HUNTING TECHNICAL SERVICES LIMITED

SOUTH EAST JOHOR PROJECT

TANJONG PENGGERANG & JOHOR TENGAH

REGIONAL MASTER PLAN

INITIAL HYDROLOGICAL REPORT

by

M. Mansell-Moullin

DECEMBER 1969

BINNIE & PARTNERS,
Chartered Engineers,
Artillery House,
Artillery Row,
London, S.W.1

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INTRODUCTION

1. The Terms of Reference for the Project's water resources studies, which are to be carried out by Binnie & Partners, were given in the "Proposal for Preparation of a Master Plan for Development of the Tanjong Pengerang and Johor Tengah Regions", January 1969. At the time of writing the present report these had not been superseded. An Annexe entitled "Scope of Work" included the following extracts:-

A. Natural Resources

(4) Water Resources:

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 schemesfor such use of water are proposed.

(d) An assessment of the requirement of industrial and potable water supplies with a projection of needs over a 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.

C. Socio-Economic Aspects of the Development Programme

(4) Water Resources:

An economic assessment will be made of the various sources of supply of water for human, industrial and agricultural

purposes and the economic implications of plans for the development of water supplies will be analysed.

The investigations and studies outlined above will of course be integrated with the many other subjects being studied in the Project.

2. Section 1B (para. 2), commenting on the Scope of Work, stated:

"Most of the field studies required will of necessity be limited to the two Regions whose development is being planned. Special situations involving some study outside the two Regions should be taken into account however, such as the maintenance of the Singapore water supply or the economic utilisation of the forest resource. Other aspects of the study, especially socio-economic, institutional and management aspects, will have to be considered within a wider frame".

3. In order to plan and initiate the hydrological investigations and water studies I visited Malaysia from 31st October to 15th November 1969. My itinerary is given in Appendix A. The fieldwork and visits were carried out with the Project Engineer (Mr. A. T. Fairley) and the Assistant Engineer (Mr. T. T. Wong) but unfortunately without the Project Hydrologist (Mr. T. J. Reardon) who was not in Malaysia at that time. He subsequently arrived in Johor Bahru on 5th December, immediately after receiving a work permit.

4. This report outlines the present development of the water resources of the two Regions and also some of the water studies which will be necessary, although until the other aspects of the Project studies are further advanced this must be speculative. The records available for the studies are reviewed. As there is little hydrological information for the Regions further intensive fieldwork has been planned to elucidate particular aspects of the water resources and this is summarised. It was started by Mr. Fairley in the latter part of November. A programme for the studies is given and the need for further visits discussed.

WATER RESOURCES - GENERAL

5. The two Regions under study - the Johor Tengah Region (370, 000 acres) and the Tanjong Pengerang Region (330, 000 acres) - differ appreciably and so their water resources will be described separately. Drawing 1 shows the Regions' locations and Drawings 2 and 3 give further information on them. Their general characteristics have been outlined by Hunting Technical Services Ltd. (Ref. 1). There are no detailed reports on their overall water resources although References 1, 2 and 3 are relevant.

Johor Tengah Region

6. The boundaries of the Region (Drawing 2) are only partially defined by watersheds and this complicates the assessment of the water resources and planning for their systematic development. The left bank of the S. Johor, the largest river in either Region, is nearly all included although the boundary, where it follows the railway, cuts across the river's headwaters. The remainder of the Region lies in the S. Endau basin south of the Kluang-Mersing road and includes portions of the catchments of several north-flowing tributaries. Two towns, Kluang and Kota Tinggi, lie partially within the Region and there is also the small town of Layang Layang. The eastern boundary consists mainly of hills which rise to 3,312 ft. (G. Blumut), but apart from ranges near this mountain the Region consists of undulating land below 200 ft. elevation with some small, swampy areas near river channels. Large portions are inaccessible and covered with primary jungle. The mean annual rainfall is about 100 inches on the south-western, western and northern boundaries and possibly as much as 140 inches in the eastern mountains, but no rainfall stations have been operated in this or the central areas.

7. The present water resources developments consist of the major water supply intake (30 m. g. d.) for Singapore on the S. Johor upstream of Kota Tinggi and a few small Public Works Department (P. W. D.) water supply schemes, e. g. Kota Tinggi's source on the S. Pelepah, Layang Layang's on the S. Sayong and Kluang's on the S. Menkibol. There are minor schemes for estate supplies and small communities. The Drainage and Irrigation Department (D. I. D.) have no irrigation or drainage schemes and there are very few minor irrigated areas. The S. Johor is used by a few small craft with outboard engines to take supplies up-river.

8. The land developments which may have affected the rivers' run-off and water quality characteristics, and which must therefore be considered in the water resources studies, are summarised below:

(a) S. Johor

Tin mining in the S. Tengkil valley and near the confluence of the S. Tengkil and the S. Linggiu; timber extraction in the southern part of the Region north of the S. Sayong and rubber tree and oil palm cultivation in the headwaters. Outside the Region but within the basin are extensive areas of rubber estates and new Federal Land Development Association (F. L. D. A.) schemes, which mostly involve forest clearing followed by the planting of rubber trees and oil palms.

(b) S. Mengkibol

A minor but developed catchment situated partially within the Region. It is the source for Kluang's water supply.

(c) S. Sembrong Kechil

An undeveloped catchment, apart from minor areas of rubber and selected timber extraction in the northern and western parts.

(d) S. Kahang

A large catchment mainly within Forest and Wild Life Reserves on the northern and western slopes of G. Blumut. There has been appreciable abstraction of selected timber and there are a few small areas of rubber south of the Kluang-Mersing road. North of the road and outside the Region there are extensive rubber plantations.

Tanjong Pengerang Region

9. The Region (Drawing 3) is situated on a peninsula bounded on three sides by water and consists of many, small river basins. The northern boundary cuts across minor right bank tributaries of the estuary of the S. Sedili Besar and across minor left bank tributaries of the S. Johor near Kota Tinggi, which lies partly in the Region and is the only important town. There are low-lying swamp areas around much of the coastline and extensive inland swamps behind the northern portions of the eastern coastline. The largest river basin, that of the S. Sedili Kechil, occupies the major portion of the swamp area. Large areas of the Region are at present undeveloped and consist of primary and secondary forest. The relief is generally low, the highest hills being slightly over 600 ft. The mean annual rainfall varies over the Region between about 115 and possibly 140 inches.

10. The water resources developments consist of minor schemes for estate water supplies and for small communities. There are no D. I. D. irrigation schemes and very few patches of irrigated land.

11. Until recently the only land developments which may have changed the river flow characteristics were the rubber estates along the eastern shores of the S. Johor estuary and the southern end of the peninsula. The secondary forest's influence on run-off can be expected to be similar to that of the original primary forest. However, the current major F. L. D. A. forest clearing and oil palm and rubber planting programme will certainly alter the river flow characteristics west of the central divide, from the Region's northern boundary nearly to the S. Lebam inlet, and in a minor northern area east of the divide. There are no drainage schemes in the eastern swamp areas.

