WATER RESOURCES PUBLICATION NO. 12

AVERAGE ANNUAL AND MONTHLY SURFACE WATER RESOURCES OF PENINSULAR MALAYSIA

1982

JABATAN PENGAIRAN DAN SALIRAN
KEMENTERIAN PERTANIAN MALAYSIA

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JPT

Bahagian Parit dan Taliair

Kementerian Pertanian

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BAHAGIAN PARIT DAN TALI AIR
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SUMMARY

This study is an extension of Water Resources Publication No. 6 on 'Average Annual Surface Water Resources of Peninsular Malaysia', 1976. While the methodology remains much the same, the study has produced in addition to an annual map, a set of monthly maps showing the spatial distribution of the surface water resources from January to December. The accuracies of the annual map remain at within ±15% while that of the monthly maps are within ±25% or a depth depending on the monthly runoff amount (25mm for runoff less than 100mm, 50mm for runoff between 100 and 300mm and 100mm for runoff greater than 300mm). A map showing the coefficient of variation of the annual runoff is also produced. This map could be used to assess the variability of the annual water resources, an example of which is included in this publication.

Based on these maps, the average annual runoff for the whole of Peninsular Malaysia was estimated to be 1173mm equivalent to 5000m³/s, about 50% of which came from months November to January.

The study is based on data from 460 selected rainfall stations and 75 streamflow stations recorded or measured during the period January 1959 to June 1975, i.e. 16½ years.

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1. INTRODUCTION

1.1 STUDY OBJECTIVE

The Water Resources Publication No. 6 (W.R.P. No. 6) enables an estimation of average annual run-off for ungauged rivers in Peninsular Malaysia to an accuracy of within ± 15%. While the Publication has served useful purposes for planning and development of water resources, it has been found that there is a need to also know the monthly distribution as well as the variability of the annual water resources. To meet this need, it was decided to update W.R.P. No. 6 with a view to produce the following:–

(i) Average annual surface water resources map with histograms showing monthly distribution of the water resources for a number of selected locations.

(ii) Average monthly surface water resources maps.

(iii) Map of coefficient of variation of annual surface water resources, and

(iv) A method of assessing the variability of the annual surface water resources.

2. METHODOLOGY

2.1 Water Balance Model

The method of analysis is the same as for W.R.P. No. 6. It is still based on the Thornthwaite and Mather Water Balance Model (1955). A description of the Model can be found in W.R.P. No.6 and is attached here as Appendix 1 for easy reference.

2.2 Processing System

The processing system still remains much the same as in W.R.P. No. 6 except that the daily rainfall records used have now been extended from the period January 1959 – June 1970 to the period January 1959 – June 1975 i.e. from record length of 11½ years to 16½ years, the first 6 months being used for establishing initial soil moisture storage conditions. The main features of the processing system are given as follows:–

(i) **Rainfall**

A total of 460 rainfall stations having 6 years or more of continuous records were selected for analysis. Two-third of these stations have 15 to 16 years of record. Selection was based on quality of data, station coverage and length of record.

(ii) **Potential Evapotranspiration**

Annual potential evapotranspiration at each rainfall station site was obtained from Tables and Evaporation Map in Water Resources Publication No. 5. The monthly distribution was then based on the nearest of 105 evaporation sites listed in W.R.P. No. 5. The evaporation surface was assumed to be forest.

(iii) **Water Holding Capacity**

As in W.R.P. No. 6, the water holding capacity was fixed at 250mm, which means the soil moisture retention constants of a and b in the soil moisture depletion equation:

$$MS = a.e^{b.APPD} \text{ (please see Appendix 1)}$$

remained at 249.5 and –0.0040 respectively.

(iv) **Recession Constant**

This was retained at 0.9 as recommended by Thornthwaite and Mather for daily modelling.

2.3 Sample Outputs

Sample outputs of the analyses are given in Appendix 2.

3. WATER RESOURCES MAPPING

3.1 Using Runoff Values Instead of (P-AE) values

In W.R.P. No. 6, the average annual surface water resources was based on (P-AE) i.e. precipitation minus actual evapotranspiration. Over long term and continuous summation, computed (P-AE) does not differ significantly from the computed runoff. This can be seen from Appendix 2 where the average annual (P-AE) is 1235mm and average annual runoff is only 1mm less at 1234mm. However, as a result of soil moisture storage and runoff retention, monthly (P-AE) and runoff values could differ significantly. Computed values for the station in Appendix 2 are shown here as example:–

Station No: 1334104

Period: 1959/60 – 1974/75

	J	F	M	A	M	J	J	A	S	O	N	D	TOTAL
Average (P–AE) (mm)	70	50	127	120	184	156	63	67	46	118	132	95	1236*
Average Runoff (mm)	86	63	106	118	176	156	116	55	55	80	128	93	1232*
Difference (%)	–19	–8	+20	+2	+5	0	–46	+22	–16	+48	+3	+2	–

*Differ a little from the annual totals as a result of rounding off of monthly values to nearest mm.

As could be seen, the difference can be as high as nearly ±50%. It is therefore not appropriate to use (P-AE) values for mapping of monthly water resources. As such, the water resources maps, both monthly and annual, were prepared based on computed runoff values.

3.2 Mapping Average Annual And Monthly Water Resources

Using maps (13 sheets in total) of Peninsular Malaysia with scale of 1:1,000,000, the location and corresponding computed average runoff values were plotted by computerised plotting. The stations with less than 15 years of record were highlighted by being underlined.

Using a constant interval of 200mm for annual runoffs and variable intervals of 25mm (runoff ⩽ 100mm), 50mm (100mm < runoff ⩽ 300mm) and 100mm (runoff > 300mm) for monthly runoff, the isohyds were drawn. Where difficulties were encountered in the construction of the isohyds, references were made to W.R.P. No. 6, Mean Annual and Monthly Rainfall Maps, D.I.D. (1950 – 1975) as well as the relief map.

3.2.1 Representativeness of rainfall during the study period

There was no attempt to use the long term mean annual precipitation to adjust the computed runoff values as was the case in W.R.P. No. 6, due mainly to the feeling that the method used could lead to an overestimation of the water resources. However, a comparative study was carried out to see how representative the 16 years of rainfall data (July 1959 – June 1975) are of the long term rainfall average. For this study, 15 rainfall stations with lengths of records of at least 30 years were selected. The results of the study are as shown in Appendix 3. Generally, the stations along the east coast as well as Kedah/ Perlis areas recorded more while elsewhere (except the high elevation station at Bukit Fraser, Pahang) recorded less during the 16 years period. However, overall, the 16 year average works out to be about 99% of the long term average, while differences at individual stations are all within ±7%. The differences could be considered small when compared with the order of accuracy associated with general water resources assessment. It appears therefore the 1959 – 1975 data could be accepted as reasonably representative of the long term rainfall average.

3.2.2 **Refinement of the water resources maps**

The streamflow records represent the best indication of the surface water resources available from the catchment areas. Streamflow records from 75 catchments (varying in area from 41 to 19,000 square kilometres – please see Appendix 4) were complied and the average monthly and annual runoffs computed. These observed runoff values were then used to visually check the plotted isohyds. In most cases the isohyds compared reasonably well with the observed values, except for the months of March, April, May and June when the observed water resources in the east coast areas were very much higher. This could be attributed to the large base flow contribution from groundwater storage brought about during the earlier monsoon months. Accordingly, the isohyds were adjusted to give a closer estimate of the water resources as have been observed.

3.3 **Comparison with Observed Water Resources**

3.3.1 **Annual water resources**

The accuracy of the derived isohyds map was then tested using the observed runoff records compiled for the 75 catchments, refered to in para 3.2.2. These catchments were used as they have records of 5 years or more during the 1959 – 1975 period. Using 'isohyetal method' (same as for estimation of catchment rainfall from rainfall isohytes), the average annual runoffs were estimated for each of the 75 catchments. The estimated or predicted runoffs were then compared with the observed runoffs and the results are as shown in Appendix 6.

It could be seen that, like in W.R.P. No. 6, for majority of the cases (57 out of 75), the estimated average annual runoff values were within ±15% deviation from the average observed runoffs.

Of the 11 where the differences exceed 20%, an investigation was carried out and the findings are as follows:–

(i) **Substantial Irrigation Extractions**

There are substantial irrigation extractions in *Sg. Muar at Kuala Pillah* and *Sg. Padang Terap at Lengkuas* resulting in the observed runoffs being much less than the predicted runoffs.

(ii) **Poor Streamflow Records**

The observed runoff data for *Sg. Segamat at Segamat, Sg. Bentong at Jambatan Kuala Marong, Sg. Slim at Kg. Slim, Sg. Gedong at Bidor, Sg. Plus at Kg. Pulau Mentimun, Sg. Ara at Batu 20 Jln. Taiping/Ijok* and *Sg. Golok at Rantau Panjang* are suspect, due largely to poor stage-discharge relationships, which are results of poor site controls (shifting low flow river beds and/or low river banks leading to overflow and bypass), and infrequent or poor quality streamflow gaugings.

(iii) **Other Reasons**

Although *Sg. Pelagat* observed runoff exceeds the predicated runoff by 26%, no suspect is placed in either the observed or the predicated data as the difference could arise from the fact that the observed runoff is based on only 5 years of streamflow records which include the 1967 wet year. *Sg. Pelas at Kg. Pilin* has an observed runoff of 1,215mm exceeding the predicated runoff of 920mm by 26% while the neighbouring catchment, *Sg. Linggi at Sua Betong* has an observed runoff of 1,123mm exceeding the predicted runoff of 910mm by

18%. That the observed runoffs are comparable and are consistently higher than the predicted runoffs by large margins makes it difficult to pinpoint which to accept. Further investigations are necessary.

3.3.2 Monthly water resources

To evaluate the accuracy of the average monthly water resources maps, a comparison was again made between the runoffs predicted from the maps and runoffs actually observed. For each of the 57 catchments where the predicted and observed average annual runoffs do not differ by more than 15%, average monthly runoffs for January through to December were predicted using the 'isohyetal method' and these were checked against the corresponding observed runoffs to see if they meet the following accuracy criteria:–

Observed Monthly Runoff (mm)	Allowable Difference between Observed and Predicted
Runoff ≤ 100	≤ 25mm or ≤ 25% of obs. runoff
100 < Runoff ≤ 300	≤ 50mm or ≤ 25% of obs. runoff
Runoff > 300	≤ 100mm or ≤ 25% of obs. runoff

It could be seen from Appendix 7 that a large majority of the cases meet the accuracy criteria – 628 out of a possible total of 684 (57 catchments x 12 months). On catchment basis, only 7 of the 57 have 3 or more of the 12 monthly runoffs failing to meet the accuracy criteria.

3.3.3. Overall map accuracies

Based on results of the above comparison, it could be stated that the annual water resources map could predict the runoffs to an accuracy of ±15% while the monthly water resources maps could predict the runoffs to an accuracy of ±25% or a depth equal to the immediate interval of isohyds ie. next higher isohyd minus the next lower isohyd.

3.3.4 Map presentations

Considering users' applications, the maps are presented as follows (available in separate volume):–

Average Annual Surface Water Resources Map (Appendix 5)	1:1,000,000 (colour)
Average Monthly Surface Water Resources Maps (Appendices 5-1 to 5-12)	1:1,000,000

For convenience of readers, the above maps are reduced to standard A.4 size for direct attachment to this publication.

3.4 Variability of Annual Water Resources

3.4.1 Mapping of coefficient of variation (Cv) of annual runoffs

Often, it is inadequate to know just the average water resources, as the variability from year to year could be high. For this reason, the coefficient of variation of annual runoff was computed for each of the 460 stations and the results are presented in the form of a Cv map, also in the scale of 1:1,000,000 (Appendix 8). The same map also appears in reduced A.4 size in this publication.

3.4.2 Comparison with Cv based on observed runoff

To test the validity of the Cv map, the Cv values of 48 catchments (where the predicted and observed annual average water resources do not differ by more than 15% and where the length of complete annual observed runoff is not less than 5 years) were determined from the Cv map using 'isohyetal method', and then compared with the Cv of the observed annual runoffs. The results show that the Cv map gives higher values in almost all cases. The exceptions are for coastal catchments in Kelantan and Trengganu States. Excluding the 4 coastal catchments in Kelantan and Trengganu States, the mean of the differences works out to be 0.098 with a standard deviation of 0.035. The low standard deviation suggests the possibility of applying a simple reduction constant to the 'map Cv' to yield a better estimate of the 'observed Cv'. A linear regression was then carried out and it was found that Co=0.977Cm−0.091 where Co is 'observed Cv' and Cm is 'map Cv', the correlation coefficient being 0.909.

3.4.3 Estimation by adjusting 'map Cv'

For convenience in Cv estimation, it has been decided to simplify the regressed equation to Ce = cm − 0.090,where Ce is the estimated Cv. Student's test was then applied to see if there is a significant difference between the simplified and the original equations. Calculated t's were found to be 0.33 for slope and 0.44 for intercept. These are much less than the critical t of 2.02 at 5% signaficance level. Therefore Cv could be estimated by just substracting 0.09 from the 'map Cv'. Thus, reducing the 'map Cv' for each of the 44 catchments by a constant amount of 0.09, the residual differences then have a mean of 0.008 and a standard deviation of 0.035. Please see these results in Apendix 9A. Based on these statistics, it could be shown that the variabilities of the annual water resources (e.g. annual water resources exceeded at certain probability level) can be assessed, at 90% confidence level, to an accuracy of within ±15% of errors (please see Appendix 9B). This is compatible with the order of accuracies that the average annual water resources map can give. As for the coastal catchments in Kelantan and Trengganu States, the 'map Cvs' are close to the 'observed Cvs' except for Sg. Dungun where the 'observed Cv' is much higher due possibly to poor sample of annual runoffs which includes the very wet year of 1967. It is therefore recommended that for coastal catchments in Kelantan and Trengganu States, no adjustment to the 'map Cv' is necessary.

