hazen Unit	45	14	45	35	45	55	35	70	65	25	40	45	40	40	35	40	30	225	150	30	40	50	25	5	25
pH	4.8	4.8	4.9	5.0	4.9	4.8	6.4	5.8	6.4	5.9	6.4	6.4	6.7	6.2	6.7	6.2	5.7	4.0	4.6	5.8	4.7	4.8	5.4	5.2	5.2

Note:

- 1) Analysis was carried out by the Department of Chemistry, Petaling Jaya.
- 2) Discharges quoted, are from the appropriate Rating Table.
- 3) A blank in any column indicates "test not carried out".
- 4) Unless stated otherwise all results are in p.p.m.

E - S. Bahan  
 F - S. Seluyut  
 G - S. Gembot  
 H - S. Sedili Kechil  
 I - S. Layu Kiri  
 J - S. Leban  
 K - S. Chemangar

+ V.sl.T. = Very slightly Turbid  
 sl.T. = slightly Turbid  
 T. = Turbid  
 ++ V.sm-q = Very small Quantity  
 sm-q = small Quantity  
 Q = Quantity  
 +++ A - S. Kahang (Lower)  
 B - S. Tempenis  
 C - S. Firau  
 D - S. Pontian Kechil





APPENDIX B-1  
APPRAISAL OF JKR SUPPLY AREAS TO BE CONSIDERED

JKR Supply Area	Assumed Future Supply Area	Classification	Population (thousands)		E.W.D.(mgd) Year 2000	Estimated Yield of Source (mgd)	To be included in study
			1957	Year Census 2000			
Johor Baharu	District of J.B. (ex. M. Sedenak) and Pekan Nenas District of Pontian)	Urban	89.8	392.6	23.6	1961 Agreement 18.0 1962 Agreement 5.0 (from PUB) (a)	Yes
		Rural	22.3	97.0	3.9		
		Scattered	47.1	206.0	4.1		
					31.6	18 - 23	
Pontian	District of Pontian (ex. Pekan Nenas)	Urban	8.5	37.2	2.2	S. Pontian Besar 5.3 Deduct Bukit Batu demand 1.3	Yes
		Rural	4.3	18.8	0.8		
		Scattered	79.2	346.0	6.9		
					9.9	4.0	
Simpang Rengam	Mukims Ulu Benut and Machap plus Machap L.C.	Urban	-	-	-	4.3	No
		Rural	2.7	11.9	0.47		
		Scattered	1.5	6.6	0.13		
					0.60		
Bukit Batu	Mukim Sedenak (District of J.B)	Urban	6.1	26.8	1.08	1.7	No
		Rural	2.9	12.6	0.25		
		Scattered	-	-	-		
					1.33		
Kluang	Mukim Kluang (except part of Machap L.C.)	Urban	31.2	136.3	8.2	S. Mengkibol 0.8 S. S. Kechil 3.2	Yes
		Rural	4.5	19.7	0.8		
		Scattered	15.5	67.9	1.4		
					10.4	4.0	
Kota Tinggi	Mukim Kota Tinggi	Urban	7.5	32.7	1.96	0.2	Yes
		Rural	0.3	1.3	0.05		
		Scattered	9.2	40.1	0.80		
					2.81		
Rengam	Mukim Rengam (excluding part of Machap L.C.)	Urban	-	-	-	0.4	No (b)
		Rural	3.2	14.0	0.56		
		Scattered	10.6	46.3	0.93		
					1.49		
Layang-Layang	Mukim Layang2 plus FLDA Tak Way Heng	Urban	-	-	-	S. Sayong 2.1 Deduct Rengam Yield 0.4	No
		Rural	2.3	10.0	0.40		
		Scattered	3.8	16.6	0.33		
					0.73	1.7	
FLDA Kulai complex U/C	FLDA Villages plus palm oil processing factory	Villages	-	12.0	0.48	1.1	No
		Factory	-	-	0.28		
					0.76		
FLDA Ayer Tawar U/C	FLDA Villages plus Mukim Johore Lama	Villages	-	15.0	0.60	1.3	No
		Rural	1.0	4.4	0.18		
		Scattered	2.4	10.5	0.21		
					0.99(c)		
FLDA Bukit Aping U/P	FLDA Villages plus Kg. Sedili Besar	Villages	-	7.0	0.28	1.3	No
		Rural	2.7	11.8	0.47		
					0.75		
South Penggerang U/P	Southern Coast of Penggerang	Rural	3.1	13.6	0.54	Not known	No (under investigation)
		Scattered (say)	3.0	13.1	0.26		
					0.80		

NOTES:

1. E.W.D. denotes estimated water demand.
2. Estimated water demand based on 3 1/4% compound increase in population from 1957 Census and water allocation in year 2000 of:-
  - Urban 60 gph/day
  - Rural 40 gph/day
  - Scattered 20 gph/day
3. No allowance for industry is included.
4. (a) Ignores Kong Kong intake. Yield = 0.2 mgd. which is negligible.
5. (b) Although the Rengam supply may come under

pressure by year 2000 (especially if the total scattered population is connected) the deficiency can easily be made up from the Simpang Rengam intake where the yield is estimated at 4.3 mgd. and the future demand only 0.6 mgd.

6. (c) Assumes no palm oil processing factory.
7. U/C denotes under construction.
8. U/P denotes under planning.

## APPENDIX B-2

JOHOR BAHRU, KLUANG, KOTA TINGGI AND PONTIAN SUPPLY AREAS.PAST CONSUMPTION (1953-69) IN M.G.D.

YEAR	STATE OF JOHOR	J.K.R. SUPPLY AREA			
		JOHOR BAHRU	KLUANG	KOTA TINGGI	PONTIAN
1953	7.2	2.18	0.77	0.19	
1954	7.8	2.32	0.86	0.19	0.26
1955	8.53	2.53	1.14	0.23	0.31
1956	9.68	2.75	1.34	0.26	0.43
1957	10.39	2.79	1.50	0.27	0.43
1958	10.96	3.01	1.51	0.29	0.44
1959	10.88	3.01	1.51	0.28	0.48
1960	11.64	3.19	1.77	0.28	0.54 <sup>h</sup>
1961	12.10	3.50 <sup>a</sup>	1.86	0.30	0.56
1962	12.75	3.78	1.76	0.30	0.57
1963	13.42	4.14 <sup>b</sup>	1.90	0.32	0.67
1964	14.45	4.49 <sup>c</sup>	2.03	0.32	0.75
1965	15.92	5.19	2.02	0.33	0.87
1966	17.09	5.54 <sup>d</sup>	2.17	0.33 <sup>g</sup>	0.91
1967	18.17	5.88	2.22	0.38	0.95
1968	19.84	6.62 <sup>e</sup>	2.47	0.39	0.80
1969	21.44	6.94 <sup>f</sup>	2.50	0.42	0.84
% increase 1959-1969	97	130	66	50	75

NOTES:

- |  |                            |
|--|----------------------------|
| a) Kg. Pulai, Scudai, Saleng, Serai and Kulai added. | e) Pandan, Plentong added. |
| b) Ulu Choh added.                                   | f) L Kedai added.          |
| c) Kulai FLDA added.                                 | g) FLDA Pasak added.       |
| d) G. Patah added.                                   | h) Kukup added.            |

## APPENDIX B-3

JOHOR BAHRU, KLUANG, KOTA TINGGI AND PONTIAN SUPPLY AREASESTIMATED FUTURE WATER DEMANDS BASED ON EXTRAPOLATION OF PAST CONSUMPTION.

Supply Area	Percent increase every 10 years from 1969	Demand mgd 1969	Estimated Water Demand (mgd)		
			1979	1989	1999
Johor Baharu	100	6.94	13.9	27.8	55.6
	70	6.94	11.8	20.1	34.2
Kluang	100	2.50	5.0	10.0	20.0
	66	2.50	4.2	6.9	11.4
Kota Tinggi	100	0.42	0.84	1.68	3.36
	50	0.42	0.63	0.94	1.41
Pontian	100	0.84	1.68	3.36	6.72
	75	0.84	1.47	2.56	4.48

APPENDIX B-4

JOHOR BAHRU, KLUANG, KOTA TINGGI AND PONTIAN WATER SUPPLY AREAS.

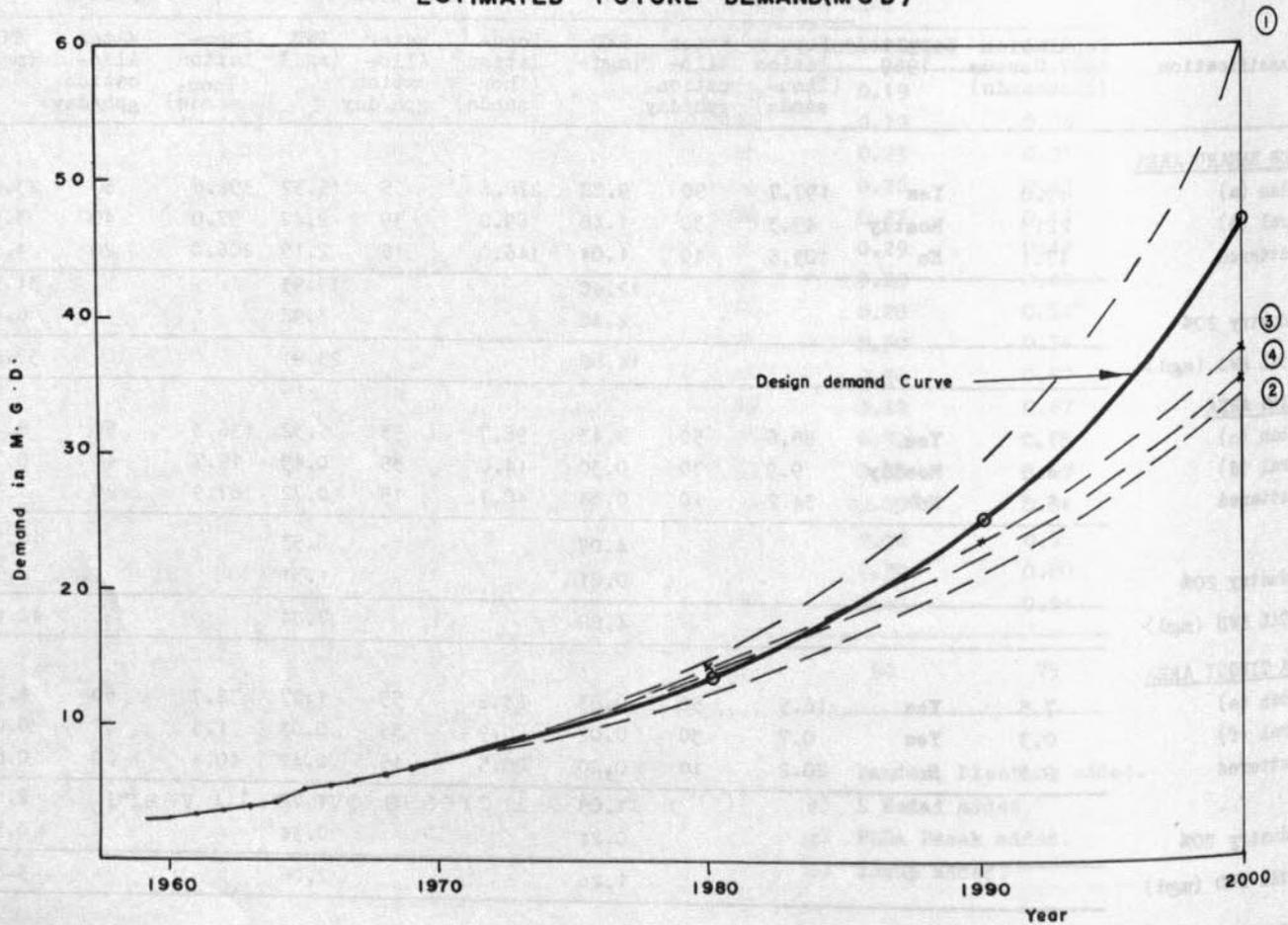
ESTIMATED FUTURE WATER DEMAND BASED 1957 CENSUS AND 34 PERCENT PER ANNUM INCREASE IN POPULATION

Classification	Year 1980					Year 1990			Year 2000		
	Population 1957 Census (Thousands)	Supplied 1969	Population (Thousands)	Water Allocation gph/day	EWD (mgd)	Population (Thousands)	Water Allocation gph/day	EWD (mgd)	Population (Thousands)	Water Allocation gph/day	EWD (mgd)
<b>JOHOR BAHRU AREA</b>											
Urban (a)	89.8	Yes	197.7	50	9.88	278.6	55	15.32	392.6	60	23.56
Rural (b)	22.3	Mostly	49.3	30	1.48	69.0	35	2.42	97.0	40	3.88
Scattered	47.1	No	103.5	10	1.04	146.0	15	2.19	206.0	20	4.12
Industry 20%					12.40			19.93			31.56
					2.48			3.98			6.31
<b>TOTAL EWD (mgd)</b>					<b>14.88</b>			<b>23.91</b>			<b>37.87</b>
<b>KLUANG AREA</b>											
Urban (c)	31.2	Yes	68.6	50	3.43	96.7	55	5.32	136.3	60	8.18
Rural (d)	4.5	Mostly	9.9	30	0.30	14.0	35	0.49	19.7	40	0.79
Scattered	15.5	No	34.2	10	0.34	48.1	15	0.72	67.9	20	1.36
Industry 20%					4.07			6.53			10.33
					0.81			1.31			2.07
<b>TOTAL EWD (mgd)</b>					<b>4.88</b>			<b>7.84</b>			<b>12.40</b>
<b>KOTA TINGGI AREA</b>											
Urban (e)	7.5	Yes	16.5	50	0.83	23.2	55	1.27	32.7	60	1.96
Rural (f)	0.3	Yes	0.7	30	0.02	0.9	35	0.03	1.3	40	0.05
Scattered	9.2	No	20.2	10	0.20	28.5	15	0.42	40.1	20	0.80
Industry 20%					1.05			1.72			2.81
					0.21			0.34			0.56
<b>TOTAL EWD (mgd)</b>					<b>1.26</b>			<b>2.06</b>			<b>3.37</b>
<b>PONTIAN AREA</b>											
Urban (g)	8.5	Yes	18.7	50	0.94	26.4	55	1.45	37.2	60	2.23
Rural (h)	4.3	No	9.5	30	0.28	13.3	35	0.46	18.8	40	0.75
Scattered	79.2	No	174.0	10	1.74	246.0	15	3.69	346.0	20	6.92
Industry 20%					2.96			5.60			9.90
					0.60			1.12			1.98
<b>TOTAL EWD (mgd)</b>					<b>3.56</b>			<b>6.72</b>			<b>11.88</b>

**NOTES:**

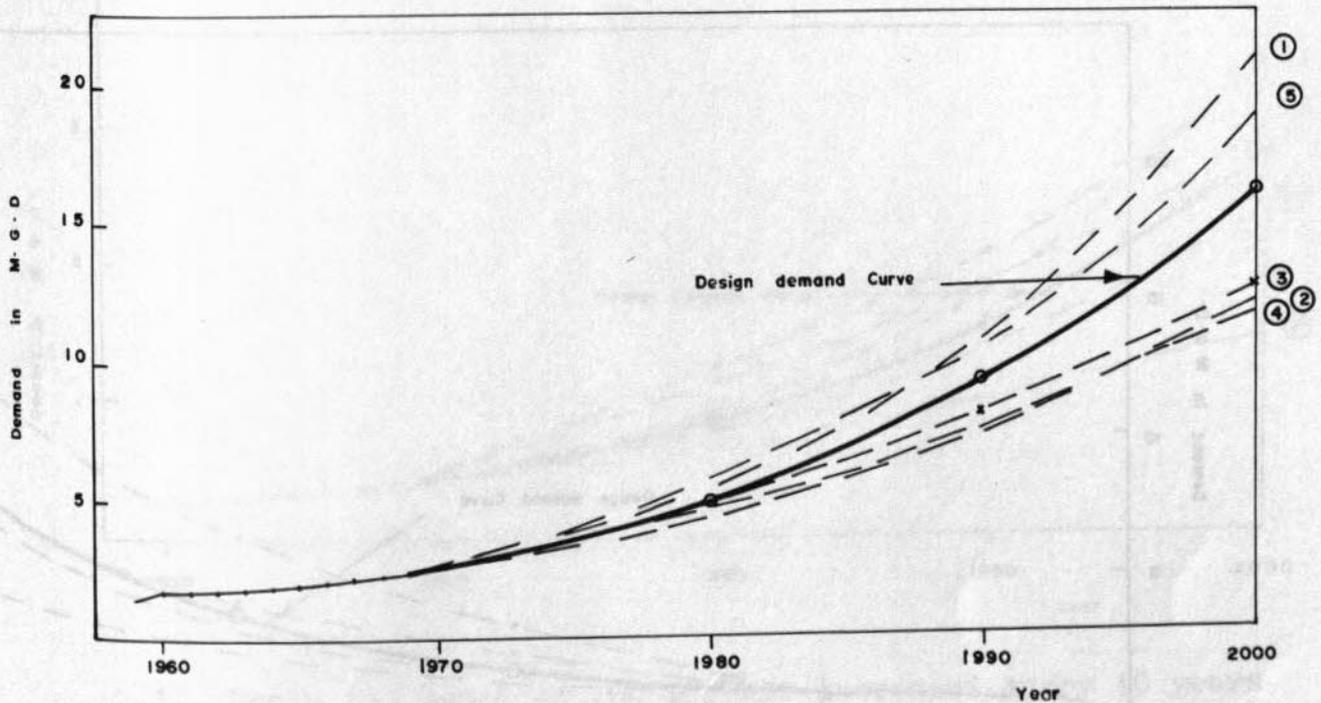
1. (a) Includes Johor Baharu town, Kulai and Pekan Nenas.
  - (b) Includes P. Putah, Masai, Plentong, Ban Foo, Kg. Tebrau, Pandan, Scudai, Lima Kedai, Gelang Patah, Sulong, Sinkang, Saleng, Senai, Ulu Tiram, Kg. Pulau and Ulu Choh.
  - (c) Includes Kluang town.
  - (d) Includes Kg. Gajah, Kg. Paya and Sri Lalang.
  - (e) Includes Kota Tinggi town.
  - (f) Includes Kg. Batu 4.
  - (g) Includes Pontian Kechil.
  - (h) Includes Benut L.C., Ayer Baloi T.C., and Permas, Kechil.
2. EWD denotes Estimated Water Demand.