WATER RESOURCES - FUTURE DEVELOPMENTS

Johor Tengah Region

12. The most important river in either Region and in the southern part of the State of Johor is the S. Johor and it may represent one of the area's most valuable resources. Singapore has an agreement with Johor State granting the right to take up to 250 m. g. d. from the river near Kota Tinggi, although present abstractions are only 30 m. g. d. Table I shows that in four recent years the estimated river flow at the intake fell below 250 m. g. d. on six different occasions. The largest deficiency or equivalent storage volume required in the basin or elsewhere to meet this demand, ignoring compensation water downstream of the intake and the problems of saline intrusion, was about 2, 300 m. g. d. Proper estimates of drought frequencies and the regulating storage volumes needed to sustain different demands will form an important part of the water resources studies.

13. The domestic and industrial water supply requirements of Johor Bahru may be expected to rise sharply and the alternative methods of meeting them will be studied, as they may have to be supplied from the S. Johor. The waters of the rivers near the town, the S. Tebrau on the east and the S. Scudai to the west, are already committed by agreement to Singapore, as also are those of the Pontian catchments further west, although arrangements could be made for their return to Johor.

14. The water of the S. Johor may therefore become a valuable export from the Johor Tengah region. If the river is to be developed extensively then regulation will be necessary, unless storage is provided elsewhere, and perhaps the most suitable tributary for this is the S. Lenggiu which was investigated in the 1920's (Ref. 2). The rainfall in its headwaters is probably high, there are damsites and the Master Plan report may recommend that the forests in the steep headwaters should be preserved. This would minimise the storage requirements, due to the less 'flashy' run-off characteristics and reduced erosion and sediment run-off from a forested catchment. However, there are other possible schemes. The topography is unlikely to be suitable for hydro-electric schemes.

15. Similarly, the northern rivers in the Region may be developed to meet external demands, e. g. Kluang water supply or irrigation schemes. The two main north-flowing rivers, the S. Sembrong Kechil and the S. Kahang, both have considerable resources and there are possible impounding sites on them. These might, for example, be used as regulating reservoirs for downstream irrigation schemes in the Endau basin outside the Project region, but there are probably other sites where this could be done and development has hardly started in this catchment. The Region, from the aspect of water resources, is a very artificial one and this will necessitate a preliminary examination of the whole areas' possible future developments and water supply

demands, as envisage in the Proposal.

Tanjong Pengerang Region

16. It appears at present that this Region's many minor rivers and streams are more likely to be developed to meet comparatively small local requirements than as sources of supply to major areas of demand. However, the total resources, although scattered, are large and the mean run-off is probably about 2,800 cusecs or 1,500 m. g. d. (say 125 in. rainfall minus say 50 in. losses = 75 in. run-off). The extent to which they may be developed probably depends mainly on the results of the other aspects of the Project investigations. In this context it was understood that the Region was not climatically well-suited for irrigation schemes. The low relief and small rivers are unlikely to be suitable for hydro-electric schemes.

Groundwater

17. The groundwater resources of the two Regions have not been assessed and, until there have been some preliminary studies of the geology and the characteristics of any aquifers, their potential must remain uncertain (see para. 27). Groundwater may prove to be a valuable source for future, minor rural water supply schemes.

External Developments

18. Apart from the developments already mentioned it was learnt that two important irrigation schemes have been proposed previously on rivers near the Project Regions. Both featured dams, one on the S. Lenggor, upstream of Station C, to the north-east of the Johor Tengah Region and one on the S. Sembrong at Station O, to the north-west (Drawing 1).

HYDROLOGICAL STUDIES

19. The general nature of the hydrological studies required for the two Regions are outlined below and are based on the types of water resources development schemes which may be investigated. They can be summarised as studies of river yields (intakes and dams); storms and floods; water resources operations; meteorology; estuarine salinity; sediment run-off; water quality; infiltration and groundwater.

Johor Tengah and Tanjong Pengerang Regions

20. The following studies are common to both Regions and include assessments of:

(a) The rainfall and run-off characteristics of the different parts of the Regions so that preliminary studies for

proposed irrigation, drainage or flood mitigation schemes can be made and to provide the data required for any fisheries or other studies.

(b) The mean and drought river flows for the larger proposed water supply schemes, including impounding schemes.

(c) Design low flows for small water supply intakes on both forested and developed catchments.

(d) The groundwater potential. This was originally to have been studied in detail by Hunting Technical Services Ltd. but has been removed from their programme.

(e) Water quality, including sediment run-off and the effect on this resulting from changes in land use, vegetation cover or from mining activities. Also to assess the rates of sedimentation of proposed reservoirs with both developed and undeveloped catchments.

(f) The meteorological characteristics, including potential evapo-transpiration and storms. The latter will include the derivation of the preliminary design storms for the spillways of any proposed reservoirs and flood mitigation schemes.

Johor Tengah Region Only

21. The S. Johor is the largest river in the two regions and its development as a major water supply source for Singapore or for other purposes will necessitate further studies, including:

(a) Studies of low flows and their frequencies for the design of river regulating reservoirs and/or major direct supply reservoirs.

(b) Studies of estuarine salinity movements and low flows to determine the conditions under which saline water will penetrate to the Singapore water supply intake and to study methods of preventing or allowing for this.

(c) Preliminary studies of the possible effects on the S. Johor's run-off resulting from changes in land use in the right bank areas outside the Project Region and possible future changes within the Region.

(d) An assessment of the importance of the pollution of the river, including that caused by the tin mining in the S. Tengkil valley.

(e) An assessment of the importance and requirements of navigation i. e. water depths for the river traffic on the S. Johor.

Programme of Studies

22. Because of the short time during the Project investigation for the collection of further hydrological data and the paucity of records observed within the Regions, the studies will have to be based largely on data transposed from other catchments in Malaysia; although this will be complicated by the poor knowledge of rainfall over the two Regions. Accordingly, an examination was made of the records from the majority of river gauging stations within Johor State except for the tidal stations and most short-term project-investigation stations. Consideration of the records and other hydrological data, the various catchment characteristics including topography and land use, and the ability to assess catchment rainfall, determined the general forms of analyses that will be made.

23. The hydrological records are summarised in Appendix B. With these and the studies which must be carried out (paras. 19 - 21) as a background, a programme of hydrological investigations has been prepared (Table 2). Information on the new river gauging and rainfall stations is given in Tables 3 and 4 and the equipment required is listed in Appendix C. Drawing 1 shows the locations of the river gauging stations in Johor State; Drawings 2 and 3 show the locations of the present and proposed rainfall, sediment, climatological and river gauging stations within and close to the two Project Regions.

24. Some comments on the programme are given below:

(a) Five river gauging stations will be operated, four at new sites and the fifth at the existing flood-level station on the S. Sembrong Kechil. These stations have been carefully sited to improve the run-off estimates of important catchments and/or to provide data on the relative run-off characteristics of different catchments i. e. forested and those developed by planting with rubber trees or oil palms. Their short records will be extended by correlations and the results should be a significant improvement over present knowledge. Access to all the stations is good or reasonable.

(b) The river flow records will be supplemented by spot flow measurements at further sites. These will be related to the main stations' records and are intended to improve the coverage

of flow data. They will also be made to check on the inflows between the gauging station at Rantau Panjang and the Singapore Water Supply Intake during any periods of low flows.