3.4.4 Examples of application of Cv map to assess variability of annual water resources

Example 1

Determine the average annual and monthly surface water resources for Sg. Rompin at Lesong Forest Road Bridge (catchment area = 3600 km^2). Also determine the probable ranges of annual runoffs at 70%, 80% and 90% probability levels.

Solution:

Step 1

Catchment boundary was demarcated in 1:1,000,000 scale at the required site ie. Sg. Rompin at Lesong Forest Road Bridge on transparent sheet.

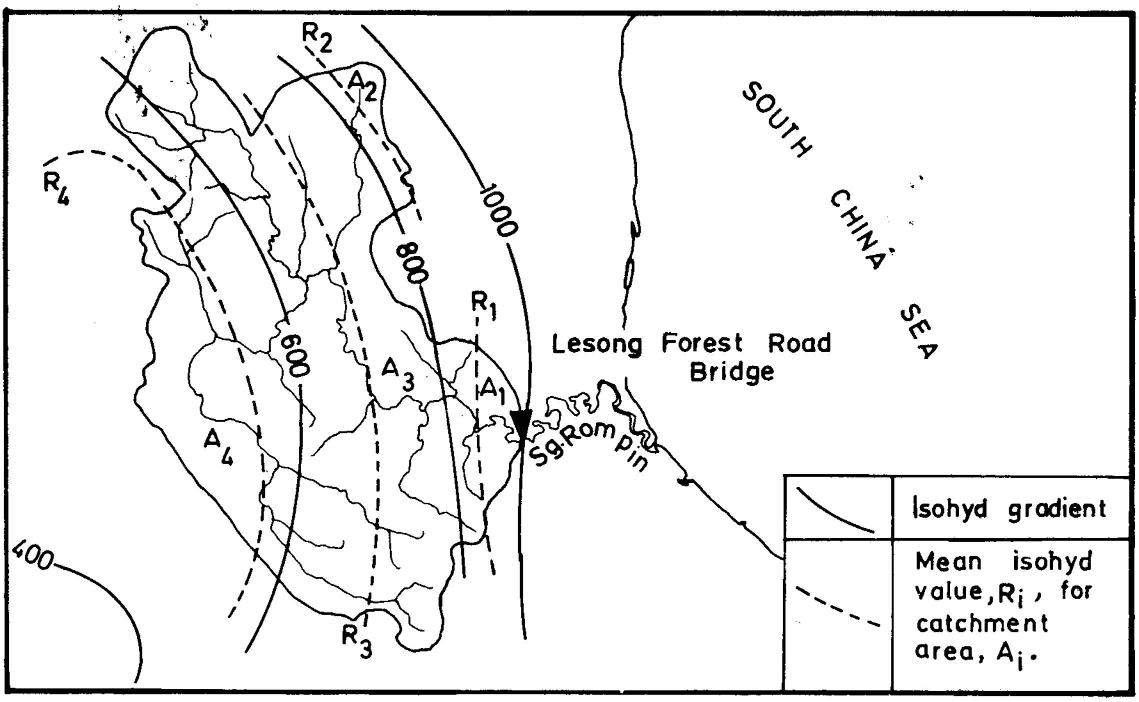
Step 2

Superimposing upon the average annual and monthly maps and using 'isohyetal method' (an example is given next page), the required average surface water resources were found as follows:–

Annual	680(mm)
January	125
February	45
March	65
April	40
May	40
June	30
July	20
August	20
September	30
October	78
November	90
December	130
TOTAL	705

(If the total of the 12 monthly runoffs differs significantly from annual runoff obtained from the annual map, say by more than 15%, adjust monthly runoffs proportionally.)

AN EXAMPLE OF DETERMINING CATCHMENT AVERAGE WATER RESOURCES USING 'ISOHYETAL METHOD'



Areas of catchment segments (in sq. km) are:–

A1	=	280
A2	=	140
A3	=	2050
A4	=	1120

Mean annual isohyd values (in mm) corresponding to each area are:–

R1	=	890
R2	=	870
R3	=	700
R4	=	570

The estimate of the average annual runoff, R_t, for the entire catchment, A_t, is obtained by taking the sum of runoffs contributed by the various catchment segments and is computed as follows:–

$$R = \frac{1}{A_t} (R1\ A1 + R2\ A2 + R3\ A3 + R4\ A4)$$

$$= \frac{1}{3590} (890 \times 280 + 870 \times 140 + 700 \times 2050 + 570 \times 1120)$$

$$= 680 \text{ (to nearest 10 mm)}$$

Step 3

Similarly, using the Cv map, the coefficient of variation of the annual runoff was found to be 0.38.

but Estimated Cv = 'Map Cv' – 0.09 (See para 3.4.3.)
= 0.38 – 0.09
= 0.29

Annual runoff, R is given by

$$R = \bar{R}\ (1 \pm Z\ Cv)$$ (See equation (ii) of Appendix 9B)

Where $\bar{R}$ is average annual runoff
Z is normal random variable with mean zero and variance 1.

In Step 2, $\bar{R}$ was found to be 680 mm.

From Table 1 of Appendix 10, the Z values for probability levels 70%, 80% and 90% are 1.04, 1.28 and 1.65 respectively.

Substituting in the above equation, the following results (to nearest 10mm) are obtained:-

Probability level	*Range of annual Runoff (mm)*
70%	470 – 890
80%	430 – 930
90%	350 – 1010

Example 2

Determine the 1 in 10 years annual water resources for Sg. Rompin at Lesong Forest Road Bridge.

Solution:

From Table 2 of Appendix 10, for 1 in 10 years frequency, Z = 1.28

$\bar{R}$ and Cv have previously been found as 680 mm and 0.29 respectively.

Substituting in equation (ii) of Appendix 9B.

$$R = 680 \times (1 \pm 1.28 \times 0.29)$$

$$= 680 \times 0.6288 \text{ or } 680 \times 1.3712$$

$$= 430 \text{ or } 930 \text{ (to nearest 10mm)}$$

This means, on the average, once in 10 years the annual runoff of Sg. Rompin at Lesong Forest Road Bridge will be

(i) equal to or greater than 930 mm or

(ii) equal to or smaller than 430 mm.

4. DISCUSSION

Generally, the main features of the spatial distribution of the annual water resources remain much the same if comparison is made with the previous map (W.R.P. No. 6, 1976). Prominant features are (i) the wet areas on and around the various mountain ranges which are exposed directly to the monsoon winds and where convective activities are most intense, and (ii) the dry areas in Negeri Sembilan extending upwards to the Pahang interior. Perlis and North east Kedah are also dry.

The monthly surface water resources are also controlled largely by the main mountain ranges and the seasonal monsoon winds. From November to January (during north east monsoon), most of the water resources are found in the east coast whereas in April and May (during South West Monsoon), water resources are in general more abundant on the West Coast, this comparison being made on unit area basis. In the drier months the influence of geology on water resources appear significant as much of the streamflows during these months are base flow contributions from groundwater storage. While the capability of the water balance model to predict the monthly runoffs is on the whole satisfactory, the model is still lacking in its capability to account for such base flow contributions (See para 2.2). It is unlikely that much could be done to improve this deficiency unless the model is restructured. As a first step, the recession constant of 0.9 used in this study should be reviewed to see if the use of a different value could bring about any improvement..

An unfavourable characteristic of the water resources in Peninsular Malaysia could be observed if one looks at the Cv map and the annual map. Negeri Sembilan and Pahang interior are generally low in water resources and yet they are subject to higher variabilities than most other areas. Perlis, low in water resources, also has quite high variabilities.

Notable areas with sparse rainfall data are Pahang Tenggara (South Pahang) and interiors of Kelantan and Pahang States. The map accuracies of these areas are naturally lower, especially for small rivers.

On a State by State basis, the annual and monthly surface water resources as determined from the maps are tabulated in Appendix 11.

5. CONCLUSION

The accuracies of the annual water resources map remain at within ±15% while that of the monthly water resources maps are within ±25% or a depth equal to the immediate interval of isohyds i.e. 25mm for runoffs less than 100 mm, 50 mm for runoffs between 100 mm and 300 mm and 100 mm for runoffs greater than 300mm. The variability of the annual water resources could also be assessed to within ±15% errors. The above are expected to be true for about 90% of the cases.

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THORNTHWAITE AND MATHER WATER BALANCE MODEL

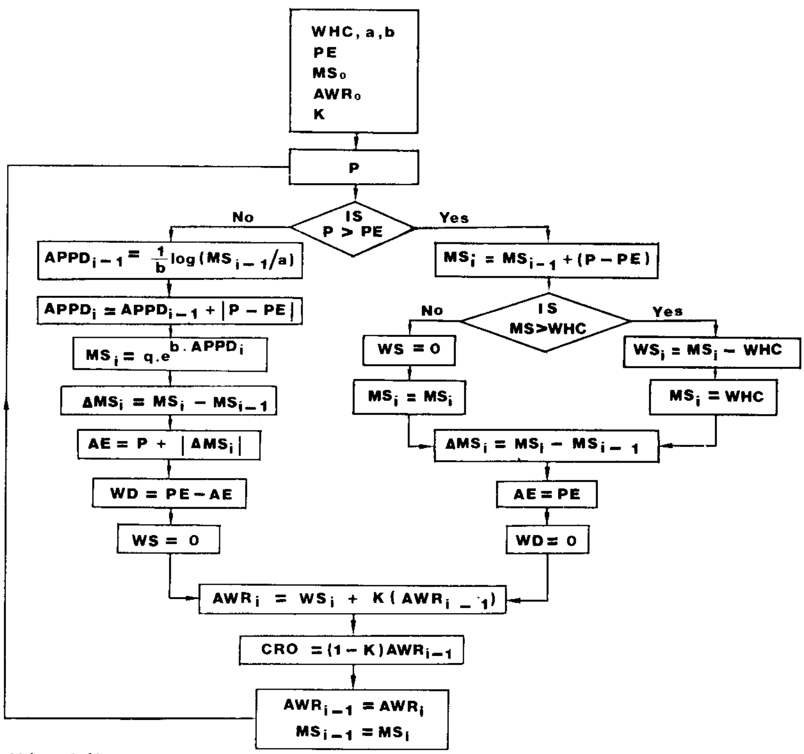
Thornthwaite and Mather (1955) constructed a single store conceptual model to simulate mathematically the evapotranspiration, soil moisture depletion and thereby rainfall-runoff processes. The model is outlined diagrammatically in Fig. 1.

Daily rainfall (P) in excess of potential evapotranspiration (PE) is added directly to the soil moisture store (MS). If the soil moisture exceeds the water holding capacity of the soil a water surplus (WS) occurs, the actual evapotranspiration (AE) for that day is equivalent to the potential rate, and there is no water deficit.

If rainfall is less than PE, the soil moisture store is adjusted according to a variable function dependant on the soil moisture status at the end of the previous day. Actual evapotranspiration is equated to any precipitation (less than PE) plus the difference in soil moisture between this and the previous day (ΔMS). Water deficit (WD) is the difference between PE and AE.

Following adjustments to the soil moisture store any water surplus is added to previous gravitational water (AWR) available to runoff, which is recessed by a factor K to compute the daily runoff.

FIG. 1 – THE THORNTHWAITE AND MATHER WATER BALANCE MODEL



Abbreviations

- P – Precipitation
- PE – Potential evaporation
- AE – Actual evapotranspiration
- MS – Soil Moisture
- ΔMS – Change of soil moisture
- AWR – Available water for runoff
- WHC – Water holding capacity
- WD – Water deficit
- WS – Water surplus
- APPD – Accumulated potential precipitation deficit
- CRO – Computed runoff
- K – Recession Constant
- a, b – Soil moisture retention

Subscripts

- o – initial value
- i – indicates today
- i−1 – indicates yesterday

APPENDIX 2

THORNTHWAITES DAILY WATER BALANCE MODEL

STATION NUMBER: 1334108 YEARLY TOTALS (in mm) PERIOD: 1959/60-1974/75
PE: 1405

Year	*Precipitation*	*Actual Evapo-Transpiration*	*Precipitation Minus Actual Evapo-Tanspiration*	*Water Deficit*	*Runoff*
1959/60	2583	1322	1260	87	1185
1960/61	2263	1334	929	71	1017
1961/62	2317	1313	1005	92	962
1962/63	2214	1303	911	102	905
1963/64	2578	1343	1235	66	1224
1964/65	3461	1334	2128	71	1973
1965/66	2430	1334	1097	71	1323
1966/67	2433	1282	1151	123	1098
1967/68	2330	1270	1060	139	1103
1968/69	2380	1285	1094	120	1051
1969/70	2818	1280	1538	125	1608
1970/71	1914	1208	706	197	637
1971/72	2246	1309	937	100	990
1972/73	2941	1270	1671	135	1606
1973/74	2486	1192	1294	213	1275
1974/75	3074	1328	1747	77	1783
Mean	2529	1294	1235	112	1234
Standard Deviation	381	44	369	44	351

APPENDIX 2 (Contd)