J K R JOHOR BAHARU SUPPLY  
ESTIMATED FUTURE DEMAND(M·G·D)



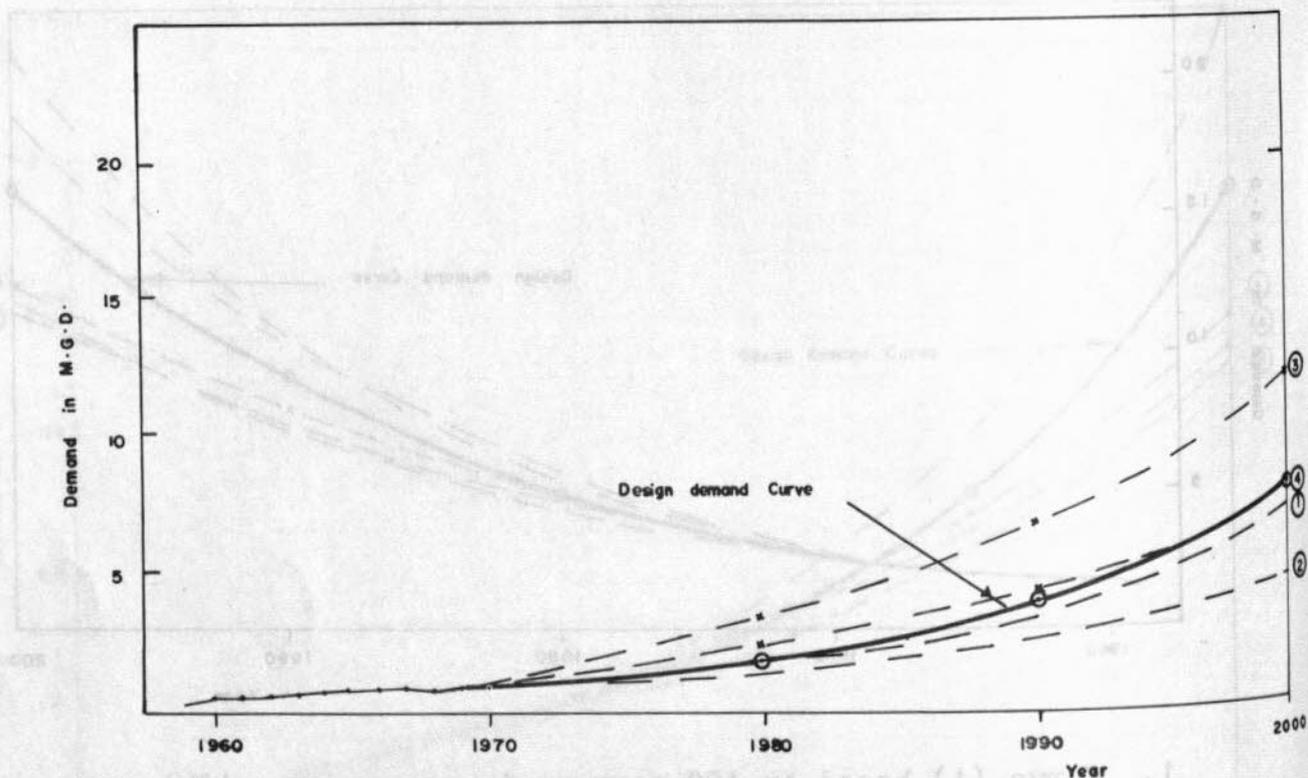
1. Curve (1) based on 100 percent increase every 10 years from 1969 (Appendix B-3)
2. Curve (2) based on 70 percent increase every 10 years from 1969 (Appendix B-3)
3. Curve (3) based on  $3\frac{1}{2}$  percent increase in population from 1957 Census and area of supply extending over District of Johor Baharu (except M. Sedenak) plus Pekan Nenas (District of Pontian). Norminal allowance for industry included and all scattered population is assumed to be supplied. (Appendix B-4)
4. Curve (4) is as Curve (3) but only 50 percent of scattered population is assumed connected.

J K R KLUANG SUPPLY  
ESTIMATED FUTURE DEMAND (M.G.D.)



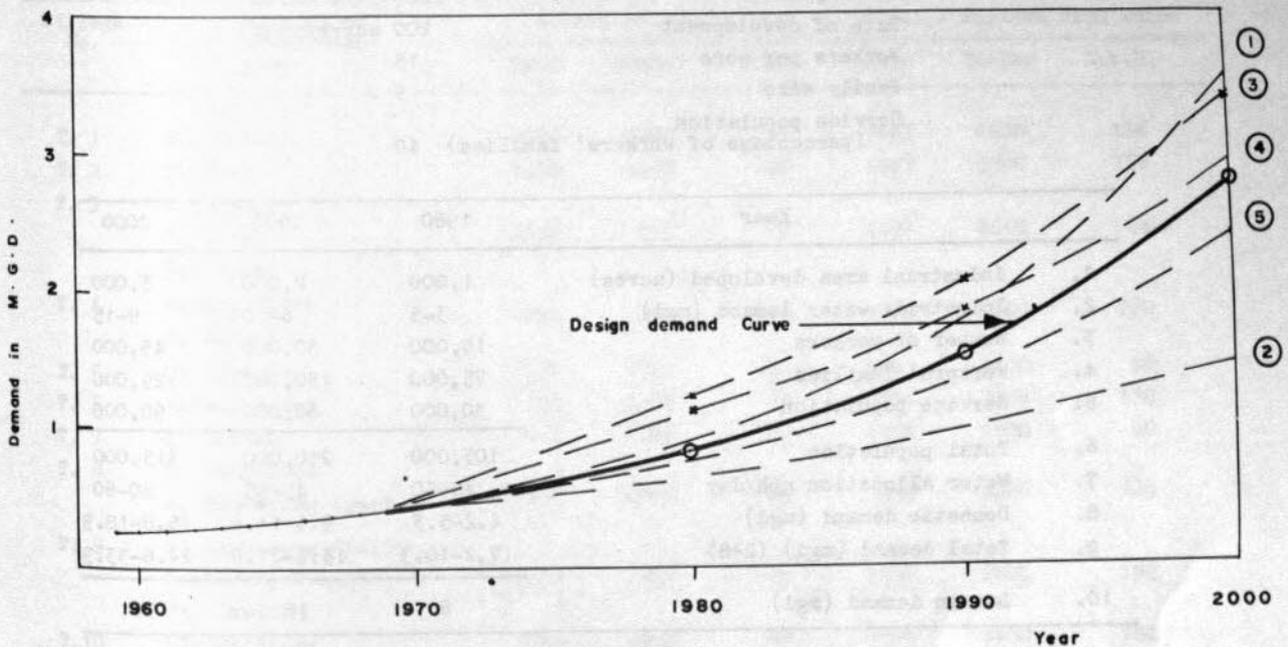
1. Curve (1) based on 100 percent increase every 10 years from 1969 (Appendix B-3)
2. Curve (2) based on 66 percent increase every 10 years from 1969 (Appendix B-3)
3. Curve (3) based on  $3\frac{1}{2}$  percent increase in population from 1957 Census and area of supply extending over the Mukim Kluang. Norminal allowance for industry included and all scattered population is assumed to be supplied (Appendix B-4)
4. Curve (4) is as Curve (3) but only 50 percent of scattered population is assumed connected.
5. Curve (5) based on 5.3 percent increase in population in Kluang Town plus  $3\frac{1}{2}$  percent increase in remainder of Mukim Kluang but only 50 percent of scattered population connected. The 5.3 percent increase is based on estimated population of Kluang town of 61000 in 1970 (given by A.D.O.) and population given in 1957 Census.

**J K R PONTIAN SUPPLY**  
**ESTIMATED FUTURE DEMAND (M.G.D.)**



1. Curve (1) based on 100 percent increase every 10 years from 1969 (Appendix B-3)
2. Curve (2) based on 75 percent increase every 10 years from 1969 (Appendix B-3)
3. Curve (3) based on  $3\frac{1}{2}$  percent increase in population from 1957 Census and area of supply extending over the District of Pontian (except Pekan Nenas), Normal allowance for industry included and all scattered population is assumed to be supplied (Appendix B-4)
4. Curve (4) is as curve (3) but only 50 percent of scattered population is assumed connected.

J K R KOTA TINGGI SUPPLY  
ESTIMATED FUTURE DEMAND (M.G.D.)



1. Curve (1) based on 100 percent increased every 10 years from 1969 (Appendix B-3)
2. Curve (2) based on 50 percent increase every 10 years from 1969 (Appendix B-3)
3. Curve (3) based on  $3\frac{1}{2}$  percent increase in population from 1967 Census and area of supply extending over Mukim Kota Tinggi. Norminal allowance for industry included and all scattered population is assumed to be supplied (Appendix B-4)
4. Curve (4) is as Curve (3) but only 50 percent of scattered population is assumed connected.
5. Curve (5) is based on estimated population of Kota Tinggi town of 8300 in 1970 (given by D.O) and 45 percent increase in population to year 2000. In addition  $3\frac{1}{2}$  percent increase in population in remainder of Mukim Kota Tinggi but only 50 percent of the scattered population connected.

APPENDIX B-9

ESTIMATED FUTURE WATER DEMAND FOR PROJECTED INDUSTRIAL AREA NEAR KG. PASIR GUDANG

Data Provided by State Engineer

Total area to be developed	5000 acres
Factory area	2000-3000 acres
Rate of development	100 acres/year
Workers per acre	15
Family size	5
Service population (percentage of workers' families)	40

	Year	1980	1990	2000
1.	Industrial area developed (acres)	1,000	2,000	3,000
2.	Industrial water demand (mgd)	3-5	6-10	9-15
3.	Number of workers	15,000	30,000	45,000
4.	Workers' families	75,000	150,000	225,000
5.	Service population	30,000	60,000	90,000
6.	Total population	105,000	210,000	315,000
7.	Water allocation gph/day	40-50	45-55	50-60
8.	Domestic demand (mgd)	4.2-5.3	9.4-11.6	15.8-18.9
9.	Total demand (mgd) (2+8)	7.2-10.3	15.4-21.6	24.8-33.9
10.	Design demand (mgd)	8	18	30

**Note:** Range of industrial water demand is based on  
3 mgd/1000 acres (similar to Petaling Jaya, Selangor) and  
5 mgd/1000 acres (similar to Jurong, Singapore).

APPENDIX B-10

ESTIMATED FUTURE WATER DEMANDS FOR TOURIST DEVELOPMENTS

	Description	Water Allocation gph/day	Demand gallons/day
INITIAL DEVELOPMENT	1. 1000 tourist beds	120	120,000
	2. 4000 resident population including service	40	160,000
	Total		280,000
PROBABLE ULTIMATE DEVELOPMENT	1. 40,000 tourist beds	150	6,000,000
	2. 60,000 resident population including service	50	3,000,000
	Total		9,000,000

## APPENDIX B-11

JOHOR TENGAH  
PROJECT VILLAGES

ESTIMATED FUTURE WATER DEMAND

Village No.	Associated Development Area	Influx of Population			Probable Maximum Population		
		Year	Number	E.W.D.	Year	Number	E.W.D.
T. 1	Bt. Jelati	1982	2900	58	1997	4600	184
T. 2	S. Yong	1982	2400	48	1997	3800	152
T. 3	S. Kahang	} 1976	800	16	1991	1600	64
	P. Hijau						
	Kg. Gajah						
T. 4	Kahang Timor	} 1977	2200	44	1992	5500	220
	S. Dengar						
T. 5	Ulu Dengar	1988	1500	30	2003	2400	96
T. 6	Kahang Barat	1976	2000	40	1991	3300	132
T. 7	G. Lambak	1974	1500	30	1974	1500	60
T. 8	S. Mengkibol	} 1982	2000	40	1997	3200	128
	S. Semberong (part)						
T. 9	S. Semberong (part)	} 1980	2500	50	1995	4800	192
	Semberong Tengah						
	Bt. Lawiang						
T.10	Ulu Belitong	1980	2900	58	1995	4600	184
T.11	Semberong Kiri (part)	1986	2000	40	2001	3200	128
T.12	Semberong Kiri (part)	1986	1000	20	2001	1600	64
T.13	Ulu Pengeli	1978	3100	62	1993	4900	196
T.14	Batu Tengkat	1979	2700	54	1994	4300	172
T.15	Ulu Chenas	1979	1500	30	1994	2400	96
T.16	Ulu Sebol	} 1974	3000	60	2000	20000	1000
	Pengeli Kechil						
T.17	Pengeli Timor	1974	3000	60	1989	5100	204
T.18	S. Sebol	1975	1900	38	1990	3200	128
T.19)		1984	1500	30	1999	2400	96
T.20)	S. Jengeli	1985	1500	30	2000	2400	96
T.21)		1986	700	14	2001	1200	48
T.22	Lubok Ajal	1978	2500	50	1993	3900	156
T.23	S. Lebak	1979	2900	58	1994	4600	184
T.24	S. Kachur	1980	1100	22	1995	1800	72
T.25	Sisek	1975	2500	50	1990	4000	160
Total E.W.D.							4,212

**NOTES:**

- T5, T7, T12, T21, T24 and T25 are reserve villages and will probably not be required.
- T4, T9 and T16 are master villages.
- T16 is the nucleus village for the possible new town (Bandar Tengah).
- EWD denotes estimated water demand in thousands of gallons/day.
- Per capita assumption at time of influx of population assumed as 20 gallons/day.
- Per capita consumption at time of maximum population assumed as 40 gallons/day.
- Population and demand build up in T16 (Bandar Tengah) is taken as follows:-

Year	Population	E.W.D.
1974	3000	60
1975	4250	
1980	6250	163
1985	10200	
1990	12900	490
2000	20000	1000

## APPENDIX B-12

TANJONG PENGGERANG  
PROJECT VILLAGES  
ESTIMATED FUTURE WATER DEMAND

Village No.	Associated Development Area	Influx of Population			Probable Maximum Population		
		Year	Number	E.W.D.	Year	Number	E.W.D.
P 1	Kayu Mati	1978	1000	20	1993	1600	64
P 2	Bt. Wah Ha	1977	2600	52	1992	4200	168
P 3	S. Wah Ha	1977	3500	70	1992	5500	220
P 4	Bt. Easter	1980	3000	60	1995	4500	180
P 5	Kr. Lo Heng Timor	1981	3400	68	1996	5400	216
P 6	Kr. Lo Heng Barat	1978	1700	34	1993	2700	108
P 7	Papan Timor	1974	3200	64	1989	5100	204
P 8	S. Papan } Ulu Papan }	1976	700	14	1991	1100	44
P 9	S. Mas	1974	3200	64	1989	5100	204
P10	S. Semenchu	1973	3400	68	1988	5400	216
P11	S. Chemenarah	1976	3300	66	1991	5600	224
P12	Bt. Adela	1975	2500	50	1990	4000	160
P13	S. Marang Besar } Bt. Tuatau }	1977	2100	42	1992	3400	136
P14	Bt Sening	1975	3800	76	1990	6200	248
P15	Bt. Tunggal	1976	1500	30	1991	2400	96
P16	Bt. Kledang	1976	3000	60	1991	4800	192
Total E.W.D.							2,680

NOTES:

1. P1 and P8 are reserve villages and will probably not be required.
2. P3, P11 and P14 are master villages.
3. P11 is the nucleus village for the possible new town.
4. E.W.D. denotes estimated water demand in thousands of gallons/day.
5. Per capita consumption at time of maximum population assumed as 40 gallons/day.



FEDERAL BUREAU OF INVESTIGATION  
 DEPARTMENT OF JUSTICE  
 MEMORANDUM FOR THE DIRECTOR

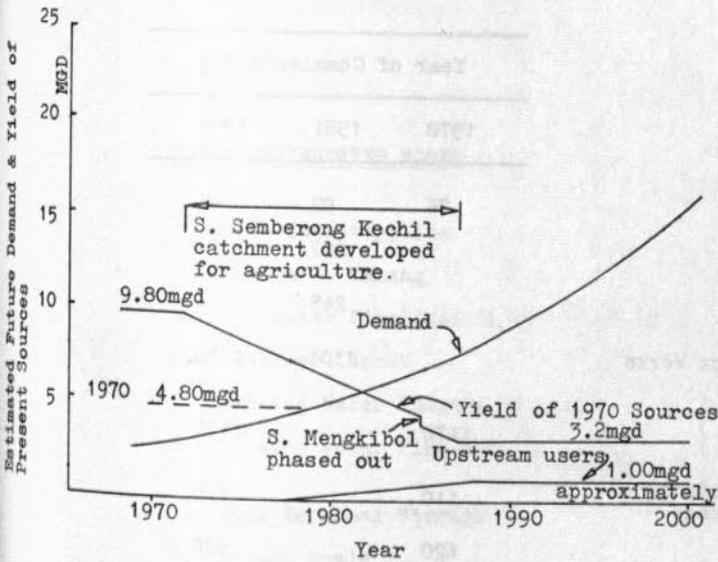
Case No.	Date	Location	Subject	Initials	Remarks
100-10000	1/15/50	Washington, D.C.	John Doe	J.D.	...
100-10001	1/16/50	Washington, D.C.	John Doe	J.D.	...
100-10002	1/17/50	Washington, D.C.	John Doe	J.D.	...
100-10003	1/18/50	Washington, D.C.	John Doe	J.D.	...
100-10004	1/19/50	Washington, D.C.	John Doe	J.D.	...
100-10005	1/20/50	Washington, D.C.	John Doe	J.D.	...
100-10006	1/21/50	Washington, D.C.	John Doe	J.D.	...
100-10007	1/22/50	Washington, D.C.	John Doe	J.D.	...
100-10008	1/23/50	Washington, D.C.	John Doe	J.D.	...
100-10009	1/24/50	Washington, D.C.	John Doe	J.D.	...
100-10010	1/25/50	Washington, D.C.	John Doe	J.D.	...
100-10011	1/26/50	Washington, D.C.	John Doe	J.D.	...
100-10012	1/27/50	Washington, D.C.	John Doe	J.D.	...
100-10013	1/28/50	Washington, D.C.	John Doe	J.D.	...
100-10014	1/29/50	Washington, D.C.	John Doe	J.D.	...
100-10015	1/30/50	Washington, D.C.	John Doe	J.D.	...
100-10016	1/31/50	Washington, D.C.	John Doe	J.D.	...
100-10017	2/1/50	Washington, D.C.	John Doe	J.D.	...
100-10018	2/2/50	Washington, D.C.	John Doe	J.D.	...
100-10019	2/3/50	Washington, D.C.	John Doe	J.D.	...
100-10020	2/4/50	Washington, D.C.	John Doe	J.D.	...
100-10021	2/5/50	Washington, D.C.	John Doe	J.D.	...
100-10022	2/6/50	Washington, D.C.	John Doe	J.D.	...
100-10023	2/7/50	Washington, D.C.	John Doe	J.D.	...
100-10024	2/8/50	Washington, D.C.	John Doe	J.D.	...
100-10025	2/9/50	Washington, D.C.	John Doe	J.D.	...
100-10026	2/10/50	Washington, D.C.	John Doe	J.D.	...
100-10027	2/11/50	Washington, D.C.	John Doe	J.D.	...
100-10028	2/12/50	Washington, D.C.	John Doe	J.D.	...
100-10029	2/13/50	Washington, D.C.	John Doe	J.D.	...
100-10030	2/14/50	Washington, D.C.	John Doe	J.D.	...
100-10031	2/15/50	Washington, D.C.	John Doe	J.D.	...
100-10032	2/16/50	Washington, D.C.	John Doe	J.D.	...
100-10033	2/17/50	Washington, D.C.	John Doe	J.D.	...
100-10034	2/18/50	Washington, D.C.	John Doe	J.D.	...
100-10035	2/19/50	Washington, D.C.	John Doe	J.D.	...
100-10036	2/20/50	Washington, D.C.	John Doe	J.D.	...
100-10037	2/21/50	Washington, D.C.	John Doe	J.D.	...
100-10038	2/22/50	Washington, D.C.	John Doe	J.D.	...
100-10039	2/23/50	Washington, D.C.	John Doe	J.D.	...
100-10040	2/24/50	Washington, D.C.	John Doe	J.D.	...
100-10041	2/25/50	Washington, D.C.	John Doe	J.D.	...
100-10042	2/26/50	Washington, D.C.	John Doe	J.D.	...
100-10043	2/27/50	Washington, D.C.	John Doe	J.D.	...
100-10044	2/28/50	Washington, D.C.	John Doe	J.D.	...
100-10045	2/29/50	Washington, D.C.	John Doe	J.D.	...
100-10046	2/30/50	Washington, D.C.	John Doe	J.D.	...
100-10047	3/1/50	Washington, D.C.	John Doe	J.D.	...
100-10048	3/2/50	Washington, D.C.	John Doe	J.D.	...
100-10049	3/3/50	Washington, D.C.	John Doe	J.D.	...
100-10050	3/4/50	Washington, D.C.	John Doe	J.D.	...