(c) Three suspended sediment sampling stations will be operated; on the forested S. Mupor catchment, the nearby wholly-developed (rubber and oil palm) S. Permandi catchment and the developed S. Sayong catchment at Layang Layang. The first two should give a direct indication of the effects of development on sediment run-off. The S. Sayong catchment has characteristics similar to those southern and western parts of the Johor Tengah Region which may be developed as a result of the Project studies and should give a good indication of the future sediment run-off from the latter. Continuous flow records will be measured on all three catchments. It is hoped that arrangements can be made for the sediment analyses to be done by the Department of Chemistry, Kuala Lumpur.

(d) The present meteorological records are adequate for the studies with the exception of rainfall data. Further stations will be operated, firstly, to sample the rainfall on roughly ENE-WSW cross sections running in from the east coast to determine the variations along this important storm track (Drawing 3) and secondly, to improve the knowledge of rainfall over the accessible southern parts of the Johor Tengah Region. Details are given on Table 4.

(e) Water sampling and quality analyses will be planned when the data collected by the P. W. D. at their water supply intakes have been studied. Monthly samples will be taken at Rantau Panjang on the S. Johor and further sampling is to be carried out at other stations(Table 3). Water temperatures will be recorded during all river flow measurements. Water samples should be sent to the Department of Chemistry, Kuala Lumpur for analysis.

(f) A programme of groundwater measurements will be prepared after the visit by our Geologist if his report shows that these resources require further study (see para. 27).

(g) Estuary salinity movements at times of low flows in the S. Johor will be studied by longitudinal boat traverses using a portable resistivity set. The results will be related to river flows and channel characteristics in order to derive a method for forecasting the frequency and duration of saline water reaching

Singapore's water supply intake when water is being abstracted at various rates up to 250 m. g. d.

(h) Infiltration estimates will initially be studied by examining rainfall, run-off and evapo-transpiration figures. Subsequently, infiltrometer tests may be made.

(i) In view of the short time available for the studies and the large amount of processing of past river data which must be completed quickly the advantages of doing this on a computer will be examined.

25. The initial estimate of the staff required to carry out the hydrological fieldwork and studies included the following, all engaged for 18 months:

Hydrologist (B. & P., London)	1
Civil Engineer/Hydrologist (B. & P. Malaysia)	1
Hydrological Assistants	3

and junior field assistants and drivers as necessary. The estimate remains unchanged. Mr. T. J. Reardon arrived in Malaysia on 5th December 1969 and Mr. T. T. Wong started work in Johor Bahru on 1st December 1969, filling the first two posts respectively. The remaining staff are being recruited locally.

26. The programme has been prepared within the present framework of the Project's programme, which is very intensive. While general information on the water resources can be derived by transposing records from elsewhere, the information within the two Regions is so sparse that it seemed essential to supplement this with local data. In order to obtain the maximum benefit from the supplementary data the hydrological field staff will have to be trained quickly and will have to carry out a large amount of fieldwork often under difficult conditions. It will be essential for them to receive every assistance in order to complete the programme satisfactorily.

VISITS

Geological

27. There are two aspects of the water resources investigations which will need experienced geological assistance: appraisal of the groundwater resources and their potential, and preliminary examination of the geological conditions at possible sites for dams and other engineering works. Both of these should be completed by early May 1970 so that the findings can be used in the studies for the water resources report to be completed by the end of June (Appendix D). A suitable geologist can be sent by Binnie & Partners from Hong Kong for a visit of about three weeks to do this work in April 1970 and it is recommended that arrangements should be made for this. The Project Engineer and Project Hydrologist should have done as much preparatory work e. g. cutting rentices, assembling groundwater data etc., as possible

before the geologist arrives. It is most desirable that the State Geologist should accompany the geologist on his field visits.

Hydrological

28. The June 1970 report will be extremely important: after examining all alternatives particular water resources schemes will be selected in the report for further investigation. Following the report it will be difficult to alter the selection due to the dependence of so many other aspects of the Project's studies on these decisions. It is therefore recommended that a second visit should be made by Mr. Mansell-Moullin in May 1970 in order to review in detail all the hydrological studies and fieldwork carried out by the Project Hydrologist, to recommend (if necessary) and possibly assist in further studies for the report and to arrange with him the programme of further fieldwork and studies.

ACKNOWLEDGMENTS

29. The members of the various Government Departments of West Malaysia with whom meetings were held were most helpful and co-operative and their interest was much appreciated. Particular mention must be made of Mr. S. Nesadurai. (State Drainage and Irrigation Engineer, Johor) who freely made available all his Department's invaluable hydrological records and of Mr. Low Theng Heng (State Water Engineer, Public Works Department, Johor). Throughout the visit all administrative arrangements were made by the staff of Hunting Technical Services Ltd. and for these and their friendly help and discussions I am most grateful.

M. Mansell-Moullin

December 1969.

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JOHOR STATE

103°00'E

104°00'E

2°30'N

2°00'N

1°30'N

3°00

2°00

6°00

7°00

NEGRI SEMBILAN

PAHANG

MALACCA

CHINA SEA

MALACCA STRAITS

SUMATRA

SINGAPORE

JOHOR TENGAH REGION

TANJONG PENGERANG REGION

LEGEND

State boundary

River basin boundary

Main road

Secondary road

Railway

River gauging station (letters refer to bar chart)