THORNTHWAITES DAILY WATER BALANCE MODEL

STATION NUMBER: 1334108 MONTHLY RUNOFF (in mm) PERIOD:1959/60-1974/75
PE: 1405

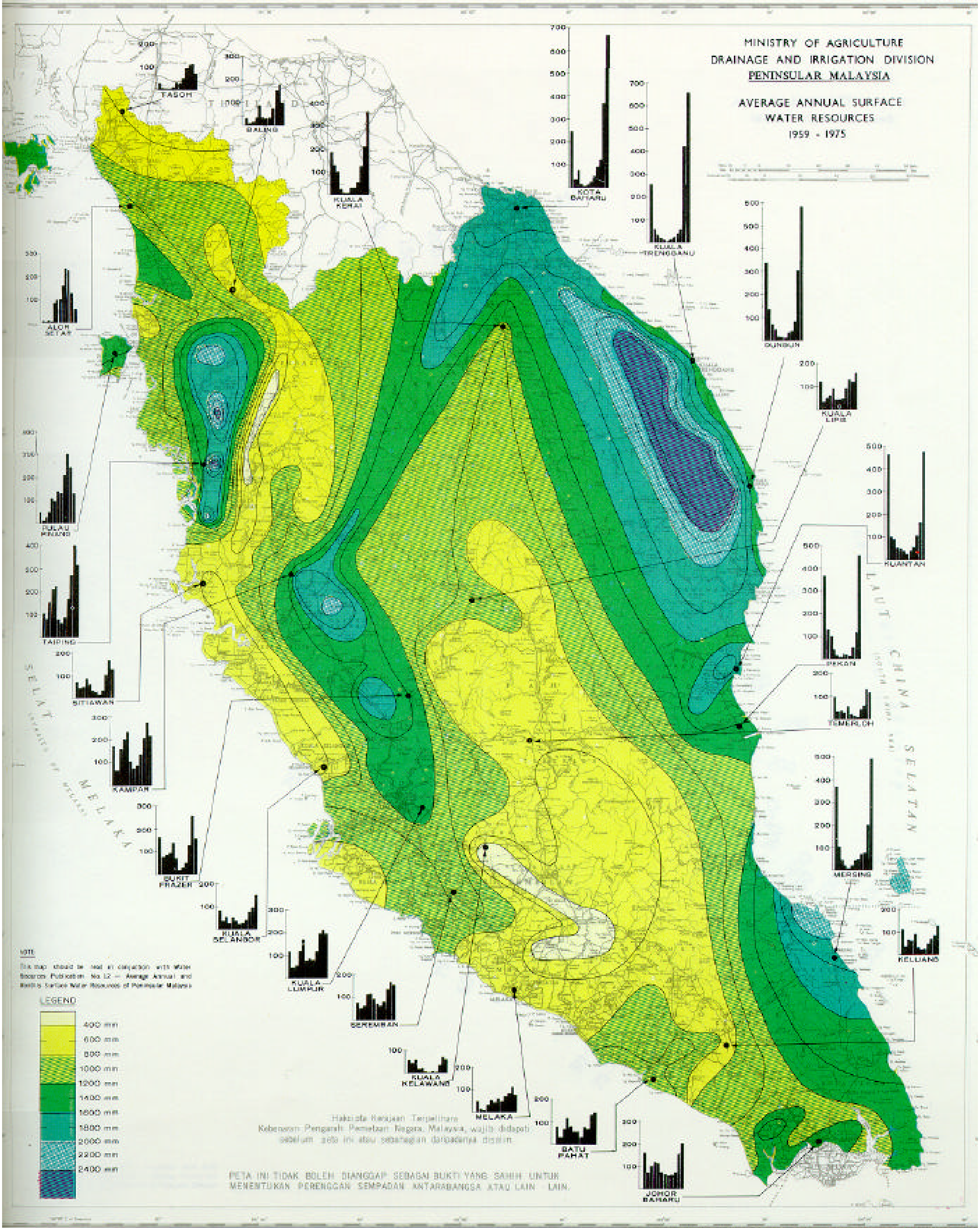
Year	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*
1959/60	63	88	6	15	194	101	218	168	46	15	119	152
1960/61	82	28	48	31	157	142	102	10	47	105	167	97
1961/62	90	69	10	2	90	116	135	40	90	137	136	48
1962/63	85	93	46	51	185	131	33	65	47	15	2	151
1963/64	38	68	49	56	79	111	159	177	239	112	95	41
1964/65	172	98	244	322	157	197	118	8	2	115	320	220
1965/66	248	146	234	27	72	188	41	110	105	52	13	89
1966/67	10	2	39	174	80	77	224	102	90	99	144	57
1967/68	174	58	16	34	162	126	90	4	56	130	224	28
1968/69	7	4	19	294	333	31	1	4	25	55	194	82
1969/70	90	41	60	77	668	408	51	18	1	108	69	17
1970/71	1	2	64	207	50	20	204	9	0	0	32	48
1971/72	156	96	79	129	112	207	57	65	12	0	37	39
1972/73	2	4	274	81	74	408	341	21	66	129	175	30
1973/74	30	118	274	235	143	199	28	1	0	17	110	120
1974/75	134	94	235	152	265	29	51	84	58	196	210	273
Mean	86	63	106	118	176	156	116	55	55	80	128	93
Standard Deviation	73	45	104	102	152	115	93	58	60	59	87	74

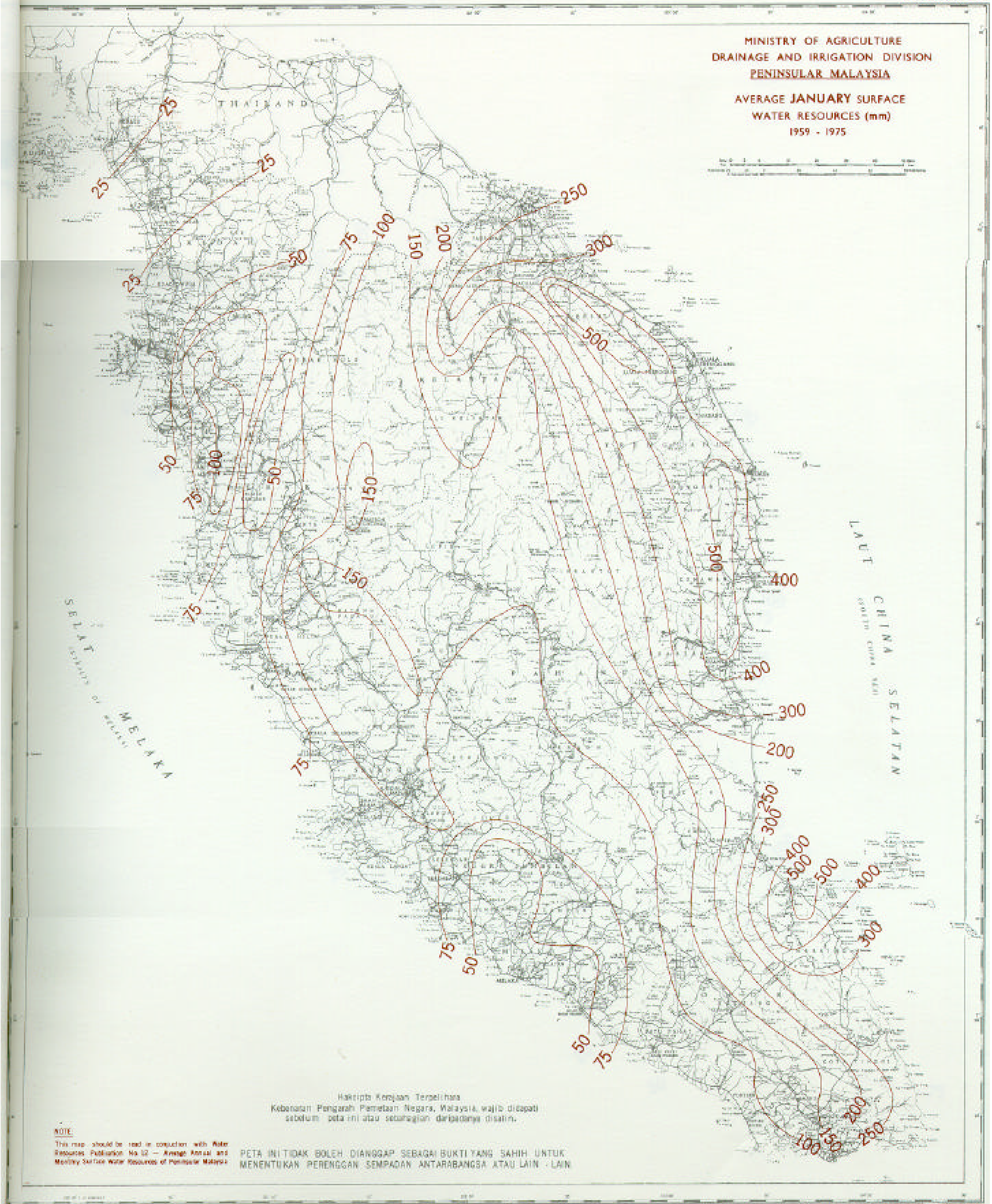
APPENDIX 3

COMPARISON OF SHORT TERM (1959 – 1975) AND LONG TERM RAINFALL FOR SELECTED LOCATIONS

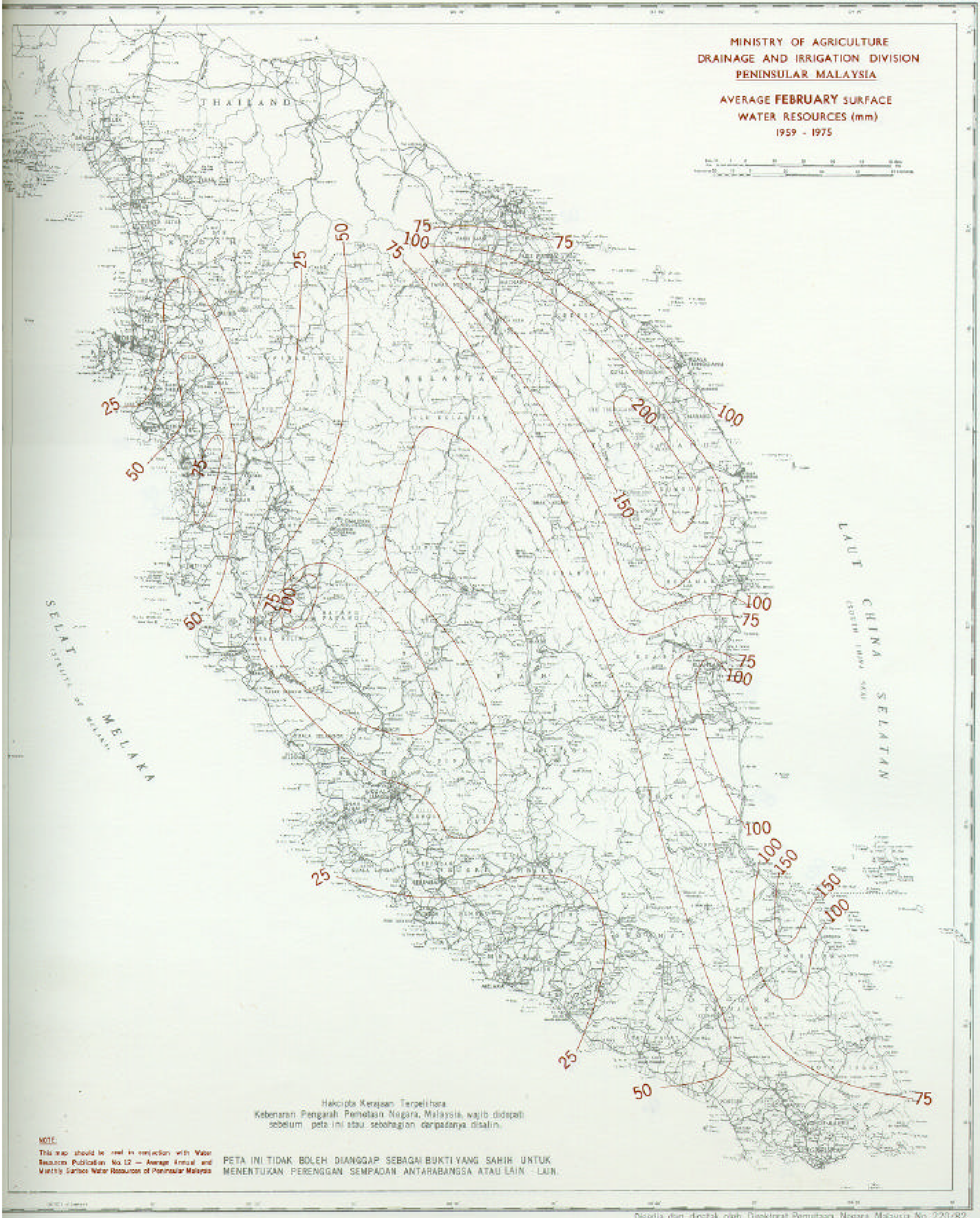
Station No.	*Location/ Station Name*	*Total Length of Record*	*A* *Long Term Mean (mm)*	*B* *Short Term Mean (1959 -1975) (mm)*	*B/A*	$\frac{B-A}{A}$ *(%)*
1537114	Johor Baru, Johor	38	2749	2579	0.94	–6
2033152	Kluang, Johor	46	2298	2140	0.93	–7
2222010	Lapangan Terbang, Melaka	32	2047	1927	0.94	–6
2438185	Mersing, Johor	39	2740	2790	1.02	+2
3313043	Kuala Selangor, Selangor	59	1930	1907	0.99	–1
3523137	Mentakab, Pahang	49	2038	2020	0.99	–1
3717051	Bukit Fraser, Pahang	47	2575	2710	1.05	+5
4120064	Kuala Lipis, Pahang	66	2478	2384	0.96	–4
4307041	Sitiawan, Perak	30	2214	2093	0.95	–5
4734079	Dungun, Trengganu	30	2607	2782	1.07	+7
4807031	Taiping Perak	74	4100	3881	0.95	–5
5609072	Baling, Kedah	57	2174	2193	1.01	+1
6105037	Gajah Mati, Kedah	43	2395	2518	1.05	+5
6122064	Kota Baru, Kelantan	42	2795	2931	1.05	+5
6401008	Kangsar, Perlis	64	2041	2083	1.02	+2
				Mean	0.99	–1