Approved: \_\_\_\_\_  
 Special Agent in Charge



APPENDIX C-1

KLUANG WATER SUPPLY AREA  
PHASING OF ALTERNATIVES



Common to all Alternatives	
6mgd	3mg
1991	1991
6mgd	3mg
1978	1978
4mgd S.S. Kechil	0.8mgd Mengkibol
Treatment Wks + treated water P.S. + pipeline to T. Storage	Bulk Terminal storage (12 hours)

Alternative 1		Alternative 2		Alternative 3A				Alternative 3B			Alternative 4			
Intake on S. Semberong-Bandau		Reservoir on S. Kahang + direct supply by pumping to treatment Wks		Reservoir on S. Kahang + transfer by pumping into S. Semberong Kechil Catchment.				Reservoir on S. Kahang + transfer by tunnel into S. Semberong Kechil Catchment			Reservoir in S. Semberong Kechil Catchment			
6mgd	13.8 mgd	13.8 mgd	6mgd	6mgd	13.8 mgd	6mgd	12mgd	13.8 mgd	6mgd	12mgd	13.8 mgd	6mgd	12mgd	
1991			1991	1991		1991			1991			1991		
7.8mgd			7.8mgd	7.8mgd		6mgd			6mgd			6mgd		
1981	1981	1981	1981	1981	1981		1978	1978	1981	1978	1978	1981	1978	1978
Raw Water pumps + pipeline to T. Wks	Intake Raw Water P.S.	Dam	R. Water pumps + pipeline to T. Wks	R. Water pumps + pipeline to S. S. Kechil Catchment	Dam + R. Water P.S. on S. Kahang	R. Water pumps + pipeline on S.S. Kechil to T. Wks	Intake+ R.W. P.S. on S.S. Kechil	Dam + Tunnel	R. Water pumps + pipeline on S.S. Kechil to T. Wks	Intake+ R.W. P.S. on S. S. Kechil	Dam	R. Water pumps + pipeline on S.S. Kechil to T. Wks	Intake+ R.W. P.S. on S.S. Kechil	

## APPENDIX C-2

KLUANG WATER SUPPLY AREAPROGRAMME OF CAPITAL EXPENDITURE  
(All Costs in Thousand Dollars)INTAKE ON S. SEMBERONG - ENDAU  
(Alternative 1)CIVIL ENGINEERING WORK

	Year of Commissioning		
	1978	1981	1991
1. Site Investigation	76	92	-
2. Intake on S. Semberong - Endau		207	
3. Raw Water Pumping Station (S. Semberong - Endau)		245	
4. Raw Water Pipelines to Treatment Works		2304	1760
5. Treatment Works	1170		1170
6. Treated Water Pumping Station			
7. Treated Water Pipelines to Terminal Storage	110		110
8. Bulk Terminal Storage	620		620
9. Access Road		96	
	1976	2944	3660
Add 10% contingencies	197	294	366
	2173	3238	4026
Add 8% engineering	174	259	322
Sub-total (1)	2347	3497	4348

PLANT AND EQUIPMENT

1. Intake Equipment (S. Semberong - Endau)		70	
2. Raw Water Pumping Equipment (S. Semberong - Endau)		263	265
3. Treated Water Pumping Equipment	222		222
4. Treatment Works Plant	800		800
	1022	333	1287
Add 5% contingencies	51	17	64
	1073	350	1327
Add 8% engineering	86	28	106
Sub-total (2)	1159	378	1433
TOTAL (1) + (2)	3506	3875	5781

KLUANG WATER SUPPLY AREAPROGRAMME OF CAPITAL EXPENDITURE

(All Costs in Thousand Dollars)

STORAGE ON S. KAHANG - DIRECTSUPPLY TO TREATMENT WORKS

(Alternative 2)

	Year of Commissioning		
	1978	1981	1991
<u>CIVIL ENGINEERING WORKS</u>			
1. Site Investigation	76	250	-
2. Dam on S. Kahang	-	2560	-
3. Raw Water Pipelines to Treatment Works	-	2325	2023
4. Treatment Works	1170	-	1170
5. Treated Water Pumping Station			
6. Treated Water Pipelines to Terminal Storage	110	-	110
7. Bulk Terminal Storage	620	-	620
8. Access Roads		444	-
	1976	5579	3923
Add 10% contingencies	198	558	392
	2174	6137	4315
Add 8% engineering	174	491	345
Sub-total (1)	2348	6628	4660
<u>PLANT AND EQUIPMENT</u>			
1. Raw Water Pumping Equipment (S. Kahang)	-	209	199
2. Treated Water Pumping Equipment	222		222
3. Treatment Works Plant	800		800
	1022	209	1221
Add 5% contingencies	51	10	66
	1073	219	1287
Add 8% engineering	86	18	103
Sub-total (2)	1159	237	1390
TOTAL (1) + (2)	3507	6865	6050

## APPENDIX C-4

KLUANG WATER SUPPLY AREAPROGRAMME OF CAPITAL EXPENDITURE  
(All Costs in Thousand Dollars)REGULATORY STORAGE ON S. KAHANG  
- WATER TRANSFER BY PUMPING  
(Alternative 3A)

	Year of Commissioning		
	1978	1981	1991
<u>CIVIL ENGINEERING WORK</u>			
1. Site Investigation	93	165	-
2. Intake on S. Semberong Kechil	180		-
3. Raw Water Pumping Station (S. Semberong Kechil)	227		-
4. Raw Water Pipelines to Treatment Works	227		227
5. Treatment Works	1170		1170
6. Treated Water Pumping Station			
7. Treated Water Pipelines to Terminal Storage	110		110
8. Bulk Terminal Storage	620		620
9. Dam on S. Kahang		2350	
10. Raw Water Pipelines from S. Kahang to S. Semberong Kechil Catchment		403	352
11. Access Roads		444	
	2627	3362	2479
Add 10% contingencies	263	336	248
	2890	3698	2727
Add 8% engineering	232	296	218
Sub-total (1)	3122	3994	2945
<u>PLANT AND EQUIPMENT</u>			
1. Intake Equipment (S. Semberong Kechil)	60		
2. Raw Water Pumping Equipment (S. Semberong Kechil)	100		100
3. Treated Water Pumping Equipment	222		222
4. Treatment Works Plant	800		800
5. Raw Water Pumping Equipment (S. Kahang)		200	191
	1182	200	1313
Add 5% contingencies	59	10	66
	1241	210	1379
Add 8% engineering	99	17	110
Sub-total (2)	1340	227	1489
TOTAL (1) + (2)	4462	4221	4434

APPENDIX C-5

KLUANG WATER SUPPLY AREA

PROGRAMME OF CAPITAL EXPENDITURE  
(All Costs in Thousand Dollars)

REGULATORY STORAGE ON S. KAHANG  
WATER TRANSFER BY TUNNEL  
(Alternative 3B)

	Year of Commissioning		
	1978	1981	1991
<b><u>CIVIL ENGINEERING WORKS</u></b>			
1. Site Investigation	93	438	
2. Intake on S. Semberong Kechil	180		
3. Raw Water Pumping Station (S. Semberong Kechil)	227		
4. Raw Water Pipeline to Treatment Works	227		227
5. Treatment Works	1170		1170
6. Treated Water Pumping Station			
7. Treated Water Pipeline to Terminal Storage	110		110
8. Bulk Terminal Storage	620		620
9. Dam in S. Kahang		2350	
10. Tunnel from S. Kahang to S. Semberong Kechil catchment		4800	
11. Access Roads		444	
	2627	8032	2127
Add 10% contingencies	263	803	213
	2890	8835	2340
Add 8% contingencies	232	707	187
Sub-total (1)	3122	9542	2527
<b><u>PLANT AND EQUIPMENT</u></b>			
1. Intake Equipment (S. Semberong Kechil)	60		
2. Raw Water Pumping Equipment (S. Semberong Kechil)	100		100
3. Treated Water Pumping Equipment	222		222
4. Treatment Works Plant	800		800
5. Tunnel Control Gates		20	
	1182	20	1122
Add 5% contingencies	59	1	56
	1241	21	1178
Add 8% engineering	99	2	94
Sub-total (2)	1340	23	1272
TOTAL (1) + (2)	4462	9565	3799

KLUANG WATER SUPPLY AREAPROGRAMME OF CAPITAL EXPENDITURE  
(All Costs in Thousand Dollars)REGULATORY STORAGE ON S. SEMBERONG  
KIRI. (Alternative 4)

	Year of Commissioning		
	1978	1981	1991
<u>CIVIL ENGINEERING WORK</u>			
1. Site Investigation	93	276	
2. Intake (S. Semberong Kechil)	180		
3. Raw Water Pumping Station (S. Semberong Kechil)	227		
4. Raw Water Pipeline to Treatment Works	227		227
5. Treatment Works	1170		1170
6. Treated Water Pumping Station			
7. Treated Water Pipelines to Terminal Storage	110		110
8. Bulk Terminal Storage	620		620
9. Dam on. S. Semberong Kiri		4600	
10. Access Road		120	
	2627	4996	2127
Add 10% contingencies	263	500	213
	2890	5496	2340
Add 8% engineering	231	440	187
Sub-total (1)	3121	5936	2527
<u>PLANT AND EQUIPMENT</u>			
1. Intake Equipment (S. Semberong Kechil)	60		
2. Raw Water Pumping Equipment (S. Semberong Kechil)	100		100
3. Treated Water Pumping Equipment	222		222
4. Treatment Works Plant	800		800
	1182		1122
Add 5% contingencies	59		56
	1241		1178
Add 8% engineering	99		94
Sub-total (2)	1340		1272
TOTAL (1) + (2)	4461	5936	3799

ECONOMIC COMPARISON OF ALTERNATIVES

KLUANG WATER SUPPLY AREA

(All Costs in Thousand Dollars)

Year	Alternative 1		Alternative 2		Alternative 3A		Alternative 3B		Alternative 4	
	Capital Invested	Operating Costs								
1972										
73										
74										
1975	3506		3507		4462		4462		4461	
76										
77										
78										
79	3875		6865		4221		9565		5936	
1980		53		53		60		60		60
81		61		61		69		69		69
82		95		95		100		97		95
83		117		112		113		110		107
84		153		134		128		123		121
1985		195		164		148		140		138
86		322		266		238		223		221
87		351		288		256		241		239
88		381		313		279		260		258
89		418		343		306		285		284
1990		443		361		321		300		297
91	5781		6050		4434		3799		3799	
92		476		387		343		320		319
93		507		419		365		341		340
94		603		474		423		393		392
1995		644		506		450		418		417
96		687		537		477		445		443
97		734		573		509		475		474
98		783		610		541		506		504
99		831		645		573		536		534
2000		885		689		610		571		569
		940		730		646		605		603
		995		772		674		640		638
Present value of	5%	12060	5%	13557	5%	11446	5%	14797	5%	12199
Total Costs from	10%	7121	10%	8422	10%	7283	10%	9828	10%	7958
1972 to 2000 at	15%	4723	15%	5750	15%	5105	15%	7024	15%	5632
Annual discount										
Rates of .....										

DAM ON S. KAHANG

LOCATION: 1" Map No. 124  
Grid Reference WM. 625,516

CATCHMENT AREA: 24.4 square miles

TECHNICAL DATA:

Assumed stream bank level (MSL)	115			
Dam height (feet): Crest level (MSL)	45:160	35:150	30:145	25:140
Maximum depth of water (feet): Conservation level (MSL)	35:150	25:140	20:135	15:130
Reservoir area (acres)	1000	650	500	350
Estimated storage (million gallons)	4200	2000	1100	600
Adopted Crest width (feet)	20			
Adopted embankment slopes	1 in 4			
Estimated crest length (feet)	1340	1240	1180	1080
Bulk excavation (cubic yards x 1000)	84	60	48	36
Embankment fill above O.G.L. (cubic yards x 1000)	267	148	110	70

ESTIMATED CAPITAL COST

	Million Dollars			
1. Reservoir clearance	0.24	0.16	0.13	0.10
2. Excavation and embankment	1.91	1.22	0.93	0.65
3. Spillway and diversion	1.25	1.20	1.15	1.10
4. Cut off and grouting	0.50	0.40	0.35	0.30
	3.90	2.98	2.56	2.15
5. Site investigation	0.23	0.18	0.15	0.13
6. Access to site	0.44	0.44	0.44	0.44
	4.57	3.60	3.16	2.72
Contingencies 10%	0.46	0.36	0.32	0.27
	5.03	3.96	3.48	2.99
Engineering 8%	0.40	0.32	0.28	0.24
<b>TOTAL Million Dollars</b>	<b>5.43</b>	<b>4.28</b>	<b>3.76</b>	<b>3.23</b>

NOTES:

1. Stream bank level and reservoir areas estimated from existing 1" maps.
2. Excavation and embankment fill estimated from site survey by clinometer.
3. Site visited by engineering geologist.

DAM ON S. SEMBERONG KIRI

LOCATION: 1" Map No. 124  
Grid Reference WM. 608.417

CATCHMENT AREA: 18.3 square miles

Assumed stream bank level (MSL)

120

Dam height (feet): Crest level (MSL)

35:155 25:145

Maximum depth of water (feet): Conservation level (MSL)

25:145 15:135

Reservoir area (acres)

1000 600

Estimated storage (million gallons)

3200 1000

Adopted crest width (feet)

20

Adopted embankment slopes

1 in 4

Estimated crest length (feet)

3400 3100

Bulk excavation (cubic yards x 1000)

200 139

Embankment fill above O.G.L. (cubic yards x 1000)

596 318

ESTIMATED CAPITAL COST

Million Dollars

1. Reservoir clearance

0.24 0.16

2. Excavation and embankment

4.40 2.55

3. Spillway and diversion

1.10 1.05

4. Cut off and grouting

0.90 0.80

5. Site investigation

6.64 4.56

6. Access to site

0.40 0.27

7. Contingencies 10%

0.12 0.12

8. Engineering 8%

7.16 4.95

0.72 0.50

7.88 5.45

0.63 0.44

8.51 5.89

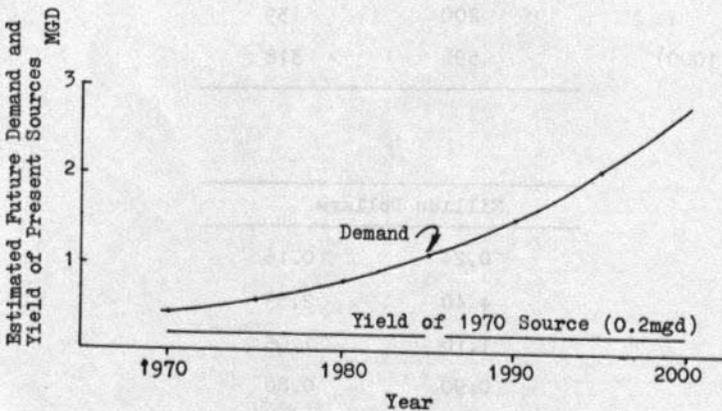
TOTAL Million Dollars

NOTE:

1. Stream bank level and reservoir areas estimated from existing 1" maps.
2. Excavation and embankment fill estimated from survey by clinometer.
3. Dam site has not been visited by engineering geologist.

APPENDIX C-10

KOTA TINGGI WATER SUPPLY AREA  
PHASING OF ALTERNATIVES



<u>Alternative 1</u> Intake on S. Johor		
2.6mgd	1.3mgd	1.3mgd
	1990	1990
	1.3mgd	.65mgd
		1981
		.65mgd
1972	1972	1972
Intake	Raw Water pumping station (Civil)	Treatment Wks + pipelines + pumps + terminal storage

<u>Alternative 2</u> Dam on S. Pelelah			
2.6mgd	1.15mgd	1.15mgd	
	1990	1990	1.84 mgd
	.65mgd	.65mgd	
	1983	1983	1983
		.65mgd	
		1972	
1972			
Dam	Treatment Works	Terminal Storage	Pipe-lines

KOTA TINGGI WATER SUPPLY AREAPROGRAMME OF CAPITAL EXPENDITURE  
(All Costs in Thousand Dollars)INTAKE ON S. JOHOR  
(Alternative 1)

	Year of Commissioning		
	1972	1981	1990
<u>CIVIL ENGINEERING WORK</u>			
1. Site Investigation	41	-	-
2. Intake	39	-	-
3. Raw Water Pumping Station (S. Johor)	40	-	40
4. Raw Water Pipelines to Treatment Works	9	9	11
5. Treatment Works	220	220	360
6. Treated Water Pumping Station }			
7. Treated Water Pipelines	90	90	105
8. Bulk Terminal Storage	208	208	330
9. Access Road	84		
Add 10% contingencies	731	527	846
	73	53	85
Add 8% engineering	804	580	931
	64	46	74
Sub-total (1)	868	626	1005
<u>PLANT AND EQUIPMENT</u>			
1. Intake Equipment	13		
2. Raw Water Pumping Equipment	39	39	64
3. Treated Water Pumping Equipment	55	55	90
4. Treatment Works Plant	115	115	220
Add 5% contingencies	222	209	374
	11	10	19
Add 8% engineering	233	219	393
	11	18	31
Sub-total (2)	244	237	424
TOTAL (1) + (2)	1112	863	1429

KOTA TINGGI WATER SUPPLYPROGRAMME OF CAPITAL EXPENDITURE  
(All Costs in Thousand Dollars)RESERVOIR ON S. PELEPAH  
(Alternative 2)

	Year of Commissioning		
	1972	1983	1990
<u>CIVIL ENGINEERING WORK</u>			
1. Site Investigation	170	16	
2. Raw Water Pipeline to Treatment Works		663	-
3. Treatment Works (no sedimentation)		80	100
4. Treated Water Pipelines to Terminal Storage		3	-
5. Bulk Terminal Storage	208	208	300
6. Dam on S. Pelepah	2520		
7. Access road	300		
Add 10% contingencies	3198	970	400
	320	97	40
Add 8% engineering	3518	1067	440
	281	87	35
Sub-total (1)	3799	1154	475
<u>PLANT AND EQUIPMENT</u>			
1. Treatment Works Plant (no sedimentation)		100	175
Add 5% contingencies		100	175
		5	9
Add 8% engineering		105	184
		8	15
Sub-total (2)	-	113	199
TOTAL (1) + (2)	3799	1267	674

ECONOMIC COMPARISON OF ALTERNATIVESKOTA TINGGI WATER SUPPLY

(All costs in Thousand Dollars)

Year	Alternative 1		Alternative 2	
	Capital Invested	Additional Operating Costs	Capital Invested	Additional Operating Costs
1972	1112		3799	
73				
74				
1975		45		
76		58		6
77		60		6
78		61		6
79	863	63		6
1980		65		6
81		73	1267	6
82		75		6
83		78		9
84		80		10
1985		82		10
86		85		11
87		88		11
88	1429	91	674	12
89		94		12
1990		106		17
91		111		18
92		116		19
93		120		20
94		125		21
1995		130		22
96		135		23
97		141		24
98		146		25
99		152		26
2000		157		27
Present Value of total costs from 1972 to 2000 at annual discount rate of .....	5%	3509	5%	5069
	10%	2453	10%	4551
	15%	1939	15%	4269

DAM ON S. PELEPAH

LOCATION: 1" Map 126  
Grid Reference WN. 089.220

CATCHMENT AREA: 2.8 square miles

TECHNICAL AREA:

Assumed Stream bank level (MSL)	380
Dam height (feet): Crest level (MSL)	70/450
Maximum depth of water (feet): Conservation Level (MSL)	60/440
Reservoir area (acres)	26
Estimated Storage (million gallons)	200
Adopted crest width (feet)	20
Adopted embankment slopes	1 in 4
Estimated crest length (feet)	710
Bulk excavation (cubic yards x 1000)	52
Embankment fill above O.G.L. (cubic yards x 1000)	262

CAPITAL COST

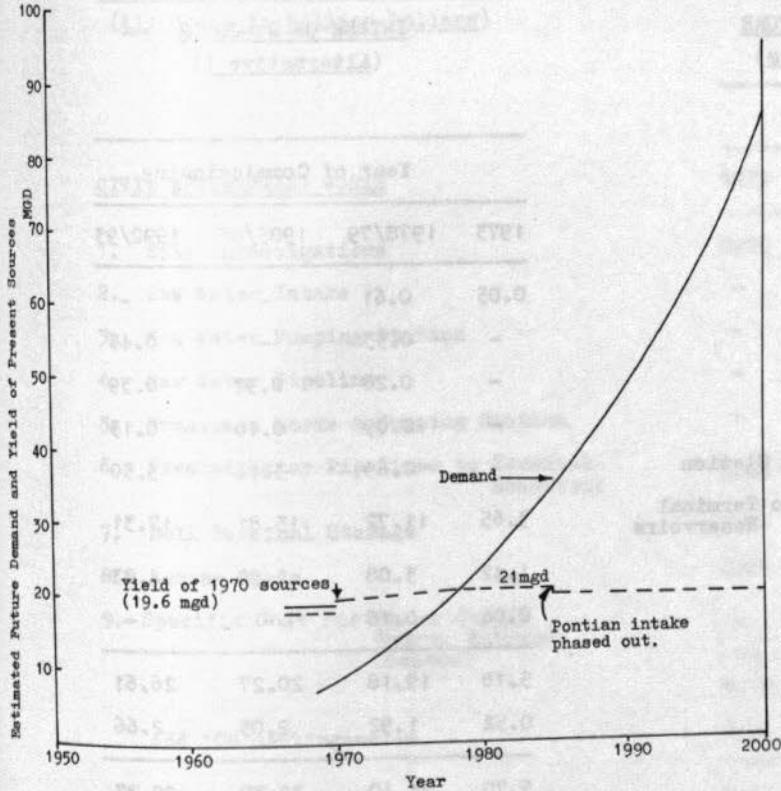
	Million Dollars
1. Reservoir clearance	0.01
2. Excavation and embankment	1.71
3. Spillway and diversion	0.60
4. Cut off and grouting	0.20
	2.52
5. Site investigation	0.15
6. Access to site	0.30
	2.97
7. Contingencies 10%	0.30
	3.27
8. Engineering 8%	0.26
<b>TOTAL Million Dollars</b>	<b>3.53</b>

NOTE:

1. Stream bank level and reservoir area estimated from existing 1" maps.
2. Excavation and embankment fill estimated from survey by clinometer.
3. Dam site has not been visited by engineering geologist.