S.E. Johor Project Region

Endau

Mersing

Segamat

Tangkak

Kesang Tasek

Muar

Batu Pahat

Ayer Hitam

Kluang

Mawai

Layang Layang

Kota Tinggi

Pontian Kechil

JOHOR BAHRU

S. Muar

S. Bekok

S. Benut

S. Endau

S. Johor

A

B

C

D

E

F

G

H

I

J

K

L

M

N

O

P

Q

R

N

Scale: 12 Miles to 1 inch

10 5 0 10 20 30

JOHOR STATE

1. BASIN	2. RIVER	3. STATION	4. D.I.D. No. Federal	5. D.I.D. No. State	6. C.AREA sq.mi.	8. FLOW MEASUREMENTS	9. REMARKS
S. Johor	Johor	A) Rantau Panjang	7551	605	430	Many	Tin mining in the catchment
S. Endau	Labong	B) Labong Dam				–	Reservoir level records
	Lenggor	C) Ms. 42, Kluang - Mersing road	7571	302	80	122 (1959-69)	Roadworks likely to change stage:discharge relationship. Tin mining in the catchment.
	Kahang	D) Ms. 26, Kluang - Mersing road				None traced	Flood levels only measured now
	Madek	E) Kahang Irrigation Scheme headworks				1 (1963)	Scheme constructed 1948
	Sembrong Kechil	F) Ms. 4½, Kluang Mersing road		309		10 (1952-56) 3 (1964)	Currently a flood level station
	Mengkibol	G) Town bridge, Kluang		307		62 (1951-66)	
	"	H) Kuala Melantai				None traced	Probably further measurements made
	"	I) Kuala S. Mengkibol		1110		None traced	Intermittent records
	Melantai	J) Ms. 1½, Kluang - Batu Pahat road		308		9 (1952-56)	
S. Muar	Muar	K) Buloh Kasap	7411	110	1210	Many	Station closed. Monthly flows January 1952-June 1960 published (Ref 3)
	Segamat	L) Segamat town bridge	7414	115	254	Many	Monthly flows January 1951-June 1960 published (Ref 3)
S. Bekok	Bekok	M) Ms. 77, Yong Peng - Segamat road		417	135	3 (1959) 96 (1964-69)	Intermittent records
	Sembrong	N) Brizay bridge, Ayer Itam (upstream)	7523	405	72	Over 550 since 1937	Monthly flows August 1949-June 1960 published (Ref 3)
	"	ditto (downstream)			72	e	
	"	O) Ulu Sembrong damsite				13 (1940-41)	Records possibly not measured but transposed from Brizay bridge station
S. Benut	Ulu Benut	P) Ms. 48, road bridge		838		41 (1954-59)	Station suffers from backing up from the downstream irrigation headworks (1951) when the gate is closed. Currently a flood level station.
	Ulu Machap	Q) Ms. 50¼, road bridge				3 (1941) 122(1954-63)	Natural channel. Currently a flood level station
Other	Kapal	R) Road bridge	–	–	2.3	–	V notch weir installed to investigate a proposed water supply scheme. Operated by the P.W.D.
	Scudai	S) Shansi Estate road bridge			72	17 (1937-57) 9 (1957-59) 21 (1961-62)	Final daily flow values not yet prepared

7. 1935 36 37 38 39 1940 41 42 43 44 1945 46 47 48 49 1950 51 52 53 54 1955 56 57 58 59 1960 61 62 63 64 1965 66 67 68 69 1970 71 72

Notes

1. The records of various short-term project stations, particularly on the West Coast, are not shown; neither are those of tidal stations.
2. Some of the recent flow records shown on the Table have not yet been prepared.
3. The records of the S, Bekok at Yong Peng bridge and the S. Sedili Besar at Ulu Sedili have not been included as both stations are believed to be affected by tidal backing-up. Both have been closed.
4. All available records may not have been traced.
5. Numbers indicate the month in which records started and stopped. Short breaks are not shown.
6. Reference letters have been given to the stations (Col.3) for their identification on Drawing 1.

Data Sources

All information was obtained from the Drainage and Irrigation Department, Malaysia who have operated all the stations except that on the S. Kapal (Johore State D.I.D. Engineer, Johor Bahru; D.I.D. District Offices at Batu Pahat and Mersing; D.I.D. Sub-District Office, Kluang; Hydrological Research Station, Ampang).

Legend

Staff gauge readings, twice daily

Water level recorder records

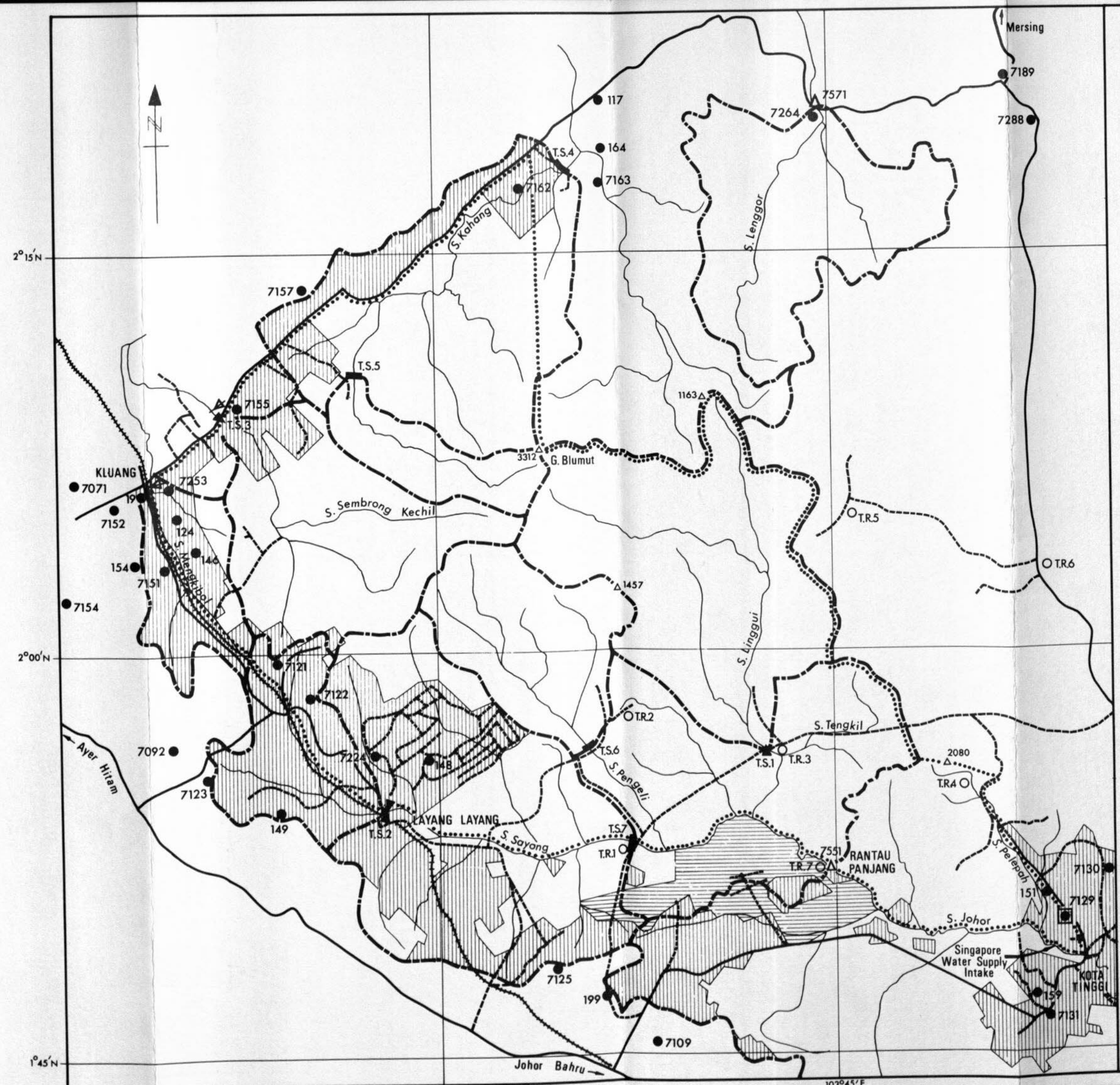
Flow records, based on twice daily staff gauge readings

Flow records, based on water level recorder data

Monthly flow figures

JOHOR STATE—RIVER RECORDS

Drawing No. 1



LEGEND

- Main roads
- Secondary roads and logging tracks
- Project Region boundary
- Catchment boundary
- Existing developed areas (rubber, oil palms)
- Proposed areas for development (F.L.D.A.)