Disedia dan dicetak oleh Direktorat Pemetaan Negara, Malaysia No. 220/82

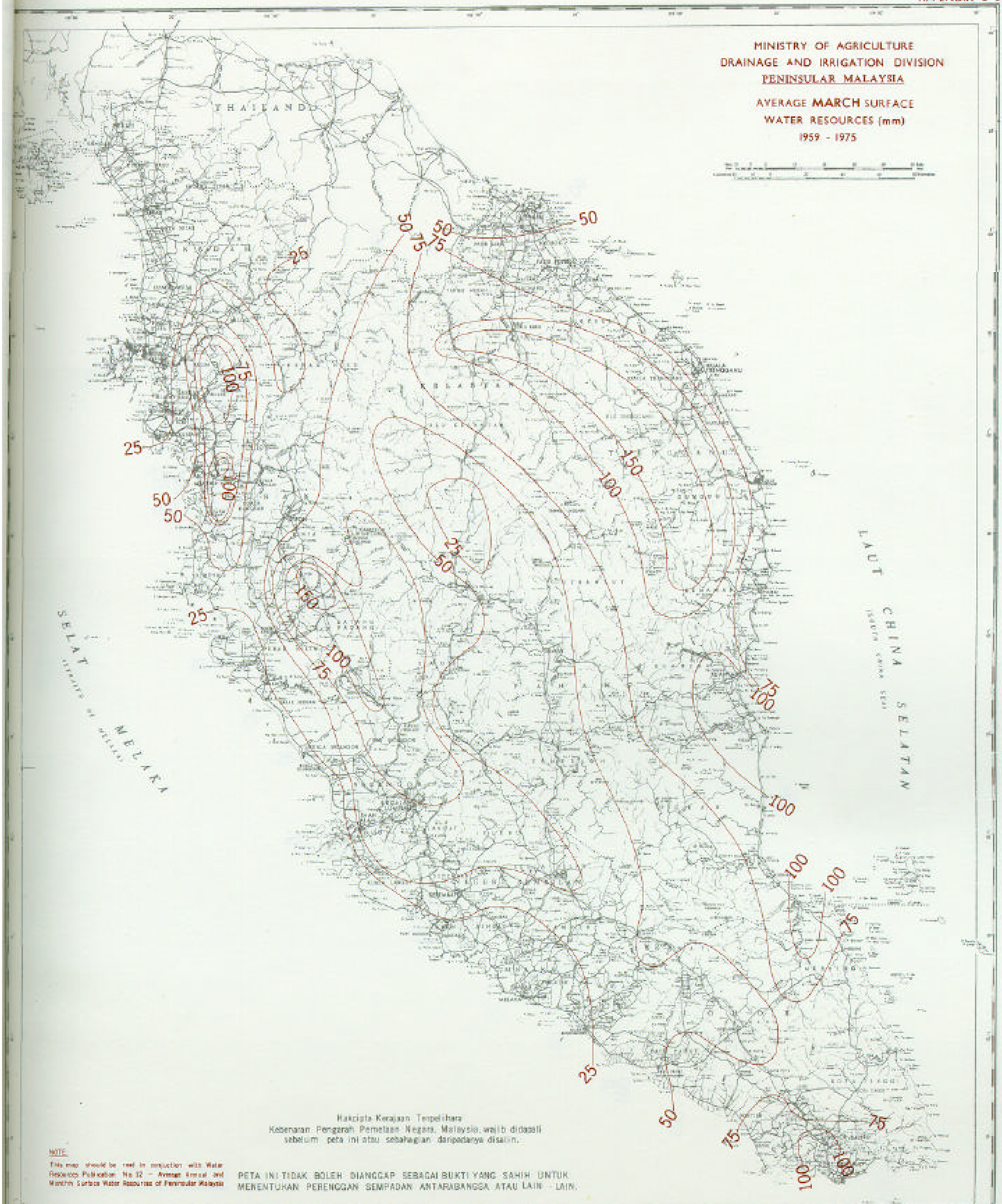

MINISTRY OF AGRICULTURE
DRAINAGE AND IRRIGATION DIVISION
PENINSULAR MALAYSIA
AVERAGE ANNUAL SURFACE
WATER RESOURCES
1959 - 1975
TASOH
BALING
KUALA KERAI
KOTA BAHARU
KUALA TRENGGANU
DUNGUN
KUALA LIPIS
KUANTAN
PEKAN
TEMERLOH
MERSING
KELUANG
ALOR SETAR
PULAU PINANG
TAIPING
SITIAWAN
KAMPAR
BUKIT FRAZER
KUALA SELANGOR
KUALA LUMPUR
SEREMBAN
KUALA KELAWANG
MELAKA
BATU PAHAT
JOHOR BAHARU
SELAT MELAKA
LAUT CHINA SELATAN
LEGEND
400 mm
600 mm
800 mm
1000 mm
1200 mm
1400 mm
1600 mm
1800 mm
2000 mm
2200 mm
2400 mm
Hakcipta Kerajaan Terpelihara
Kebenaran Pengarah Pemetaan Negara, Malaysia, wajib didapati sebelum peta ini atau sebahagian daripadanya dicetak.
PETA INI TIDAK BOLEH DIANGGAP SEBAGAI BUKTI YANG SAHIH UNTUK MENENTUKAN PERENGGAN SEMPADAN ANTARABANGSA ATAU LAIN - LAIN.



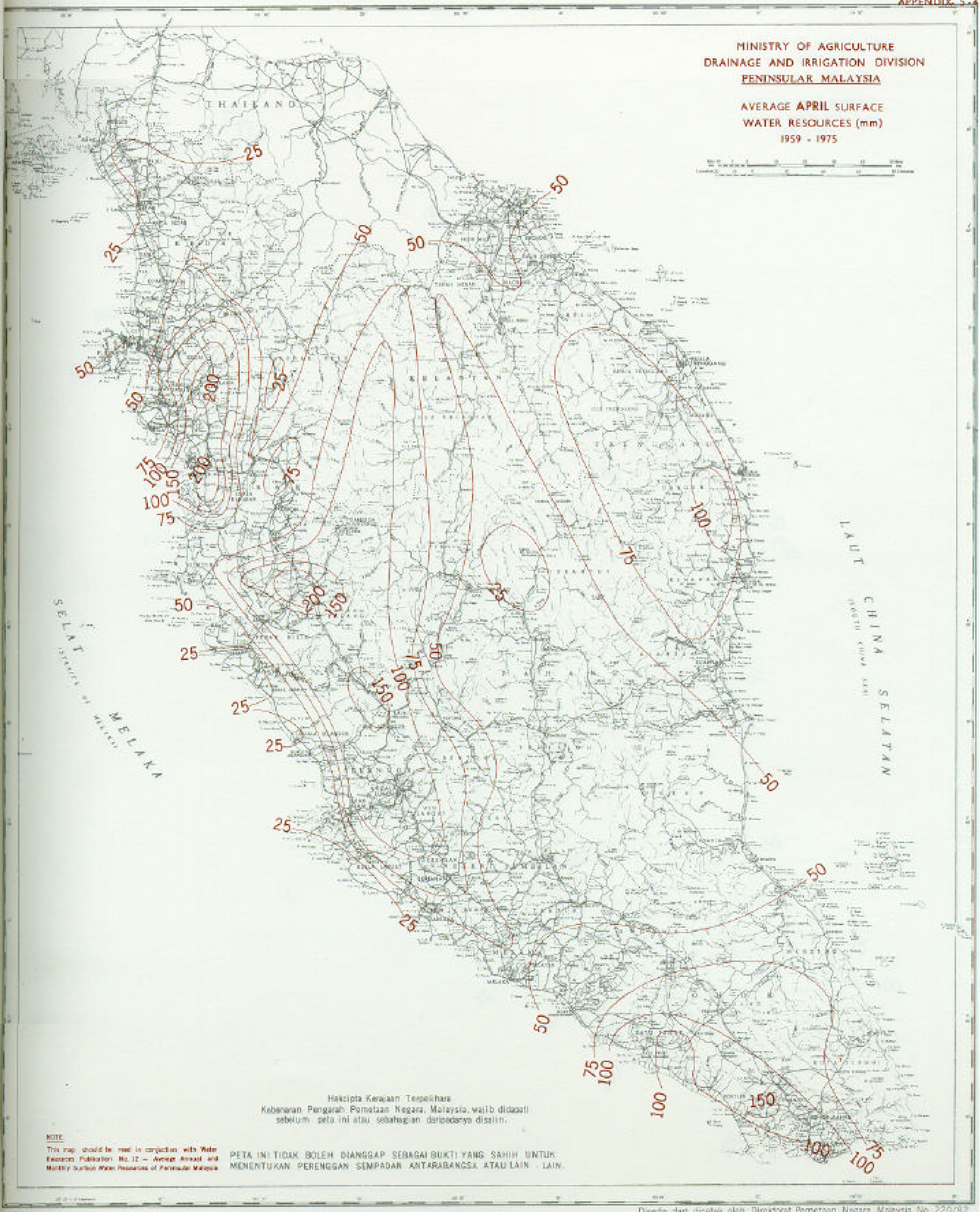
Disedia dan dicetak oleh Direktorat Pemetaan Negara, Malaysia No. 220/82.



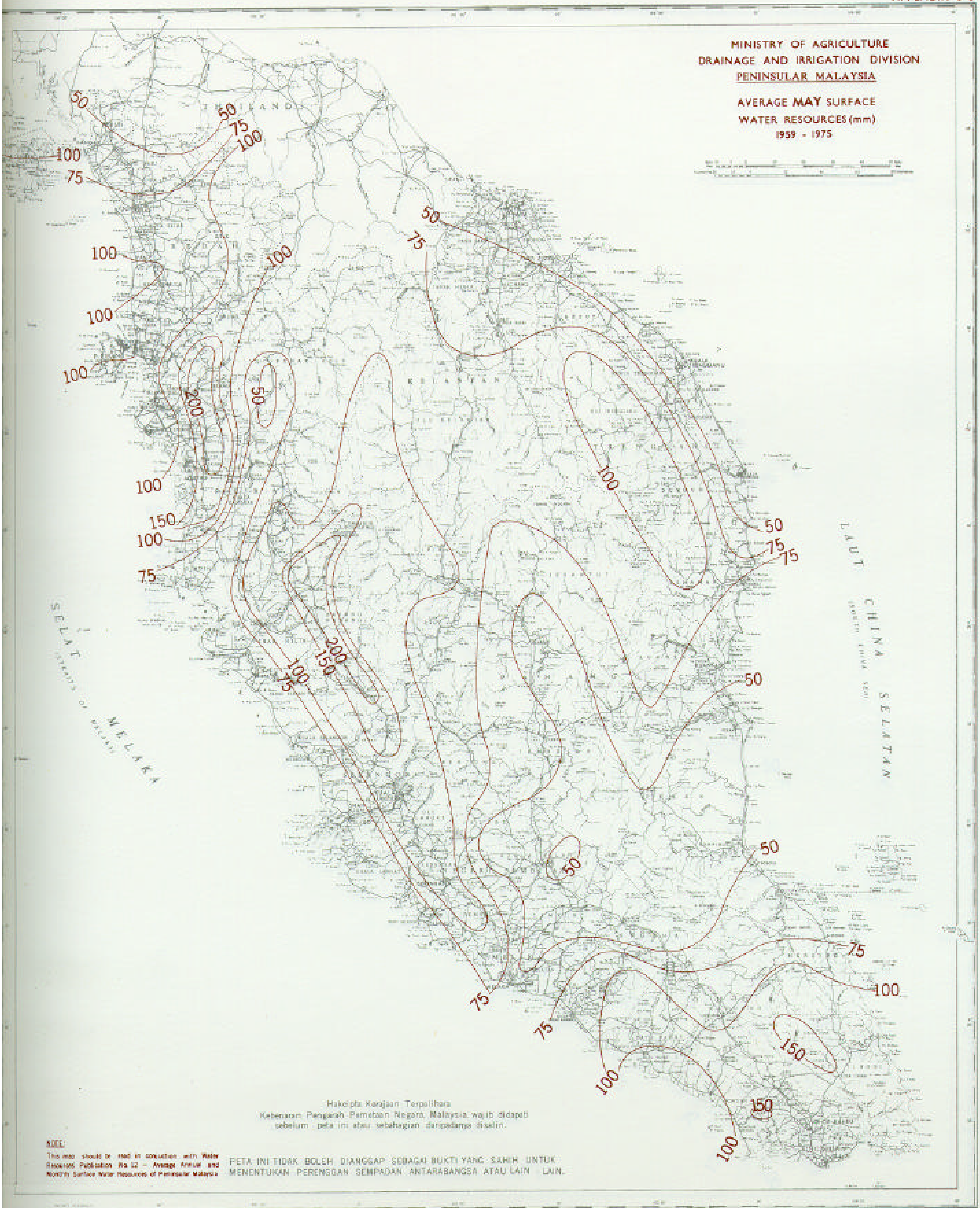
Disedia dan dicetak oleh Direktorat Pemetaan Negara, Malaysia No. 220/82.



Disedia dan dicetak oleh Direktorat Pemetaan Negara, Malaysia No. 220/82.



Disedia dan dicetak oleh Direktorat Pemetaan Negara, Malaysia No. 220/82.