**JOHOR BAHRU, PONTIAN, INDUSTRIAL AREA  
AND PORT WATER SUPPLY AREA**

**PHASING OF ALTERNATIVES**



FLOW DIAGRAM

Demand mgd				Total Sources + Demands Mgd		Phase
To-tal	Port	J. Bahru	PUB-20	New Sources-65	New - 30 Sources	
85	8	30	47	PUB-20 Pontian Port 7 JB 5 Port 8 JB 42 Port 23	Port 9.1 JB 20.9	
1992/93						
55	4.8	21.9	29.3	PUB-20 Pontian Port 7 JB 2.2 JB 2.1 Port 3.9	New - 35 Sources Port 7.6 JB 12.4	
1985/86						
35	2.9	13.3	16.8	PUB-20 Pontian Port 7 JB 10.1 JB 8.7 Port 6.3	New - 15 Sources Port 6.3 JB 8.7	
1978/79						
21	1.8	7.0	12.2	Pontian Intake-1 PUB-20 Pontian 1.8 JB 12.2 Port 7.0	Pipeline from PUB mains to port capacity 7mgd	

NS - New Source

Alternative 1

Intake on S. Johor

200			
30 mgd S. Johor		30 mgd	30 mgd
1992/93		1992/93	1992/93
20 mgd S. Johor		35 mgd	20 mgd
1985/86			1985/86
15 mgd S. Johor			15 mgd
1978/79		1978/79	1978/79
1mgd Pontian (8 mgd 1961) 2 mgd 1962) Agreements	7 mgd pipeline PUB mains to Port Area		
	1973		
	Intake + water pipelines + terminal Storage 'D'	Intake + Intake equipment	Raw + treated water pumping stations, pumps, pipelines, treatment Works + Equipment, Terminal storage

Alternative 2

Reservoir on S. Tebrau and intake on S. Johor

30 mgd S. Johor		30 mgd S. Johor	30 mgd S. Johor
1992/93		1992/93	1992/93
20 mgd Tebrau Reservoir		35 mgd Tebrau reservoir	20 mgd Tebrau reservoir
1985/86			1985/86
15 mgd Tebrau reservoir			15 mgd Tebrau reservoir
1978/79		1978/79	1978/79
1 mgd Pontian (8 mgd 1961) 2 mgd 1962) Agreements	7 mgd pipeline PUB mains to Port Area	1975 Commission date for barrage 1975 Water available 1978 to allow for improvement in quality	
	1973		
Treated water pipelines + terminal storage D	Barrage + Pollution Control	Intakes + Intake equipment	Raw + treated water pumping stations, pumps pipelines. Treatment Works + equipment. Terminal storage.

JOHOR BAHRU, PONTIAN, INDUSTRIAL AREA AND PORT COMPLEX,  
WATER SUPPLY AREA

PROGRAMME OF CAPITAL EXPENDITURE  
(All Costs in Million Dollars)

INTAKE ON S. JOHOR  
(Alternative 1)

	Year of Commissioning			
	1973	1978/79	1985/86	1992/93
<u>CIVIL ENGINEERING WORK</u>				
1. Site Investigations	0.05	0.61	-	-
2. Water Intake	-	0.53	-	0.45
3. Raw Water Pumping Station	-	0.28	0.32	0.39
4. Raw Water Pipeline	-	0.09	0.10	0.13
5. Treatment Works & Pumping Station	-	2.69	3.14	3.50
6. Treated Water Pipelines to Terminal Reservoirs	3.65	11.72	13.81	17.31
7. Bulk Terminal Storage	1.42	3.08	2.90	4.83
8. Access Roads	0.06	0.18	-	-
	5.18	19.18	20.27	26.61
Add 10% contingencies	0.52	1.92	2.03	2.66
	5.70	21.10	22.30	29.27
Add 8% engineering	0.46	1.69	1.78	2.34
Sub-total (1)	6.16	22.79	24.08	31.61
<u>PLANT AND EQUIPMENT</u>				
1. Intake Equipment	-	0.18	-	0.15
2. Raw Water Pumping Equipment	-	0.49	0.47	0.59
3. Treatment Works Plant	-	1.72	1.91	2.00
4. Treated Water Pumping Equipment	-	0.36	0.39	0.44
		2.75	2.77	3.18
Add 5% contingencies		0.14	0.14	0.16
		2.89	2.91	3.34
Add 8% engineering		0.23	0.23	0.27
Sub-total (2)		3.12	3.14	3.61
TOTAL (1) + (2)	6.16	25.91	27.22	35.22

APPENDIX C-17

JOHOR BAHRU, PONTIAN, INDUSTRIAL AREA AND PORT COMPLEX

WATER SUPPLY AREA

PROGRAMME OF CAPITAL EXPENDITURE  
(All Costs in Million Dollars)

BARRAGE ON S. TEBRAU AND  
INTAKE ON S. JOHOR  
(Alternative 2)

	Year of Commissioning				
	1973	1975	1978/79	1985/86	1992/93
<u>CIVIL ENGINEERING WORKS</u>					
1. Site Investigations	0.05		0.34		0.27
2. Raw Water Intake	-		0.05	-	0.45
3. Raw Water Pumping Station	-		0.34	0.38	0.39
4. Raw Water Pipeline	-		0.13	0.15	0.13
5. Treatment Works & Pumping Station	-		2.96	3.45	3.50
6. Treated Water Pipelines to Terminal Reservoir	3.65		5.94	6.49	17.31
7. Bulk Terminal Storage	1.42		2.44	2.25	4.83
8. Access Roads	0.06		0.41	-	0.18
9. Specific Cost for Water Supply (Tebrau Barrage Scheme)	-	1.03 <sup>+</sup>	-	-	-
	5.18	1.03	12.61	12.72	27.06
Add 10% contingencies	0.52	0.10	1.26	1.27	2.71
	5.70	1.13	13.87	13.99	29.77
Add 8% engineering	0.46	0.09	1.11	1.12	2.38
	6.16	1.22	14.98	15.11	32.15
Sub-total (1)					
<u>PLANT EQUIPMENT</u>					
1. Allow for Intake Equipment	-		0.05	-	0.15
2. Raw Water Pumping Equipment			0.46	0.29	0.80
3. Treatment Works Plant			1.72	1.91	2.00
4. Treated Water Pumping Equipment			0.47	0.55	0.44
			2.70	2.75	3.39
Add 5% contingencies			0.14	0.14	0.17
			2.84	2.89	3.56
Add 8% engineering			0.23	0.23	0.28
			3.07	3.12	3.84
Sub-total (2)					
TOTAL (1) + (2)	6.16	1.22	18.05	18.23	35.99

<sup>+</sup> See Feasibility Report by Binnie and Partners (Malaysia)  
Specific Cost to Water Supply \$Millions

1. Site clearance of reservoir 0.37
2. Effluent canal 0.66

Total

\$ 1.03 millions

APPENDIX C - 18

ECONOMIC COMPARISON OF ALTERNATIVES

JOHOR BAHRU, PONTIAN, INDUSTRIAL AREA

PLUS PORT SUPPLY AREA

(All Costs in Million Dollars)

Year	Alternative 1		Alternative 2	
	Capital Invested	Operating Costs	Capital Invested	Operating Costs
72	6.16		7.38 <sup>+</sup>	
73		0.01		0.01
74		0.01		0.01
1975		0.01		0.01
76	25.91	0.01	18.05	0.01
77		0.01		0.01
78		0.01		0.01
79		0.21		0.20
1980		0.30		0.27
81		0.43		0.39
82		0.55		0.49
83	27.22	0.67	18.23	0.59
84		0.81		0.72
1985		0.94		0.82
86		1.17		1.05
87		1.30		1.18
88		1.47		1.33
89		1.58		1.44
1990	35.22	1.75	35.99	1.59
91		1.90		1.72
92		2.05		1.86
93		2.34		2.16
94		2.51		2.34
1995		2.71		2.52
96		2.93		2.77
97		3.15		2.97
98		3.39		3.24
99		3.64		3.43
2000		3.90		3.72
Present Value of total costs from 1972 to 2000 at Annual discount rates of .....	5%	72.55	5%	61.24
	10%	45.72	10%	38.07
	15%	32.43	15%	27.03

- +
- 1. Phase 1 pipelines 6.16
  - 2. Specific cost to Water Supply of Tebrau Barrage scheme 1.22
- 
- 7.38

SELECTION OF PIPELINE ROUTE FROM S. JOHOR TO  
TERMINAL STORAGE (point C) AND LOCATION OF INTAKE

Possible pipeline routes from the S. Johor to Johor Baharu are largely dictated by the presence of the military firing range, situated north-west of Ulu Tiram. It would be imprudent to lay a major pipeline in this area which is subject to firing hazard and possibly littered with ammunition. The pipeline route would therefore have to be located west of the firing range or pass through the eastern edge of it, keeping as close as possible to the main Johor Baharu/Kota Tinggi road. The latter is the route of the PUB pipeline in this area. This restriction on pipeline routes in turn dictates the economic location of intakes on the S. Johor. For the western route the shortest pipeline length is given by locating the intake near Kg. Semangar just downstream of the confluence of the S. Johor and S. Semangar. For the eastern route the shortest pipeline length is given by locating the intake near the existing PUB intake.

Under this study no detailed survey of these routes has been carried out. For the economic analysis we have adopted the western route, with the intake at Kg. Semangar, for the following reasons:-

- a) The pipeline length is marginally shorter.
- b) The pumping lead (and hence pumping costs) would be slightly less as Kg. Semangar is about 7-8 miles upstream of the PUB intake.
- c) With the present state of development, land acquisition costs and compensation for damage to plantations would likely be less. However this condition could alter in time as further land development takes place.
- d) The intake would be less liable to be subject to saline intrusion, unless independent measures were taken to prevent saline intrusion at the PUB intake.

An important consideration in the selection of pipeline route is ease of access for construction and subsequent maintenance. In this respect the eastern route would be preferable as it would never be further than 2/3 miles from the main Johor Baharu/Kota Tinggi road. With the present state of land development access to the western route is restricted over several miles; however this can be expected to improve as further land development takes place.

It is considered essential therefore that for future studies it would be necessary to survey both pipeline routes in order to evaluate items (a) to (c) in more detail together with the possible relative economies due to detailed pipeline design. An economic comparison of these factors could then be made with ease of access for each route nearer the time of construction.

APPENDIX C-20  
PROJECT VILLAGES T1-T6

ECONOMIC COMPARISON OF SEPARATE AND  
GROUP WATER SUPPLY SCHEMES

TABLE 1  
Year of Implementation and Maximum Demands

Village	Year of Implementation	Maximum Demand Mgd		
		Domestic	Factories	Total
T1	1982	.184	-	.184
T2	1982	.152	-	.152
T3	1976	.064	-	.064
T4	1977	.220	.300 <sup>+</sup>	.520
T5	1988	.096	-	.096
T6	1976	.132	-	.132
Total				1.148 mgd

<sup>+</sup>Palm oil mill

TABLE 2  
Separate Village Schemes

PROGRAMME OF CAPITAL EXPENDITURE  
(All costs in thousand dollars)

	Year of Commissioning					
	1976		1977	1982		1988
	T3	T6	T4	T1	T2	T5
<u>Civil Engineering Work</u>						
1. Site investigation	4	5	11	6	6	5
2. Intake	5	5	15	5	5	5
3. Raw water pumping station	5	6	18	8	7	7
4. Raw water pipelines	5	5	8	5	5	5
5. Treatment works and treated water pumping station	45	70	190	85	75	55
6. Treated water pipelines	55	55	80	55	55	55
7. Terminal storage	30	65	185	85	75	50
8. Access roads	60	60	60	60	60	60
10% contingencies	209	271	567	309	288	242
	21	27	57	31	29	24
8% engineering	230	298	624	340	317	266
	18	24	50	27	25	21
Total (1)	248	322	674	367	342	287
<u>Plant and Equipment</u>						
1. Intake equipment	2	2	3	2	2	2
2. Raw water pumping equipment	10	14	25	16	15	12
3. Treated water pumping equipment	20	28	65	36	32	25
4. Treatment plant	16	24	90	33	28	18
5% contingencies	48	68	183	87	77	57
	3	3	9	2	2	2
8% engineering	51	71	192	89	79	59
	4	6	15	7	6	5
Total (2)	55	77	207	96	85	64
Total (1) + (2)	303	399	881	463	427	351

TABLE 3

Economic Comparison of Alternatives  
(All costs in thousand dollars)

Year	INDIVIDUAL VILLAGE SCHEMES							GROUP SCHEME			
	Capital Invested	Operating Costs						Total Costs	Capital Invested	Operating Costs	Total Costs
		T1	T2	T3	T4	T5	T6				
1972		-	-	-	-	-	-			-	
73		-	-	-	-	-	-			-	
74	702	-	-	-	-	-	-	702	1,021	-	1,021
75	881	-	-	-	-	-	-	881	482	-	482
76		-	-	11	-	-	12	23		14	14
77		-	-	11	12	-	12	35		22	22
78		-	-	11	12	-	12	35		26	26
79		-	-	11	12	-	12	35		33	33
1980	890	-	-	11	13	-	12	36	926	36	755
81		-	-	18	13	-	19	50		41	41
82		12	12	18	20	-	19	81		54	54
83		12	12	18	20	-	19	81		56	56
84		13	12	18	21	-	20	84	154	59	213
85		13	12	18	21	-	20	84		66	66
86	350	13	13	25	22	-	27	100	450	71	463
87		20	20	25	30	-	27	122		75	75
88		21	20	25	30	11	28	135		81	81
89		21	20	25	31	11	28	136		83	83
1990		21	21	26	31	11	29	139		87	87
91		22	21	26	32	11	30	142		89	89
92		29	28	26	33	12	30	158		91	91
93		30	29	26	33	18	30	166		93	93
94		30	29	26	33	18	30	166		95	95
95		31	30	26	33	18	30	168		98	98
96		31	30	26	33	19	30	169		100	100
97		32	30	26	33	19	30	170		102	102
98		32	30	26	33	27	30	178		104	104
99		32	30	26	33	27	30	178		105	105
2000		32	30	26	33	27	30	178		107	107
Present value of							5%	3.67	5%	3.16	
Total costs from 1974							10%	2.76	10%	2.49	
to 2000 at annual							15%	2.28	15%	2.12	
discount rates of											

At all discount rates the Group scheme is more attractive than individual schemes.

## NOTES:-

1. Table 1 is based on Appendices B-11 and B-13
2. Capital costs for separate village schemes assume that each village would have its own intake treatment works, terminal storage and that the average distance from the intakes to the villages is 2 miles.
3. For capital cost of group scheme see Appendix C-21.
4. Operating costs based on Appendix C-28.
5. The figures given for present value take into account all capital costs of construction and site investigations, and annual operation i.e. power for pumping, labour, chemicals and annual maintenance up to the perimeter of the village. Land acquisition, costs, compensation costs and the cost of the reticulation system within the village are excluded.

## APPENDIX C-21

JOHOR TENGAH - VILLAGE GROUP T1-T6PROGRAMME OF CAPITAL EXPENDITUREINTAKE ON S. KAHANG

(All costs in Thousand Dollars)

	Year of Commissioning				
	1976	1977	1982	1986	1988
<u>Civil Engineering Work</u>					
1. Site investigation	18	5	9	-	3
2. Intake	20				
3. Raw water pumping station	35				
4. Raw water pipelines	35				
5. Treatment Works and treated water pumping station	130		130		130
6. Treated water pipelines	284(a)	162(b)	275(c)	-	50(d)
7. Terminal storage	50(e)	95(f)	130(g)	130(h)	80(i)
8. Access roads	120		40		
	698	262	584	130	263
10% contingencies	69	26	8	13	26
	761	288	592	143	289
8% engineering	61	23	47	11	23
Total(1)	822	311	639	154	312
<u>Plant and Equipment</u>					
1. Intake equipment	5				
2. Raw water pumping equipment	50				
3. Treated water pumping equipment	50(a)	150(b)			
4. Treatment plant	70		70		70
	175	150	70	-	70
5% contingencies	9	8	4		4
	184	158	74	-	74
8% engineering	15	13	6	-	6
Total (2)	199	171	80	-	80
Total(1) & (2)	1021	482	719	154	392

Notes:-

- a) Treatment Works to T3 and T6
- b) Treatment works to T4
- c) From terminal storage commanding T4 and T5 to T1 and T2
- d) From terminal storage commanding T4 and T5 to T5
- e) 98000 gallons commanding T3 and T6
- f) 210,000 gallons commanding T4 and T5
- g) (i) 168000 gallons commanding T1 and T2  
(ii) Expansion of (e) to 196,000 gallons
- h) Expansion of (f) to 516,000 gallons
- i) Expansion of g(i) to 336,000 gallons.

JOHOR TENGAH - VILLAGE GROUP T7-T12PROGRAMME OF CAPITAL EXPENDITUREINTAKE ON S, SEMBRONG KECIL

(All costs in thousand dollars)

	Year of Commissioning					
	1974	1980	1982	1986	1990	2000
<u>Civil Engineering Work</u>						
1. Site investigation	4	40	1	14	4	1
2. Intake	2	30				
3. Run water pumping station	5 <sup>+</sup>	50				
4. Run water pipelines	11 <sup>+</sup>	40				
5. Treatment Works and treated water pumping station		270		270		
6. Treated water pipelines	39(a)	1085(b)	18(c)	303(d)		
7. Booster stations		40(e)		8(f)		
8. Terminal storage	15(g)	220(h)	50(1)	120(j)	210(k)	35(1)
9. Access roads	120	60				
	196	1835	69	715	214	36
10% contingencies	20	184	7	72	21	4
	216	2019	76	787	235	40
8% engineering	17	161	6	63	19	3
Total(1)	233	2180	82	850	254	43
<u>Plant and Equipment</u>						
1. Intake equipment		8				
2. Raw water pumping equipment	15 <sup>+</sup>	65				
3. Treated water pumping equipment		130				
4. Treatment plant		140		140		
5. Booster pumps		130		15		
	15	473	-	165		
5% contingencies	1	24	-	8		
	16	497		173		
8% engineering	1	40		14		
Total(2)	17	537		187		
Total(1) & (2)	250	2717	82	1037	254	43

NOTES:-

- a) Treatment works to T7.
- b) Treatment works to T9 and T10.
- c) From terminal storage to T8.
- d) From terminal storage commanding T9 to T11 and T12.
- e) On line to T9, T10, T11 and T12.
- f) One line to T11 and T12.
- g) 30,000 gallons commanding T7.
- h) (i) 64,000 gallons commanding T8.  
(ii) 136,000 gallons commanding T9.  
(iii) 272,000 gallons commanding T10.
- i) Expansion of (g) to 130,000 gallons.
- j) (i) 96,000 gallons commanding T11 and T12.  
(ii) Expansion of h(i) to 128,000 gallons.  
(iii) Expansion of h(iii) to 360,000 gallons.
- k) (i) Expansion of (i) to 200,000 gallons.  
(ii) Expansion of h(ii) to 460,000 gallons.  
(iii) Expansion of j(i) to 192,000 gallons.
- l) Expansion of k(ii) to 540,000 gallons.

+ Denotes cost of temporary supplies to reserve village T7.