- Auxiliary Meteorological station (M.M.S.)
- Raingauge – existing
- Raingauge – Project
- River flow gauging station
- River gauging station – abandoned
- Project river gauging station
- Project river gauging and sediment sampling station
- Project spot flow gauging station (regular measurements)

NOTES

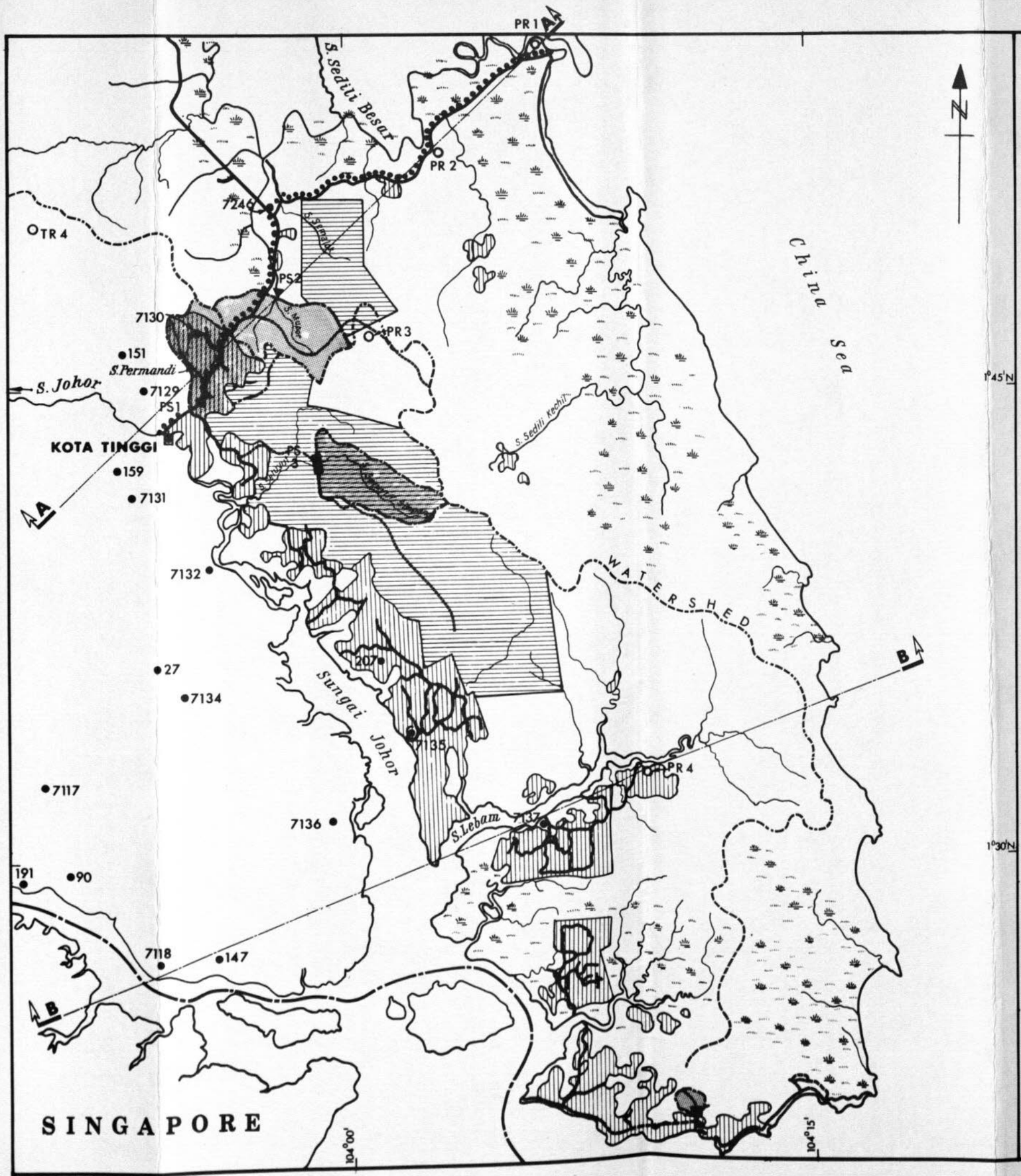
1. Some of the proposed areas for development have already been cleared and planted by the F.L.D.A.; further clearing is in progress.
2. The Project river gauging and rainfall stations are described on Tables 3 and 4.

– Scale in Miles –

5 0 5 10

JOHOR TENGAH REGION

Drawing No. 2



LEGEND

- Main roads
- Secondary roads and logging tracks
- Project Region boundary
- Catchment boundary
- Existing developed areas (rubber, oil palms)
- Proposed areas for development (F.L.D.A.)
- Swamp areas

- Auxiliary Meteorological station (M.M.S.)
- Raingauge – existing
- Raingauge – project
- River gauging station – abandoned
- Project river gauging & sediment sampling station
- Project spot flow gauging stn.
- Rainfall : topography cross section

NOTES

1. Some of the proposed areas for development have already been cleared and planted by the F.L.D.A.; further clearing is in progress
2. The Project river gauging and rainfall stations are described on Tables 3 & 4

— Scale in Miles —

5 0 5 10

TANJONG PENGERANG REGION

Drawing No. 3

S. JOHOR FLOWS (PRELIMINARY) AT RANTAU PANJANG (CATCHMENT AREA 430 SQ. MILES)

WATER YEAR		OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	ANNUAL DISCHARGE M.G.D. MEAN	ANNUAL DISCHARGE M.G.D. MIN.	ANNUAL DEFICIENCY BELOW 250 M.G.D. M.G.
1962-63	a) Mean flow mgd												603	—		
	b) Min. flow mgd												215		—	
1963-64	a) Mean flow mgd	778	1080	1162	814	818	1945	1174	1307	411	845	384	716	955		
	b) Min. flow mgd	457	670	490	328	360	651	490	344	282	282e	229	282		229	
1964-65	a) Mean flow mgd	565	344	1213	921	300	125	470	826	310	203	468	272	505		
	b) Min. flow mgd	242	202	135	202	188	58e	269e	522	188	110	188	135		58e	
1965-66	a) Mean flow mgd	836	1296	1180	820	364	378	578	455	482	660	757	511	696		
	b) Min. flow mgd	269	764	915	457	229	202	161	269	229	188	457	256		161	
1966-67	a) Mean flow mgd	788	1177	1080	1570	1800	1012	809	1315	552	403	258	494	938		
	b) Min. flow mgd	328	442	670	620	328	377	377	620	382	233	175	291		175	
1967-68	a) Mean flow mgd	500												—		
	b) Min. flow mgd	225													—	