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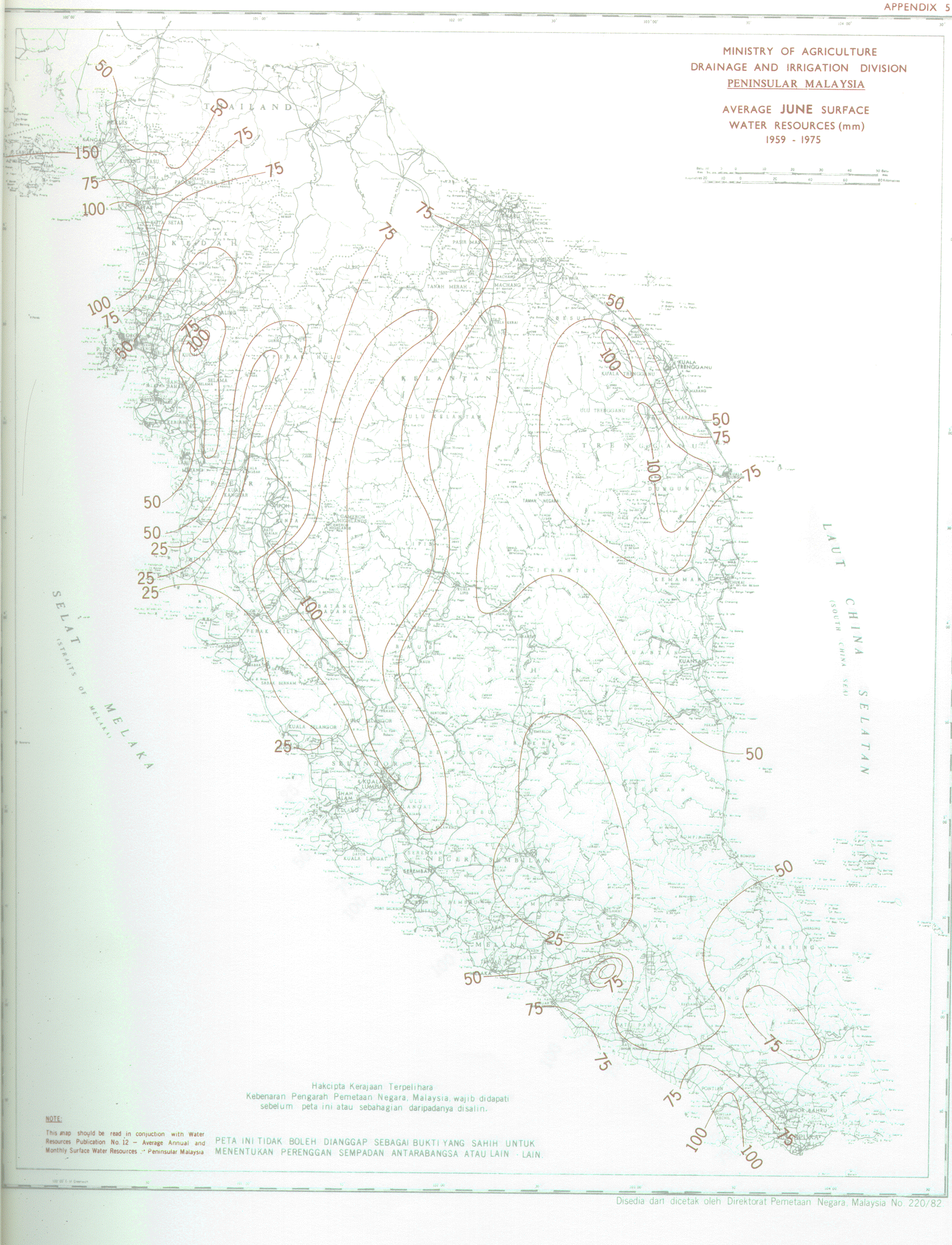
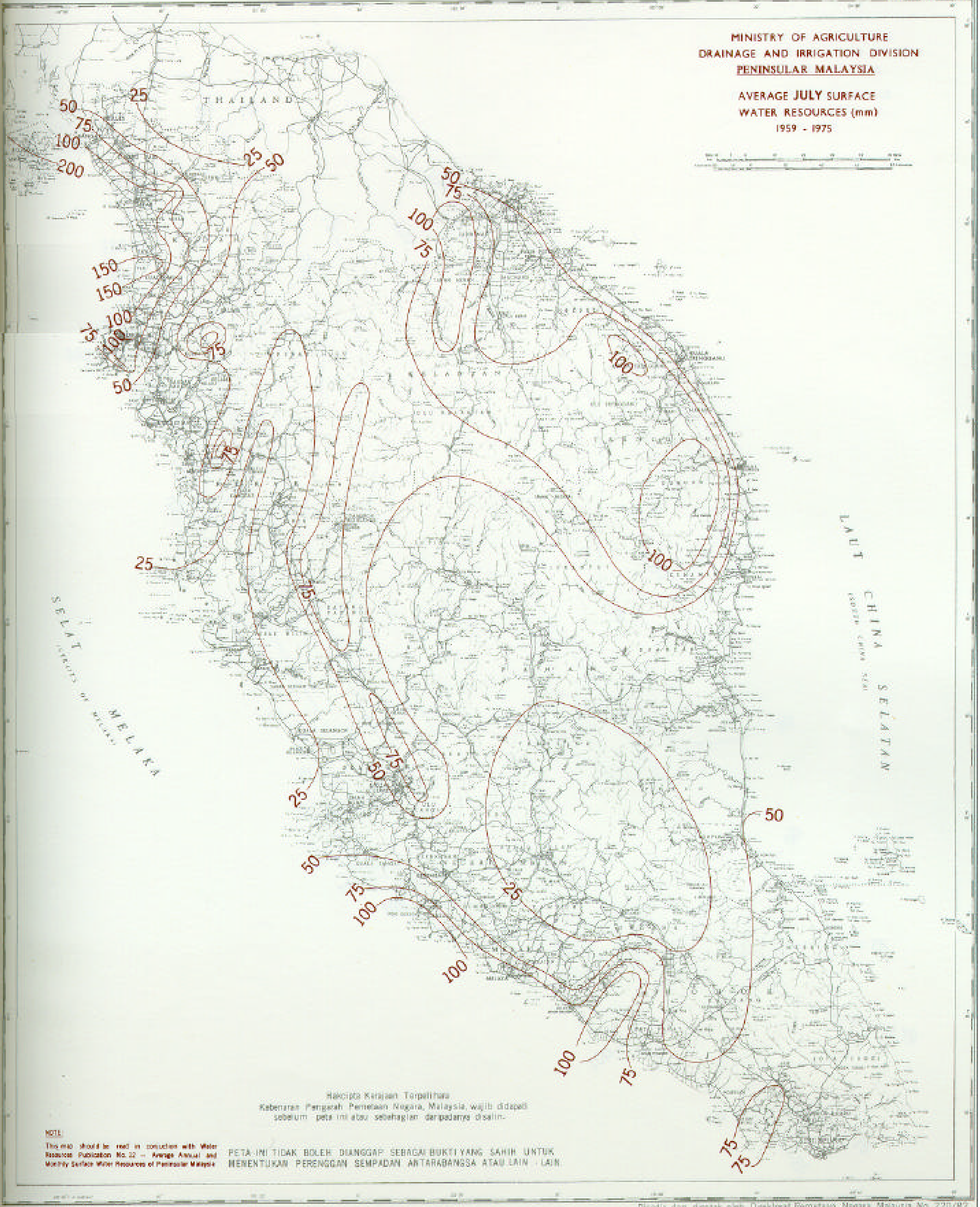