PROGRAMME OF CAPITAL EXPENDITURE

(All costs in Thousand Dollars)

INTAKE ON S. PENGELI

	Year of Commissioning				
	1974	1978	1980	1984	1990
<u>Civil Engineering Work</u>					
1. Site investigation	36	12	-	15	
2. Intake	40				
3. Raw water pumping station	87				
4. Raw water pipelines	52				
5. Treatment works and treated water pumping station	400			400	
6. Treated water pipelines	371(a)	491(b)	-	345(c)	-
7. Terminal storage	320(d)	105(e)	75(f)	425(g)	115(h)
8. Access roads	120	60	-	-	-
	1426	668	75	1385	115
10% contingencies	143	67	7	139	12
	1569	735	82	1524	127
8% engineering	125	59	6	122	10
Total(1)	1694	794	88	1646	137
<u>Plant and Equipment</u>					
1. Intake equipment	10				
2. Raw water pumping equipment	120				
3. Treated water pumping equipment	215(a)	105(b)	-	120(c)	-
4. Treatment plant	240			240	
	585	105	-	360	-
5% contingencies	30	5	-	18	-
	615	110	-	378	-
8% engineering	49	9	-	30	-
Total(2)	664	119	-	408	-
Total(1) & (2)	2358	913	88	2054	137

NOTES:-

- a) Treatment works to T16, T17 and T18.
- b) Treatment works to T13, T14 and T15.
- c) Treatment works to T19, T20, T21.
- d) (i) 820,000 gallons commanding T16.  
(ii) 166,000 gallons commanding T17 and T18.
- e) (i) 48,000 gallons commanding T15.  
(ii) 84,000 gallons commanding T13 and T14.
- f) Expansion of d(ii) to 332,000 gallons.
- g) (i) 220,000 gallons commanding T19, T20 and T21.  
(ii) Expansion of d(i) to 1,500,000 gallons.  
(iii) Expansion of e(i) to 96,000 gallons.  
(iv) Expansion of e(ii) to 368,000 gallons.
- h) Expansion of g(i) to 484,000 gallons.

JOHOR TENGAH - VILLAGE GROUP T22-T24PROGRAMME OF CAPITAL EXPENDITUREINTAKE ON S. JOHOR

(All costs in Thousand Dollars)

	Year of Commissioning				
	1978	1979	1980	1984	1986
<u>Civil Engineering Work</u>					
1. Site investigation	12	2	2		
2. Intake	10				
3. Raw water pumping station	15				
4. Raw water pipelines	8				
5. Treatment works and treated water pumping station	100			100	
6. Treated water pipelines	184(a)	33(b)	78(c)		
7. Terminal storage	80(d)	20(e)		80(f)	20(g)
8. Access roads	80	40			
	489	95	80	180	20
10% contingencies	49	10	8	18	2
	538	105	88	198	22
8% engineering	43	8	7	16	2
Total(1)	581	113	95	214	24
<u>Plant and Equipment</u>					
1. Intake equipment	4				
2. Raw water pumping equipment	35				
3. Treated water pumping equipment	75	25			
4. Treatment plant	40			40	
	154	25		40	
5% contingencies	8	2		2	
	162	27		42	
8% engineering	13	2		2	
Total(2)	175	29	-	44	-
Total(1) & (2)	756	142	95	258	24

NOTES:-

- a) Treatment works to T22
- b) From terminal storage commanding T22 and T23, to T23
- c) Treatment works to T24.
- d) 170,000 gallons commanding T22 and T23.
- e) 36,000 gallons commanding T24.
- f) Expansion of (d) to 340,000 gallons.
- g) Expansion of (e) to 72,000 gallons.

## APPENDIX C-25

JOHOR TENGAH - VILLAGE T25PROGRAMME OF CAPITAL EXPENDITURE  
(All Costs in Thousand Dollars)EXPANSION OF PROPOSED NEW SOURCE  
ON S. JOHOR FOR KOTA TINGGIYear of CommissioningCIVIL ENGINEERING WORK1975

1. Site Investigation	5
2. Intake	-
3. Extension Raw Water Pumping Station	8
4. Raw Water Pipeline	2
5. Treatment Works and Treated Water Pumping Station	40
6. Treated Water Pipeline	138
7. Terminal Storage	75
8. Access Road	24
	<hr/>
	292
10% Contingencies	29
	<hr/>
	321
8% Engineering	26
	<hr/>
TOTAL (1)	347
	<hr/>

PLANT AND EQUIPMENT

1. Intake Equipment	-
2. Raw Water Pumping Equipment	15
3. Treated Water Pumping Equipment	35
4. Treatment Plant	30
	<hr/>
5% Contingencies	80
	4
	<hr/>
	84
8% Engineering	7
	<hr/>
TOTAL (2)	91
	<hr/>
TOTAL (1) + (2)	438
	<hr/>

## APPENDIX G-26

## TANJONG PENGGERANG - VILLAGE GROUP P1-P6

## PROGRAMME OF CAPITAL EXPENDITURE

## INTAKE ON S. SEDILI KECHIL

(All costs in Thousand Dollars)

Civil Engineering Work	Year of Commissioning					
	1977	1978	1980	1981	1984	1986
1. Site investigation	24	7	2	-	-	-
2. Intake	20					
3. Raw water pumping station	40					
4. Raw water pipelines	14					
5. Treatment Works & treated water pumping station	250				160	
6. Treated water pipelines	423(a)	189(b)	104(c)	12(d)		
7. Booster station		10(e)				
8. Terminal storage	195(f)	140(g)	-	-	130(h)	55(i)
9. Access road.	120					
	1088	346	106	12	290	55
10% contingencies	109	35	11	1	30	5
	1197	381	117	13	320	60
8% engineering	96	31	9	1	26	5
Total(1)	1293	412	126	14	346	65
<b>Plant and Equipment</b>						
1. Intake equipment	5					
2. Raw water pumping equipment	65					
3. Treated water pumping equipment	50(a)	170(b)				
4. Treatment plant	140				70	
5. Booster pumping equipment		20				
	260	190			70	
5% contingencies	13	10			4	
	273	200			74	
8% engineering	22	16			6	
Total(2)	295	216	-	-	80	-
Total(1) & (2)	1588	628	126	14	426	65

## NOTES:-

- a) Treatment Works to P2 and P3
- b) Treatment Works to P6, from terminal storage commanding P2 to P1.
- c) From terminal storage commanding P3 and P4, to P4
- d) From terminal storage to P5.
- e) On line to P6.
- f) (i) 400,000 gallons commanding P3 and P4.  
(ii) 84,000 gallons commanding P2.
- g) (i) 32,000 gallons commanding P1.  
(ii) 108,000 gallons commanding P5.  
(iii) 54,000 gallons commanding P6.
- h) (i) Expansion of f(ii) to 168,000 gallons.  
(ii) Expansion of g(i) to 64,000 gallons.  
(iii) Expansion of g(iii) to 108,000 gallons.
- i) Expansion of g(ii) to 216,000 gallons.

## APPENDIX C-27

TANJONG PENGGERANG - VILLAGE GROUP P7-P16  
plus Initial Tourist Development

INTAKE AND DAM ON S. LEBAM

## PROGRAMME OF CAPITAL EXPENDITURE

(All costs in Thousand Dollars)

	Year of Commissioning						
	1974	1975	1976	1977	1980	1983	1992
<b>Civil Engineering Work</b>							
1. Site investigation	40	23	7	153	6	4	
2. Intake	40						
3. Raw water pumping station	80						
4. Raw water pipelines	52						
5. Treatment works and treated water pumping station	400				400		
6. Treated water pipelines	712(a)	667(b)	294(c)	160(d)			
7. Booster stations	16(e)	45(f)	10(g)				
8. Terminal storage	155(h)	378(i)	20(j)		320(k)	190(l)	100(m)
9. Access roads	80	80	20	120			
10. Dam on S. Lebam				2410			
	1575	1193	351	2843	726	194	100
10% contingencies	158	120	35	284	73	19	10
	1733	1313	386	3127	799	213	110
8% engineering	139	105	31	254	64	17	8
Total(1)	1872	1418	417	3381	863	230	118
<b>Plant and Equipment</b>							
1. Intake equipment	10						
2. Raw water pumping equipment	120						
3. Treated water pumping equipment	75	210					
4. Treatment plant	250				250		
5. Booster pumps	55	100	15				
	510	310	15		250		
5% contingencies	26	16	1		13		
	536	326	16		263		
8% engineering	43	26	2		21		
Total(2)	579	352	18		284		
Total (1) & (2)	2451	1770	435	3381	1147	230	118

## NOTES:-

- a) Treatment works to P7, P9 and P10.
- b) Treatment works to P12, P14 and initial tourist development.
- c) From terminal storage to P8, from terminal storage to P11, from terminal storage to P16, from terminal storage commanding P14 and P16 to P15.
- d) From terminal storage to P13.
- e) On line to P7, P8 and P10.
- f) (i) On line to P14 and P16.  
(ii) On line to P13 and initial tourist development.
- g) On line to P15.
- h) (i) 102,000 gallons commanding P9.  
(ii) 232,000 gallons commanding P7, P8 and P10.
- i) (i) 80,000 gallons commanding P12.  
(ii) 328,000 gallons commanding P14 and P16.  
(iii) 58,000 gallons commanding P11.  
(iv) 366,000 gallons commanding P13 and initial tourist development.
- j) 48000 gallons commanding P15.
- k) (i) Expansion of h(i) to 204,000 gallons.  
(ii) Expansion of h(ii) to 464,000 gallons.  
(iii) Expansion of i(i) to 160,000 gallons.  
(iv) Expansion of i(ii) to 616,000 gallons.
- l) (i) Expansion of (j) to 96,000 gallons  
(ii) Expansion of l(ii) to 406,000 gallons.  
(iii) Expansion of l(iv) to 432,000 gallons.
- m) Expansion of l(ii) to 626,000 gallons.

APPENDIX G-28

PROJECT AREA - VILLAGE WATER SUPPLIES

Annual Operating Costs At Maximum Demand

JOHOR TENGAH TANJONG PENGGERANG

	T1-T6	T7-T12	T13-T21	T22-T24	T25	P1-P6	P7-P16
1. Fuel for power	37.6	56.0	83.5	16.3	4.8	46.3	79.2
2. Chemicals	23.0	31.0	63.0	9.0	3.5	25.4	59.5
3. Labour	36.0	51.0	36.0	21.6	-	43.5	66.0
4. Civil Maintenance	1.9	3.0	3.7	0.9	0.3	1.9	7.0
5. Equipment Maintenance	9.3	13.0	21.0	4.4	1.6	10.4	22.0
<b>Total \$ x 1000</b>	<b>107.8</b>	<b>154.0</b>	<b>207.2</b>	<b>52.3</b>	<b>10.2</b>	<b>127.5</b>	<b>233.7</b>
Average Maximum Demand mgd.	1.05	1.41	2.78	0.41	0.16	1.16	2.72
Cost per 1000 gallons cents	28.0	30.0	20.4	35.0	17.7	30.0	23.5

BASIS OF COSTS

1. Fuel for power 5 cents per WHP hour.
2. Chemicals 6 cents per 1000 gallons
3. Labour
  - a) Treatment Works and Main Pumping Stations
    - Up to 0.5 mgd. \$600/month/shift.
    - 0.5 - 1.0 mgd. \$750/month/shift.
    - 1.0 - 5.0 mgd. \$1000/month/shift.
  - b) Booster Stations \$200/month/shift.
4. Civil Maintenance 0.1 percent capital cost.
5. Equipment Maintenance 2.0 percent capital cost.

DAM ON S. LEBAM

LOCATION: 1" Map No. 132  
Grid Reference WS 540.873

CATCHMENT AREA: 8.2 square miles

TECHNICAL DATA:

Assumed stream bank level (MSL)	15		
Dam height (feet): Crest level (MSL)	45:60	35:50	25:40
Maximum depth of water (feet): Conservation level (MSL)	35:50	25:40	15:30
Reservoir area (acres)	1000	600	300
Estimated Storage (million gallons)	3700	1500	450
Adopted crest width (feet)	20		
Adopted embankment slopes	1 in 4		
Estimated crest length (feet)	1520	1400	1220
Bulk excavation (cubic yards x 1000)	119	91	74
Embankment fill above O.G.L. (cubic yards x 1000)	447	280	161

ESTIMATED CAPITAL COST

	Million Dollars		
1. Reservoir clearance	0.24	0.16	0.08
2. Excavation and embankment	3.39	2.23	1.43
3. Spillway and diversion	0.70	0.65	0.60
4. Cut off and grouting	0.50	0.40	0.30
	4.83	3.44	2.41
5. Site investigation	0.29	0.21	0.15
6. Access to site	0.12	0.12	0.12
	5.24	3.77	2.68
7. Contingencies 10%	0.52	0.38	0.27
	5.76	4.15	2.95
8. Engineering 8%	0.46	0.33	0.24
	6.22	4.48	3.19
TOTAL Million Dollars	6.22	4.48	3.19

NOTE:

1. Stream bank level, reservoir areas, excavation and embankment fill estimated from existing 1 inch and 1 in 25000 maps.
2. Dam site has not been surveyed or visited by engineering geologist.

ESTIMATED CAPITAL AND ANNUAL OPERATING COSTS FOR A  
SPRAY IRRIGATION SCHEME OF 80 ACRES OF OIL PALM NURSERY

CAPITAL COST

1. Intake, pumphouse and pumps	\$ 15,000
2. Main pipeline from pumphouse to nursery	10,000
3. Spraylines, fittings and main pipeline in nursery	25,000
	<hr/>
	\$ 50,000
10% Engineering	5,000
	<hr/>
	\$ 55,000

Capital Cost/Acre = \$690

ANNUAL OPERATING COST

1. Labour	\$ 25,000
2. Fuel and oil	8,000
3. Maintenance (3% Capital Cost)	1,500
	<hr/>
	\$ 34,500
4. Dismantling and setting up in New Areas	5,500
	<hr/>
	\$ 40,000

Annual Operating Cost/Acre = \$500

ESTIMATED NUMBER OF DAYS WHEN ABSTRACTION AT INDICATED FLOW WOULD NOT BE FULLY PRACTICAL DUE TO THE EFFECT OF: SALINE INTRUSION, CHANGES IN CATCHMENT COVER and UPSTREAM ABSTRACTIONS BY JOHOR STATE. (Based on Water Year 1964/65)

Figure 1. SALINE INTRUSION

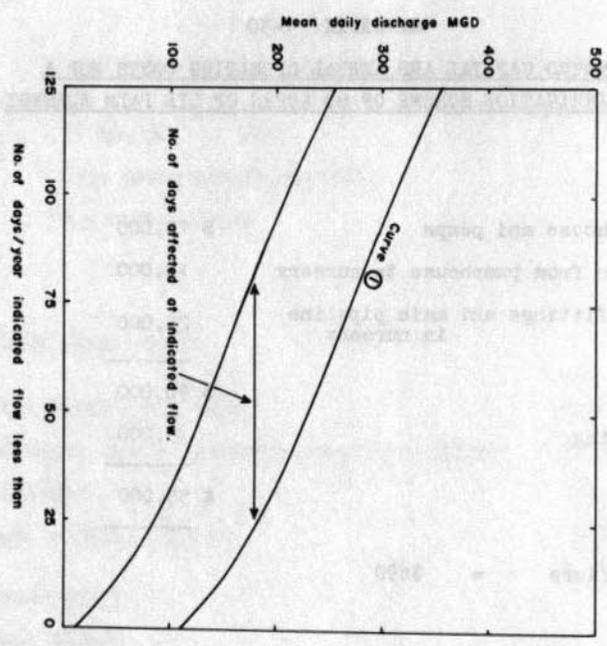


Figure 2. CHANGES in CATCHMENT COVER

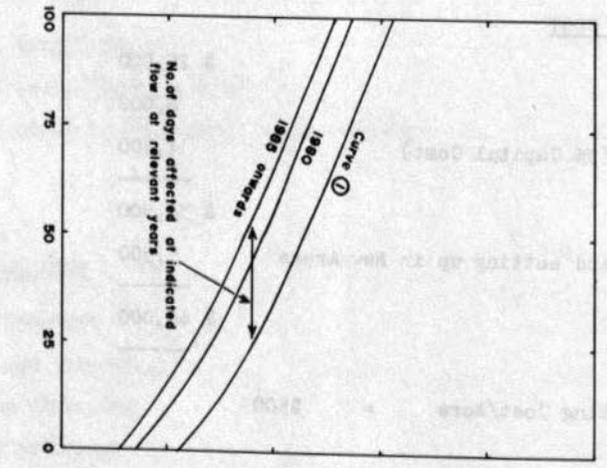
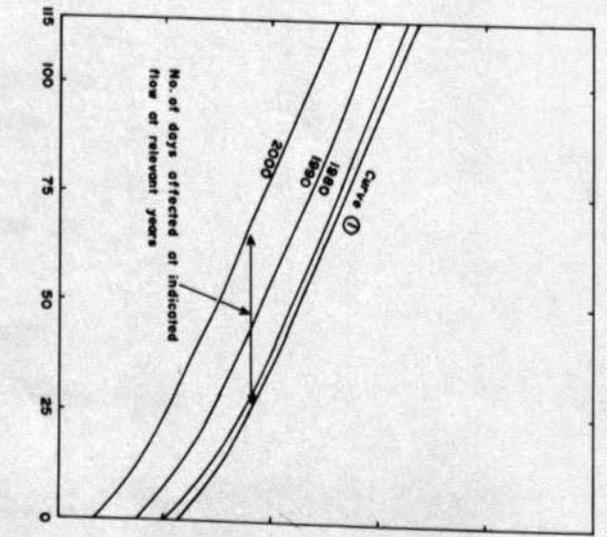


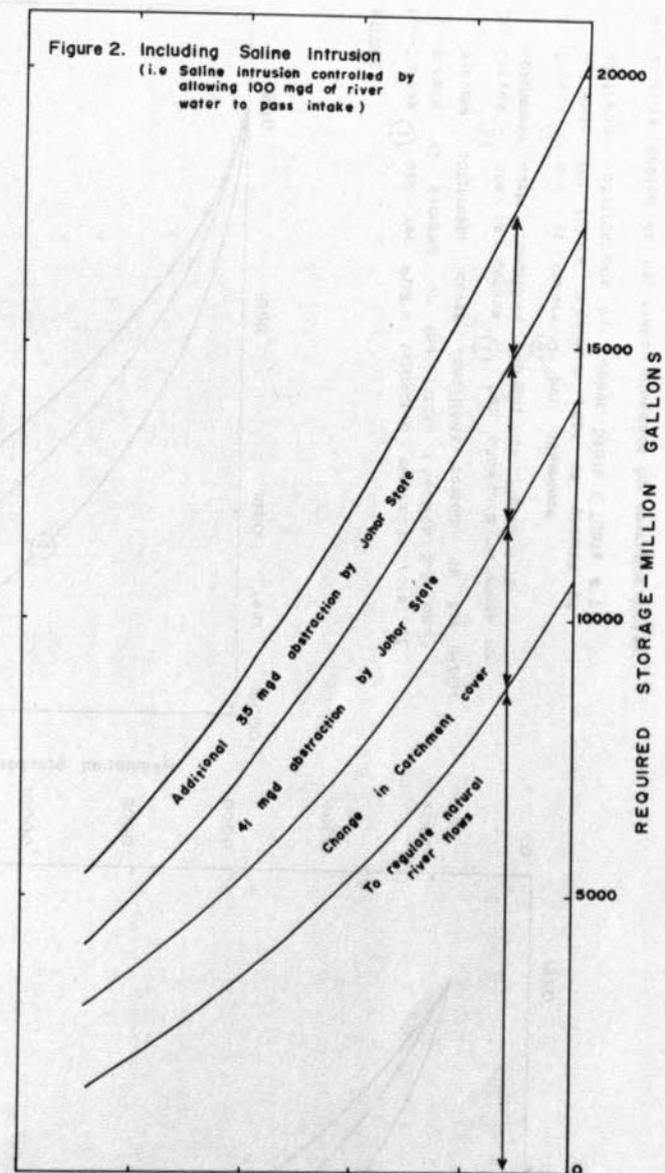
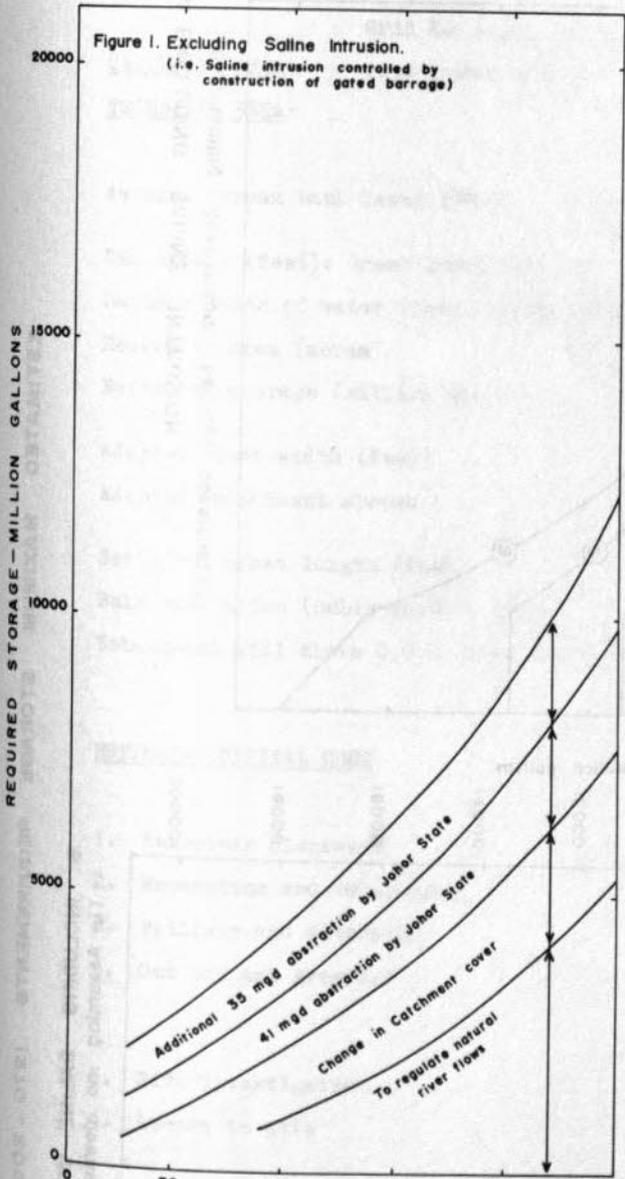
Figure 3. ABSTRACTIONS by JOHOR STATE



- NOTES:
1. Curve ① is part of the natural River Flow Duration Curve for 1964/65 (See Figure 4.11)
  2. The effects of saline intrusion will only be felt during part of the high tide.