S. JOHOR FLOWS (PRELIMINARY) AT SINGAPORE'S WATER SUPPLY INTAKE (CATCHMENT AREA 590 SQ. MILES)

1962-63	a) Mean flow mgd												827	—		
	b) Min. flow mgd												295		—	
	c) Deficiency mg												—			—
	d) Total Dfcy mg												—			
1963-64	a) Mean flow mgd	1070	1485	1600	1120	1120	2670	1610	1800	565	1160	527	985	1310		
	b) Min. flow mgd	629	920	674	450	495	895	674	474	388	388	314	388		314	
	c) Deficiency mg	—	—	—	—	—	—	—	—	—	—	—	—			Nil
	d) Total Dfcy mg	—	—	—	—	—	—	—	—	—	—	—	—			
1964-65	a) Mean flow mgd	776	472	1665	1265	412	172	645	1134	426	279	643	373	693		
	b) Min. flow mgd	332	277	185	277	258	80	369	717	258	151	258	185		80	
	c) Deficiency mg	—	—	170	—	—	2300	—	—	—	810	—	130			3410
	d) Total Dfcy mg	—	—	170	—	—	2300	—	—	—	810	—	130			
1965-66	a) Mean flow mgd	1148	1779	1620	1126	500	519	794	625	662	906	1039	702	956		
	b) Min. flow mgd	369	1049	1256	627	314	277	221	369	314	258	627	351		221	
	c) Deficiency mg	—	—	—	—	—	—	28	—	—	—	—	—			28
	d) Total Dfcy mg	—	—	—	—	—	—	28	—	—	—	—	—			
1966-67	a) Mean flow mgd	1082	1616	1483	2156	2471	1389	1111	1805	758	553	354	678	1288		
	b) Min. flow mgd	450	607	920	851	450	518	518	851	524	320	240	400		240	
	c) Deficiency mg	—	—	—	—	—	—	—	—	—	—	14	—			14
	d) Total Dfcy mg	—	—	—	—	—	—	—	—	—	—	14	—			
1967-68	a) Mean flow mgd	685												—		
	b) Min. flow mgd	309													—	
	c) Deficiency mg	—														—
	d) Total Dfcy mg	—														

e — Estimated figure, due to break in record.

Notes
1 — The Table is based on the field observations of D.I.D. Malaysia. Flows since October 1967 are not yet available.
2 — Deficiencies (c) are the volumes below 250 mgd and their totals (d) are the sum of these for individual events.
3 — The preliminary flows at the intake are the Rantau Panjang flows scaled up to the ratio of the catchment areas (590:430). This probably results in underestimates of the deficiencies below 250 mgd and the true value in March 1965 might have been over 2500 mg.

S. JOHOR FLOWS

Table 1

	REF. NO.	DESCRIPTION	1969 SEP	OCT	NOV	DEC	1970 JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	1971 JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	REMARKS
INITIAL WORK	I.1	Initial review of hydrological data; Field visits. Plan fieldwork and studies.																									
	I.2	Order hydrological equipment.																									
FIELDWORK	F.1	Install and operate new hydrological stations.																									River gauging; rainfall; suspended sediment sampling; water sampling; infiltration measurements.
	F.2	Special fieldwork in S. Johor estuary.																									Timing depends on occurrence of low flows.
	F.3	Special fieldwork on river channel losses.																									Timing depends on occurrence of low flows.
	F.4	Special fieldwork for groundwater studies																									Fieldwork may continue dependent on groundwater potential.
	F.5	Special fieldwork for possible schemes.																									
	F.6	Special fieldwork related to transfers from outside the Regions.																									May be unnecessary.
	F.7	Hand over or close down hydrological stations.																									
OFFICE WORK	O.1	Determine operation and yields of existing water development schemes.																									
	O.2	Routine analysis of incoming field data.																									
	O.3	Copy river records and derive daily flows.																									
	O.4	Prepare mean annual isohyetal map.					Initial													Final							
	O.5	Prepare computer programme for basic hydrological analyses						Initial																			
	O.6	Prepare evapotranspiration, open water evaporation and basin loss estimates.														Final											
	O.7	Assess river channel losses																									
	O.8	Assist in studies relating to Singapore's water supply interests																									
	O.9	Prepare hydrological design values for all proposed schemes.																									
	O.10	Extend runoff records. Derive flow frequencies; study yields and storages.																									
	O.11	Estimate flows at sites of possible water resources schemes.																									
	O.12	Infiltration studies.																									
	O.13	Groundwater potential studies.									Initial																Further studies subsequently, if necessary.
	O.14	Study integration of water resources developments; operation; forecasting.										Initial															
	O.15	Perform flood frequency studies. Derive data for flood control schemes.											Initial														
	O.16	Sediment runoff and reservoir sedimentation studies.																Final									
	O.17	Study effects on runoff of catchment use.																		Final							
	O.18	Relate estuary saline intrusion to abstractions and flow frequencies.															Final										
	O.19	Final filing of data and completing calculation files.																									

Hydrologist leaves Malaysia

	Reports	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG
					D.P.		D.P.			D	R	P	D	R	P			?	?				?	?	?

Start of Project

Initial Hydrological Report (Internal)

Prelim. Hydrological Report (Internal)

Prelim. Water Resources Report (Internal)

Interim Report (Internal)

Draft Project Report

Final date for inserting hydrological data and studies

Master Plan

LEGEND:

Reports

Malaysia — D — Draft; R — Review

London — P — Printing/Typing

Water Supply (Sources, Amounts, Occurrence Variability, Quality).
Project Studies (System and Operation).

WATER STUDIES PROGRAMME

Table 2

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
NO	RIVER AND STATION NAME	C. AREA SQ. MI.	WATER LEVEL MEASUREMENTS			FLOW MEASUREMENTS (Current meter)			FREQUENCY OF VISITS	ACCESS (HRS)		CAR/ LANDROVER	CATCH-MENT TYPE	WATER QUALITY MEAS.	REMARKS
			Staff Gauge (Range ft)	Recorder (Range ft)	Recorder Type	Wading	Boat	Bridge		Johor Bahru	Other				
TANJONG PENGERANG REGION (P)															
P.S.1	S. Permandi near Ms. 27¼, Johor Bahru-Mersing road	7.1	0 - 10	0 - 10	Pressure bulb	Possibly at low flows	–	✓ (gauging br.)	Weekly	¾	Kota Tinggi 5 mins.	Car	Rubber and palm oil	Water analysis Sediment	Foot bridge to be built (approx. 25ft span). Local gauge reader to make daily water level observations.
P.S.2	S. Mupor near Ms.32, Johor Bahru-Mersing road	8.1	0 - 10	0 - 10	Pressure bulb	Possibly at low flows	–	✓ (gauging br.)	Weekly	1	Kota Tinggi ¼	Car (normally)	Forest	Water analysis Sediment	Foot bridge to be built (approx. 25ft span). No local gauge reader.
JOHOR TENGAH REGION (T)															
T.S.1	S. Linggiu upstream of S. Tengkil confluence	112	0 - 13.33	0 - 20	Pressure bulb	–	✓	Flood flows	Weekly	2¼ via Kulai	–	Landrover	Forest with tin mining	–	Monthly water sampling upstream of tin mines.
T.S.2	S. Sayong at P.W.D. intake, Layang Layang	39	0 - 13.33	0 - 5 per drum rev.	Float	Possibly at low flows	✓	Possibly at high flows	Weekly initially	1½	–	Car	Rubber and palm oil	Water analysis Sediment	P.W.D. observer will make twice daily water level observations. Visits twice monthly when rating established.
T.S.3	S. Sembrong Kechil at Ms. 4½, near Kg. Sembrong	77	0 - 20	? (See remarks)	? (Float)	Low, medium	–	High flows	Weekly initially	2	Kluang ¼	Car	Forest, minor rubber area	–	Local gauge reader to make twice daily gauge readings. If unsatisfactory a water level recorder and pipe well will be installed on bridge.