Disedia dan dicetak oleh Direktorat Pemetaan Negara, Malaysia No. 220/82



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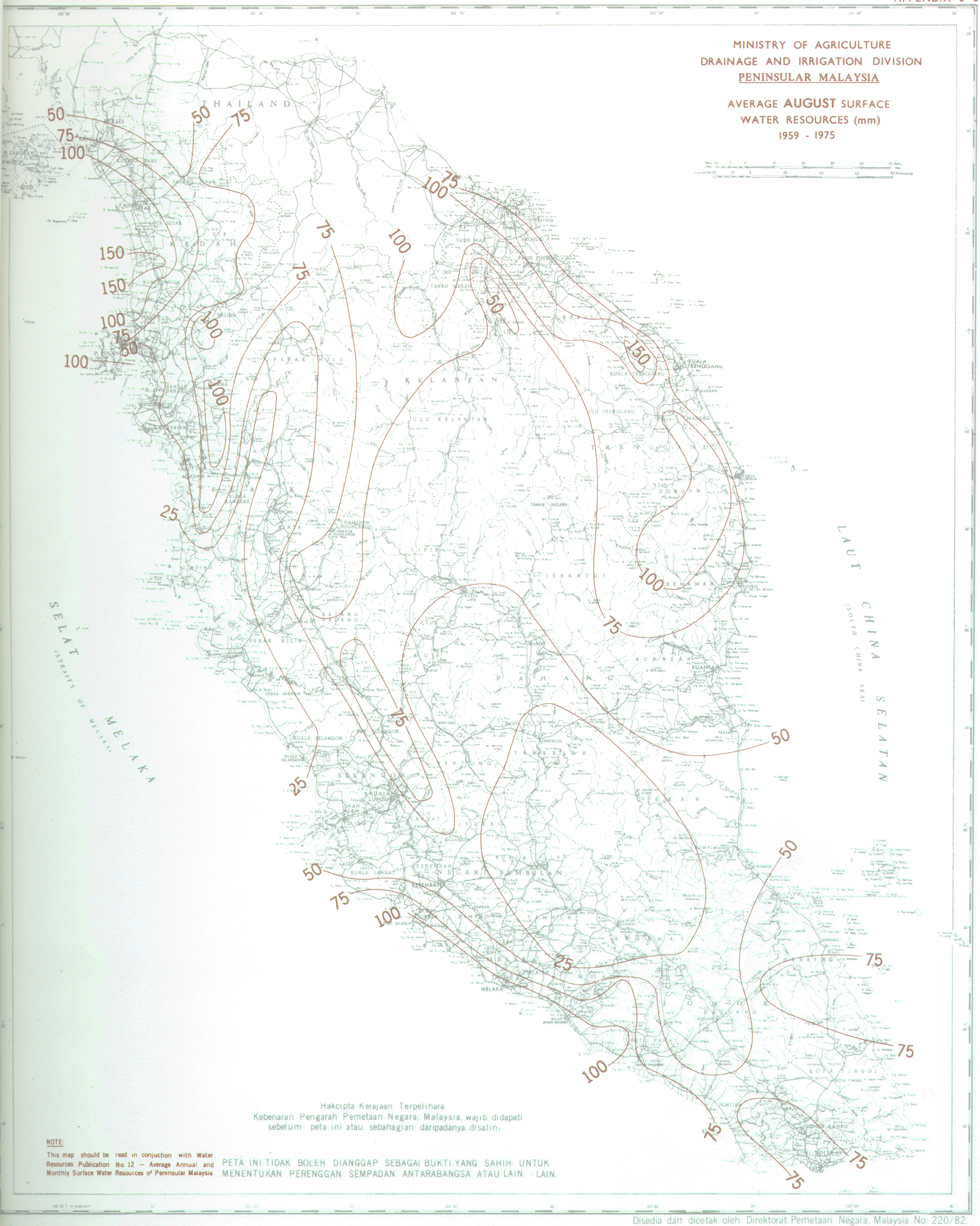
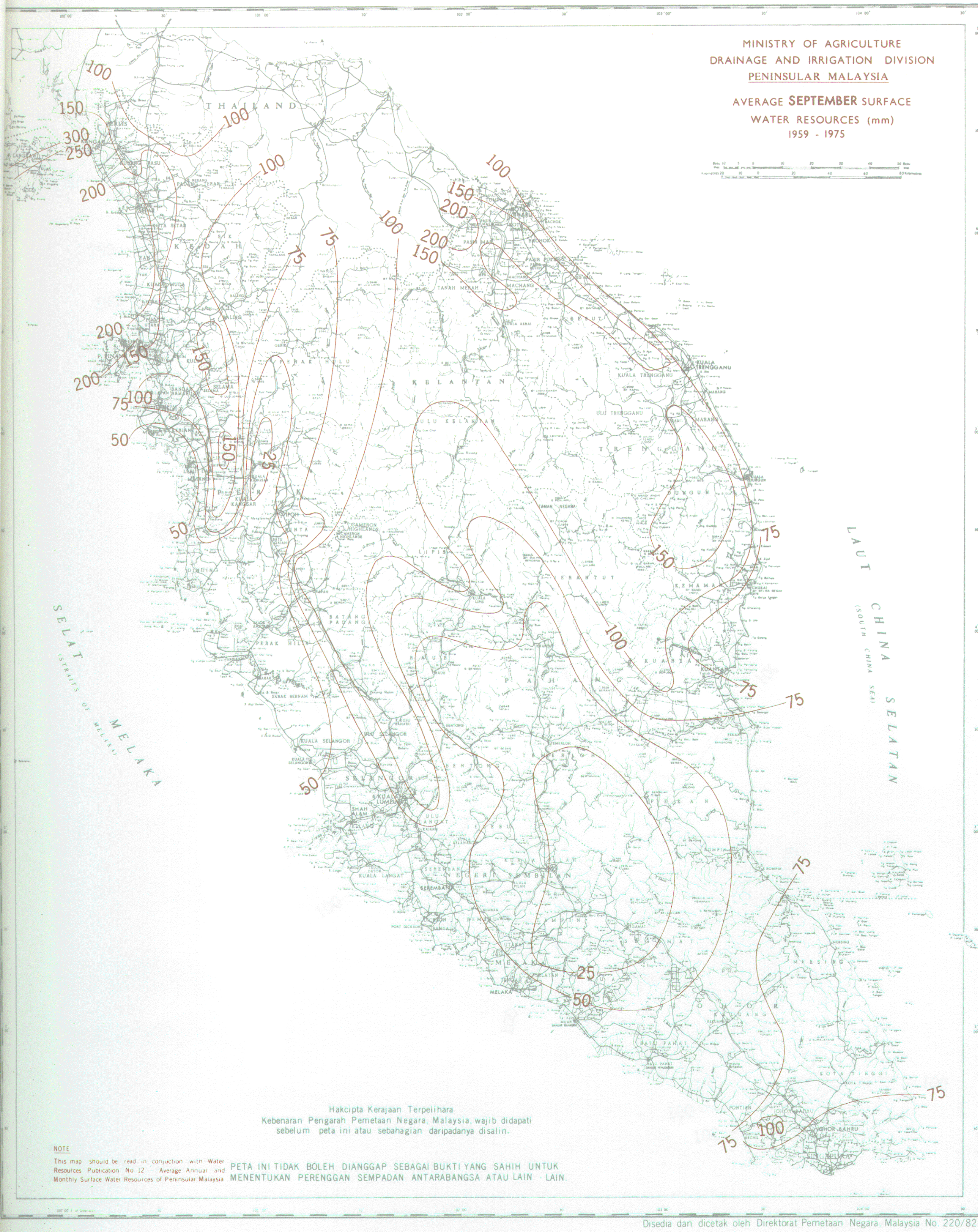
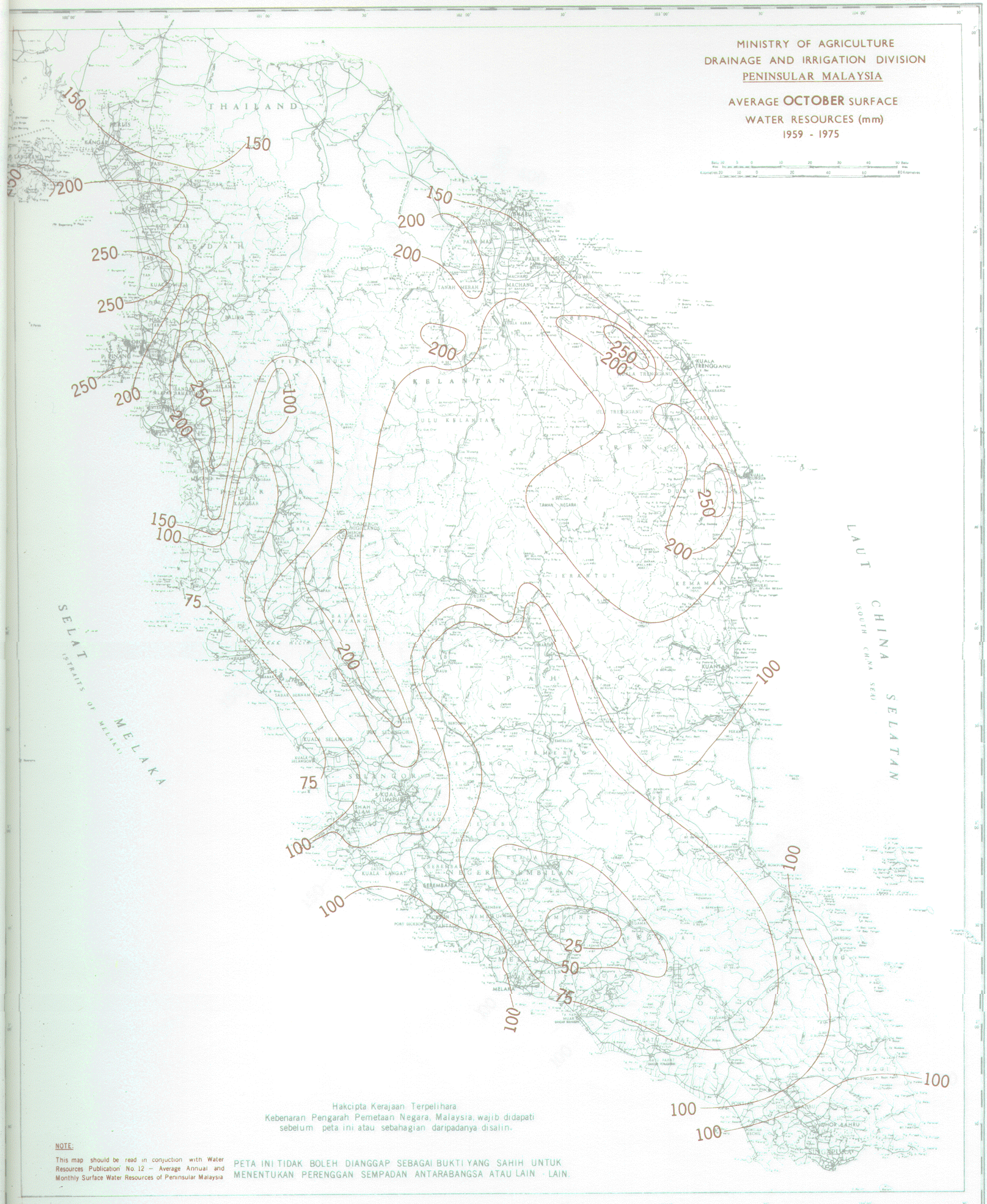
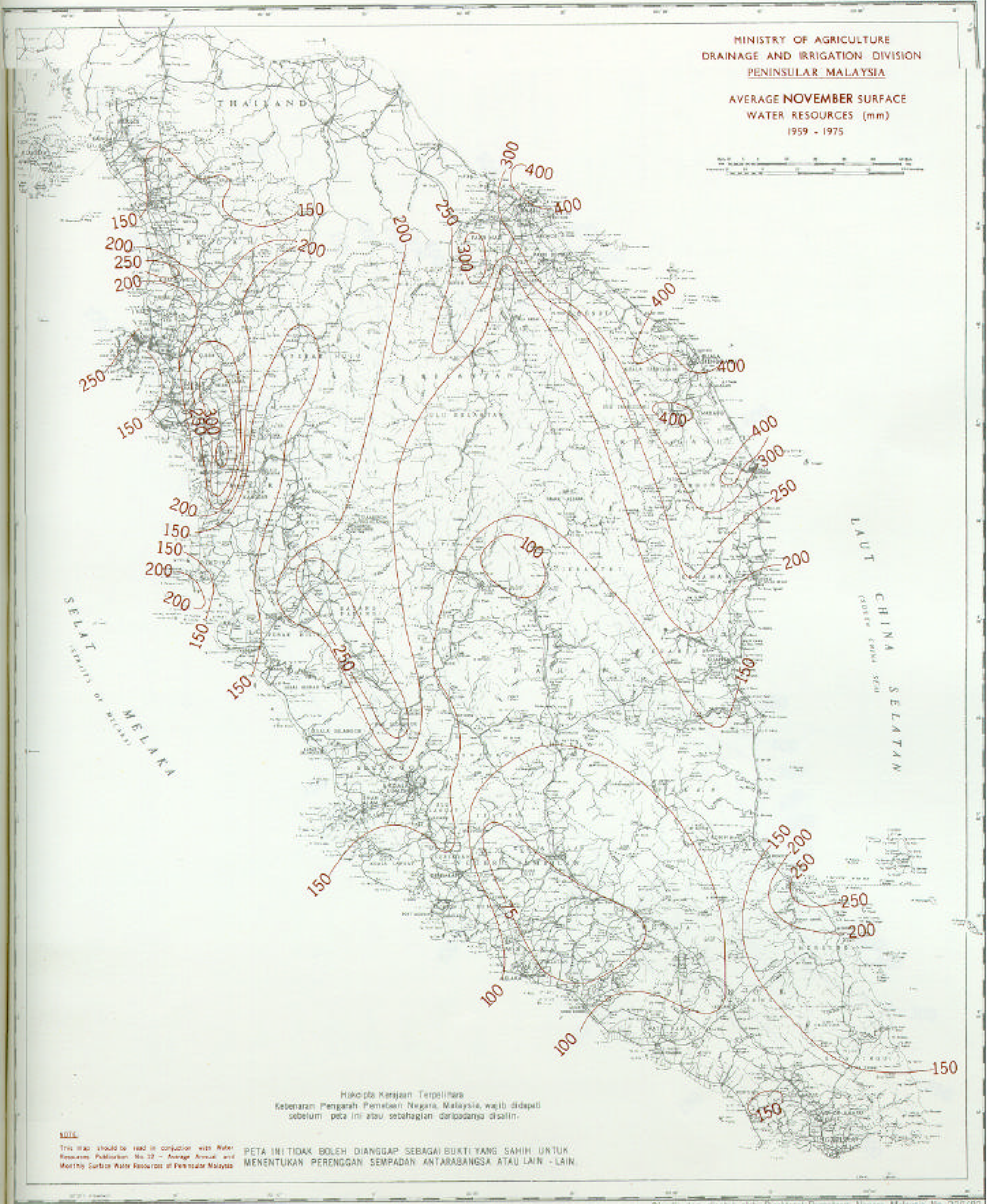

MINISTRY OF AGRICULTURE
DRAINAGE AND IRRIGATION DIVISION
PENINSULAR MALAYSIA
AVERAGE AUGUST SURFACE
WATER RESOURCES (mm)
1959 - 1975
THAILAND
KEDAH
KELANTAN
ULU KELANTAN
TRENGGANU
ULU TRENGGANU
KUALA TRENGGANU
DUNGUN
KEMAMAN
KUANTAN
PAHANG
JERANTUT
LIPIS
CAMERON HIGHLANDS
BATANG PADANG
PERAK HILIR
KUALA SELANGOR
SELANGOR
KUALA LUMPUR
SHAH ALAM
KUALA LANGAT
SEREMBAN
NEGERI SEMBILAN
MELAKA
JOHOR
KOTA TINGGI
JOHOR BAHRU
SINGAPURA
PONTIAN
SELAT MELAKA
(STRAITS OF MELAKA)
LAUT CHINA SELATAN
(SOUTH CHINA SEA)
Hakcipta Kerajaan Terpelihara
Kebenaran Pengarah Pemetaan Negara, Malaysia, wajib didapati sebelum peta ini atau sebahagian daripadanya disalin.
NOTE:
This map should be read in conjuction with Water Resources Publication No. 12 — Average Annual and Monthly Surface Water Resources of Peninsular Malaysia
PETA INI TIDAK BOLEH DIANGGAP SEBAGAI BUKTI YANG SAHIH UNTUK MENENTUKAN PERENGGAN SEMPADAN ANTARABANGSA ATAU LAIN - LAIN.
Disedia dan dicetak oleh Direktorat Pemetaan Negara, Malaysia No. 220/82.



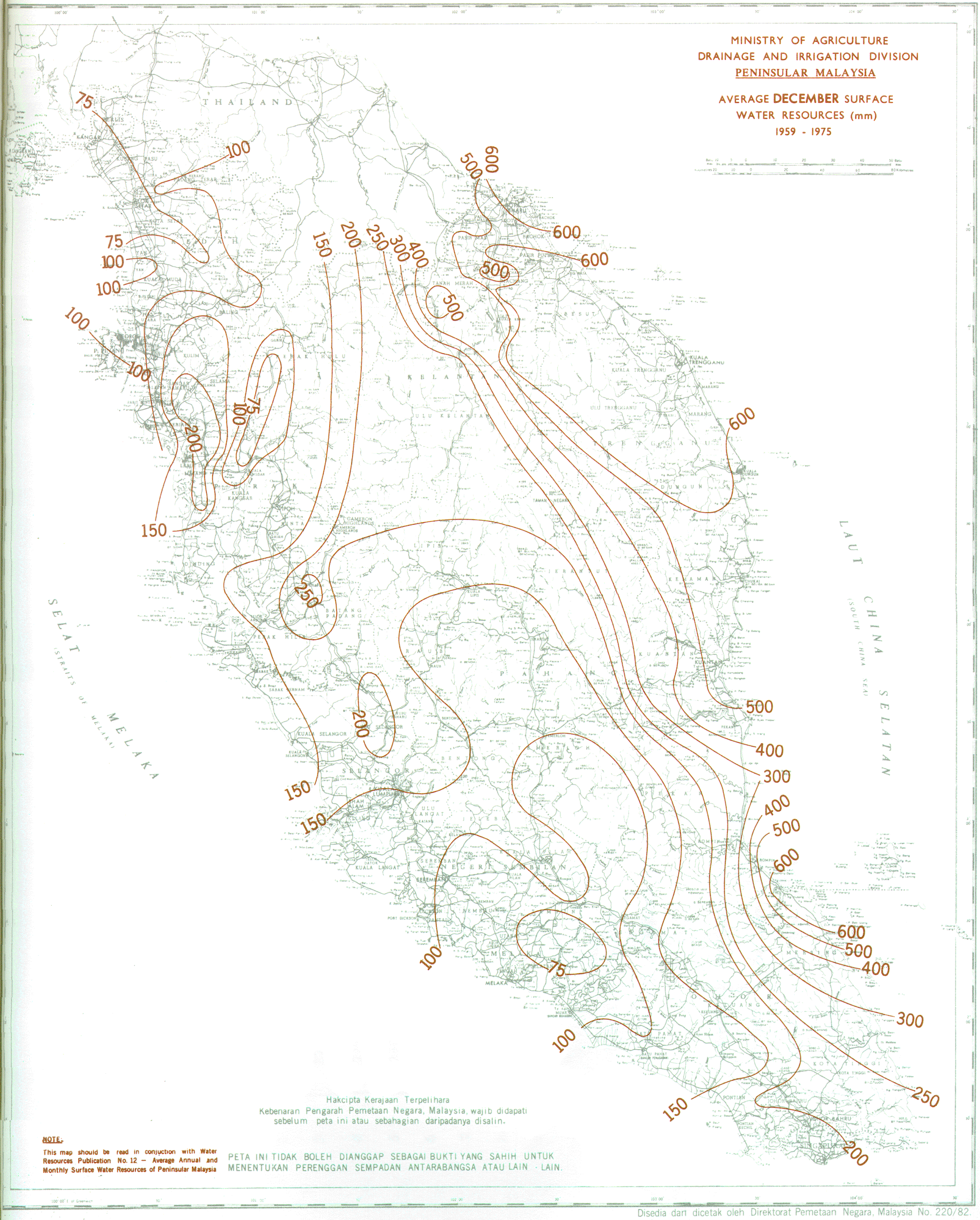
Disedia dan dicetak oleh Direktorat Pemetaan Negara, Malaysia No. 220/82.