ALTERNATIVE STORAGE REQUIREMENTS FOR RANGE OF PUB

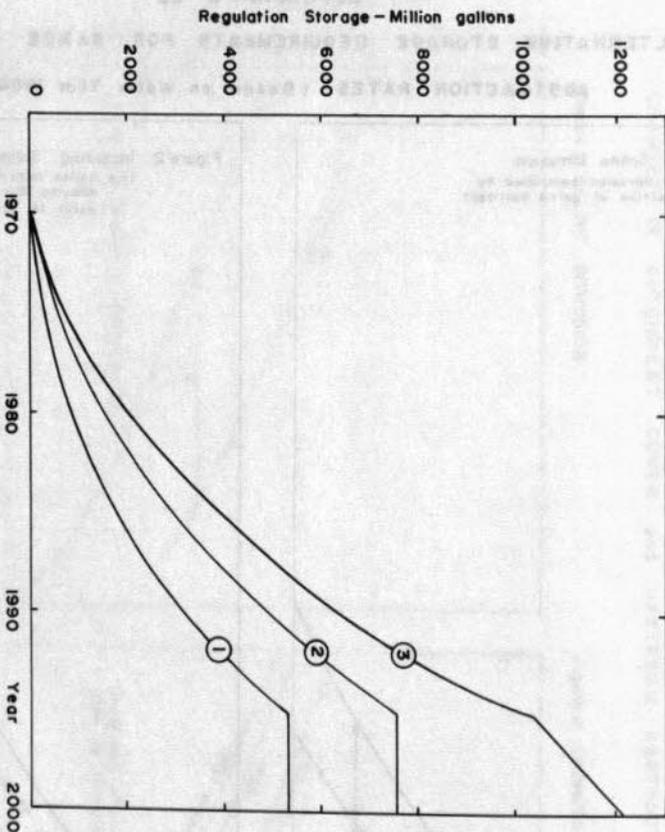
ABSTRACTION RATES (Based on Water Year 1964/65)



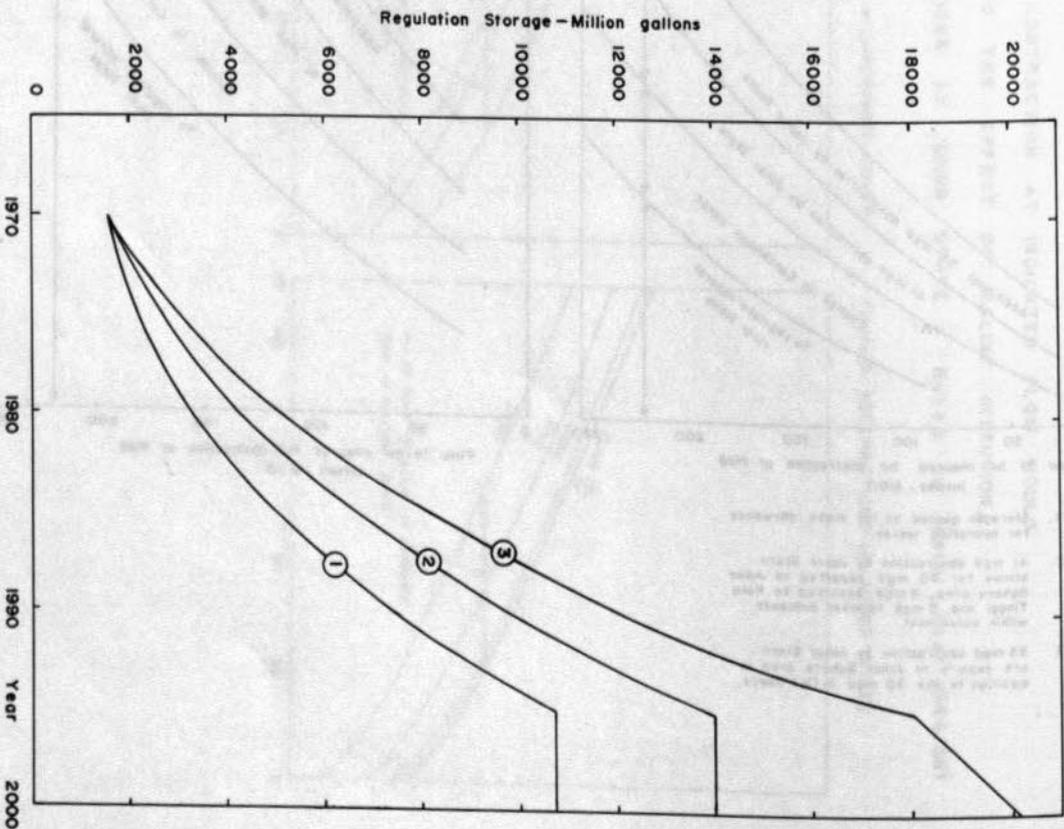
- NOTES:
1. Storages quoted do not make allowance for operating losses.
  2. 41 mgd abstraction by Johor State allows for 30 mgd exported to Johor Baharu area, 3 mgd exported to Kota Tinggi and 8 mgd to meet demands within catchment.
  3. 35 mgd abstraction by Johor State are exports to Johor Baharu area in addition to the 30 mgd in (2) above.

ESTIMATED MAXIMUM STORAGE REQUIREMENTS 1970 - 2000

A. EXCLUDING SALINE INTRUSION  
(ie Assuming downstream barrage constructed)



B. INCLUDING SALINE INTRUSION  
(ie Assuming no downstream barrage constructed)



NOTES:-

1. Curves ① are for PUB's estimated maximum rate of growth of demand on the intake (Section 3.3) and assume catchment cover conditions remain as for 1970.
2. Curves ② are as curves ① but allowance is made for catchment cover conditions changing as Figure 4-12
3. Curves ③ are as curves ② but allowance is made for future maximum rate of growth of upstream abstractions by Johor State (Table 4-7)
4. Storage quoted do not make allowance for operating losses.

DAM A ON S. PENGELI

LOCATION: 1" Map No. 125  
Grid Reference WM 739.333

CATCHMENT AREA: 12.4 square miles

TECHNICAL DATA:

Assumed stream bank level (MSL)

Dam height (feet): Crest level (MSL)

Maximum depth of water (feet): Conservation level (MSL)

Reservoir area (acres)

Estimated storage (million gallons)

Adopted crest width (feet)

Adopted embankment slopes

Estimated crest length (feet)

Bulk excavation (cubic yards x 1000)

Embankment fill above O.G.L. (cubic yards x 1000)

ESTIMATED CAPITAL COST

1. Reservoir clearance
2. Excavation and embankment
3. Spillway and diversion
4. Cut off and grouting

5. Site investigation
6. Access to site

7. Contingencies 10%

8. Engineering 8%

TOTAL Million Dollars

	120		
	70:190	60:180	40:160
	60:180	50:170	30:150
	1100	850	400
	7000	4400	1500
	20		
	1 in 4		
	1300	1150	960
	84	64	40
	430	270	90

Million Dollars

	0.26	0.20	0.10
	2.79	1.83	0.80
	1.00	0.95	0.90
	0.50	0.40	0.30
	4.55	3.38	2.10
	0.27	0.20	0.12
	0.12	0.12	0.12
	4.94	3.70	2.34
	0.50	0.37	0.23
	5.44	4.07	2.57
	0.44	0.33	0.22
	5.88	4.40	2.79

NOTES:

1. Stream bank level, reservoir areas, excavation and embankment fill estimated from existing 1" and 1 in 25000 maps.
2. Dam site has not been surveyed or visited by an engineering geologist.

APPENDIX C-35

DAM B ON S. PENGELI

LOCATION: 1" Map No. 125  
Grid Reference WM 806.322

CATCHMENT AREA: 8.4 square miles

TECHNICAL DATA:

Assumed stream bank level (MSL)	130		
Dam height (feet): Crest level (MSL)	70:200	60:190	50:180
Maximum depth of water (feet): Conservation level (MSL)	60:190	50:180	40:170
Reservoir area (acres)	600	450	350
Estimated storage (million gallons)	4200	2700	1600
Adopted crest width (feet)	20		
Adopted embankment slopes	1 in 4		
Estimated crest length (feet)	900	850	760
Bulk excavation (cubic yards x 1000)	78	64	42
Embankment fill above O.G.L. (cubic yards x 1000)	360	240	170

ESTIMATED CAPITAL COST

	Million Dollars		
1. Reservoir clearance	0.14	0.10	0.08
2. Excavation and embankment	2.39	1.67	1.23
3. Spillway and diversion	0.80	0.75	0.70
4. Cut off and grouting	0.40	0.30	0.20
	3.73	2.82	2.21
5. Site investigation	0.22	0.17	0.13
6. Access to site	0.12	0.12	0.12
	4.07	3.11	2.46
7. Contingencies 10%	0.41	0.31	0.25
	4.48	3.42	2.71
8. Engineering 8%	0.36	0.27	0.22
<b>TOTAL Million Dollars</b>	<b>4.84</b>	<b>3.69</b>	<b>2.93</b>

NOTES:

1. Stream bank level, reservoir areas, excavation and embankment fill estimated from existing 1" and 1 in 25000 maps.
2. Dam site has not been surveyed or visited by an engineering geologist.

DAM A ON S. LINGGIU

LOCATION: 1" Map No. 125  
 Grid Reference WM 923.308

CATCHMENT AREA: 80 square miles

TECHNICAL DATA:

Assumed stream bank level (MSL)

60

Dam height (feet): Crest level (MSL)

60:120 50:110 40:100 30:90

Maximum water depth (feet): Conservation level (MSL)

50:110 40:100 30:90 20:90

Reservoir area (acres)

5700 4200 2800 1500

Estimated storage (million gallons)

31000 17700 8200 2700

Adopted crest width (feet)

20

Adopted embankment slopes

1 in 4

Estimated crest length (feet)

1230 1100 990 900

Bulk excavation (cubic yards x 1000)

106 80 56 37

Embankment fill above O.G.L. (cubic yards x 1000)

456 262 149 72

ESTIMATED CAPITAL COST

Million Dollars

1. Reservoir clearance
2. Excavation and embankment
3. Spillway and diversion
4. Cut off and grouting

1.32 1.00 0.70 0.40  
 3.08 1.95 1.23 0.67  
 2.00 1.95 1.90 1.85  
 0.50 0.40 0.30 0.30

5. Site investigation
6. Access to site

6.90 5.30 4.13 3.22  
 0.41 0.32 0.25 0.20  
 0.18 0.18 0.18 0.18

7. Contingencies 10%

7.49 5.80 4.56 3.60  
 0.75 0.58 0.46 0.36

8. Engineering 8%

8.24 6.38 5.02 3.96  
 0.66 0.51 0.40 0.32

TOTAL Million Dollars

8.90 6.89 5.42 4.28

NOTES:

1. Stream bank level and reservoir areas estimated from existing 1" maps.
2. Excavation and embankment fill estimated from site survey by clinometer.
3. Site visited by engineering geologist.

DAM B ON S. LINGGIU

LOCATION: 1" Map No. 125  
Grid Reference WM. 859.408

CATCHMENT AREA: 23.6 square miles

TECHNICAL DATA:

Assumed stream bank level (MSL)	110			
Dam height (feet): Crest level (MSL)	100:210	80:190	60:170	40:150
Maximum depth of water (feet): Conservation level (MSL)	90:200	70:180	50:160	30:140
Reservoir area (acres)	2000	1500	900	400
Estimated storage (million gallons)	21000	11000	4800	1500
Adopted crest width (feet)	20			
Adopted embankment slopes	1 in 4			
Estimated crest length (feet)	1270	1060	850	600
Bulk excavation (cubic yards x 1000)	130	90	55	26
Embankment fill above O.G.L. (cubic yards x 1000)	730	390	180	60

ESTIMATED CAPITAL COST

	Million Dollars			
1. Reservoir clearance	0.44	0.34	0.20	0.10
2. Excavation and embankment	4.67	2.62	1.37	0.52
3. Spillway and diversion	1.50	1.40	1.30	1.20
4. Cut off and grouting	0.70	0.60	0.50	0.40
5. Site investigation	0.44	0.30	0.20	0.14
6. Access to site	0.48	0.48	0.48	0.48
7. Contingencies 10%	8.23	5.74	4.05	2.84
8. Engineering 8%	0.73	0.51	0.36	0.25
<b>TOTAL Million Dollars</b>	<b>9.78</b>	<b>6.82</b>	<b>4.82</b>	<b>3.37</b>

NOTES:

1. Stream bank level and reservoir areas estimated from existing 1" maps.
2. Excavation and embankment fill estimated from site survey by clinometer.
3. Site visited by engineering geologist.

DAM ON S. SEMANGAR

LOCATION: 1" Map No. 130  
Grid Reference WM. 990.111

CATCHMENT AREA: 53.0 square miles

TECHNICAL DATA:

Assumed stream bank level (MSL)	40		
Dam height (feet): Crest level (MSL)	50:90	40:80	30:70
Maximum depth of water (feet): Conservation level (MSL)	40:80	30:70	20:60
Reservoir area (acres)	7600	5300	3200
Estimated storage (million gallons)	35000	17700	6800
Adopted crest width (feet)	20		
Adopted embankment slopes	1 in 4		
Estimated crest length (feet)	1900	1800	1650
Bulk excavation (cubic yards x 1000)	250	200	145
Embankment fill above O.G.L. (cubic yards x 1000)	624	400	226

ESTIMATED CAPITAL COST

	Million Dollars		
1. Reservoir clearance	1.66	1.20	0.72
2. Excavation and embankment	4.86	3.37	2.10
3. Spillway and diversion	1.50	1.45	1.40
4. Cut off and grouting	0.70	0.60	0.50
	8.72	6.62	4.72
5. Site investigation	0.52	0.40	0.28
6. Road realignment	1.20	0.80	0.30
	10.44	7.82	5.30
7. Contingencies 10%	1.04	0.78	0.53
	11.48	8.60	5.83
8. Engineering 8%	0.92	0.69	0.47
<b>TOTAL Million Dollars</b>	<b>12.40</b>	<b>9.29</b>	<b>6.30</b>

NOTE:

- Stream bank level, reservoir areas, excavation and embankment fill estimated from existing 1" and 1 in 25000 maps.
- Dam site has been visited by an engineering geologist but has not been surveyed.

## APPENDIX C-39

DAM ON S. JOHOR

LOCATION: 1" Map No. 130  
Grid Reference WM. 935.189

CATCHMENT AREA: 420 square miles

TECHNICAL DATA:

Assumed stream bank level (MSL)		20
Dam height (feet): Crest level (MSL)	50:70	40:60
Maximum depth of water (feet): Conservation level (MSL)	40:60	30:50
Reservoir area (acres)	9600	7700
Estimated storage (million gallons)	45000	21000
Adopted crest width (feet)		20
Adopted embankment slopes		1 in 4
Estimated crest length (feet)	2150	1900
Bulk excavation (cubic yards x 1000)	210	133
Embankment fill above O,G.L. (cubic yards x 1000)	400	220

ESTIMATED CAPITAL COST

	Million Dollars	
1. Reservoir clearance	1.92	1.54
2. Excavation and embankment	3.42	1.99
3. Spillway and diversion	3.00	2.80
4. Cut off and grouting	1.00	0.90
	9.34	7.23
5. Site investigation	0.56	0.43
6. Access to site	0.36	0.36
	10.26	8.02
7. Contingencies 10%	1.03	0.80
	11.29	8.82
8. Engineering 8%	0.90	0.71
TOTAL Million Dollars	12.19	9.53

NOTE:

1. Stream bank level, reservoir area, excavation and embankment fill estimated from 1" and 1 in 25000 maps.
2. Dam site has been visited by engineering geologist but has not been surveyed.

## APPENDIX C-40

ESTIMATED CAPITAL COST OF TIDAL BARRAGE ON S. JOHORMillion DollarsCivil Engineering Work

1. Excavation, site clearance and river closure	0.60
2. Reinforced concrete (including piling)	1.40
3. Sheet piling	0.50
4. Rip rap and turfing	0.10
5. Access roads and Drainage works	0.30
	<hr/>
	2.90
10% contingencies	0.29
	<hr/>
	3.19
8% engineering	0.25
	<hr/>
Total (1)	3.44
	<hr/>

Equipment

1. Gates	0.50
2. Stop logs, sluices etc.	0.20
	<hr/>
	0.70
5% contingencies	0.03
	<hr/>
	0.73
8% engineering	0.06
	<hr/>
Total (2)	0.79
	<hr/>
Total (1) + (2)	\$ Millions 4.23
	<hr/>

# APPENDIX D

ENGINEERING GEOLOGY

## 1 INTRODUCTION.

The general geology of the Project Area, including a description of the lithological formation present and the distribution of the solid formations, is described in Supporting Volume 2.

Engineering geological studies have been carried out to provide a preliminary assessment of:-

- a) the possible sites for dams and impounding reservoirs.
- b) the groundwater resources and their potential.

An engineering geologist visited the Project from 19th April to 6th May and from 21st October to 4th November 1970. The geological information available consisted mainly of the 1 inch maps prepared by Geological Survey, Ipoh. These were studied in conjunction with the limited groundwater data collected. Due to the short time available only brief field visits were possible at certain dam sites and to examine formations of hydrogeological interest. The field visits involved surface inspections only and no exploratory borings or drillings have been carried out.

The locations of the dam sites discussed and possible areas having groundwater potential are shown in Figures 1 and 2. Of the dam sites only the Kahang, Linggiu and Lebam sites are recommended for development (See Sections 4.2.1, 4.7 and 4.2.4 of main text respectively). The geological aspects of the remaining sites are included for completeness.

## 2 DAM SITES.

## 2.1 Sites Visited by Geologist

a) Kahang Site (Grid Reference WM.625.516)

A dam height of about 30 feet has been considered at this site. The alluvial flood plain is about 500 feet wide and the abutments have moderate slopes generally up to 15 degrees. A stream incised into the right bank trends to the W.N.W., oblique to the possible centre-line, and has formed locally steeper slopes.

The existing geological maps show the dam site to be formed of Panti sandstones. These beds overlie granite which is shown outcropping about 1/4 mile upstream from the site on the eastern valley side and 1/4 mile upstream on the western. The boundary between the two rock types trends E.N.E. and granite covers most of the proposed reservoir area.

Rock outcrops were not seen at the site but it is inferred that the proposed abutments are formed mainly of medium to thick beds of sandstone which may have a moderate to high permeability. Black, firm-stiff fissured clay-shale is exposed in a valley half a mile to the west and such comparatively weak clays may occur interbedded with the sandstone at the site. The beds can be expected to dip generally downstream at a flat angle.