Notes:

1. Spot-flow gauging stations will also be operated, initially at P.S.3 and T.S.4 to 7. Locations are shown on Drawings 2 and 3. The frequency of measurements will be approximately once-monthly but this will be increased during low flows and as necessary to establish correlations with other stations.
2. Further spot-flow gauging stations may become necessary during the course of the investigations.
3. Staff gauges (range 0 - 6.66 ft) will be established at T.S. 5 and T.S.6.

PROJECT RIVER GAUGING STATIONS

Table 3

1	2	3	4	5	6	7	8	9	10	11	12
NO.	NAME	GRID REF.	ELEVATION (APPROX.) FT.	RAINGAUGE			OBSERVER	FREQUENCY OF PROJECT VISITS	ACCESS FROM JOHOR BAHRU HRS	CAR/ LAND-ROVER	REMARKS
				FORTNIGHTLY	WEEKLY	DAILY					
TANJONG PENGERANG REGION (P)											
P.R.1	Kg. Tg. Lembu	WN4333	10		✓	(If possible)	Local and project staff	Weekly	1½	Car	Mile 49 from Johor Bahru
P.R.2	Kangkar Lama	WN3527	50		✓	(If possible)	Local and project staff	Weekly	1¼	Car	Mile 42½ from Johor Bahru. Other sites in vicinity.
P.R.3	Ulu Seluyut	WN3015 (v. approx)	200	✓			Project staff	Fortnightly	2	Landrover	Near logging trail.
P.R.4	Kg Bahru	WS4886	50			✓	Local	Infrequent	3 - 4 ?	Car, ferry and taxi.	Will only be operated if a local observer can be found.
JOHOR TENGAH REGION (T)											
T.R.1	S. Sayong road bridge near confluence with S. Pengeli	WM8217	50		✓		Project staff	Weekly	1½	Landrover	
T.R.2	Ulu Pengeli	WM8227 (v. approx)	200?	✓			Project staff	Fortnightly	2	Landrover	
T.R.3	Hup Seng Kung mining camp	WM9225	50		✓	(If possible)	Local and project staff	Weekly	2¼	Landrover	
T.R.4	Kota Tinggi Waterworks Intake dam	WN0922	350?	✓		✓	P.W.D. and project staff	Fortnightly	1¼	Car	Arrangements made for a P.W.D. observer.
T.R.5	Ulu Sedili	WM9941 (v. approx)	2-500?	✓			Project staff	Fortnightly	2 - 2½	Landrover	
T.R.6	Lee Sawmill No. 4 HQ, Mile 47 Johor Bahru-Mersing road	WN1438	70	✓		(If possible)	Local and project staff	Fortnightly	1½	Car	
T.R.7	Kg Rantau Panjang	WM9815	30			✓	Local	Infrequent	1½	Landrover	Will only be operated if a local observer can be found.

Notes: 1. All raingauges will be read on the morning of the first of each month so that monthly rainfall totals can be derived. The weekly and fortnightly observations will mainly be read during river gauging field trips.
2. Station locations are shown on Drawings 2 and 3.

PROJECT RAINFALL STATIONS

Table 4

ITINERARY IN MALAYSIA
OCTOBER AND NOVEMBER 1969
(M. Mansell-Moullin)

Date	Day		
30/10	Thurs.	p.m.	Leave London (Flight BA 798)
31/10	Fri.	p.m.	Arrive Singapore. Met by Mr. W. Trevett, Hunting Technical Services (H. T. S.) Stay Johor Hotel, Johor Bahru.
1/11	Sat.		Discussions with Project Engineer, Binnie & Partners (Mr. A. T. Fairley) and staff of H. T. S. Plan programme for visit.
2/11	Sun.		0900 hrs. Meeting with State Drainage and Irrigation Engineer, Johor (Mr. S. Nesadurai). Examine and discuss hydrological records.
3/11	Mon.		1130 hrs. Meeting with State Water Engineer, Public Works Department (Mr. Low Theng Heng). Plan field visits. Engineer (Mr. T. T. Wong) from Binnie & Partners (Malaysia) arrives from Kuala Lumpur. Stay Rest House, Johor Bahru.
4/11	Tues.		Start 3 day field trip with Messrs. Fairley and Wong. Visit Bukit Batu water supply intake, Drainage and Irrigation Department (D. I. D.) District Office, Batu Pahat (Mr. A. Samad) and D. I. D. Sub-District Office, Kluang. Visit D. I. D. river gauging stations and examine records. Stay New Kluang Hotel, Kluang.
5/11	Wed.		Visit D. I. D. river gauging stations, Kahang (Madek) irrigation headworks and D. I. D. District Office, Mersing (Mr. K. Balakrishnan). Reconnaissance of logging trails and access to rivers in the upper S. Kahang basin.
6/11	Thurs.	a.m.	Examine D. I. D. river records held in Kluang.
		p.m.	Reconnaissance of upper S. Sayong basin. Return to Johor Bahru. Discussions with Mr. Smethurst (Binnie & Partners). Stay Johor Bahru Rest House.

Date	Day		
7/11	Fri.	a. m.	Travel to Changi Airport for flight over the project regions. This is later cancelled due to the poor weather conditions.
8/11	Sat.		Examine hydrological data held in D. I. D. offices, Johor Bahru. Consider present and possible future developments in Tanjong Pengerang region.
9/11	Sun.		Field visit with Messrs. Fairley and Wong to Kota Tinggi - east coast - northern areas of Tanjong Pengerang region, including current F. L. D. A. developments. Visit Kota Tinggi water supply intake.
10/11	Mon.		Field visit with Messrs. Fairley and Wong to S. Johor basin in S. Sayong - S. Pelepah - S. Linggiu area, returning via Ulu Dohol and Kota Tinggi.
11/11	Tues.		Planning programme of water resources and hydrological investigations. Final visits to State Drainage and Irrigation Engineer and Water Engineer.
12/11	Wed.		Discuss programme and staff, instruments, transport etc. with staff of Binnie & Partners and Hunting Technical Services.
		p. m.	Fly to Kuala Lumpur with Messrs. Fairley and Wong. Stay Pacific Hotel.
13/11	Thurs.		Visit offices of Binnie & Partners (Malaysia).
			1000 hrs. Meeting at D. I. D. headquarters with the Assistant Director-South (Mr. J. G. Daniel) and Assistant Director-Technical (Mr. Fam Seng Lin). Visit D. I. D. Research Station, Ampang (Mr. Tan Hoe Tim) and collect river records.
		p. m.	Discussionson hydrological instruments at factory of Messrs. George Kent (Malaysia).
14/11	Fri.		Review hydrological information relevant to the project held by Binnie & Partners (Malaysia).

Date	Day		
15/11	Sat.	a. m.	Finalise orders for hydrological equipment. Loan some equipment for the Project from Binnie & Partners (Malaysia).
		p. m.	Fly Kuala Lumpur - London (Flight QF 741).
16/11	Sun.	a. m.	Arrive London.