Disedia dan dicetak oleh Direktorat Pemetaan Negara, Malaysia No. 220/82



Disedia dan dicetak oleh Direktorat Pemetaan Negara, Malaysia No. 220/82



Disedia dari dicetak oleh Direktorat Pemetaan Negara, Malaysia No. 220/82.

COMPARISON OF PREDICTED AND OBSERVED AVERAGE
ANNUAL RUNOFFS

Catchment No.	*Station No.*	*River*	*Station*	*Catchment Area (km²)*	*No. of Years of Flow Records*	*Observed Mean Annual Runoff (mm)*	*Predicted Mean Annual Runoff (mm)*	*% Difference*	*Remarks*
1	1737451	Sg. Johor	Rantau Panjang	1130	12	1218	1250	+3	Negligible water supply extractions
2	1931423	Sg. Sembro–ng	Brizay Bridge	1186	11	973	845	−12	Negligible water supply extractions
3	2224432	Sg. Kesang	Chin Chin	161	15	490	550	+12	Considerable irrigation extractions
4	2237471	Sg. Lengor	Batu 42 Jln. Kluang/Mersing	207	13	1673	1550	−7	Negligible water extrac-tions
5	2322413	Sg. Melaka	Pantai Belimbing	350	15	519	570	+10	Considerable irrigation extractions
6	2322415	Sg. Durian Tunggal	Bt. 11 Air Resam Rd	73	7	498	550	+10	Nil water resources utilisation
7	2519421	Sg. Linggi	Sua Betong	523	15	1123	920	−18	Some water supply and irrigation extractions
8	2520423	Sg. Pedas	Kg. Pilin	111	15	1215	910	−25	Some water supply and irrigation extractions
9	2524416	Sg. Gemen-cheh	Gedok	133	13	555	580	+5	Some irrigation extrac-tions
10	2525415	Sg. Gemen–cheh	Jln. Gemas/ Rompin	453	14	619	500	−19	Some irrigation extrac-tions
11	2527411	Sg. Muar	Buloh Kasap	3130	8	529	500	−5	Some water supply and irrigation extractions
12	2528414	Sg. Segamat	Segamat	660	12	1100	680	−38	Some water supply and irrigation extractions Suspect poor stream-flow records
13	2625412	Sg. Muar	Batu 57 Jln. Rompin/Gemas	1212	15	633	600	−5	Some water supply and irrigation extractions
14	2719422	Sg. Linggi	Pahang	189	12	968	965	0	Some water supply and irrigation extractions
15	2722413	Sg. Muar	Kuala Pilah	370	14	544	670	+23	Considerable irrigation extractions
16	2816441	Sg. Langat	Dingkil	1240	15	934	995	+7	Considerable (since 1973) water supply extractions
17	2917442	Sg. Langat	Kajang	380	9	1178	1095	−7	Considerable (since 1973) water supply extractions
18	2918443	Sg. Seme-nyih	Semenyih	210	14	1248	1025	−18	Nil water resources utilisation

APPENDIX 6 (Contd)

Catchment No.	*Station No.*	*River*	*Station*	*Catchment Area (km²)*	*No. of Years Of Flow Records*	*Observed Mean Annual Runoff (mm)*	*Predicted Mean Annual Runoff (mm)*	*% Difference*	*Remarks*
19	2920432	Sg. Triang	Kg. Chenor	228	5	680	600	–12	Some irrigation extractions
20	3015431	Sg. Klang	Puchong	712	5	1103	1215	+10	Some water supply and industrial extractions
21	3022431	Sg. Triang	Juntai	904	15	771	725	–6	Some irrigation extraction
22	3116430	Sg. Klang	Jam. Sulaiman	468	10	1099	1215	–11	Considerable water supply extractions
23	3116434	Sg. Batu	Sentul	145	15	1268	1300	+3	Negligible water supply extractions
24	3118445	Sg. Lui	Kg. Lui	70	9	1027	1000	–3	Negligible irrigation extractions
25	3414421	Sg. Selangor	Rantau Panjang	1450	15	1368	1340	–2	Negligible water extractions
26	3424411	Sg. Pahang	Temerloh	19000	12	1137	1020	–10	Negligible water extractions
27	3516422	Sg. Selangor	Rasa	321	12	1401	1290	–8	Negligible water supply extractions
28	3519426	Sg.Bentong	Jam. Kuala Marong	241	5	1436	1056	–26	Negligible water extractions. Suspect poor streamflow records.
29	3615412	Sg. Bernam	Tanjong Malim	186	15	1637	1650	+1	Negligible water extractions
30	3813411	Sg. Bernam	SKC Bridge	1090	14	1779	1640	–8	Negligible water extractions
31	3813414	Sg. Trolak	Trolak	66	12	1528	1500	–2	Negligible water supply extractions
32	3814413	Sg. Slim	Kg. Slim	314	9	891	1420	+59	Nil water resources utilisation. Poor streamflow records.
33	3814415	Sg. Bil	Jln. Tanjong Malim/Slim	41	15	1453	1500	+3	Negligible irrigation extractions
34	3814416	Sg. Slim	Slim River Town	455	8	1213	1420	+17	Negligible irrigation extractions
35	3911457	Sg. Sungkai	Jln. Anson/ Kampar	479	15	1631	1530	–6	Negligible water supply extractions
36	3913458	Sg. Sungkai	Sungkai	289	15	1470	1600	+9	Negligible water supply extractions
37	4011451	Sg. Bidor	Batu 9, Jln. Anson/Kampar	373	15	1823	1800	–1	Negligible water supply extractions

APPENDIX 6 (Contd)

Catchment No.	*Station No.*	*River*	*Station*	*Catchment Area (km²)*	*No. of Years Of Flow Records*	*Observed Mean Annual Runoff (mm)*	*Predicted Mean Annual Runoff (mm)*	*% Difference*	*Remarks*
38	4012452	Sg. Bidor	Batu 18, Jln. Anson/Kampar	339	15	2074	1850	–11	Negligible water supply extractions
39	4019462	Sg. Lipis	Benta	1670	10	952	895	–6	Some irrigation extrac-tions
40	4111455	Sg. Batang Padang	Tanjong Keramat	445	15	1747	1770	+1	Diversion of hydro-electric waters into river
41	4112454	Sg. Bidor	Bidor	84	15	1813	1950	–8	Negligible water supply extractions
42	4112456	Sg. Batang Padang	Tapah	376	10	1379	1550	+12	Diversion of hydro-electric water into river
43	4112459	Sg. Gedong	Bidor	108	8	2456	1950	–20	Nil water resources utilisation. Suspect poor streamflow records
44	4232451	Sg. Kemaman	Kuala Tayor	630	9	2216	1965	–11	Negligible irrigation extractions
45	4311464	Sg. Kampar	Kg. Lanjut	432	15	1209	1400	+16	Negligible water supply extractions
46	4410461	Sg. Kinta	Batu Gajah	1054	10	1057	920	–13	Some water supply extractions
47	4410465	Sg. Raja	Old Kinta Kellas Estate	251	6	1060	980	–8	Negligible water supply extractions
48	4510462	Sg. Kinta	Ipoh	313	11	892	775	–13	Negligible water supply extractions
49	4610466	Sg. Pari	Jln. Salibin, Ipoh	245	13	1109	895	–19	Some water supply extractions
50	4611463	Sg. Kinta	Tanjong Rambutan	267	13	919	850	–7	Negligbible water supply extractions
51	4809443	Sg. Perak	Iskandar Bridge	7769	15	845	895	+6	Negligible water supply and irrigation extrac-tions.
52	4810444	Sg. Plus	Kg. Pulau Mentimun	1388	8	1049	800	–24	Negligible water supply and irrigation extrac-tions. Suspect poor streamflow records.
53	4831441	Sg. Dungun	Kg. Jerangau	1410	7	2507	2350	–6	Nil water resources utilisation
54	4907422	Sg. Kurau	Batu 14, Jln. Taiping/Ijok	80	10	1530	1740	+14	Some irrigation extrac-tions

APPENDIX 6 (Contd)

Catchment No.	*Station No.*	*River*	*Station*	*Catchment Area (km²)*	*No. of Years Of Flow Records*	*Observed Mean Annual Runoff (mm)*	*Predicted Mean Annual Runoff (mm)*	*% Difference*	*Remarks*
55	4911445	Sg. Plus	Kg. Lintang	1088	6	766	830	+8	Nil water resources utilisation
56	5007421	Sg. Kurau	Pondok Tanjong	337	15	1794	1745	–3	Some irrigation extractions
57	5007423	Sg. Ara	Batu 20, Jln. Taiping/Ijok	140	15	2186	1561	–29	Some irrigation extractions. Suspect poor streamflow records.
58	5106431	Sg. Krian	Dusun Rimau Cableway	694	13	1684	1790	+6	Negligible irrigation extractions
59	5106433	Sg. Ijok	Titi Ijok	216	15	2122	1940	–8	Considerable irrigation extractions
60	5130432	Sg. Trengganu	Kg. Tanggol	3340	12	2323	2070	–11	Negligible irrigation extractions
61	5206432	Sg. Krian	Selama	629	10	2138	1840	–14	Negligible water supply and irrigation extractions
62	5405421	Sg. Kulim	Ara Kuda	129	15	1549	1520	–2	Nil water resources utilisation
63	5505412	Sg. Muda	Ladang Victoria	4010	10	814	890	+9	Some irrigation and water supply extractions
64	5506413	Sg. Muda	Batu Pekaka	3340	13	937	880	–6	Some irrigation and water supply extraction
65	5506416	Sg. Sedim	Merbau Pulas	440	12	1652	1630	–1	Negligible irrigation extractions
66	5506417	Sg. Karangan	Titi Karangan	83	10	1844	1800	–2	Nil water resources utilisation
67	5624412	Sg. Besut	Rantau Panjang	712	8	1776	1910	+8	Negligible irrigation extractions
68	5721442	Sg. Kelantan	Guillemard Bridge	11900	15	1487	1270	–15	Negligible irrigation extractions
69	5724411	Sg. Besut	Jerteh Bridge	787	5	1824	1910	+5	Negligible irrigation extractions
70	5724413	Sg. Pelangat	Pelangat	57	5	2689	2000	–26	Nil water resources utilisation
71	5806414	Sg. Muda	Jeniang	1710	15	724	860	+19	Considerable irrigation

APPENDIX 6 (Contd)

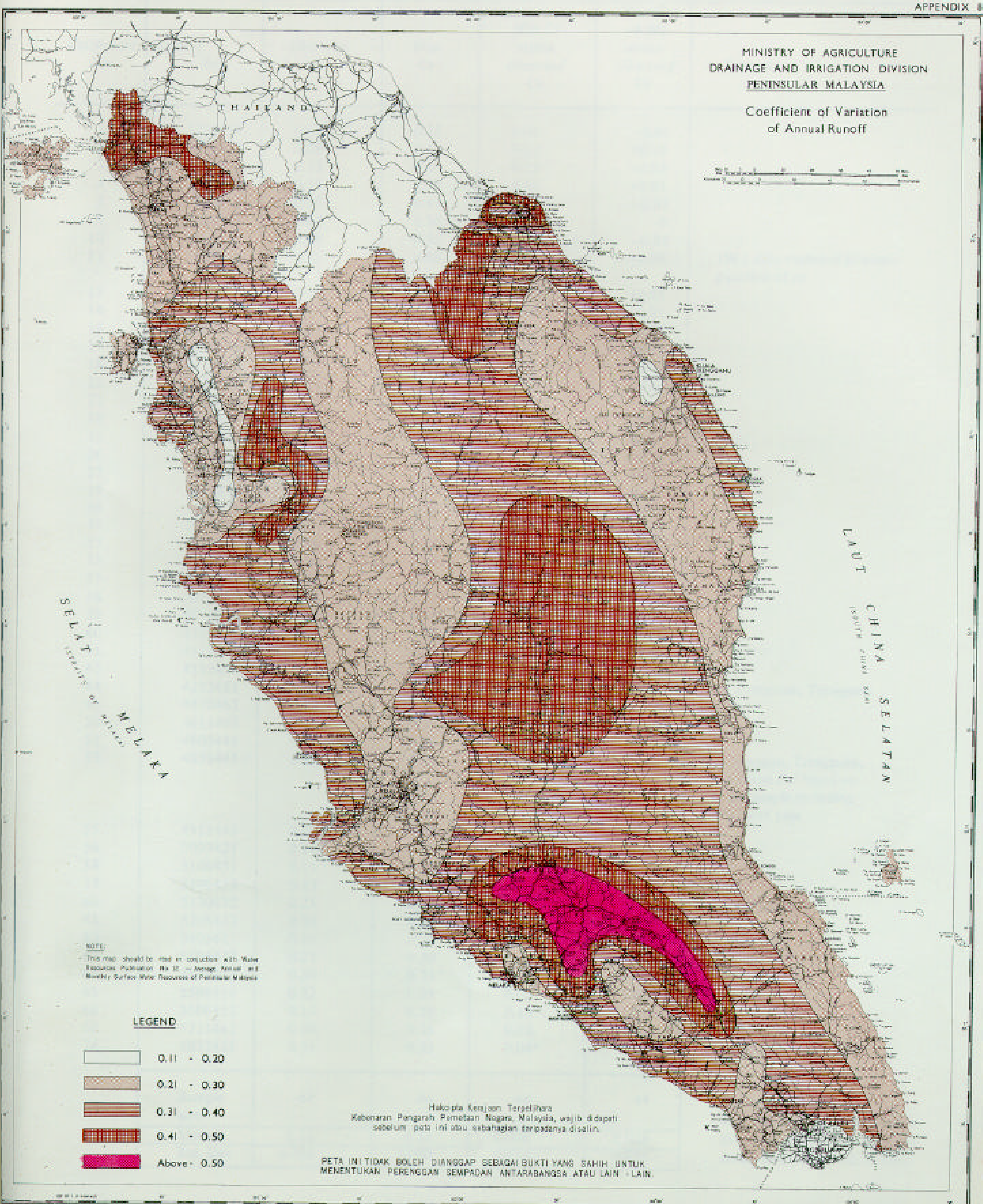
Catchment No.	*Station No.*	*River*	*Station*	*Catchment area (km^2)*	*No. of Years of Flow Records*	*Observed Mean Annual Runoff (mm)*	*Predicted Mean annual Runoff (mm)*	*% Difference*	*Remarks*
72	6007415	Sg. Muda	Nami	1220	13	670	770	+15	Considerable irrigation - extractions
73	6019411	Sg. Golok	Rantau Panjang	561	12	2463	1660	–32	Negligible water extractions. Suspect poor streamflow records
74	6022421	Sg. Kemasin	Peringat	48	14	2022	1800	–11	Nil water resources utilisation
75	6204421	Sg. Padang Terap	Lengkuas	1270	7	480	650	+35	Considerable irrigation extractions