Small banks of uniform, medium-grained quartz sand are spread across the flood plain in parts of the site and the alluvium may be predominantly sandy. Tin prospecting boreholes were sunk in 1968 and about 1 1/2 miles upstream and recorded between 20 and 30 ft. of alluvium above weathered granite near the river. The method of boring and the reliability of these records is not known but previous dam site investigations further north in Malaya also indicate that 30 ft. would be a reasonable estimate of the thickness of alluvium in this stretch of the valley.

To avoid excessive stripping the site favours an earth fill embankment dam which probably could be founded on alluvium in the valley sections on the sandstone, or its weathering products, on the abutments. It is reasonable to assume that the sandy alluvium would have adequate strength to be left in place beneath the shoulders. To safeguard the foundations of the dam a positive cut-off wall may need to be constructed through the alluvium.

A borrow area to work weathered granite, suitable for earth fill, could almost certainly be opened in the reservoir area within 1 mile of the dam site.

The abutments are probably formed of pervious sandstone and allowance must be made for cement grouting, to seal open fractures, at the dam site. In this rock type grout takes can be expected to be moderate to high. Some grouting may be needed at two low cols to the east; the col nearest the dam site is underlain by sandstone and the other by granite. However, the hazard of leakage through bedrock is not considered great because the proposal is to impound about 20 ft. of water whereas the abutments rise approximately 120 feet above assumed stream bank level and must support a water table well above flood plain level approaching or even above proposed topwater level. Thus the cost of grouting should not make the site impracticable.

The features which could upset the estimates most at this site are the nature and depth of the alluvium. The site investigation would need to check that extensive, weak clay layers are not present and prove if any buried channels exist. The investigation would also have to establish the permeability of the abutments and the position of the water table to decide the extent of grouting.

b) Linggiu Site A (Grid Reference WM.923.308)

A dam height of about 55 feet has been considered at this site.

The site is situated about 300 ft. downstream from the S. Linggiu and S. Tempenis confluence and the alluvial flood plain is about 500 feet wide.

The aerial photographs show prominent north-south strike ridges of steeply-dipping Linggiu sandstone forming the right bank of the reservoir. The ridges swing NW - SE towards the river at the dam site. Similar ridges continue to the south of the site, on a north-south trend, on the eastern valley side but are dissected by streams flowing from Bt. Pachat. Volcanic rocks form the upper slopes of Bt. Pachat.

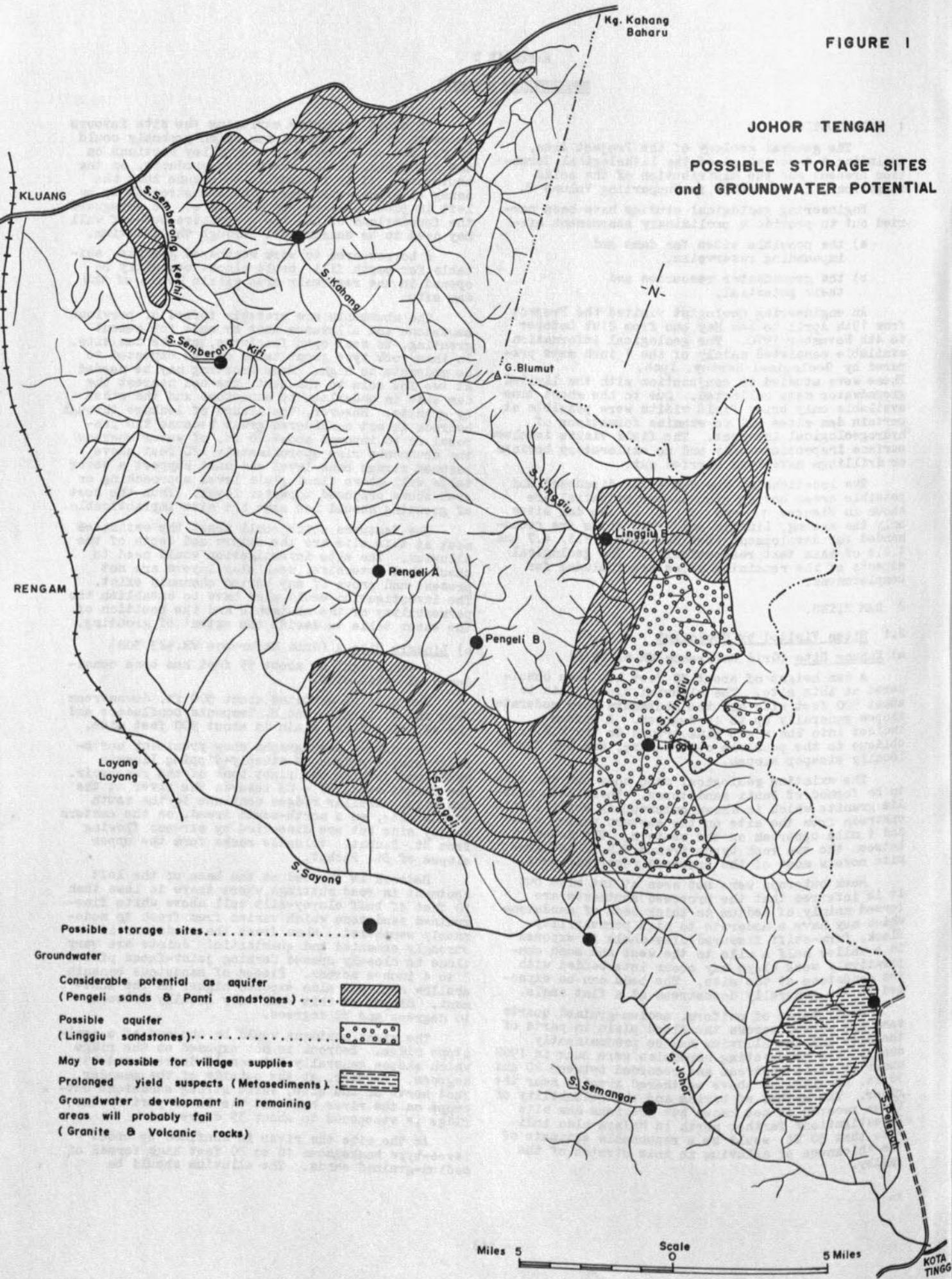
Bedrock is exposed at the base of the left abutment in road cuttings where there is less than 10 feet of buff clayey-silt soil above white fine-grained sandstone which varies from fresh to moderately weathered. When fresh the sandstone is strongly cemented and quartzitic. Joints are very close to closely spaced forming joint-faced pieces 2 to 4 inches across. Pieces of sandstone beneath shallow soil are also exposed higher on the abutment. Slopes on this bank vary locally between 10 degrees and 30 degrees.

The right abutment would be the end of a sandstone ridge. Bedrock is not exposed on the ridge which slopes generally between 15 degrees and 25 degrees. However, at the outside of the meander just north of the site, white strong sandstone outcrops on the river bank and the lower part of the ridge is steepened to about 35 degrees.

At the site the river is confined by broad levee-type banks some 10 to 20 feet high formed of medium-grained sands. The alluvium should be

FIGURE 1

**JOHOR TENGAH**  
**POSSIBLE STORAGE SITES**  
**and GROUNDWATER POTENTIAL**

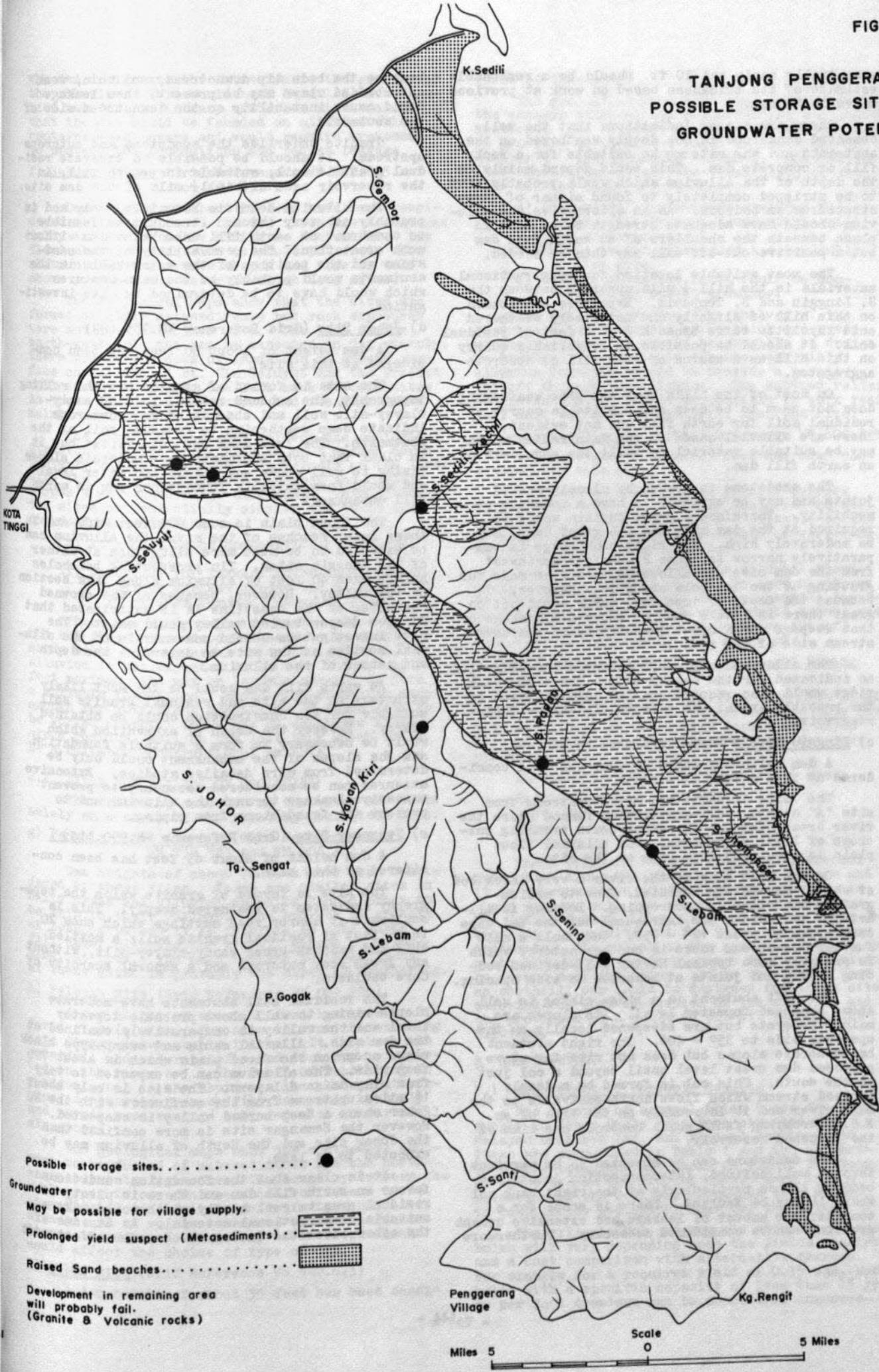


- Possible storage sites..... ●
- Groundwater
- Considerable potential as aquifer  
(Pengeli sands & Pantu sandstones)..... [diagonal hatching]
- Possible aquifer  
(Linggiu sandstones)..... [dotted pattern]
- May be possible for village supplies  
Prolonged yield suspects (Metasediments)..... [horizontal hatching]
- Groundwater development in remaining  
areas will probably fail  
(Granite & Volcanic rocks)

Miles 5      Scale 0      5 Miles

KOTA TINGGI

TANJONG PENGERANG  
 POSSIBLE STORAGE SITES and  
 GROUNDWATER POTENTIAL



essentially sandy and 30 ft. should be a reasonable estimate of its thickness based on work at previous sites in Malaya.

There are strong indications that the well-cemented sandstone is not deeply weathered on the abutments and the site may be suitable for a rock fill or concrete dam. This would depend mainly on the depth of the alluvium which would probably have to be stripped completely to found either of these structures on bedrock. As an alternative the alluvium should have adequate strength to be left in place beneath the shoulders of an earth fill dam but a positive cut-off wall may then be needed.

The most suitable location for constructional materials is the hill  $\frac{1}{2}$  mile upstream between the S. Linggiu and S. Tempenis. Exposures are common on this hill of slightly and moderately weathered acid rhyolitic tuffs beneath 2 to 4 feet of residual soil. It should be possible to establish a quarry on this hill as a source of rock fill or concrete aggregates.

On most of the hills near the site weathering does not seem to be deep and a suitable source of residual soil for earth fill was not evident. There are alluvial sands in the main valley which may be suitable material to build the shoulders of an earth fill dam.

The sandstone is broken by closely-spaced joints and may be expected to have a moderate permeability. Therefore a grout curtain would be required at the dam site and the grout takes may be moderately high. The right bank ridge is comparatively narrow for some 2,000 feet northwest from the dam site and allowance should be made for grouting at two low cols along it. However, because the depth of impounded water would not be great there is little risk of excessive leakage or that seepage would cause instability on the downstream side of the ridge.

The alluvium would need thorough investigation as indicated for the Kahang site. The right bank ridge would also require special investigation of the probable extent and effects of leakage from a reservoir.

c) Linggiu Site B (Grid Reference WM.859.408)

A dam height of about 80 feet has been considered at this site.

The site is about ten miles upstream from site "A" at a valley constriction formed where the river breaks through the north-south trending outcrops of Panti sandstones. The alluvial flood plain is about 400 feet wide at this site.

On the left bank of the river a very thick bed of white, moderately cemented, fine to medium-grained sandstone is outcropping. Bedding is ill-defined and joints are infrequent but the bed dips downstream at about  $12^{\circ}$  -  $15^{\circ}$ . Some half a mile further downstream there is another outcrop which is probably more typical having well-defined bedding planes and joints at moderate to wide spacing.

The left abutment is a ridge rising to well above proposed topwater level. Its slopes are mainly moderate but are steepened locally on the upstream side to  $35^{\circ}$  -  $40^{\circ}$ . The right abutment has moderate slopes but does not rise far above proposed dam crest level until beyond a col just to the south. This col is formed by a deeply incised stream which flows north-eastwards to the main river and it is roughly on the line of an E.N.E. trending fault which controls one limb of the proposed reservoir.

The sandstone can be expected to be pervious through well defined, interconnecting joints and bedding planes particularly at the right bank col where it may be faulted. There is scope for a considerable amount of leakage and extensive cement grouting can be considered necessary. Furthermore

because the beds dip downstream, and thin, weak interbedded clays may be present, then leakage could cause instability on the downstream side of the abutments.

Granite underlies the sandstone and outcrops upstream. It should be possible to excavate residual granitic soil, suitable for earth fill, in the reservoir area within  $\frac{1}{2}$  mile of the dam site.

The alluvium seems to be mainly sandy and is probably not very thick. It should be feasible to construct an earth fill embankment dam without much excavation. The permeability of the sandstone and the position of the water table in the abutments would probably be the main features which would have to be determined by site investigation.

d) Johor Site (Grid Reference WM.935.189).

A dam height of about 50 feet has been considered at this site.

The site is formed of granite but the rolling topography, the subdued relief, reddish sandy-clayey-silt soil and absence of rock outcrops indicate deep weathering to residual soil at the abutments. The left bank was not visited but it is clear that both abutments have moderate slopes rising to well above any likely top water level and would form suitable foundations for an earth fill embankment.

The flood plain is some 600 feet wide and in these lower reaches of the river the alluvium can be expected to be much more silty than at either of the Linggiu sites. Tin prospecting boreholes have proved 40 feet of alluvium along this section of the valley. However, because of the drowned character of the coastline it is anticipated that an even deeper buried valley could exist. The site investigation should concentrate on the alluvial section of the site to determine the depth and nature of the alluvium.

An earth fill dam would be the most likely structure at the site and residual granite soil suitable for its construction could be obtained nearby. However the depth of excavation which would be necessary to form a suitable foundation and the slopes of the embankment could only be determined from more detailed studies. Extensive measures can be considered necessary to prevent excessive leakage through the alluvium and to protect the foundations from piping.

e) Semangar Site (Grid Reference WM.990.111)

A dam height of about 45 feet has been considered at this site.

The site is formed of granite which the topography indicates is weathered deeply. This is confirmed at nearby road cuttings which show 20 to 35 feet of residual granite soil; a mottled buff and reddish-brown sandy-clayey-silt, without any fresh rock outcrops and a general scarcity of core boulders.

The residual soil abutments have moderate slopes rising to well above probable topwater level and the valley is comparatively confined at the dam site. Alluvial sands and swamp-type black clays occur on the flood plain which is about 700 feet wide. The alluvium can be expected to vary from clay to sand layers. The site is only about  $\frac{1}{2}$  miles upstream from the confluence with the S. Johor where a deep buried valley is suspected. However the Semangar site is more confined than the Johor site and the depth of alluvium may be expected to be less.

It is clear that the foundation conditions favour an earth fill dam and there is plenty of residual granite soil nearby which would make a suitable constructional material. As at some of the other sites the factor which would affect most

the dam design and the estimates is the geology of the alluvium. This would need detailed investigation but for preliminary estimates it is assumed that the dam would be founded on alluvium which contains weak layers and would require treatment to protect the foundations and reduce leakage.

f) Seluyut Sites (Grid References WN 287.095 and WN 265.102)

Dam heights of about 25 feet have been considered at these sites. The two sites are topographically and geologically similar. The width of the flood plain at each site is about 300 feet. The abutments have moderate slopes and rise to well above proposed top water level at both sites.

The geological maps show that the sites are formed of older metasediments but rock exposures were not seen at either site. The beds strike north-westwards and can be expected to dip steeply. There are many blocks of sandstone at ground surface on and around Bt. Ulu Seluyut and the Project soil survey indicates the left bank at both sites is probably mainly arenaceous and the right bank mainly argillaceous.

The rivers of the area reflect the geological structure and the upper site is on a marked north-westerly valley alignment. Conversely at the lower site the river is running south-west and cutting across a watershed ridge alignment. Thus although the sites are essentially similar the lower has the following advantages:

- i) it should be on comparatively stronger bedrock.
- ii) potential for leakage is reduced because bedrock strikes across the site whereas it strikes through the upper site.

There are sandy deposits in the river channel but the flood plain deposits seem to be mainly sandy silt. From general evidence in Malaya the alluvium is not expected to be very thick, say 30 feet maximum, and may be largely removed to form a suitable foundation. Weathering should be deep enough for sufficient quantities of earth fill to be worked nearby. There may be weathered sandstone residual soil on the left bank which would be a suitable constructional material.

2.2 Sites Not Visited by Geologist

The following comments on the sites are based solely on a study of the existing geological maps.

g) Pengeli Sites A and B (Grid References WM 739.333 and WM 806.322)

Dam heights of about 70 feet have been considered at these sites. These are similar sites in hilly areas and alluvial deposits should prove to be thin in their valleys. The bedrock is granite at both sites and it is feasible to cost earth fill dams, allowing for a small amount of stripping, at them. The main feature to investigate at these sites is probably the depth of weathering.

h) Pelepah Site (Grid Reference WN 089.220)

A dam height of about 70 feet has been considered at this site. The site is near the existing Kota Tinggi water supply intake. It is above the waterfall and outcrops of sound rock may be expected in the river bed. The depth of weathering to residual soil in the abutments is unknown but perhaps, a concrete or rock fill dam could be built and permit some savings compared with an earthfill structure.

The geological maps show the south-west abutment to be formed of metasediments and the north-east abutment of granite. The boundary between the rock types is one feature which would have to be investigated in detail to determine whether it is a fault and if so the extent to which the foundations are weakened. This may be a factor which would affect the choice of type of dam.

i) Lebam Site (Grid Reference WS 540.873)

A dam height of about 35 feet has been consi-

dered at this site.

The geological maps show that granite forms the western abutment and metasediments the eastern abutment. The boundary between the two rock type is possibly an important fault as described in Chapter 2 in Supporting Volume 2. However the fault should not affect the feasibility of the site for the following reasons:-

- a) An earthfill embankment designed for comparatively weak foundations could be constructed.
- b) Malaya is not considered a seismically active area.
- c) Leakage along the fault could be controlled by cement grouting.

The site is low along the thalweg of the river so alluvium may be quite thick and predominately silty. It should be possible to design an earthfill dam suitable for the weak silty alluvium foundations and to provide a positive cut-off through the alluvium. The subdued relief indicates that it should be possible to work residual soil suitable as earthfill near the site.

j) Semberong Kiri Site (Grid Reference WM 608.417)

A dam height of about 25 feet has been considered at this site.