HYDROLOGICAL RECORDS

River Records

B.1 There are two short records of river flows in the two Project Regions; those for the S. Johor at Rantau Panjang (w. e. f. 1963), whose monthly flows are shown in Table 1 and those for a small stream, the S. Kapal, on the southern tip of the Tanjong Pengerang peninsula (1959 - 1963). There are also long water level records on two further rivers (the S. Sembrong Kechil and the S. Mengkibol) from which it may be possible to derive reliable river flows. These, although supplemented by further fieldwork, will be inadequate for the water resources studies of the regions and it will be necessary to transpose river flow records from catchments outside them. Accordingly, the records of the whole of the State of Johor have been examined and they are summarised, with minor exceptions, and their locations shown on Drawing 1. They have been operated by the Drainage and Irrigation Department, with the exception of the S. Kapal station, which was operated by the Public Works Department. Notable droughts occurred in 1958/59 and 1963.

B.2 The records up to June 1960 of three stations have been published (Ref. 4) and the recent data from five Federal stations, on the S. Johor, Muar, Lenggor, Sembrong and Segamat are being processed at the D. I. D. Hydrological Research Station, Ampang.

B.3 The D. I. D. have carried out surveys of areas inundated during floods and have prepared reports following particular floods (e. g. Refs. 5, 6). Flood level measuring stations are operated and a flood warning system is based on them. The most severe flood recorded on many rivers and reputedly the worst in living memory occurred in December 1967 but a flood experienced during the preparation of this report may have been more severe.

Meteorological Records

B.4 The Malaysian Meteorological Service operate a Synoptic Station at Mersing and Auxiliary Stations at Johor Bahru, Kota Tinggi, Segamat, Tangkak, Muar and Pontian Kechil. Summaries of the records are published. Full meteorological observations are made at several stations in Singapore and are published.

B.5 There were 151 rainfall stations operating in Johor State on 1st September 1969, of which 15 were located within the Project Regions, all near the peripheries. The records up to 1958 have been published (Ref. 7). A map showing the locations of all the present stations has been prepared from D. I. D. information and those near the Project

Regions are shown on Drawings 2 and 3. Recording raingauges are operated by the Meteorological Service at Mersing and by the D. I. D. at Mawai and Kluang in the Project Regions and at several other stations in South-East Johor. Several general isohyetal maps covering southern Malaysia have been prepared, including those by Dale (Ref. 8), the Drainage and Irrigation Department and the Singapore Meteorological Service (Ref. 9). None give a detailed picture of the mean rainfall over the two regions due largely to the lack of rainfall observations within them.

B. 6 Pan and tank evaporation measurements are made at the following D. I. D. stations in Johor:

D. I. D. Store, Johor Bahru,	w. e. f. June 1962	Class A pan	
D. I. D. Office, Kluang,	w. e. f. June 1962	Class A pan	
D. I. D. Store, Batu Pahat,	w. e. f. Feb. 1961	Class A pan/	Colorado tank
Endau village,	w. e. f. July 1962	Class A pan	
Kesang Tasek Pump House,	w. e. f. July 1962	Class A pan	

The Class A pan mean annual evaporation values vary between 60 and 70 in., those for Kesang Tasek being slightly higher than this. The relationship between these and lake evaporation is uncertain. Pan evaporation is difficult to measure in Malaysia due to splash-out and overflow during the frequent periods of heavy rain. As a result the measurements tend to err on the high side. Nieuwolt (Ref. 10) has made a general assessment of evaporation and water balances. The best estimates of actual catchment losses will be based on measured catchment rainfall less measured catchment run-off.

Water Quality Records

B. 7 There are twenty-six water supply schemes in Johor, apart from the large Pontian, Tebrau, Scudai and Johor River schemes operated by Singapore's Public Utilities Board. It is understood that at all of them raw water samples are taken and analysed regularly by the Public Works Department. Schemes within the Project Regions include those for the towns of Kota Tinggi, Layang Layang and Kluang. Studies of saline intrusion in the S. Johor estuary have been carried out for the Public Utilities Board, Singapore.

B. 8 There have been few studies of sediment run-off in Malaysia and none in Johor. Some data obtained during investigations for hydro-electric schemes have been published recently (Ref. 11) and these can be used to provide first estimates of the sediment run-off from the forested, mountainous areas of the Johor Tengah region. The effects of clearing forest areas and the relative sediment yields of forested catchments

and catchments planted with rubber trees or oil palms has not been determined, although it is understood that the University of Malaysia (Dr. Douglas) is studying this.

Soil Moisture Records

B. 9 It is uncertain whether there have been any routine measurements of soil moisture or infiltration in Johor but it appears rather unlikely.

Groundwater Records

B. 10 Preliminary enquiries have not traced any routine well pumping or rest water levels in Johor and it appears that only minor rural groundwater wells are in use. A borehole was sunk near Mile 27 on the Pontian road for a pineapple factory but it is believed to have been unsuccessful.

APPENDIX C

HYDROLOGICAL EQUIPMENT

Full details of the equipment and instruments required are not detailed below as they, together with spares, have already been specified and ordered. Minor items are not shown. Some further instruments may be needed.

River gauging reels	2
River staff gauge plates, 3.33 ft. lengths	46
Current meter sets with weights and wading rods	2
Pygmy current meter set	1
River gaugings boats, approx. 12 ft. length	2
Outboard engines	2
Water level recorders - pressure bulb	5
Water level recorders - float operated	2
Taglines	3
Depth-integrating suspended sediment sampler, complete	1
Waders	6
Lifejackets	6
Stopwatches	3

Fabricated locally:-

Raingauges, non-recording (20, 40, 60 in. capacity)	22
Water level recorder boxes	7
Boat gauging booms	2
Bridge river gauging crane	1

It has been assumed that survey levels, staffs, tapes, compasses, planimeters etc. will be made available from the Project's general equipment.

APPENDIX D

PROGRAMME FOR WATER RESOURCES REPORTS

(Discussed in Johor Bahru with Mr. Swinson and Mr. Fairley on 11th November, 1969)

Starting Date of Project	1st September 1969.
Preliminary Hydrological Report (Internal)	End February 1970.

Outline of previous hydrological reports and notes. Summary of initial findings on the water resources of the Regions so that preliminary engineering studies can be started. The summary will be based on existing hydrological data, as the data collected by the Project will be too short to be of assistance at that time.

Preliminary Water Resources Report (Internal)	End June 1970.

Outline of preliminary selection of water resources developments, in conjunction with all other aspects of the Project's work, so that the subsequent water resources studies can be concentrated on particular schemes.

Interim Report (Internal)	Mid September - October 1970.

A first draft of the Draft Project Report. The water resources section will include proposed schemes with cost estimates. The report will be discussed with the client and further work may be necessary depending on his comments.

Draft Project Report Submitted	End January 1971.

Recommendations for the development of the Regions including water resources development proposals.

Final data for incorporating further hydrological studies and refinements to water resources studies into the Master Plan Report. End of hydrological investigations. Make arrangements for continuation of specific data collection and studies.	End March 1971.
Hydrologist leaves Malaysia (after 18 months tour)	May 1971.
Master Plan Report Submitted	August 1971.