APPENDIX 7
COMPARISON OF PREDICTED AND OBSERVED AVERAGE MONTHLY RUNOFFS

(X denotes failure in meeting accuracy criteria given in para 3.3.2)

Catchment No.	*Station No.*	*Jan.*	*Feb.*	*Mar.*	*April.*	*May.*	*June*	*July*	*Aug*	*Sept.*	*Oct*	*Nov*	*Dec*
1	1737451												
2	1931423									x			
3	2224432												
4	2237471									x			
5	2322413												
6	2322415				x								
9	2524416									x			
11	2527411												
13	2625412	x	x				x		x				
14	2719422												
16	2816441												
17	2917442												
19	2918443												
20	3015431												
21	3022431												
22	3116430												
23	3116434												
24	3118445												
25	3414421			x	x			x					
26	3424411							x	x				
27	3516422												
29	3615412												
30	3813411												
31	3813414							x					
33	3814415												
35	3911457												
36	3913458												
37	4011451												
38	4012452												
39	4019462												
40	4111455									x			

Catchment No.	Station No.	Jan.	Feb.	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
41	4112454												
42	4112456												
44	4232451												
46	4410461												
47	4410465	x											
48	4510462												x
50	4611463					x							
51	4809443									x	x		
53	4831441												
54	4907422					x							
55	4911445	x									x		x
56	5007421			x				x					
58	5106431				x								
59	5106433	x			x	x		x					x
60	5130432				x								
61	5206432	x	x					x	x	x			
62	5405421		x	x			x	x					
63	5505412					x							
64	5506413					x							
65	5506416												
66	5506417	x											
67	5624412									x			x
68	5721442									x			x
69	5724411									x			x
72	6007415					x			x	x			
74	6022421						x			x			



Disedia dan dicetak oleh Direktorat Pemetaan Negara, Malaysia No. 220/82.

APPENDIX 9A

COMPARISON OF 'MAP Cv' AND 'OBSERVED Cv'

Catchment No.	Station No.	Observed Cv	Map Cv	Map Cv minus Observed Cv	(Map Cv −0.09) minus Observed Cv	Remarks
1	1737451	0.29	0.35	0.06	−0.03	
2	1931423	0.29	0.41	0.12	+0.03	
3	2224432	0.33	0.45	0.12	+0.03	
4	2237471	0.19	0.29	0.10	+0.01	
5	2322413	0.33	0.41	0.08	−0.01	
9	2524416	0.41	0.50	0.09	0	
10	2525415	0.49	0.55	0.06	−0.03	
11	2527411	0.35	0.50	0.15	+0.06	1967 data excluded in computation of cv
13	2625412	0.29	0.43	0.14	+0.05	
14	2719422	0.27	0.37	0.10	+0.01	
16	2816441	0.22	0.26	0.04	−0.05	
17	2917442	0.11	0.25	0.14	+0.05	
18	2918443	0.17	0.28	0.11	+0.02	
21	3022431	0.27	0.33	0.06	−0.03	
22	3116430	0.16	0.25	0.09	0	
23	3116434	0.19	0.25	0.06	−0.03	
25	3414421	0.11	0.25	0.14	+0.05	
26	3424411	0.34	0.42	0.08	−0.01	
27	3516422	0.16	0.33	0.17	+0.08	
29	3615412	0.17	0.27	0.10	+0.01	
30	3813411	0.15	0.26	0.11	+0.02	
31	3813414	0.20	0.26	0.06	−0.03	
33	3814415	0.16	0.25	0.09	0	
35	3911457	0.16	0.28	0.12	+0.03	
37	4011451	0.20	0.28	0.08	−0.01	
38	4012452	0.16	0.27	0.11	+0.02	
39	4019462	0.17	0.32	0.15	+0.06	
40	4111455	0.20	0.28	0.08	−0.01	
41	4112454	0.14	0.26	0.12	+0.03	
42	4112456	0.17	0.26	0.09	0	
44	4232451	0.24	0.26	0.02*		Sg. Kemaman, Trengganu
46	4410461	0.13	0.30	0.17	+0.08	
50	4611463	0.26	0.33	0.07	−0.02	
51	4809443	0.27	0.33	0.06	−0.03	
53	4831441	0.39	0.25	−0.14*		Sg. Dungun, Trengganu, 'Observed Cv' based on small sample including 1967 wet year
55	4911445	0.20	0.32	0.12	+0.03	
56	5007421	0.12	0.27	0.14	+0.05	
58	5106431	0.11	0.23	0.12	+0.03	
59	5106433	0.13	0.25	0.12	+0.03	
60	5130432	0.25	0.25	0*		Sg. Trengganu
61	5206432	0.20	0.25	0.05	−0.04	
62	5405421	0.16	0.20	0.04	−0.05	
63	5505412	0.21	0.30	0.09	0	
64	5506413	0.30	0.33	0.03	−0.06	
65	5506415	0.22	0.29	0.07	−0.02	
66	5506417	0.16	0.29	0.13	+0.04	
68	5721442	0.30	0.38	0.08	−0.01	
74	6022421	0.31	0.35	0.04*		Sg. Kemasin, Kelantan
	Sample size	44	44	44	44	* Coastal catchments in Kelantan and Trengganu States Excluded from computation of means and standard devaitions.
	Mean	0.22	0.32	0.098	0.008	
	Std. Dev	0.086	0.080	0.035	0.035	

APPENDIX 9B

A STUDY ON PROBABLE ERRORS IN ASSESSING THE VARIABILITIES OF THE ANNUAL RUNOFF USING THE Cv MAP

Annual runoff, R for any one year can be expressed as follows:–

$$R = \bar{R} \pm ZS \quad .. \quad .. \quad (i)$$

where $\bar{R}$ is average annual runoff

Z is normal (assumed) random variable with mean zero and variance 1.

S is standard deviation

But coefficient of variation $Cv = \frac{S}{\bar{R}}$

Therefore (i) can be reexpressed as

$$R = \bar{R} \pm Z\,Cv\,\bar{R}$$
$$= \bar{R}(1 \pm Z\,Cv) \quad .. \quad .. \quad (ii)$$

Arising from (ii), it follows that error in R, Δ R, can be expressed as

$$\Delta R = \pm Z\,\Delta Cv\,\bar{R} \quad .. \quad .. \quad (iii)$$

where ΔCv is error in Cv estimation.

Percentage error in R therefore becomes

$$\frac{\Delta R}{R} = \frac{\pm Z\,\Delta Cv\,\bar{R}}{(1 \pm Z\,Cv)\,\bar{R}}$$

$$\text{or} = \frac{Z\,\Delta\,Cv}{1 \pm Z\,Cv} \quad .. \quad .. \quad (iv)$$

The probable error in Cv estimation depends on the confidence level one chooses, and can be expressed as

$$\Delta Cv = ZS'$$

where S' is the standard deviation of the differences between 'Map Cv' and 'Observed Cv'.

For normal probability distribution and at 90% confidence level,

Z = 1.65 (Please see Table 1of Appendix 10).
With $S' = 0.035$ (from Appendix 9A)

$$\Delta Cv = 1.65 \times 0.035$$
$$= 0.058$$

Substituting this in (iv), the equation becomes

$$\frac{\Delta R}{R} = \frac{0.058Z}{1 \pm ZCv} \quad .. \quad ..(v)$$

Using a mean Cv of 0.22 (See Appendix 9A), the percentage error in R estimation becomes solely dependent on Z which is determined by the choice of probability or frequency level.

(v) thus becomes

$$\frac{\Delta R}{R} = \frac{0.058Z}{1 \pm 0.22Z} \quad .. \quad .. \text{(vi)}$$

Thus, if one is interested in determining the variabilities of the annual runoff to 90% probability level (or in determining the 1 in 20 year annual runoffs), their Z = 1.65 and

$$\frac{\Delta R}{R} = \frac{0.058 \times 1.65}{1 \pm 0.22 \times 1.65}$$

$$= \frac{0.095}{1.363} \text{ and } \frac{0.095}{0.637}$$

$$= 0.07 \text{ and } 0.15$$

which means the upper range of the 90% probable annual runoff has a probable error of 7% arising from the error in Cv estimation while the lower range of the 90% probable annual runoff has a probable error of 15% arising from the error in Cv estimation.

For probable levels lower than 90%, the assessment of variabilities of the annual runoff is less affected by errors in Cv estimated.

APPENDIX 10

NORMAL PROBABILITY TABLES

TABLE 1

Probability Level (%)	50	55	60	65	70	75	80	85	90
Z	0.68	0.76	0.84	0.93	1.04	1.15	1.28	1.44	1.65

TABLE 2

(Frequency in) Years	2	5	10	15	20
(Z)	0	0.84	1.28	1.51	1.65

APPENDIX 11

AVERAGE ANNUAL AND MONTHLY SURFACE WATER RESOURCES FOR STATES IN PENINSULAR MALAYSIA

State	*Area (km²)*	*Mean Monthly Runoff (mm)*												*Mean annual Runoff (mm)*	
		Jan	*Feb.*	*Mar.*	*April*	*May*	*June*	*July*	*Aug*	*Sept.*	*Oct.*	*Nov.*	*Dec.*	*From Monthly Maps*	*From Annual Map*
Perlis	822	25	3	10	15	50	55	50	58	125	140	135	75	741	720
Kedah															
Mainland	9,268	30	11	21	39	108	67	58	70	132	213	200	92		1062
P. Langkawi	366	15	1	7	8	100	150	140	100	270	175	140	51		1400
State Total	9,634	29	11	20	39	108	70	61	71	137	212	198	90	1046	1075
Penang															
P. Pinang	281	35	8	20	43	100	63	88	75	200	263	245	100		1375
Province Wellesly	744	40	6	15	63	80	35	50	65	120	197	190	107		955
State Total	1,025	39	7	16	58	85	43	60	68	142	215	205	105	1043	1070
Perak	21,560	80	40	50	80	120	60	50	40	70	165	200	160	1115	1130
Selangor	8,330	105	45	60	80	115	45	35	45	60	130	185	170	1075	1020
N. Sembilan	7,288	65	28	40	45	60	30	20	25	35	60	85	100	593	580
Melaka	1,710	45	11	20	45	60	45	50	65	40	70	80	80	611	630
Johor	19,320	180	55	60	75	110	65	45	55	65	75	135	180	1110	1110
Pahang	37,670	205	35	50	30	60	37	30	50	60	120	140	240	1057	1020
Trengganu	13,257	390	150	110	60	65	55	80	90	110	160	300	555	2125	2190
Kelantan	13,807	190	50	50	35	70	60	60	70	105	140	220	355	1405	1390
Peninsular Malaysia (total)	134,423	167	49	54	53	85	52	46	55	77	131	176	235	1180	1173

WATER RESOURCES PUBLICATIONS PREVIOUSLY PUBLISHED

1.	Surface water Resources Map (Provisional) of Peninsular Malaysia (1974)	$ 5.00
2.	Hydrological Regions of Peninsular Malaysia (1974)	$ 6.00
3.	Sungai Tekam Experimental Basin Annual Report No. 1 for 1973-1974 (1975)	$ 5.00
4.	Notes on Some Hydrological Effects of Land Use Changes in Peninsular Malaysia (1975)	$ 5.00
5.	Evaporation in Peninsular Malaysia (1976)	$ 5.00
6.	Average Annual Surface Water Resources of Peninsular Malaysia – (1976)	$ 5.00
7.	Sungai Lui Representative Basin Report No. 1 for 1971/72 to 1973/74 (1977)	$ 5.00
8.	Water Resources for Irrigation of Upland Crops in South Kelantan	$ 5.00
9.	Sungai Lui Representative Basin Report No. 2 for 1974/75 to 1975/76	$ 5.00
10.	Sungai Tekam Experimental Basin Report No. 2 for September, 1974 to March 1977 (1978)	$ 5.00
11.	Comparison of Performance of U.S. Class A Evaporation pans made of Galvanised Iron and Aluminium (1982)	$ 5.00