The site is underlain by granite bedrock which is probably quite deeply weathered on the valley sides. There should be a suitable amount of residual soil nearby which could be worked as earthfill for an embankment dam.

There is a moderately wide alluvial flood plain and this site is similar to several others in that the alluvium would require careful investigation and is the factor which could affect most the dam design and costs. A positive cut-off would be required through the alluvium.

k) Sedili Kechil, Layau Kiri, Papan and Sening Sites

Dam heights of about 25 feet have been considered at the Papan and Sening sites. No dams have been considered at the Sedili Kechil and Layau Kiri sites but they are mentioned here for completeness.

The grid references of these sites are:-

Sedili Kechil	:	WN 394.071
Layau Kiri	:	WS 400.952
Papan	:	WS 473.955
Sening	:	WS 511.820

These sites, in Tanjong Penggerang, are all quite high along the thalweg of their rivers and it is reasonable to assume that the alluvium in their valleys will not exceed 30 feet thickness. The Sedili Kechil, Layau Kiri and Sening sites are underlain by granite and the Papan site by metasediments. The relief of the areas is subdued thus weathering should be deep enough for earthfill to be worked near the sites. It is considered that an earthfill dam could be designed for these sites allowing for some excavation of the alluvium and the provision of a positive cut-off through the alluvium.

3 GROUNDWATER.

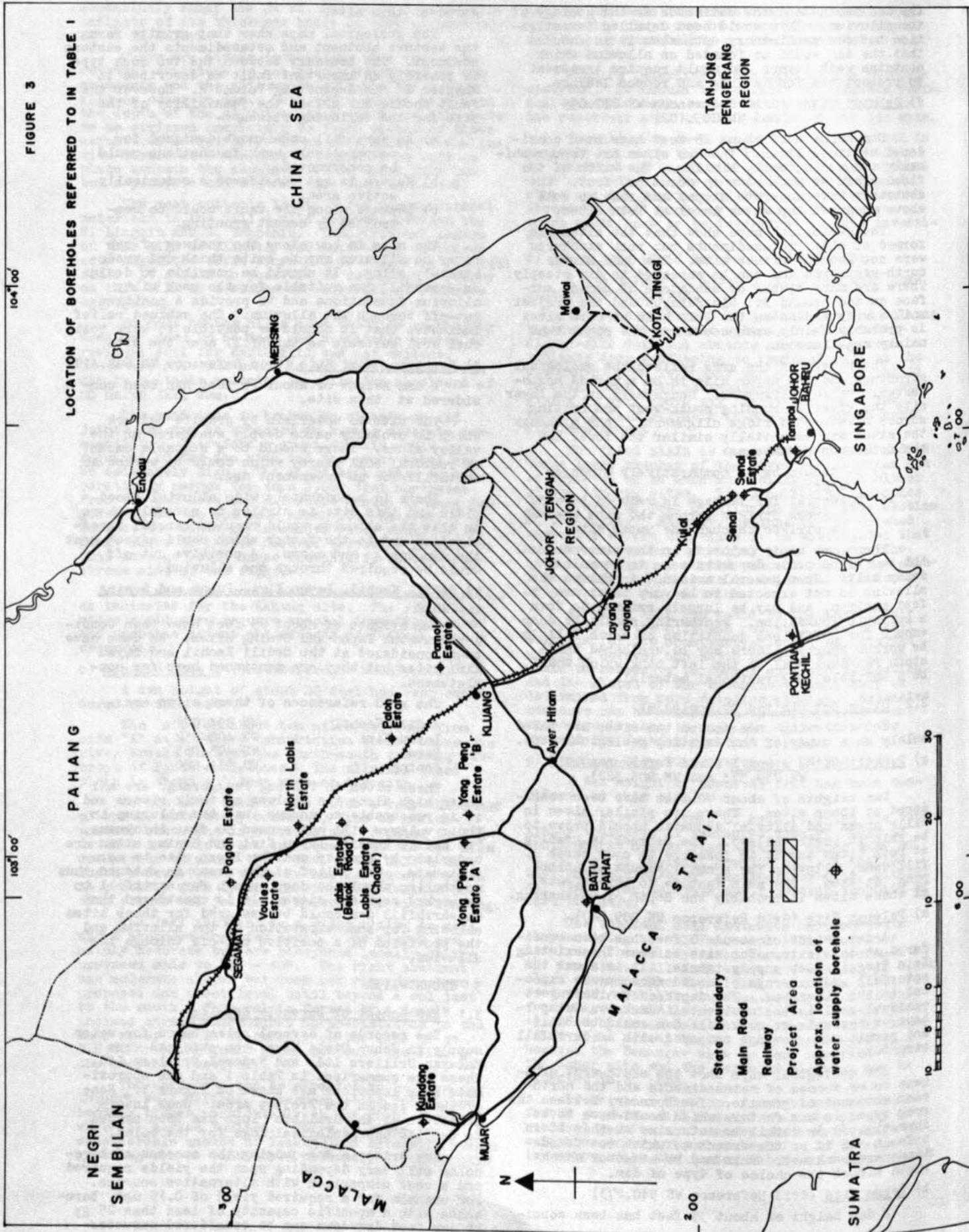
3.1 Assessment of Borehole Results

The records of several holes bored for water supply in Johor State have been obtained from Malayan Drillers Ltd. and Federal Drillers Ltd. These are summarised in Table 1 and the approximate hole locations are shown on Figure 3. None of these are in the Project Area. Some interpretation of the drillers' logs has been needed to compile the geological logs for the holes.

The criteria for judging the success of boreholes will vary depending upon the yields required and a cost comparison with alternative sources. For example for a required yield of 0.15 mgd, boreholes with a specific capacity of less than 25 gp hr per foot drawdown can be considered unsuccess-

FIGURE 3

LOCATION OF BOREHOLES REFERRED TO IN TABLE 1



successful. Therefore the borehole results can be summarized as follows:-

<u>Lithological formation</u>	<u>Total holes</u>	<u>Percent Success</u>
Older alluvium	1	100
Rhyolite tuff	5	20
Shale/slate	10	70
Granite	20	25

Therefore even with this modest criterion for success and allowing for inadequacies in the drillers' logs, boreholes in the granite or volcanic rock areas have a high probability of failure.

Chances of success appear far higher in the metasediments as the rock is probably strong enough for the very closely spaced cleavage fractures to be open slightly and to yield some water. However the specific capacities listed in Table 1 are for the initial pump test only and experience with boreholes sunk in metasediments further north in W. Malaysia, has shown that the prolonged yield may be much less. The holes probably tap localized underground reservoirs which do not readily recharge through the clayey soils developing on the argillaceous metasediments. Hence the yields may not be permanent.

### 3.2 Groundwater Potential in Project Area

#### a) Granite, Volcanics and Metasediments

The results of the water well boring in surrounding areas of Johor State confirm that further consideration of underground supplies from granite and volcanic rocks would be unjustified. The metasediments could be considered locally for village supplies of about 0.15 mgd but the rocks are not very permeable and probably at least four holes would be required to obtain this yield. Also because of doubts about recharge, surface water sources are preferable in these areas.

#### b) Linggiu Sandstones

On lithological grounds the greatest potential for groundwater development from rock formations is afforded by the Linggiu and Panti sandstones but none of the boreholes listed in Table 1 were sunk into these formations. The Linggiu sandstones are strongly fractured and may, therefore, be reasonably permeable. However because of their moderately to steeply dipping structure individual beds will have a small outcrop area and if lateral intercommunication between beds is restricted then the aquifer may be of limited value. Thus the limited evidence available suggests that this unit should have low priority in any future exploration.

#### c) Panti Sandstones

This formation holds considerable promise for successful groundwater development. Argillaceous beds are very minor and the structure of the sandstone is favourable with bedding planes typically at 6 inches to 4 feet spacing and sets of major joints present. Cuestas are formed by the shallow dip and individual beds have a comparatively large outcrop area.

The formation has a similar lithology, structure and thickness (totalling some 800 feet) to sandstones which have been studied at Sandakan, Sabah. These have a transmissibility varying between 3,000 and 10,000 gpd/ft., depending upon the density of fracturing, and preliminary estimates suggest a recharge of 0.5 to 1.0 mgd per square mile of outcrop area. If this comparison is valid then individual holes could yield some 0.1 to 0.25 mgd each.

#### d) Pengeli Sands

Field observations of the Pengeli sands, in the S. Pengeli-Belitong area, indicate that this deposit, in general, may comprise poorly sorted

clayey sands and fine gravels. If this is the case then the clayey matrix will reduce its permeability. This is confirmed by the borehole at Tampoi which did not have a very good result although it was drilled deeply into the Older Alluvium which is a deposit similar to and probably contemporaneous with the Pengeli sands. However the stream gauging carried out on the S. Pengeli, as part of the Hydrological studies, suggests that some groundwater storage, attributable to the Pengeli sands, may occur in the catchment. Therefore better sorted more permeable sand and gravel beds may be present.

#### e) Recent Alluvium

At present recent alluvium is the only deposit being exploited for groundwater within the Project Area. A considerable number of shallow, large diameter dug wells are used to supply some settlements. A study of existing wells was not undertaken, as it would not have been generally relevant to any future proposals, because the permeability and thickness of alluvium can be expected to vary considerably within the Project Area.

Recent alluvium along river valleys could possibly provide groundwater supplies for small local areas. This would apply particularly in catchments containing sandstone and granite which would contribute abundant quartz sand after erosion.

Due to shortage of time, the raised sand beaches on the east coast of Tanjong Penggerang were not visited by the engineering geologist. However the soil maps in Supporting Volume 2 show that the outcrop areas are quite small, with the result that yields may also be quite small. In addition, except for the proposed initial tourist development and village P13 (See Figure 4.6 Chapter 4), the proposed villages in Tanjong Penggerang are remote from the outcrops. The potential for development of these areas for small yields would depend on their elevation relative to adjacent stream levels, and on the thickness and the extensions underground, beneath other deposits, of the sands. A geological/geophysical survey would be required to define the outcrop area, thickness and extension of the sands, before any exploration borings could be considered. It should be noted that these deposits could be similar to deposits in other certain coastal areas of W. Malaysia, where the sands are restricted to ribbon like channel deposits, among silts and clays, and are difficult and costly to locate. For example the boreholes at Pontian Kechil and Batu Pahat (Table 1) all penetrated impermeable clayey alluvium.

#### f) Summary

The general potential for developing rural supplies from groundwater is summarised on Figures 1 and 2. The areas indicated are the outcrops of the various lithological formations and borehole results probably would not be the same throughout each area. To obtain best results boreholes would have to be sited with due regard to the geological structure and the topography.

It is considered that the formation with the best potential for groundwater development are the Panti Sandstones and the Pengeli sands described as "Potential Aquifer" in Johor Tengah.

### 3.3 Future Investigations

Before any proposal for supplying an area from groundwater can be reliably evaluated it will be essential to carry out more intensive investigations. These should include geological and geophysical studies supported by a programme of exploratory boring and pump testing. This would permit an assessment of the transmissibility and amount of groundwater storage of the aquifer and would indicate whether boreholes can obtain economically the amount of water required. If this should prove favourable then a more extended water

balance study should be made to determine the safe yield (recharge) of the aquifer.

It is important to realize that the recharge of an aquifer could be affected adversely, by clearing the jungle cover from its catchment, in a manner similar to surface river flows (see Chapter 1). If any groundwater resources are developed it will be necessary to consider this aspect in relations to the assessment of the reliable yield.

## Summary of Borehole Records

LOCATION	DATE	DRILLING CO.	GEOLOGICAL LOG	DISCHARGE GALLS PER HR	BREAKDOWN FT.	SPECIFIC CAPACITY G.P.H. PER FT	REMARKS
Pook Heng Distillery Tampoi	12.12.68 to 6.2.69	M.D. Ltd.	0 - 275' gravelly-sandy-silt Older Alluvium	3,000	127	24	
Lee Rubber Fact., Pontian Keohil	12.11.60 to 13.12.60	M.D. Ltd.	0 - 97' clayey alluvium 97' - 161' shale (black)	4,998	73	68	brackish
Lee Rubber Fact., Pontian Keohil	16.12.60 to 4.2.61	M.D. Ltd.	0 - 87' clayey alluvium 87' - 318' black shale & slate	dry		0	
Lee Rubber Fact., Pontian Keohil	7.2.61 to 28.2.61	M.D. Ltd.	0 - 88' clayey alluvium 88' - 182' black shale & slate	1,500	130	12	brackish
Lee Rubber Co., Batu Pahat	28.12.60 to 18.1.61	M.D. Ltd.	0 - 85' sandy-clay & clay alluvium 85' - 121' weathered granite 121' - 134' fresh granite	3,360	54	62	
United Rubber Millers Co., Batu Pahat	22.11.62 to 12.12.62	M.D. Ltd.	0 - 50' sandy-clay alluvium 50' - 82' weathered granite 82' - 95' fresh granite	1,950	37	53	
United Rubber Millers Co., Batu Pahat	14.1.63 to 15.1.63	M.D. Ltd.	0 - 90' alluvium over granite?	1,605	38	42	pump test record only
Kundong Estate	Oct. '64	F.D. Ltd.	0 - 82' alluvium over granite?	dry		0	
Kundong Estate	Nov. '64	F.D. Ltd.	0 - 82' alluvium over granite?	dry		0	
Kundong Estate	18.11.64 to 31.12.64	F.D. Ltd.	0 - 100' sandy-clay alluvium 100' - 138' weathered granite 138' - 195' fresh granite (quartz veined)	2,060	115	18	
Senai Estate	6.1.56 to 21.1.56	M.D. Ltd.	0 - 123' weathered granite 123' - 125' fresh granite	2,000	45	45	iron present
Senai Village	16.7.58 to 26.7.58	M.D. Ltd.	0 - 98' weathered granite 98' - 100' fresh granite	3,500	50	70	
Senai Village	5.8.58 to 7.8.58	M.D. Ltd.	0 - 58' weathered granite 58' - 63' fresh granite	dry		0	
Kulai Village	23.5.58 to 29.5.58	M.D. Ltd.	0 - 81'6" weathered granite 81'6" - 82' fresh granite	dry		0	
Kulai Village	2.6.58 to 9.6.58	M.D. Ltd.	0 - 80' weathered granite 80' - 83' fresh granite	dry		0	
Kulai Village	11.6.58 to 19.6.58	M.D. Ltd.	0 - 87' weathered granite 87' - 88'6" fresh granite	dry		0	
Kulai Village	27.6.58 to 2.7.58	M.D. Ltd.	0' - 72' weathered granite 72' - 75' fresh granite	dry		0	
Kulai Village	10.7.68 to 13.7.68	M.D. Ltd.	0 - 60' weathered granite 60' - 68' fresh granite	dry		0	
Yong Peng Estate 'A'	6.8.62 to 31.8.62	M.D. Ltd.	0 - 47' sandy clay (alluvium?) 47' - 113' slate	3,105	59	53	
Yong Peng Estate 'B'	11.9.62 to 8.10.62	M.D. Ltd.	0 - 30' weathered shale 30' - 181' black hard shale & slate	2,385	94	25	
Famol Estate	5.10.64 to 19.10.64	F.D. Ltd.	0 - 46' superficial clay & clayey-sand 46' - 85' weathered tuff 85' - 200' rhyolite tuff	dry		0	
Famol Estate	24.10.64 to 27.10.64	F.D. Ltd.	0 - 26' superficial clay & sand 26' - 56' weathered tuff 56' - 57'6" rhyolite tuff	dry		0	
Famol Estate	31.10.64 to 9.11.64	F.D. Ltd.	0 - 20' weathered rhyolite 20' - 56' rhyolite	dry		0	
Faloh Estate	Mar to Apr '70	F.D. Ltd.	0 - 39' superficial clay & sandy-clay 39' - 209' weathered granite	slow seepage		0	
Labis Estate (Cha'ah)	11.8.64 to 4.9.64	F.D. Ltd.	0 - 56' superficial clay & sand 56' - 106' black slate (?) 106' - 135' rhyolite tuff (?)	slow seepage		0	
Labis Estate (Ch'ah)	5.9.64 to 29.9.64	F.D. Ltd.	0 - 32' superficial clay 32' - 61' weathered siltstone 61' - 114'6" black siltstone	7,160	32	220	
Labis Estate (Cha'ah)	17.7.65 to 30.9.65	F.D. Ltd.	0 - 32' superficial clay 32' - 205' hard black shale	4,350	72	61	
Labis Estate (Bekok Rd.)	10.8.65 to 22.9.65	F.D. Ltd.	0 - 60' superficial clay & sand 60' - 114' rhyolite agglomerate	2,500	52	48	
North Labis Estate	11.11.64	F.D. Ltd.	0 - 57' weathered granite 57' - 58' fresh granite	slow seepage		0	
North Labis Estate	not known	F.D. Ltd.	0 - 101' weathered granite 101' - 106' fresh granite	slow seepage		0	
North Labis Estate	"	F.D. Ltd.	0 - 110' weathered granite 110' - 144' fresh granite	dry		0	
North Labis Estate	"	F.D. Ltd.	0 - 172' weathered granite	seepage		0	
North Labis Estate	31.5.65	F.D. Ltd.	0 - 378' weathered granite	dry		0	
Voules Estate	Oct. to Dec. '63	F.D. Ltd.	0 - 135' superficial silty clay 135' - 141' black hard shale or slate 141' - 157' sandstone 157' - 225' black hard shale or slate	5,500		35 - 100	
Pogah Estate	10.7.64	F.D. Ltd.	0 - 14' superficial clay 14' - 107' hard siltstone	5,225	31	170	

M.D. Ltd. - Malayan Drillers Ltd.  
F.D. Ltd. - Federal Drillers Ltd.

# APPENDIX E

APPENDIX E

GLOSSARY OF TERMS

1. Run-of-River Yield

Run-of-river yield is defined as the uniform rate at which water can be drawn from a river for a specified return period of failure of river flow.

2. Return Period of Failure

A "return period of failure of 1 year in 10 years" is defined as a failure to meet the full supply, for a duration of no more than a few days, during 1 year out of 10 years on the long term average.

3. Direct Supply Reservoir Yield

Direct supply reservoir yield is defined as the uniform rate at which water can be drawn from the reservoir, throughout a dry period of specified severity (return period of failure), without depleting the contents of the reservoir to such an extent that withdrawal at that rate is no longer possible.

4. Regulated River Abstractions.

The yield of a regulated river abstraction scheme is defined as the uniform rate at which water can be drawn from the river, throughout a dry period of specified severity (return period of failure) without depleting the contents of the upstream regulation reservoir to such an extent that continuous withdrawal at that rate is no longer possible.

5. Biochemical Oxygen Demand (BOD)

Biochemical oxygen demand of water is that depletion of oxygen in solution brought about in the breaking down of organic matter by aerobic bacteria. The generally accepted standard test measures the depletion (i.e. oxygen demand) in the dark after 5 days at 20° Centigrade and, within its limitations, provides a fair measure of oxidizable constituents and hence of impurity.

6. Present value

If \$1 is borrowed from a bank at an interest rate of 10 percent per annum, then the amount owing in one year's time will be \$1.1. Another way of expressing this is to say that the 'present value' of \$1.1 receivable one year from now at an interest rate of 10 percent per annum is \$1. Thus, in order to calculate the present value of an amount receivable or payable at some time in the future, one discounts the amount by the interest rate used. The 'discount rate' is therefore merely the reciprocal of the interest rate, and discounting is therefore the process of attaching weights to future sums in order to reflect the value of having money today rather than tomorrow.

The present value of a sum of money receivable in the future is therefore the amount discounted at the interest rate used. In comparing the economics of alternative water supply schemes the present values of total costs have been calculated at discount rates of 5, 10 and 15 percent per annum. (For a further discussion of the methods and principles used, see Volume 10).

7. Internal rate of return.

The internal rate of return of a project is the rate of interest or discounting rate which when applied to the cash flows gives a present value for the expenditures equal to the present value of the receipts. It is referred to as the rate of return in this volume.

8. Sensitivity Analysis

The forecast of demand for water over a period of 30 years is necessarily very uncertain. In certain cases the effect of differing demand estimates in alternative or preferred solutions have been analysed in discounted terms. This type of analysis is commonly referred to as a sensitivity analysis.

# APPENDIX F

APPENDIX F

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